ADVANTEST®
ADVANTEST CORPORATION

INSTRUCTION MANUAL TR9407 DIGITAL SPECTRUM ANALYZER

MANUAL NUMBER OED00 9205

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First printing June, 1986
Printed in Japan

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1. GETTING STARTED

1.1 HOW TO USE THIS MANUAL

This manual explains the TR9407 operation procedures with practical examples. Section 2 explains the basic keys for operating the TR9407 and how to read the data on the display screen. If you do not have experience in the spectrum analyzer operation, please read Section 1 first, and then Section 2.

Before starting measurement, guess the required procedure according to the measurement outline chart given in Section 2.4 and read the relevant explanation in this manual.

If you want to know the function of a certain key, read Section 6 or find the page of interest referring to the index given at the end of this manual.

1.2 GENERAL INFORMATION

TR9407 Dual-channel Digital Spectrum Analyzer combines high-speed, high-sensitivity analog technology plus a high level of signal processing and computer technology (surpassing regular minicomputers) with an FFT (fast Fourier transform) system designed to make CRT graphic displays easier to read and easier to use.

In addition to the basic analytical functions such as transfer functions, the TR9407 is also capable of handling cepstrum, pre-envelope functions, group delay, signal-to-noise ratios, and other new analytic parameters. And with a capacity to measure transfer functions in excess of 120 dB plus 4-decade logarithmic frequencies, and by featuring the unwrapping function which displays phase up to ±25600° without wraparound (these are the world's first features since TR9406), the highly advanced TR9407 represents a completely new approach to measuring procedures.

Memory of 512K words can be enhanced in the new features such as the level monitor in which time-varying spectrum can be observed or the resampling in which the time data are decimated so that the whole memory contents can be viewed without using the data window.

Spectrum zooming by up to 256 times from frequencies of 0.0025 Hz to 1 MHz is possible, and a wide range of input levels from -120 dBV to +30 dBV (1 µVrms to 31.6 Vrms) can be measured at high resolution and high sensitivity.

The highly versatile TR9407 is thus ideal for use in a very wide range of applications including vibration and noise analysis, structural analysis, audio equipment analysis, chemical analysis, somatological experiments, communication line analysis, and the measurement of noise in semiconductors.

1.2.1 FEATURES

(1) Ample measuring functions include:

- Oscilloscope, transient memory (digital storage oscilloscope), signal averager, time interval meter, digital voltmeter
- Correlator
- Histogram meter (probability density function meter)
- Spectrum analyzer, octave-band noise analyzer, distortion analyzer, frequency counter, frequency response analyzer (servo analyzer), phasemeter, group delay analyzer, signal-to-noise ratio meter

(2) Ample analyzing and operational functions

Analyzing functions
- Time domain data
- Time domain averaged data
- Complex spectrum
- Power spectrum
- Liftered spectrum (power spectrum envelope)
- Cross spectrum
- Transfer function
- Group delay
- Coherence function
- Signal-to-noise ratio (SNR)
- Coherent output power
- Impulse response
- ML (Maximum Likelihood; measurement of time delay depending on S/N ratio)
- SCOT (Smoothed Coherence Transform)
- Amplitude probability density function
- Autocorrelation function
- Cross-correlation function
- Power cepstrum
- Pre-envelope function
- Third octave and full octave band analysis

Math operational functions
+, −, x, ÷, $\int dt$, d/dt, x $(j\omega)^n$, V/EU, coherence blanking, equalization, conversion from open-loop transfer function to closed-loop transfer function or vice versa, Fourier transform and inverse Fourier transform and trend removal.

(3) Advanced functions and an entirely new approach to measurement and analysis

- Transfer function measurements using 4-decade logarithmic frequencies.
- Transfer function measurements with dynamic range in excess of 120 dB by use of differential input and auto range with the aid of the TR98201 Signal Generator.
- Sequence function -- an entirely new concept in transfer function measuring procedures. Involves the use of the TR98201 Signal Generator, and permits a high degree of freedom.
- Phase display without wraparound

(4) High input sensitivity, wide frequency range and broad dynamic range
The TR9407 covers a frequency range of up to 100 kHz with input sensitivity range from +30 dBV (31.6 Vrms) to −120 dBV (1 μVrms). The broad dynamic range of 72 dB allows you to measure two dissimilar strength spectra.

(5) Differential input measuring capability
The TR9407 has both single ended and differential inputs capabilities. Differential input mode can be utilized to minimize the errors due to the common mode voltage. This assures high precision measurement.

(6) Zoomed spectrum of transient record
The TR9407 contains 512K words time data buffer and can continuously record up to 512K (256K x 2) words of single (dual) channel time data for use in signal analysis.
The TR9407 performs spectrum zooming in the frequency domain up to a factor of 256 in binary sequence.

(7) Ample display features

- Displays real part, imaginary part, magnitude, phase for Bode diagram; real part and imaginary part for Nyquist diagram; phase and dBMag for Nyquist diagram and Nichols chart.
- Variation with time of the peak values or the overall values of the spectrum within the specified frequency range can be observed by displaying 1024 points of data over the time axis (Level monitor).
- Long-standing measurement results are decimated in the time domain. Using the data window means the observation of the data piece wise while this resampling capability allows you to grasp the whole data at a glance. Time compression by a factor of 2 to 256 in binary steps.
- The unwrapping function displays transfer function phase without wraparound.
- Data at an arbitrary point on a signal trace can be directly read out by pointing it with a cursor.
- The available spectrum display resolution is 800 lines for single channel, 400 lines for dual channel, and 1116 lines for 4-decade logarithmic frequency analysis mode.
- Combination of memory, dual display and superimposition features permits accurate comparison between two sets of data or clear understanding of the relation between the time and frequency domains.
- The display features also include Δt and ΔV in the time domain, Δf and dBR in the frequency domain, mathematical operations between data, overall RMS readout, auto peak search, list of harmonics with total harmonic distortion, etc.
- Ample trigger modes and flexible trigger condition setup capability with the aid of cursors enable accurate observation and analysis of transient phenomena.
- Readout units in the time domain and the frequency domain can be converted into the desired engineering units with the scaling function.
- Three-dimensional display capability allows up to 14 lines of arbitrary displayed data to be stacked on the CRT (Three-dimensional display of Nyquist diagram (or Nichols chart) with frequency axis and orbit diagram with time axis).

(8) Signal generator interface included as standard accessory
When the TR9407 is used together with the TR98201 Signal Generator (which has been designed to achieve optimum results in combination with the TR9407 Dual-channel Digital Spectrum Analyzer), high-precision transfer functions can be measured at speeds of up to 10 to 100 times faster than in conventional system.

When the TR9407 differential input and auto range are used, transfer functions with a dynamic range in excess of 120 dB can be measured. The TR98201 can also be used as a function generator capable of generating a wide range of time data measured by the TR9407. That is, the TR98201 can generate seismic waves which only occur once, and other signals which are difficult to reproduce.

(9) GPIB, plotter and floppy disk interface provided as standard
The TR9407 has the interface of GPIB, plotter and floppy disk as standard feature. This enables you to put the TR9407 as an instrumentation part of a larger system configuration. High-speed data file or sophisticated recording function can be implemented by interconnecting an optional digital plotter or floppy disk with the instrument. TR9835R or TR9832 Plotter is available for continuous data plotting or multi-color recording. The measurement data can be plotted in flexible layout with respect to the size and orientation of the plots. This feature greatly simplifies report preparation. The plotter interface also supports HP-GL plotters (models 7470A, 7225A by Hewlett-Packard). TR98102 Floppy Disk Digital Data Recorder may be used to record the analyzed vibrations of rotating bodies or random impact pulses. TR7200 Universal Scanner is provided to accept multiple input signals.

(10) Third octave band and full octave band analysis
The TR9407 is capable of 1/3- and 1/1-octave analysis. Since the instrument uses filters that comply with the international standard, it produces 1/3- and 1/1-octave analysis data compatible with those obtained from conventional analog type octave analysis. The 1/3- and 1/1-octave analysis feature is particularly useful for acoustic research and engineering applications.

1.3 PREPARATION AND GENERAL PRECAUTIONS

1.3.1 CHECK

Upon receipt of the instrument, examine it for any damage sustained in transit, taking special note on panel switches, CRT display, and terminals. If the instrument is damaged or does not operate properly, contact your nearest Advantest representative.

1.3.2 Preparation and General Precautions

(1) Power supply
The proper line voltage at which the instrument should be operated is factory-set and indicated at the power cable outlet on the rear panel. The operating voltage is selectable from 90-132 Vac or 198-249 Vac, 50/60 Hz (see Figure 1-1).

Before plugging the power cable into an AC source, check to make sure that the POWER switch is set at the OFF position.

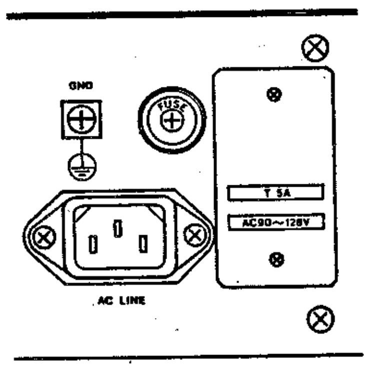
CAUTION

Never turn on or turn off the POWER switch while the incoming signal is being applied.

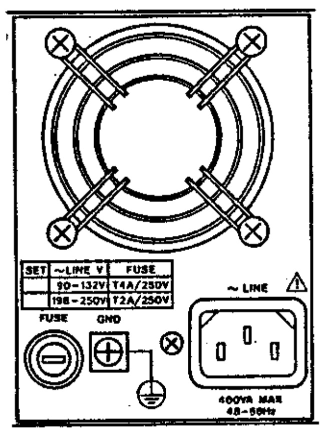
(2) Power cable
The power cable has a three conductor plug at its end, the center pin being for the ground. The instrument should be powered from a three-conductor outlet as much as possible. If only a two conductor outlet is available, use the supplied plug adapter for power connection. In this case, be sure to connect either the ground lead of the plug adapter or the rear GND terminal on the instrument to an external ground or earth (see Figures 1-1 and 1-2).

Because of its wide-band, high-sensitivity design, improper grounding may cause the instrument to be subject to noise interference. Be sure to ground the instrument especially when it is used in a high-sensitivity range (see Figure 1-3(a) and (b)).

In A09034, the two prongs of A and B have different width as shown in Figure 1-2 (b). Therefore, before inserting the plug into the receptacle, check the relative position between the plug and the receptacle. If A09034 cannot be connected to a desired receptacle, obtain the optional adapter KPR-13.

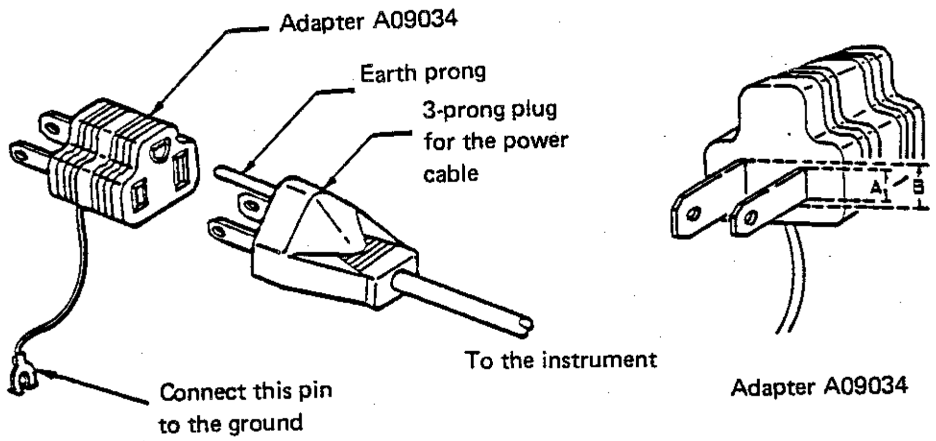


Display Unit



Input Unit

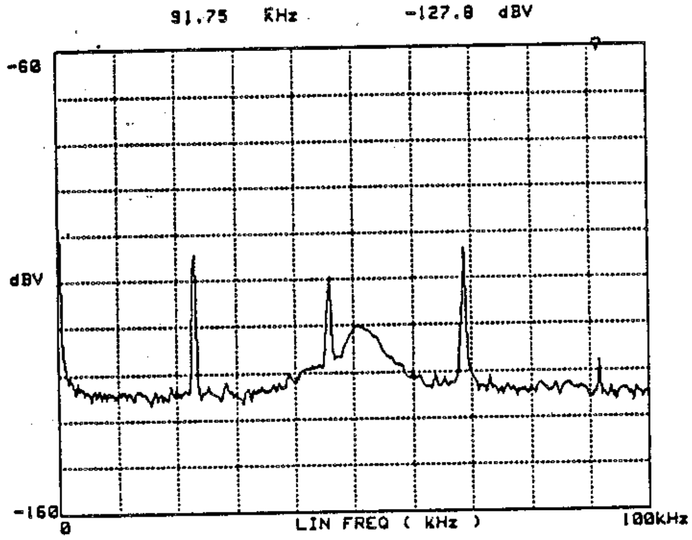
Figure 1-1 Line Voltage Plate and GND Terminal



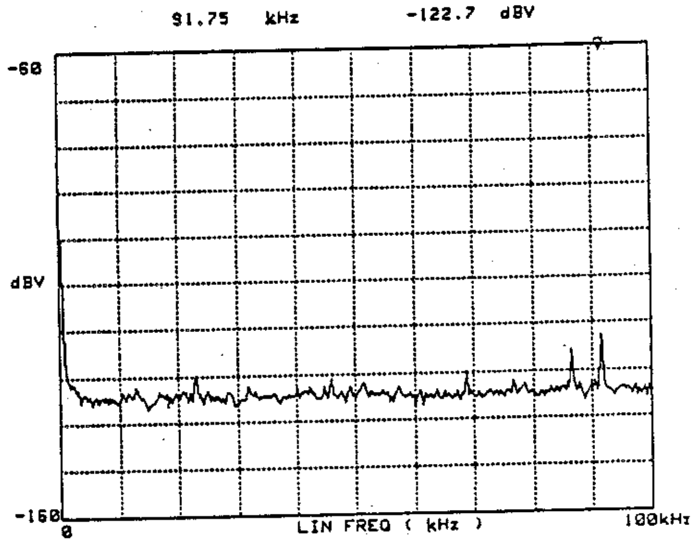
(a)

(b)

Figure 1-2 Power Cable Plug and Plug Adapter



(a)



(b)

Figure 1-3 Grounding effect ((a): not grounded (b): grounded)

(3) Connection of display unit and input unit.
Stack the display unit on the input unit and connect the AIO connectors on the rear panels with the supplied cable (DCB-RR2057 x 01).

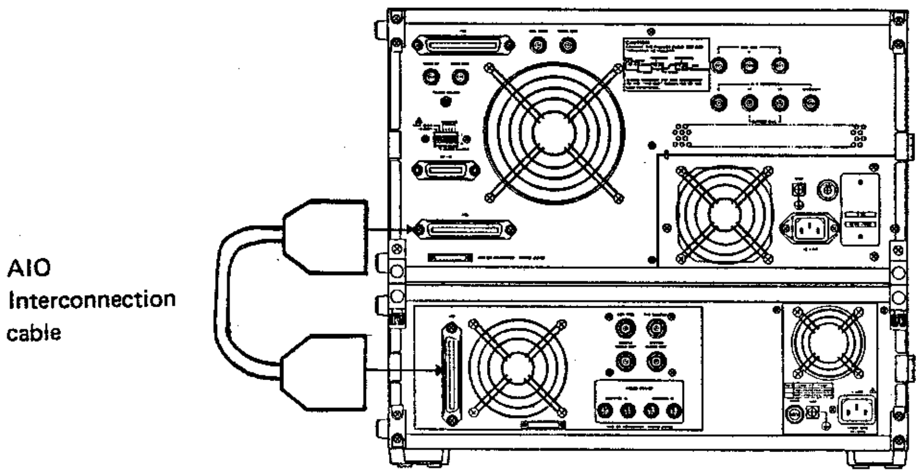


Figure 1-4 Connection of diplay unit and input unit

(4) Fuse replacement
The line fuse is contained in a fuse holder on the rear of the instrument. When replacing the fuse, remove the cap from the fuse holder. The ratings of the fuse are shown below:

100-115 Vac	5 A
200-230 Vac	2.5 A

CAUTION

When replacing the fuse, be sure to set the POWER switch to OFF and unplug the power cable from its outlet.

(5) Operating environment
The instrument should be situated in a place where it will not be exposed to excessive dust, direct sunlight or corrosive gas.
The operating temperature should be between 0°C and +40°C, with relative humidity under 85%.

(6) Ventilation
The instrument uses two exhaust type cooling fans. Allow sufficient space around the instrument, especially on the rear side of the instrument. Do not place the instrument on its rear panel.

(7) Although the instrument is designed for immunity from AC line noise, it should be operated from a line with the least possible noise level. If the line power is contaminated with excessive noise, use a line filter.

(8) When the instrument is to be attached to a controller or other instrumentation equipment for system setup, study the instruction manuals for each device carefully.

(9) Do not situate the instrument in places where it will be subject to excessive vibration.

(10) The storage temperature for the instrument is between -20°C and +70°C. If the instrument is to be left unused for a long period of time, wrap it with a vynil cloth or put it in a carton box.
The storage site should be free of direct sunlight or excessive moisture.

(11) Halation on the CRT display
When the display trace is concentrated in a relatively small area with high intensity, halation may result. If halation is intense, use the INTENSITY control on the left side panel to reduce intensity.

(12) Device breakdown due to the CMV loop formed in the power supply line:
The TR9407 can be used with various peripheral devices such as a desk-top computer, floppy disk drive, digital plotter, and X-Y recorder. When attaching any peripheral device to the TR9407, be careful about the generation of common mode noise voltage (CMV) caused by defective power-supply ground wirings.
If the power supply line is floated from the ground, an AC voltage (CMV) of approximately 50 V will appear across terminals a1 and a2, and b1 and b2 through the loop shown in Figure 1-5. At this time, if terminals a1 and a2 are connected together with terminals b1 an b2 left open, the input circuit devices in circuits 1 and 2 may be damaged or subject to serious degradation. To prevent this, the power supply line must always be grounded. A similar CMV will also be generated if the analyzer is turned on or off with its power cable plugged in or out of the electrical outlet. The analyzer should always be turned on or off with its front panel POWER switch.
If use of a floated power supply is unavoidable, establish the ground terminal connections and all other signal cable connections before plugging the analyzer into an electrical outlet and then switching it on.

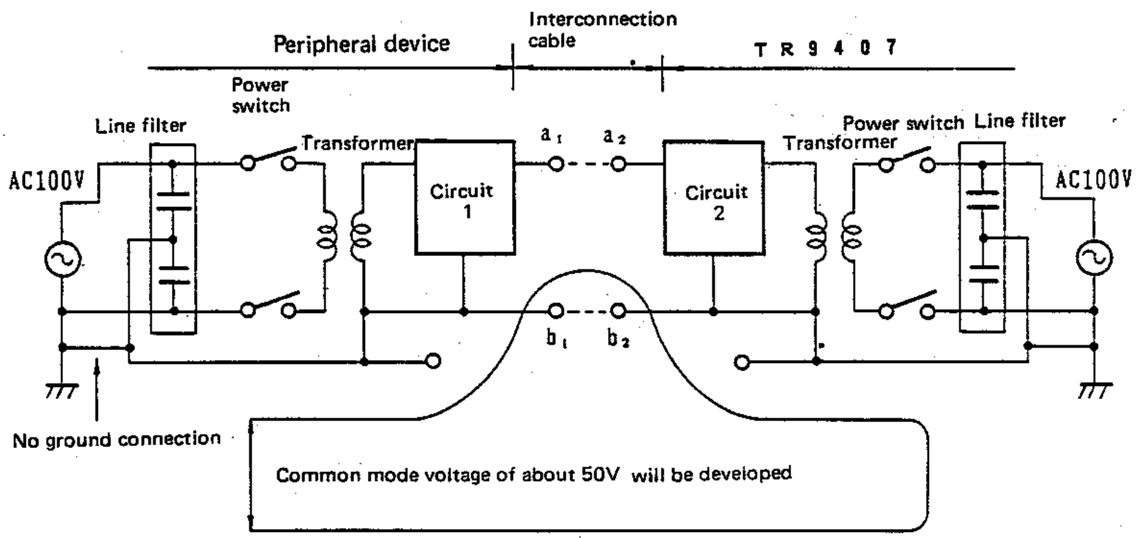


Figure 1-5 CMV loop in a power supply line

1.4 POWER ON AND SELF DIAGNOSTICS

1.4.1 Self Diagnostics

When the analyzer is switched on, a self diagnostics sequence is automatically initiated. If everything is found to be normal, the instrument becomes ready for operation approximately 15 seconds after power on.

In order to back up the internal memory against power off, the analyzer contains a Ni-Cd battery. The battery is automatically charged during power on, and backs up memory for about one week to maintain measurement condition setup data intact during power off.

If power off condition continues for more than one week, the contents of the memory may evapolate. If this happens, set up the necessary measurement conditions again after power on.

CAUTION

- o Before switching on the analyzer, check to see that the operating voltage indicated on the rear of the instrument agrees with the local line voltage.
- o Once the analyzer is switched off, do not switch it on again within 3 seconds after the power off. If it is switched on again within 3 seconds, the power supply circuit may malfunction.
  If this happens, switch off the analyzer, and then switch it on again several seconds later.

If everything is normal, the self diagnostics sequence is completed approximately 15 seconds later, and the analyzer shows the TIME data on channel A on its display or is placed under the previous measurement condition stored in internal memory (PANEL section) to be ready for operation. Upon the end of the self diagnostics sequence, "pip" tone will sound consecutively four times to alert the operator for the end of the sequence, and then the LED indicators on the front panel return to the normal condition.

If the power to the instrument is left off for more than five minutes, it takes approximately 30 seconds for the CRT display to warm up and provide the normal information display. So no message pertaining to the self diagnostic test will be observed on the display upon initial power on. If you turn on the power several seconds after power off, you will be able to see message

"SELF TEST IN PROGRESS !!"

on the display. Upon the end of the diagnostic sequence, message

"TEST COMPLETED !!"

will be shown for a few seconds, and the analyzer becomes ready for operation after giving off audible "pip" tone.

If any defect or malfunction is detected in the internal circuit or part, the display will show the function-classified defect locations upon the end of the diagnostic sequence.

Error message "FAIL GPIB" in the self-diagnostics is derived from:

(1) The status of the bus where other devices are connected with the GPIB cable upon TR9407 power turn-on.
(2) The internal circuitry being damaged.

In case of (1), making the TR9407 run by pressing a front-panel key will restore the instrument into normal condition. If it is not still properly working, turn on the power without connecting interconnection cables. When the error message still remains, it comes from (2); contact your Advantest's local representative.

1.4.2 Initializing the TR9407

(1) Initialization by panel keys
The TR9407 is initialized by pressing LOCK CLR LOCAL while the message SELF TEST IN PROGRESS!! is blinking during the self-diagnostics routine just after power-on. The TR9407 produces the CRT display as shown below.

(2) Initialization by GPIB controller
Sending the IN command initializes the TR9407.

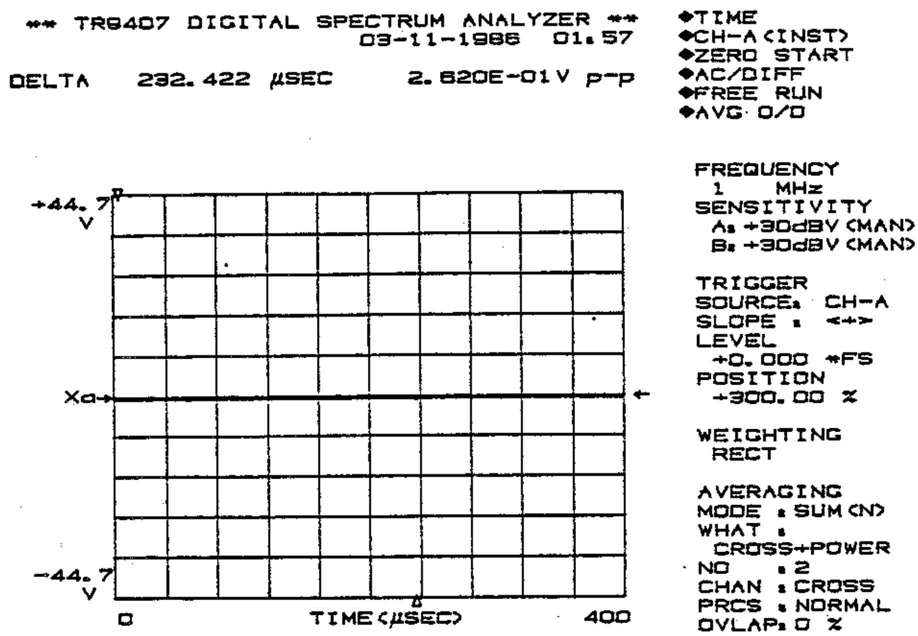


Figure 1-6 Display during Initialization

1.5 SETUP IN THE INPUT SECTION

1.5.1 Differential Input Method and Single-ended Input Method

The TR9407 permits both the differential input method in which signals are applied to the (+) and (-) terminals (these two common mode signals are removed through the differential amplifier) and the single-ended input method in which one terminal is grounded.

When high sensitivity and wide dynamic range are required, use the differential input scheme.

Figure 1-7 shows a differential input example in which the incoming signal to the DUT is connected to channel A and the output signal from the DUT is connected to channel B.

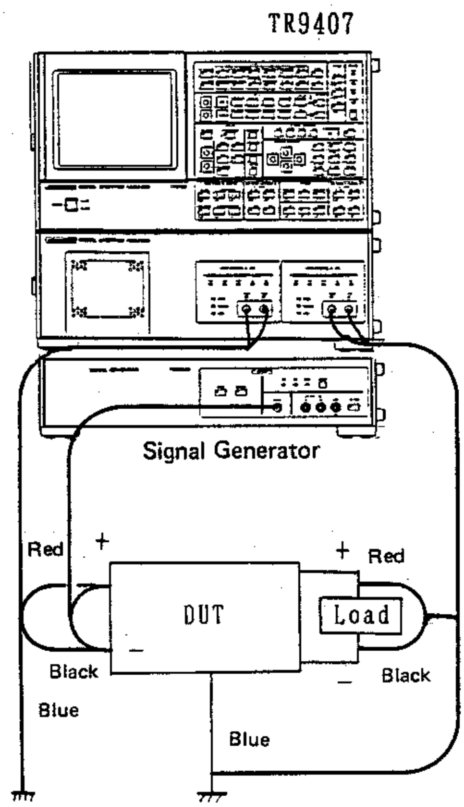
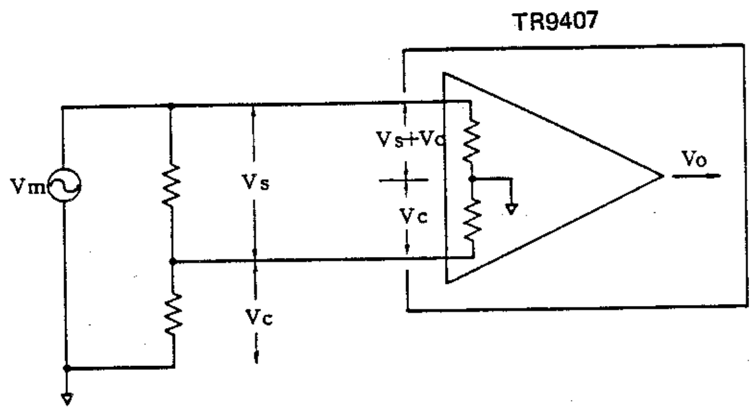


Figure 1-7 Differential Input Example (both channels A and B)

(1) Differential input method
Broadly speaking, the differential input method can be used for the following three signal sources, which enhances high-sensitivity and wide-dynamic-range measurement even if there is common-mode noise or common-mode voltage.

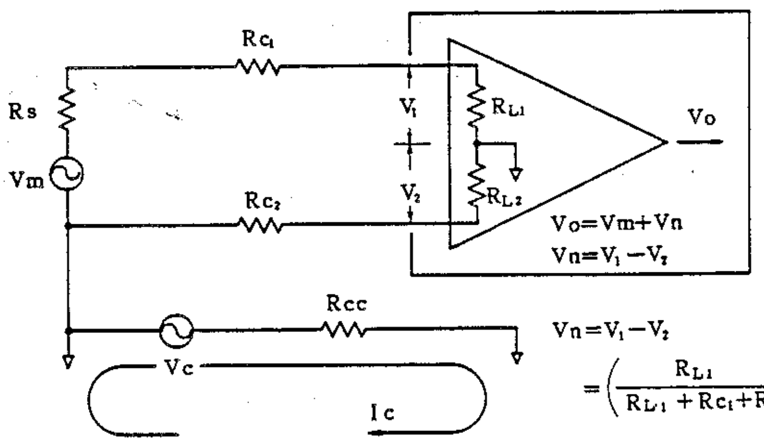
a. The signal source is floating off the common ground. As shown in Figure 1-8, signal source Es to be measured is floated by bias signal Ec (common-mode voltage). This occurs when measurement is made for the AC bridge output or at the intermediate point of the feedback system.



Vm: Measurement voltage
Vc: Common-mode noise
Vn: Differential amplifier output

Figure 1-8 Common-mode Voltage when Signal Source is Floating

b. A long cable is required between the TR9407 and signal source, or measurement is hindered by common-mode noise contained in power line because the transducer or sensor is directly connected to a large DUT.
In these cases, the ground current or the current flowing through the DUT causes common-mode noise as shown in Figure 1-9.



$$= \left(\frac{R_{L1}}{R_{L1} + R_{c1} + R_s} - \frac{R_{L2}}{R_{L2} + R_{c2}} \; V_c \right)$$

Figure 1-9 Signal Source Liable to Common-mode Noise

c. The output of the signal source is balanced.
This type is often found in the output of audio amplifiers or test oscillators.

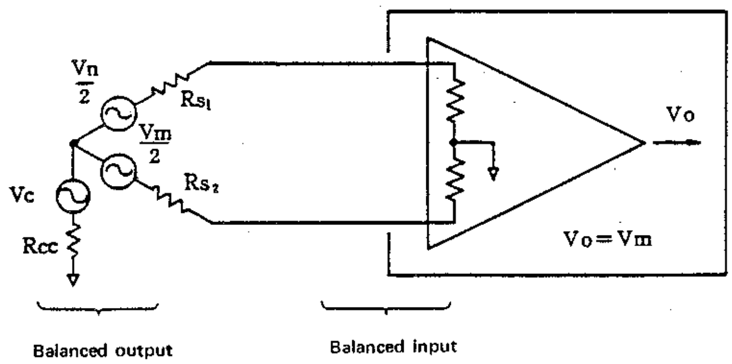


Figure 1-10 Balanced Signal Source

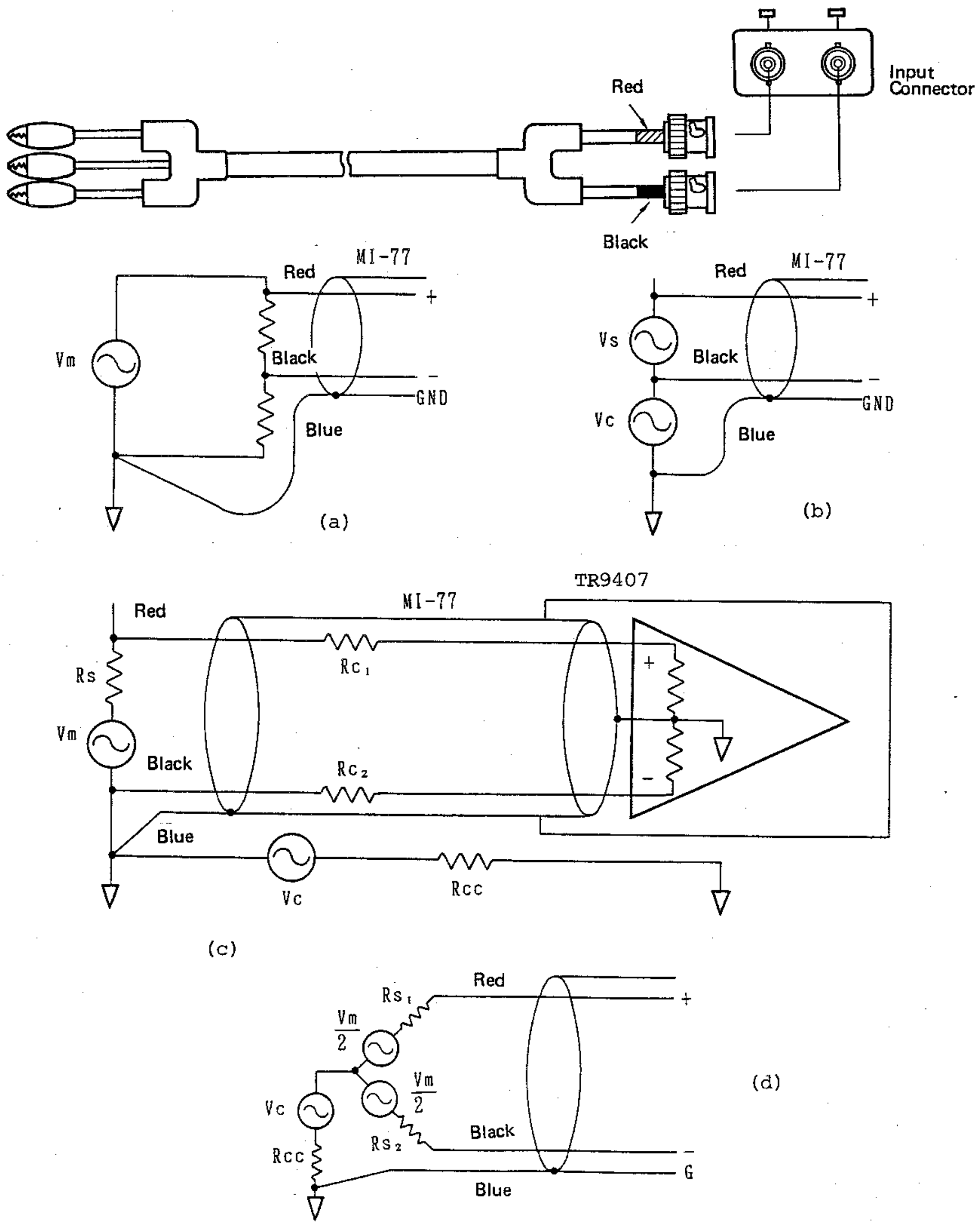


Figure 1-11 Connection of MI-77 Cable Dedicated to the Differential Input

(2) Single-ended input mode and its connection
All signal sources having a grounded return line can be measured in the single-ended input mode.

The singled-ended input mode may be applicable to the cases wherein common mode noise is extremely low in level, measurement is hardly affected by the presence of common mode noise, or dynamic range may be sacrified to some extent. An example of signal source measurable with the single-ended mode is shown in Figure 1-12.

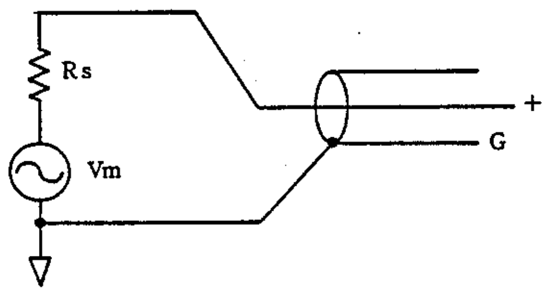


Figure 1-12 Signal source which allows single-ended mode

Either the supplied cable (MI-77) or other compatible cables may be used for input connection for the single-ended mode. For instance, if a shielded input cable with BNC connectors at its both ends is to be used for single-ended input connection (see Figure 1-13 (a) or (b)), connect one end of the cable to either the + or - input connector on the TR9407. If it is connected to the + connector and the -GND mode is selected as shown in Figure 1-13 (a), the input of the instrument becomes an inverting input.

If the cable is connected to the - input and the +GND mode is selected as shown in Figure 1-13 (b), the input of the instrument is a noninverting input. When the single-ended input mode is used, the input signal polarity is reversed, especially when making analysis of phase information, cross correlation function or magnitude probability density function.

NOTE

Be sure to use the +GND and -GND keys to ground either the + or - input which is not used.

If unused input is left open (see Figure 1-14), the input may be affected by the other input due to induction (Figure 1-14 (a)) or by external noise interference (Figure 1-14 (b)). This may result in appreciable measurement error.

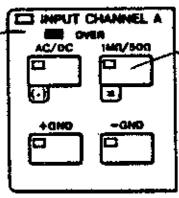
NOTE

The tradeoff in the implementation of the TR9407 in the high-sensitivity range is that the single-ended input scheme may be subject to line voltage noise in the system or peripheral device noise introduced through the interconnection cables because of its nature of high sensitivity.

In the system configuration, therefore, the least possible cable connections are recommended to lessen the noise contribution. (Disconnect the unused cables.) For the measurement under these circumstances, differential input mode is recommended instead of single-ended mode.

Display in the input section

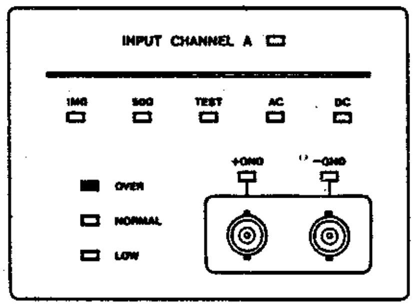
Overload in the GPIB or floppy disk



(lamps on the display unit)

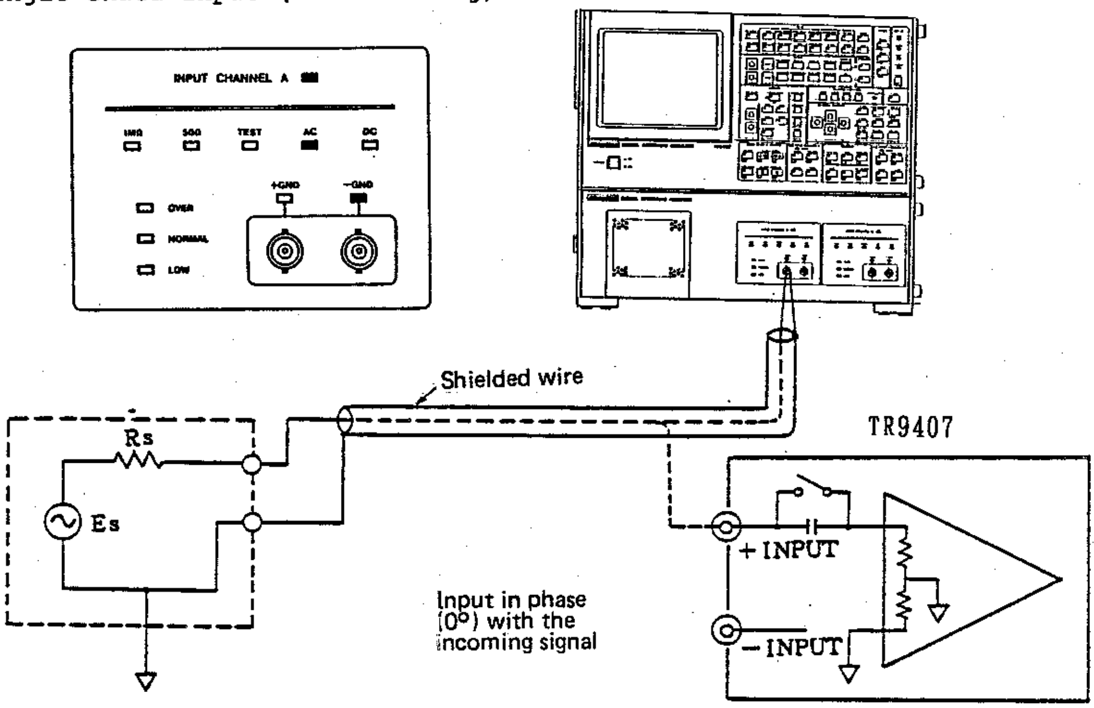
Press and hold it for 1 sec or more to switch over (So that the input impedance is not subject to easy change) (Only 1MΩ is effective in the +30dB sensitivity range)

Input overload from the A/D converter



(lamps in the input unit)

(a) Single-ended input (noninverting)



(b) Single-ended input (inverting input)

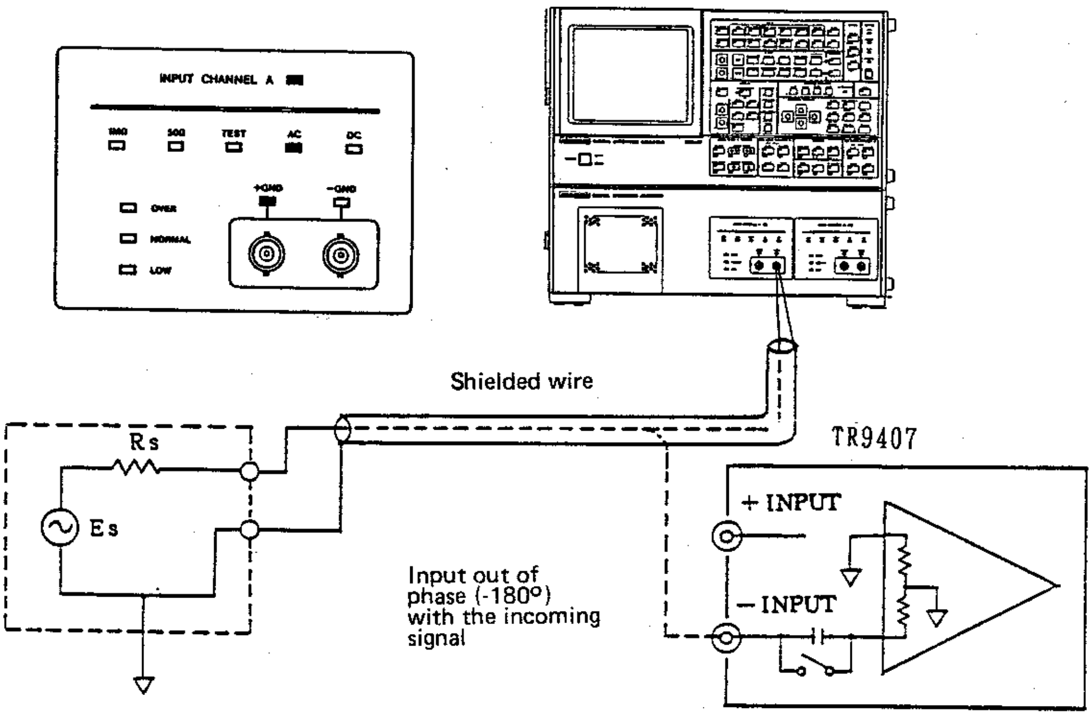
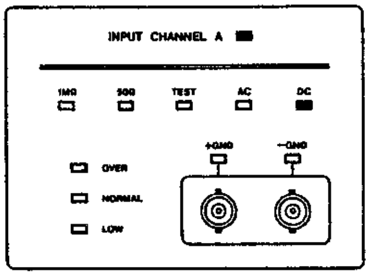
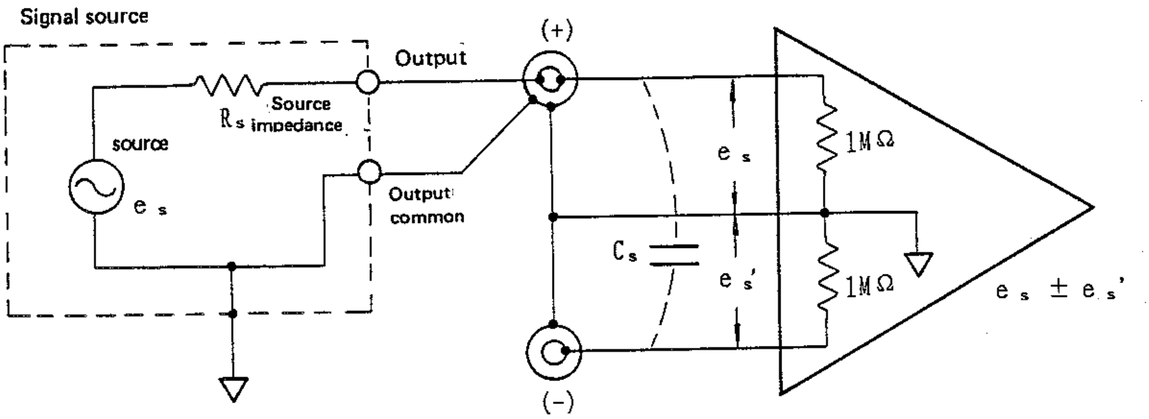


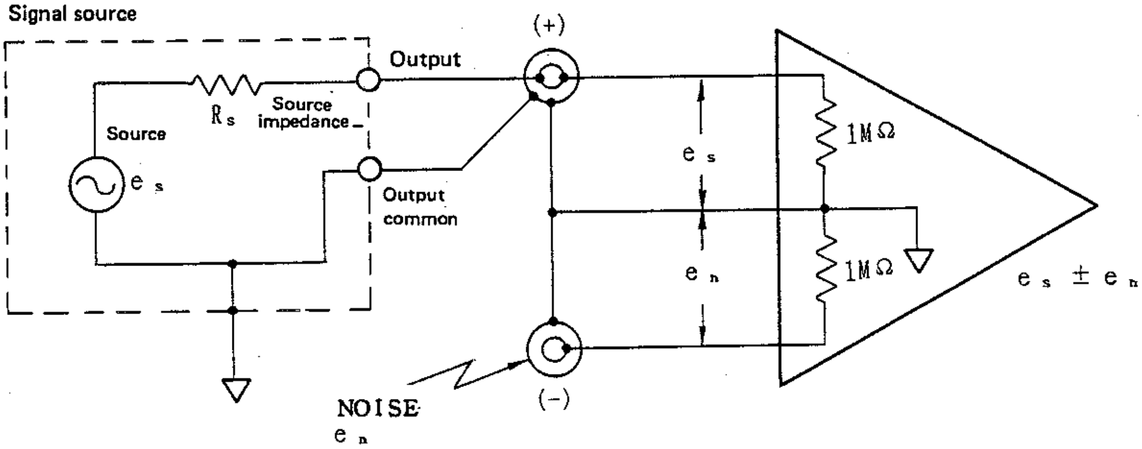
Figure 1-13 Single-ended Input



(a) The correct level is not obtained because e_S leaks to (-) INPUT



(b) The correct level is not obtained because -INPUT is directly
interferred with inductive noise



* If the input is left open, the noise level will be extremely high due to thermal noise from the high input impedance (approx. 1MΩ), as well as to signal leakage or external noise sources, especially when the analyzer is in a high sensitivity range.

Figure 1-14 Wrong Usage of Single-ended Input Mode

1.5.2 Switching of Input Coupling Mode

(1) DC coupling
The DC coupling mode directly couples the input signal to the input amplifier, and is useful to capture transient signals and other irregular signals. The AC coupling mode is unalternatively selected when the TEST mode is entered. If measurement mode is switched from the TEST into other measurement mode, check to see that the adequate input coupling mode is selected.

(2) AC coupling
With the Ac coupling mode each input connector is capacitively coupled with input amplifier (Figure 1-15 (a) (b) (c)). The cutoff frequency is 0.5 Hz (at -3dB).
The AC coupling mode is useful to eliminate DC bias (or offset) voltage from the input signals. It may also be useful for measurement of steady signals whose mean level is always constant.

(3) GND coupling
The +GND and -GND keys are used to ground one of the two differential inputs of the instrument to obtain the single-ended input mode.
If the TEST mode is selected during GND mode, the input coupling mode is forcibly switched into the AC mode. These input coupling modes are shown in the top right display area on the display.
The usage of these four keys and TEST mode is summarized in Figure 1-15. Figure 1-15 (a) and (e) indicate the differential input mode, while (b), (c), (f) and (g) indicate the usage in the single-ended intput mode.

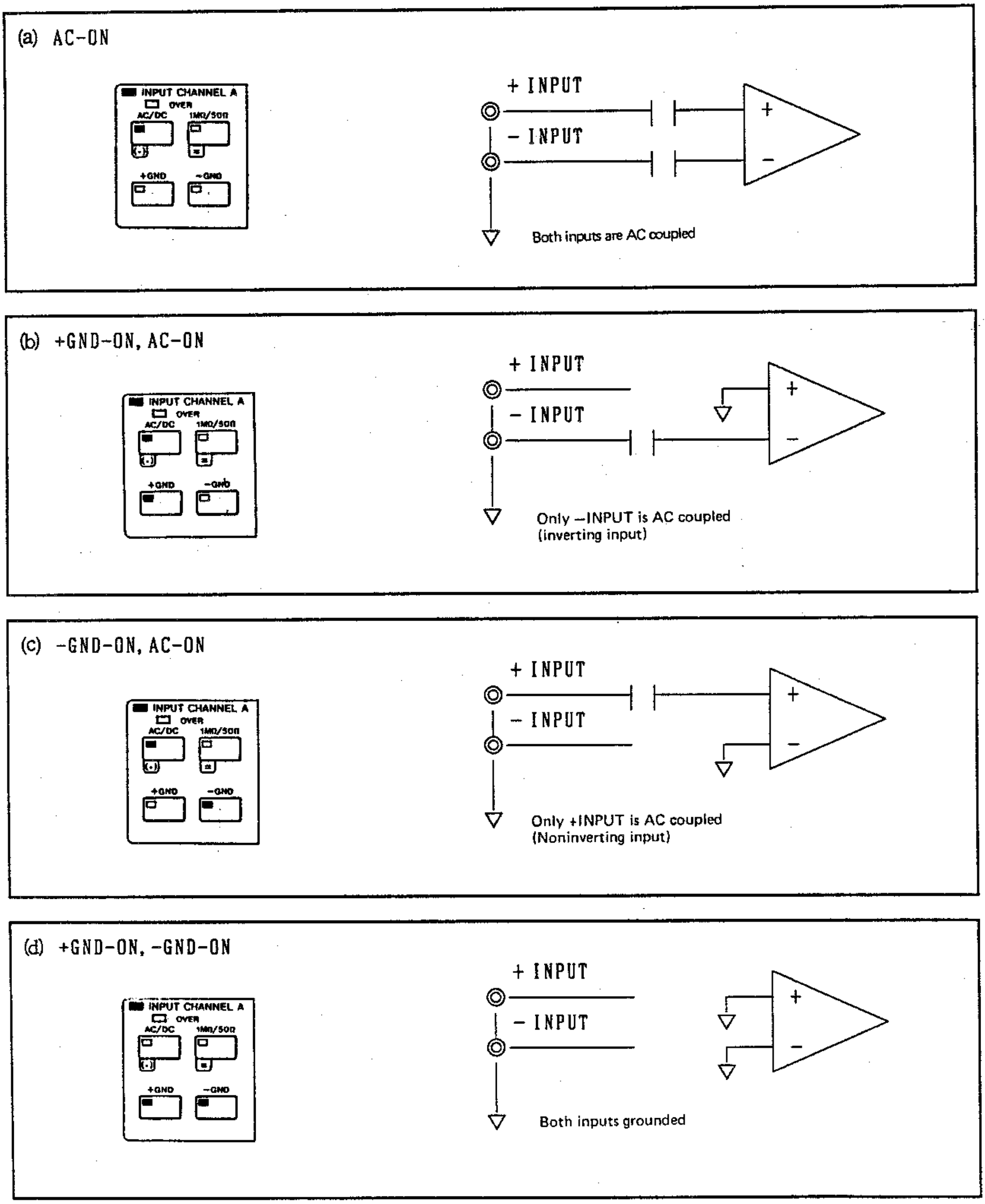
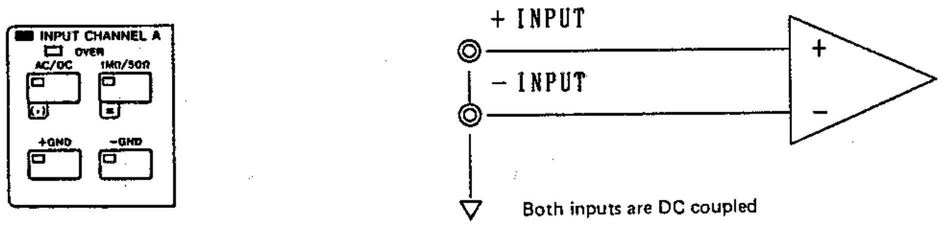
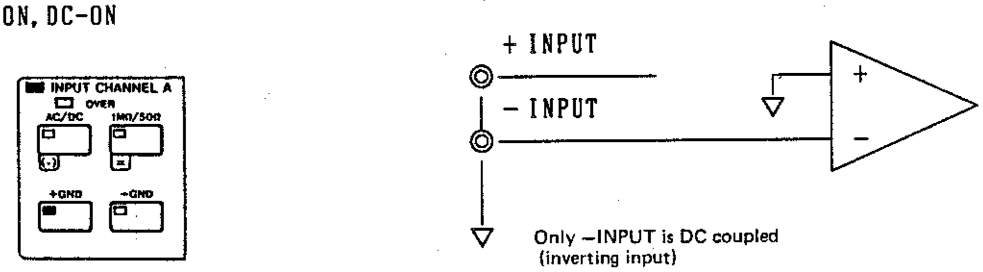


Figure 1-15 Usage of AC/DC and GND Keys

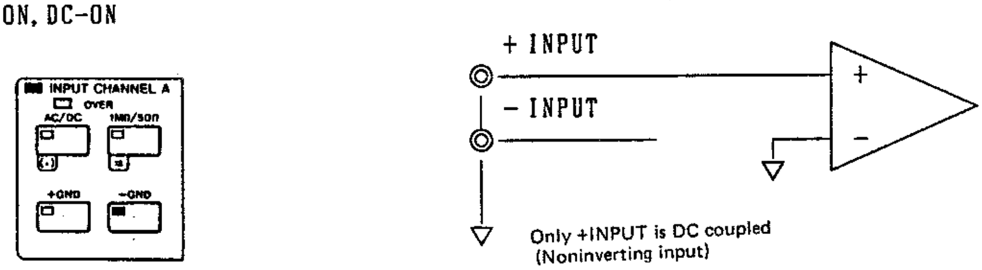
(e) DC-ON



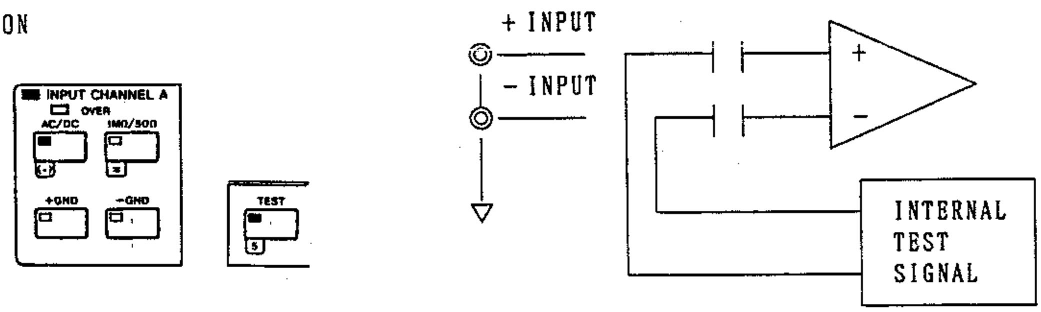
(f) +GND-ON, DC-ON



(g) -GND-ON, DC-ON



(h) TEST-ON



* The same applies to the input channel B. The TEST key is applicable to both channels.

Figure 1-15 (Cont'd)

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2. FOR FIRST USER OF THE FFT ANALYZER

2.1 HOW TO READ DATA ON CRT DISPLAY

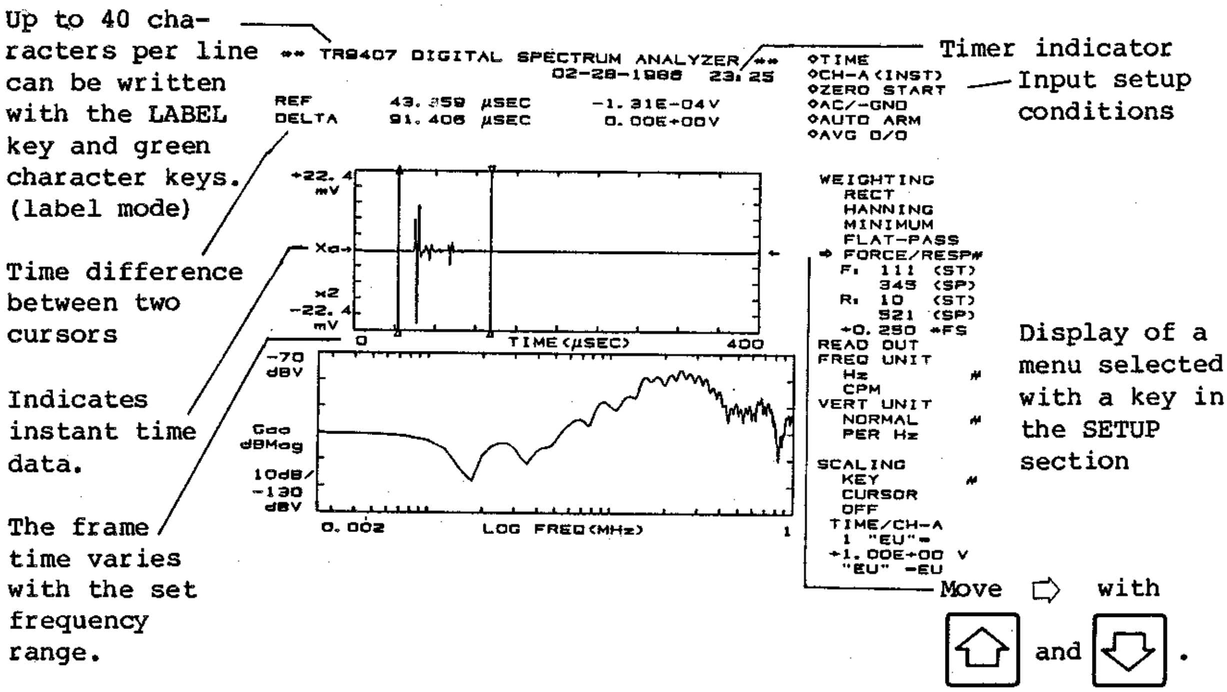
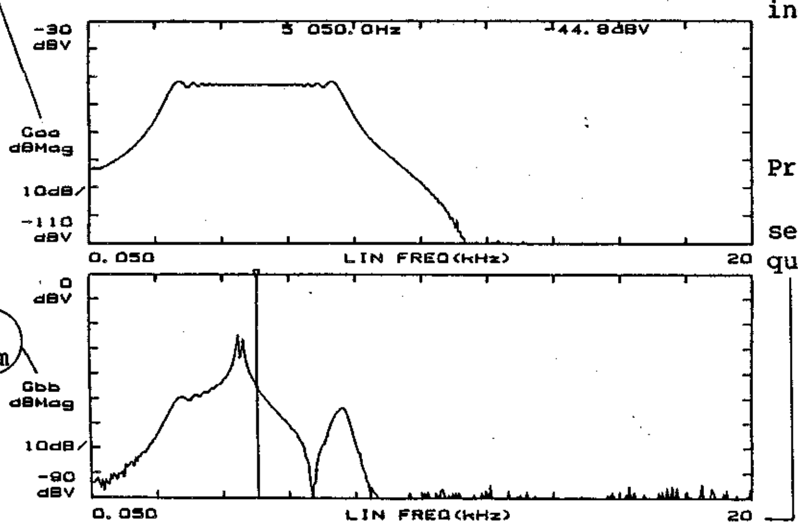


Figure 2-1 Time Waveform Display (TIME key)

Channel A input spectrum

Press [DISPLAY CTL] to modify the amplitude display unit and the dB value per division.

Press [UPSCALING] to enlarge the trace by erasing the menu.



Press [FREQUENCY] to set the frequency range.

Channel B input spectrum

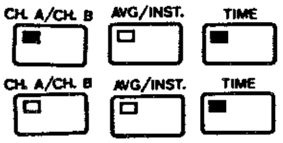
Press [LIN./LOG. FREQ.] to display log.

Frequency of the minimum resolution for AC coupling. "0.05 kHz" is displayed because one channel contains 400 lines (20 kHz/400)

Figure 2-2 Spectrum Data Display Example ([SPECTRUM] [BOTH])

2.2 BASIC CAPABILITIES OF PANEL KEYS

2.2.1 Displaying and Observing Waveform



: Input time waveform Xa

: Output time waveform Xb

To achieve high-resolution measurement, select the sensitivity range by which input/output time waveforms are generated to the full scale so that the number of digitized bits by A/D converter is maximized.

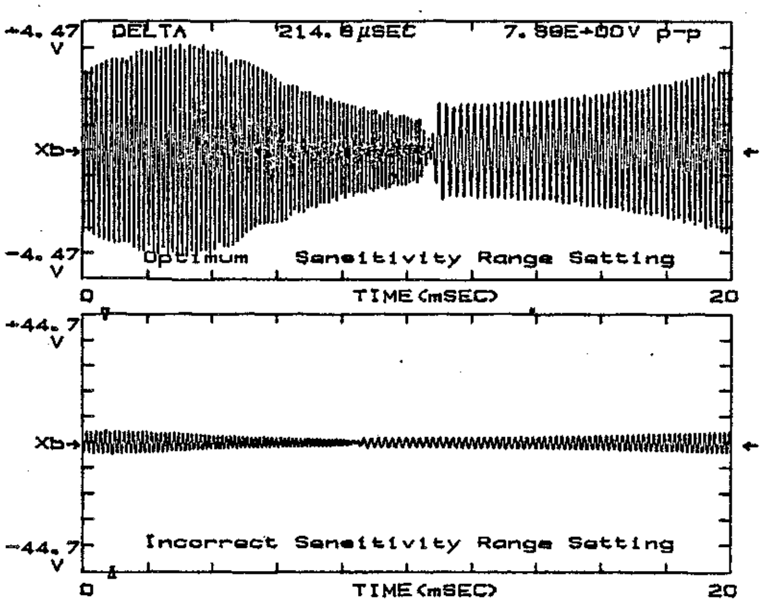


Figure 2-3 Optimum Sensitivity Range (Upper) and Improper Sensitivity Range (Lower)

2.2.2 Displaying Measurement State

CH. A/CH. B UPPER/LOWER SET REF. ON/OFF and others: When the characters of functions on the keys are separated by the slash (/), the LED lights when the function to the left is being used.

IN PROCESS : Averaging is in progress to measure transfer function.

OVERLOAD : Overload state. (Buzzer sounds.)

GPIB status display:

REMOTE : The TR9407 is under the control of the controller. Press LOCAL to change into the state in which the keys on the front panel are

effective.

TALK : This device is in the talker state to send the data. When the TALK ONLY/ADDRESSABLE switch on the rear panel is set to TALK ONLY and power is turned on again, the talker state is entered. Waveforms or transfer function can also be output to a plotter of HPGL type in the LISTEN ONLY mode.

LISTEN : Listener state ready to receive data

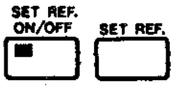
SRQ : Request for service, such as that on completion of averaging, is sent to the controller.

In addition to the above information, various status information (termination, process) is displayed as an annotation on the CRT screen. Operational progress is confirmed with this information. When your attention is required, audible tone is produced in addition to a display.

2.2.3 Cursor

: A maximum value is automatically searched for and the positions of the peak values (positive and negative) are indicated by the marks "Δ" and "∇". (Auto peak search mode)

: The displayed vertical cursor is moved. If the gain of transfer function is displayed, the frequency of the vertical cursor abd dB value are output at the upper portion of the CRT.



: In addition to the vertical cursor, the reference cursor is displayed. Information about the differences between the cursor-specified data is output at the upper portion of the CRT.

: When the horizontal cursor is not displayed, the reference cursor is moved.

Positive and negative maximum values are detected in time domain data; if the vertical cursor is turned on, the cursor is automatically located in the position of the maximum value.

: When the cursor is in the upper screen, the vertical cursor is moved to a negative maximum value.

: When the cursor is in the lower screen, the vertical cursor is moved to a positive maximum value.

2.2.4 Dual Display

Dual display is performed on the CRT display in the following steps:

Upper display: Time waveform of channel B (output channel)
Lower display: dBMag of transfer function

1. Press TRANS. FCTN. (Transfer function display)
2. Press MAG. to display amplitude.
3. Press DISPLAY CTL to display DISP CTRL menu and set DISP MODE to dBMag.

   In this way the setup for the lower screen is completed.

4. Press BOTH to enable dual display.
5. Press UPPER/LOWER to enable the setup for the upper screen parameters (the lamp within the key lights).
6. Press TIME to display time domain data.
7. Turn off the lamp within CH. A/CH. B to monitor channel B. Thus, the time data is displayed in the upper screen.

When the lower portion is used in dual display for a transfer function of 4-decade logarithmic frequency analysis, the menu display must be erased by pressing UPSCALING before 4.

The dual display helps the user to simultaneously observe during sweep averaging both of the output time waveform and transfer function.

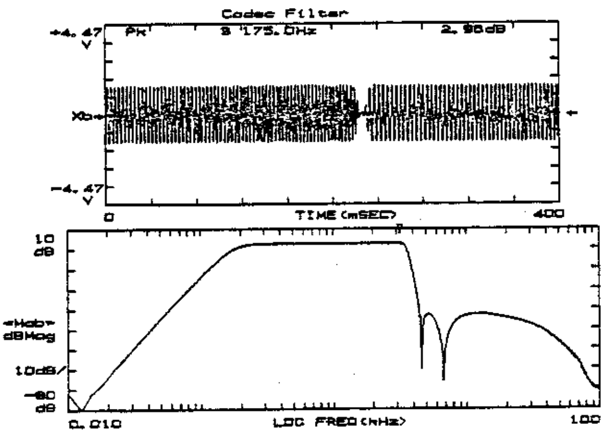


Figure 2-4 Dual Display of Output Time Waveform and Transfer Function

2.2.5 Setting the TR9407 Menu

- **Setting**
  - **Setting items marked with #**
    - The pointer and # mark are moved together with [⇧] and [⇩] and the item is set.

      (Example) Selection of frequency range
    - Only the pointer is moved by [⇧] and [⇩]; when [SETUP] is pressed, the # mark is moved to the pointer position, then the item is set.

      (Example) Selection of AVG MODE
  - **Setting items not marked with #**
    - The pointer (⇨) blinks. The display item is changed at each press of [SETUP] or [DISP.] for setup.

      (Example) Selection of OUTPUT MODE of S.G.
    - The ▪ mark blinks. Characters and numeric values are set. For a numeric value, the setting place is moved left or right by the general cursor sections [⇨] and [⇦], the numeric value can be incremented or decremented by [⇧] and [⇩].

      (Example) Entry of amplitude value of S.G.
  - **Setting by [SET X]**
    - By moving the horizontal and vertical cursors and pressing the SET X switch, the parameter of interest is defined by the position of the cursor.

      (Example) Fmin and Fmax of SINE and SWEPT SINE

2.2.6 Features of Keys in VIEW Mode

Table 2-1 Relations of VIEW modes, Functions, Data Assignments, Readout Units and AVG/INST Data Types

Data Mode	VIEW mode	Analyzing function	Instant (AVG/INST.) CH A/CH B		Averaging (AVG/INST.) CH A/CH B		Display unit X axis	Display unit Y axis
SINGLE	TIME	Time series data	Xa	Xb	<Xa>	<Xb>	sec, msec	V
	AUTO-CORR.	Pre-envelope	Za Real	Zb Real	-	-	sec, msec	V
			Za Imag	Zb Imag	-	-		
			Zaa Mag	Zbb Mag	-	-		
	SPECTRUM	Complex spectrum	Sa Mag	Sb Mag	<Sa> Mag	<Sb> Mag	Hz, kHz CPM	dBV, V, V^2 dBV/$\sqrt{Hz}$, V/$\sqrt{Hz}$, V^2/Hz
			Sa Phase	Sb Phase	<Sa> Phase	<Sb> Phase		degree
			Sa Real	Sb Real	<Sa> Real	<Sb> Real		V, V Hz
			Sa Imag	Sb Imag	<Sa> Imag	<Sb> Imag		
		Auto power spectrum	Gaa	Gbb	<Gaa>	<Gbb>		dBV, V, V^2 dBV/$\sqrt{Hz}$, V/$\sqrt{Hz}$, V^2/Hz
		Level monitor	GaaL	GbbL	-	-	%, sec	dBMag
	AUTO-CORR.	Auto correlation function	Raa	Rbb	<Raa>	<Rbb>	Lag sec, msec	±1.0 (Dimensionless)
	CROSS-CORR.	Cross correlation function	Rab		<Rab>		Lag sec, msec	±1.0 (Dimensionless)
	HIST.	Amplitude probability density function (histogram)	Pa	Pb	<Pa>	<Pb>	V, mV	/V
	AUTO-CORR.	Cepstrum	Ca Real	Cb Real	-	-	Lag sec, msec	±1.0 (Dimensionless)
			Caa Mag	Cbb Mag	-	-		

Table 2-1 (Cont'd)

Data Mode	Analyzing function				Display unit	
	VIEW mode	Analyzing function	Instant AVG/INST. (CH A/CH B)	Averaging AVG/INST. (CH A/CH B)	X axis	Y axis
CROSS	CROSS SPECT.	Cross spectrum	Gab Mag	<Gab> Mag	Hz, kHz CPM	dBV, V^2, V^4 dBV/$\sqrt{Hz}$, V^2/Hz, V^4/Hz
			Gab Phase	<Gab> Phase		degree
			Gab Real	<Gab> Real		V^2, V^2/Hz
			Gab Imag	<Gab> Imag		
			Gab GDelay	<Gab> GDelay		sec, msec, µsec
	TRANS. FCTN	Transfer function	-	<Hab> Mag	Hz, kHz CPM	dB, 1.0 - 0 (Dimensionless)
			-	<Hab> Phase		degree
			-	<Hab> Real		±1.0 (Dimensionless)
			-	<Hab> Imag		
			-	<Hab> G.Delay		sec, msec, µsec
	COHERENCE	Coherence function	-	<COH>	Hz, kHz CPM	1.0 - 0 (Dimensionless)
	C.O.P.	Coherent output power	-	<C.O.P.>	Hz, kHz CPM	dBV, V, V^2 dBV/$\sqrt{Hz}$, V/$\sqrt{Hz}$, V^2/Hz
		Signal-to-noise ratio	-	<SNR>	Hz, kHz CPM	(Dimensionless)
	IMPUL. RESP.	Impulse response	-	<IMPLS>	Lag sec, msec	±1.0 (Dimensionless)
		ML	-	<ML>		
		SCOT	-	<SCOT>		

2.3 FFT (FAST FOURIER TRANSFORM) ANALYZER IN A NUTSHELL

The FFT analyzer analyzes signals on the basis of the fast Fourier transform (FFT) technology for converting time-domain data to frequency-domain data (or inverse Fourier transform technology) and the latest digital processing technology. Moreover, use of this analyzer allows high-speed and accurate processing of data such as amplitude and phase (not available with the spectrum analyzer).

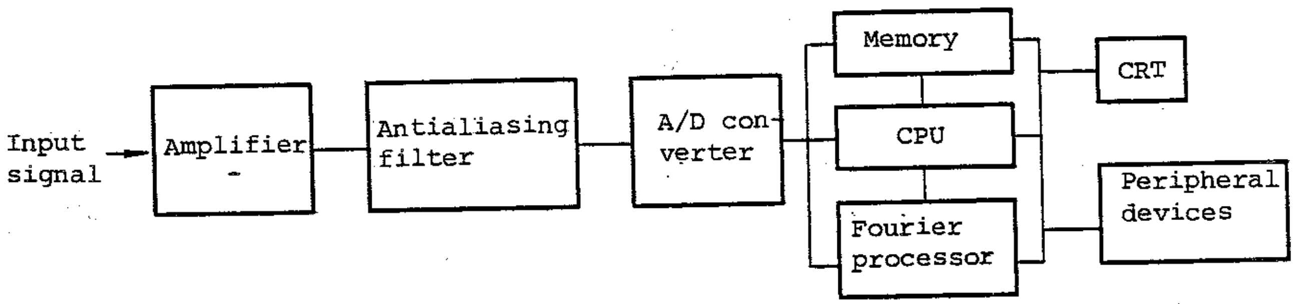


Figure 2-5 FFT Analyzer Configuration

After the frequency components outside the input analog signal band are truncated by filters, signals are converted to digital signals via the A-D converter and sampled until the time buffer becomes full. The digital data read from the input buffer memory is processed by the CPU for various math operations.

Upon completion of fast Fourier transform, signals are stored in the data memory together with annotations and setup conditions, then displayed on the CRT after D-A conversion.

To prevent an aliasing error, the sampling frequency must be twice or more the maximum input frequency (Nyquist theorem). Thus, the foldout components are kept outside the input frequency range.

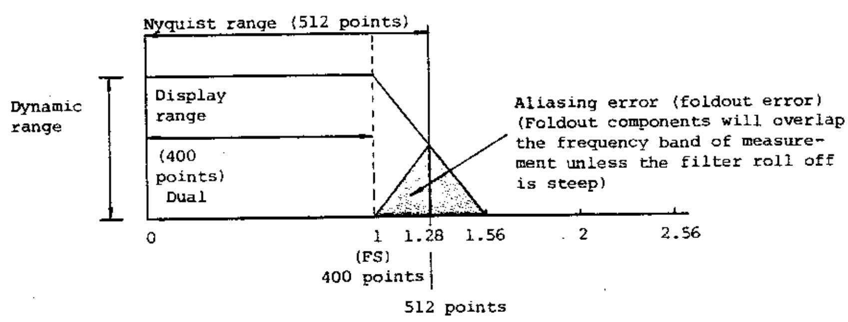


Figure 2-6 Antialiasing Filter Characteristics

Since the FFT analyzer cannot measure the originally infinite signal, actual measurement is made using a finite window. FFT processing is performed using periodicity (recursiveness) of signals. The cycle of each signal must always be repeated within the time record truncated by the FFT analyzer; however, most signal cycles are not periodic. Therefore, weighting functions are used depending on the signal type and measurement purpose to repeat signal cycles within the time record.

	Number of points in the time domain		Number of lines in the frequency domain
1ch	2048	FFT →	1024 → 800
2ch	1024/1ch	← IFFT	512 → 400

For the TR9400 Series, aliasing errors occur in the 20% of the high frequency range, so 800 and 400 lines (among 1024 and 512 lines) are used to obtain spectra to assure the specified dynamic range.

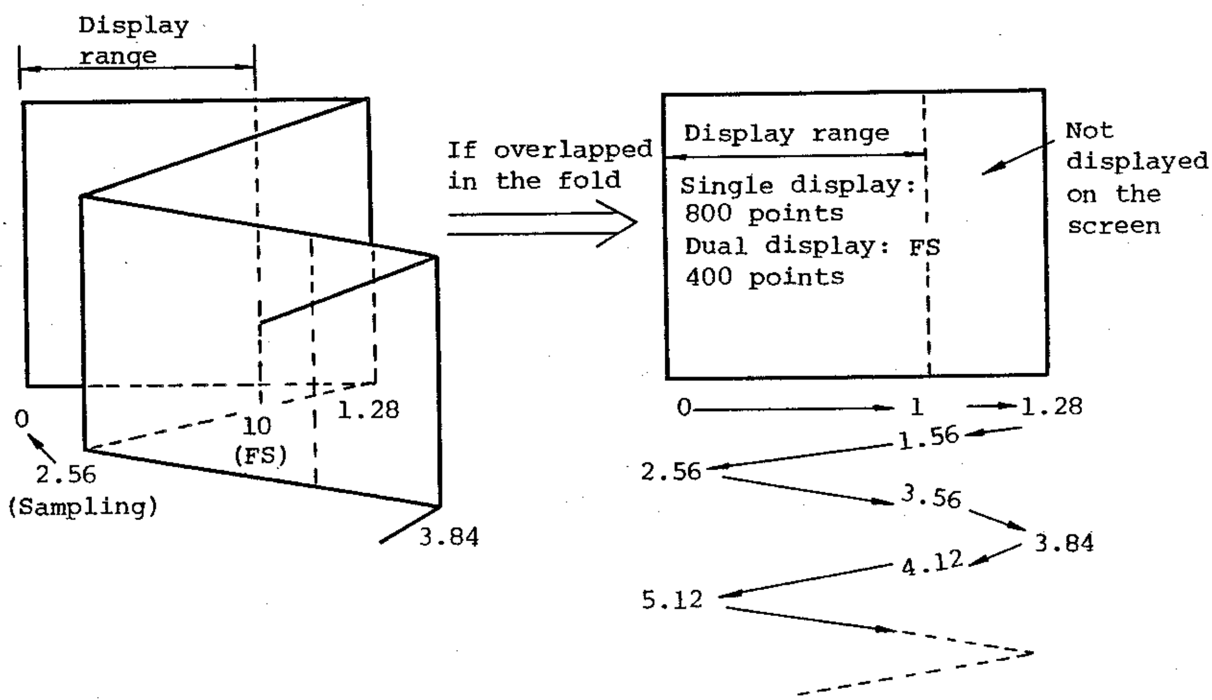
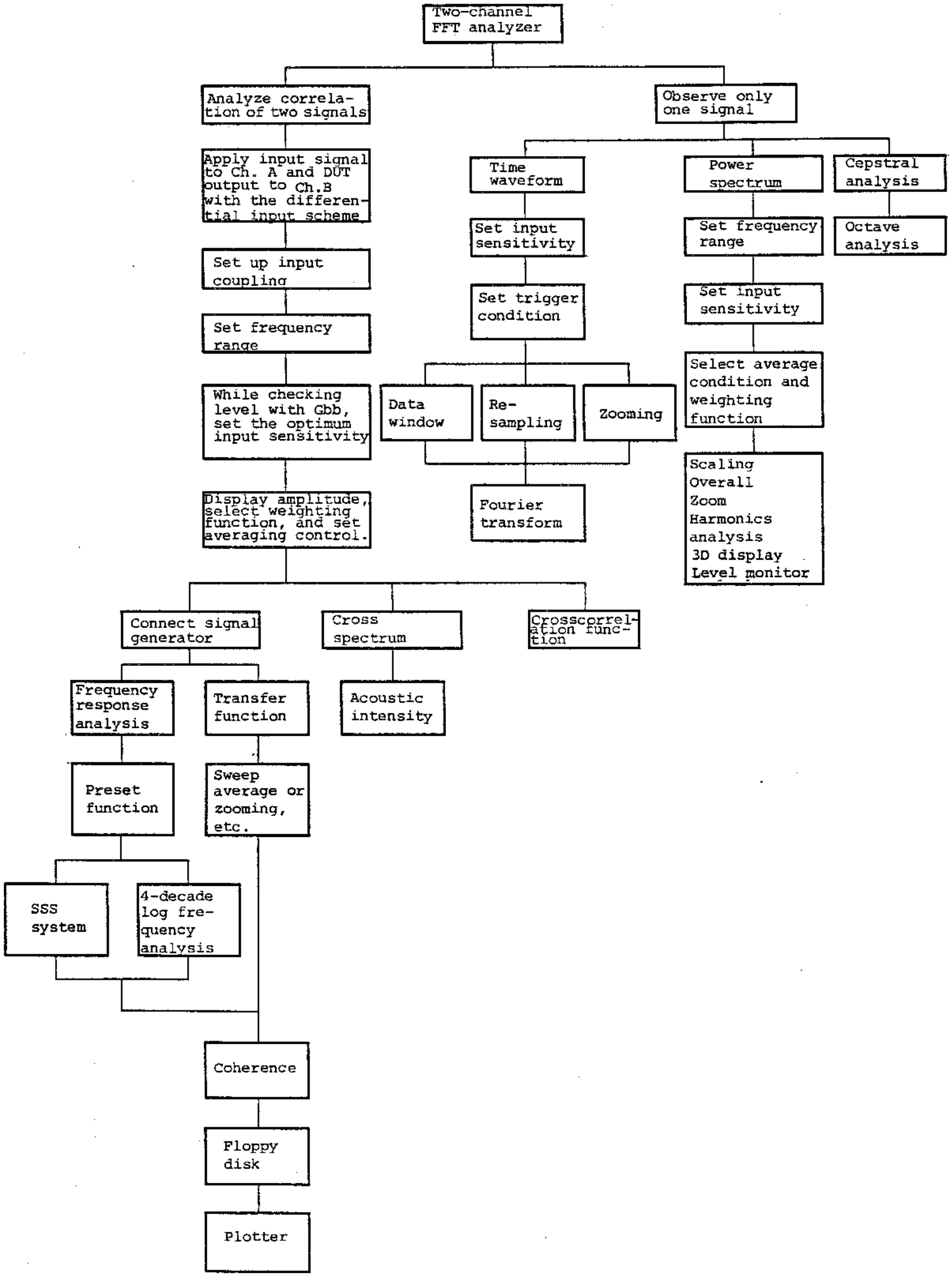


Figure 2-7 Aliasing Error

2.4 OUTLINE OF MEASUREMENT PROCEDURE



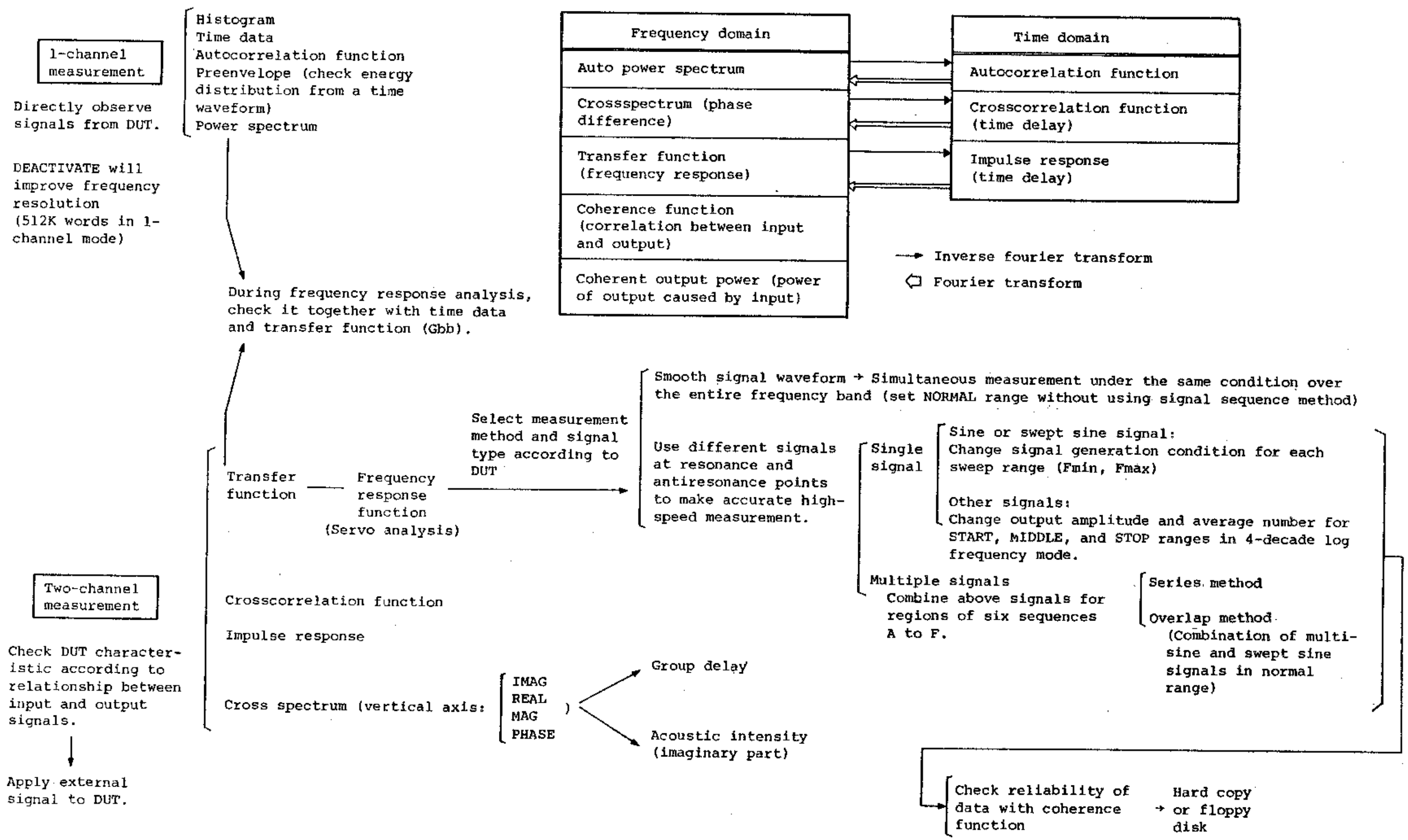


Figure 2-8 Measurement Scheme Classification

MEMO

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3. MEASUREMENT OF TRANSFER FUNCTION

3.1 FREQUENCY RESPONSE ANALYSIS

3.1.1 Outline

Conventionally, frequency response analyzer is committed to the measurement of transfer function while the FFT analyzer to the frequency analysis in the fields such as acoustics, noise and vibration measurements. The TR9407, combined with the dedicated signal generator TR98201 or TR98202, accomplishes the capabilities which the conventional FFT analyzer or frequency response analyzer alone fail to achieve.

In linear frequency analysis, the transfer function is measured by fast Fourier transforming (FFT) the 1024-point time waveforms sampled at a constant interval to an equally spaced frequency resolution spectrum of 401 lines.

The transfer function of the frequency range of up to 100 kHz can be measured at high speed.

Moreover, by using running zoom capability, a high resolution frequency domain analysis of up to x256 zoom factor can be conducted.

In analysis based on equal-space frequency resolution, f/f (resolution-to-frequency ratio) varies in the range of 1 to 1/400. As a result, the structure of a transfer function on the low-frequency range deteriorates in resolution with a resultant lack of clarity. The logarithmic frequency analysis utilizes the high-speed performance of FFT and enables a sufficiently high frequency resolution over the entire analysis frequency range. In other words, with the sampling clock varied during measurement as follows,

Start range: Middle range: Stop range = 100 : 10 : 1,

high-resolution measurement is made over the logarithmic frequency band extending for four decades by combining one or two decades on the high-frequency side of the results of FFT of each range.

For description of the SERVO menu, see the rear of this manual.

3.1.2 Flowchart for the General Procedure of the FRF Measurement

START

↓

Connection of equipment — See Section 1

↓

Preset on the TR9407 — See APPENDIX 6 Presettings

LOCAL LOCAL AVG MODE (to SPECTRUM)

↓

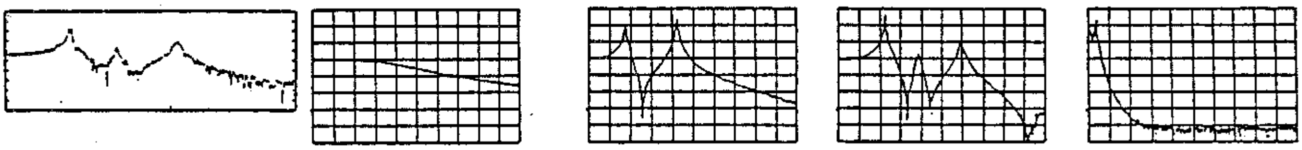
Check FRF of DUT with MULTI-SINE

↓

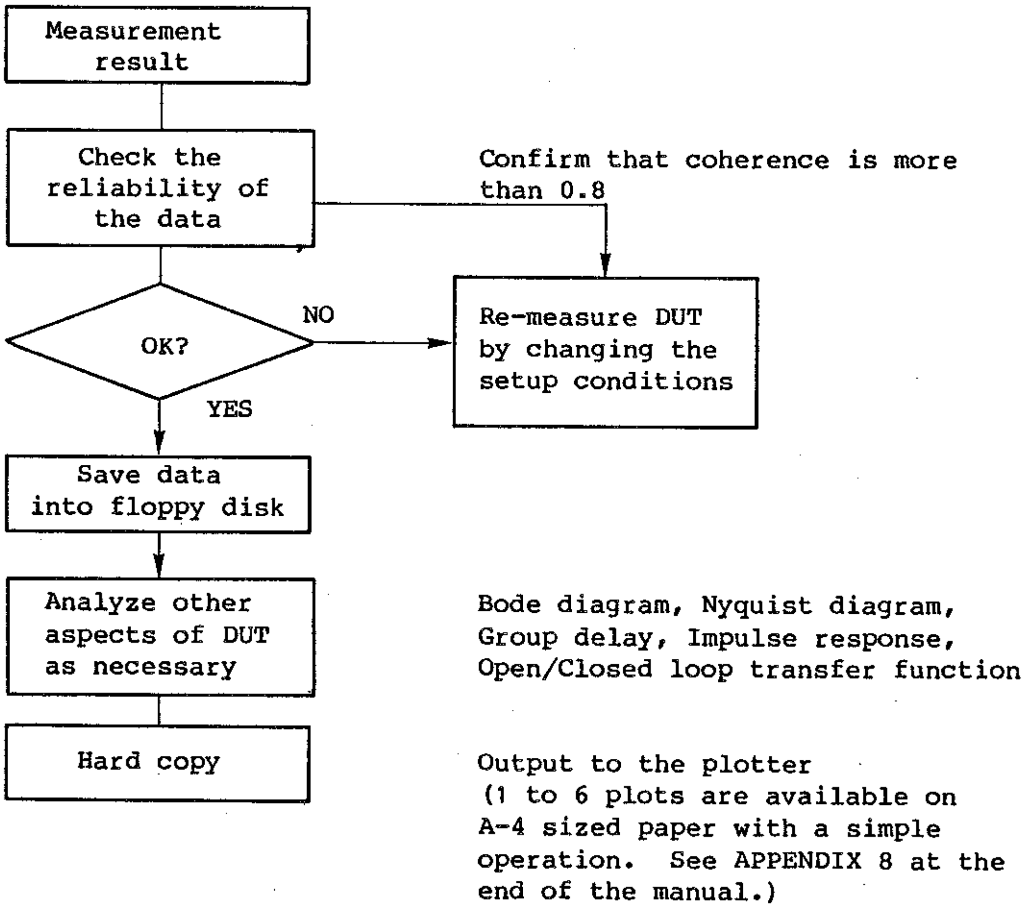
Satisfactory result? — Yes → End

No ↓

Select optimum signal according to the linearity or nonlinearity of DUT and required dynamic range.



Distorted waveforms. Dynamic range up to 60 dB. Linear system: Lower the voltage to be applied. Nonlinear system: Use RANDOM or SINE wave-forms.	No resonances. Dynamic range up to 70 dB. MULTI-SINE (P. 3 - 16)	There are resonances. Dynamic range up to 70 dB. MULTI-SINE (SWEPT-SINE at anti-resonance, if necessary) (P. 3 - 16)	There are resonances. Dynamic range up to 110 dB. SSS scheme (P. 3 - 37)	Dynamic range more than 110 dB. Further measurements required at low level. Use SSS scheme and signal sequence in combination (P. 3 - 51)


Measurement result
Check the reliability of the data
Confirm that coherence is more than 0.8
OK?
NO
YES
Re-measure DUT by changing the setup conditions
Save data into floppy disk
Analyze other aspects of DUT as necessary
Bode diagram, Nyquist diagram, Group delay, Impulse response, Open/Closed loop transfer function
Hard copy
Output to the plotter (1 to 6 plots are available on A-4 sized paper with a simple operation. See APPENDIX 8 at the end of the manual.)

3.1.3 Setting for Frequency Response Analysis

FREQUENCY : Set the frequency range to be analyzed

ADVANCED ANALYSIS EXECUTE : SERVO menu is displayed for the next settings.

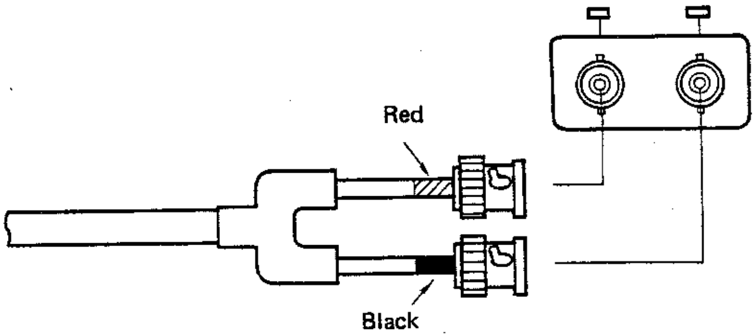
```
ADVANCED SELECT
   SERVO
   <ENABLE>
ANALYSIS LINE
   NORMAL
SENS CTRL
   CH-A: AUTO
   CH-B: AUTO
WEIGHTING CTRL
   AUTO
SG OPERATION
   ON-AVG
NON-STOP AVG
   NON-STOP
AVG NUMBER
   2
AVG PROCESS
   SWEEP
AMPLITUDE CTRL
   CH-B: MONITOR
CTRL LEVEL <F>
   +00.0±0.0 dBV
OVER LEVEL <Vpp>
   CH-A:+02.0E-0
   CH-B:+02.0E-0
OVER & SERVICE
➡ BEEP ON
```

- Number of lines to be analyzed
  Linear frequency analysis: 400 lines
  Logarithmic frequency analysis: 1116 lines
- Automatic selection of optimum input sensitivity range
- Automatic selection of optimum window function corresponding to generated signal
- Generation of signals only during measurement (averaging)
  (e.g., for preventing noise)
- Is measurement repeated by the specified average number infinitely?
  (e.g., adjustment on the production line)
- Average count (corresponding to integration time)
- Is the frequency of generated signal swept for averaging?
- Monitoring amplitude of a signal applied to a DUT.

AC/DC +GND −GND : Is the input AC or DC coupled?

- Single ended or differential input?

Differential input is used to reject the common mode noise.



Use the differential input scheme when measuring the transfer function of wide dynamic range.

(1) Precautions on frequency response analysis

(a) When the "SERVO" menu is set to <ENABLE>, "OCTAVE," "CEPSTRUM," and "P-ENVELOPE" are automatically set to <DISABLE>.

(b) When the ADVANCED ANALYSIS EXECUTE key is ON (with the lamp within the key turned on), switching between <ENABLE> and <DISABLE> in the "SERVO" menu is inhibited.

(c) Frequency response analysis is only valid when averaging is executed. During the frequency response analysis,

"IN PROCESS : AVG"

is displayed on the CRT.
"SENS CTRL," "WEIGHTING CTRL," and "ANALYSIS LINE" updating is inhibited during the frequency response analysis.

(2) Setup of the averaging conditions
AVG MODE in the frequency response analysis includes the following setup.

AVG MODE : SUM (N)
AVG WHAT : CROSS + POWER
AVG CHANNEL : CROSS
(In the CROSS + POWER mode, CROSS is automatically executed even when AVG CHANNEL is set to CH-A or CH-B.)

The TR9407 will assume the SWEEP mode if one of the following menus of

AVG PROCESS in the AVG MODE menu
AVG PROCESS in the SERVO menu
OUTPUT MODE in the SIGNAL G. menu

is set to the SWEEP.

The AVG No. is settable either in the AVG MODE or SERVO menu, but the highest priority is given to the value set in the SEQUENCE menu when connected with the signal generator TR98201.

NOTE

In the SWEEP mode averaging, use the window functions of "RECT" or "HANNING."
When the WEIGHTING CTRL of the SERVO menu is set to AUTO with the TR9407 connected with the TR98201, the optimum window (RECT or HANNING) according to the generated signal will be automatically applied.
Use of FLAT-PASS window will not give a correct measurement result in the neighborhood of dc level of the signal.

(3) Non-stop averaging function
If the NON-STOP AVG is set to NON-STOP, the TR9407 will repeat the averaging of the set up number infinitely. This is particularly useful in the line to check the transfer function of the DUTs.

(a) STOP
When the incremental averaging number reaches the set up number the averaging process is ended, with the IN PROCESS lamp turned off followed by the several "pip" audible tones.

(b) NON-STOP

AVG NO.	Audible tone
1, 2, 4	No audible tones
8, 16, ... 8192	High-pitched "pip" tones are continuously sounded several times

Use the following procedure to execute this function

1. Set up the NON-STOP.
2. Set <DISABLE> to <ENABLE> in the SERVO menu
3. Press the EXECUTE key for the ADVANCED ANALYSIS. (LED lamp within the key turned on)
4. Press START in the AVERAGE CONTROL section to start the non-stop averaging . The following display blinks for a couple of seconds in the center of the CRT.

"START NON-STOP AVGING"

To stop this averaging process, press STOP .

When CONT. is pressed afterward, the averaging process will be resumed.

NOTE

- If AVG PROCESS is set to "+1 AVG" in the SERVO <ENABLE> state, NON-STOP AVG is automatically set to STOP.
- If SERVO menu is set to <ENABLE> in the "+1 AVG" mode, "NON-STOP" AVG mode is automatically set to "STOP."
- If the SEQUENCE averaging is executed, "NON-STOP" averaging is automatically set to "STOP."

In other words:

Setup	Internal process
Execution of SEQUENCE average	NON-STOP AVG : STOP
"AVG PROCESS" is set to "+1 AVG" with SERVO menu set to <ENABLE>.	
SERVO menu is set to <ENABLE> with "AVG PROCESS" in "+1 AVG" mode	

3.1.4 Signal Generator

I/O EXECUTE

```
I/O SELECT
  SIGNAL G.
FUNCTION
⇨ SWEPT SINE
FREQ <LINE>
  MANUAL
  200
AMPLITUDE
  02.0E-3 Vpp
OFFSET
  +00.0E-0 V
OUTPUT MODE
  LIN SWEEP
SYNC OUT
  PER 1    FRAME
INTERVAL TIME
  .0 SEC
OUTPUT FRAME
  1
LINE CTRL
  Fmin : 1
  Fmax : 400
  WIDTH: 20
  DIREC: L⇨U
  RANGE: NORMAL
SEQUENCE
  D, E, F
```

Setup		
Swept Sine		(Type of output signal)
Unnecessary		
2mVpp -30 Vpp		(Output signal amplitude)
-10 V to +10 V		
LINE SWEEP	LOG SWEEP	(Sweep of sine/swept sine)
Unnecessary		
0 to 999.9 sec		(Delay time during sweep)
Unnecessary		
1 to 400		(Frequency span for sweep)
4 to 100	20, 40, 80/D	(Lines (steps), Lines per decade)
L → U, U → L		(Sweep direction)
NORMAL		
Unnecessary		

OPERATE : Starts signal output

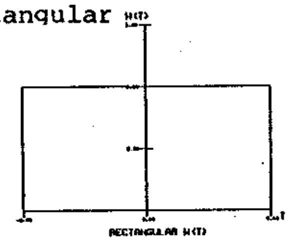
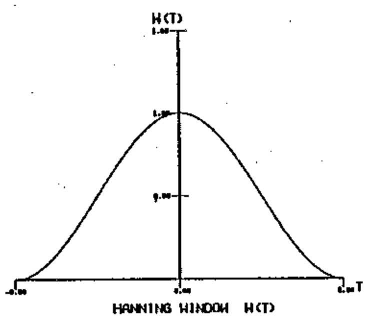
> The output of the signal generator cannot be internally connected direct with the TR9407.

Table 3-1 Features of Signal Source of TR98201

SIGNAL from TR98201	Features	Application	Remarks
Sine	• Signal source of a conventional frequency response analyzer. • Small crest factor. • Large power in the frequency components.	• Dynamic range is the widest.	• Measurement time is the longest (esp. in the low frequency band). • Response is susceptible to distortion at resonance because the energy is concentrated to a single frequency line.
Swept sine	• Intermediate between sine and multi-sine. • Sweeping the swept sine achieves shorter measurement time than sine and wider dynamic range than multi-sine.	• Flexible in that (e.g.) number of generated signal lines is changeable (WIDTH is used) to meet the requirements of measurement time or accuracy.	• Fast and high-precision measurements in combination with the signal sequence technique.
Multi-sine	• Synthesized 400-line sine waves to meet the frequency resolution.	• Used to grasp the overall response of the DUT. • Being band-limited, power is larger than random waves. • Wider dynamic range measurement in short time for DUT having resonances.	
Weighted multi-sine	• Multi-sine weighted in the time domain, band-limited in the frequency range being selected.		
Random	• There are RANDOM (band-unlimited), BAND SELECTED, PERIODIC and BURST signals (band-limited).	• Used to measure the nonlinear transfer function or coherence function.	
Impulse	• Measurements of time response and frequency response of a system made easy	• Vibration analysis and response analysis of mechanical system	
Memory	• Time data either obtained from the TR9407 or externally transferred via the GPIB are stored in the TR98201 memory and they can be output in various simulated modes	• Reproduction of seismic waves that happen only once; reproduction of car vibration and its estimate of contribution to the parts.	

If the "WEIGHTING CTRL" is set to "AUTO", the weighting function is automatically selected as shown in Table 3-2, according to the generated signal from the TR98201.

Table 3-2 Relation Between Output Signal and Weighting Function

Signal waveform	Optimum window
Sine Swept sine Multi-sine Weighted multi-sine Impulse Memory Random { Periodic Random { Burst	Rectangnular 
Random { Random Random { Band select	Hanning 

3.1.5 Frequency Response Function Measurement

Measurement method	Output signal used
(1) Precautions on logarithmic frequency analysis	
(2) Linear frequency analysis	Multi-sine wave
(3) Zooming	(Used to grasp the configuration of DUT)
(4) Logarithmic frequency analysis	
(5) Linear frequency analysis Linear sweep Log sweep	Sine wave (Measurement takes long time, but precise)
(6) Logarithmic frequency analysis Linear sweep Log sweep	
(7) Linear frequency analysis Linear sweep Log sweep	Swept sine wave (Most flexible in measurement procedures)
(8) Logarithmic frequency analysis Linear sweep Log sweep	
(9) Logarithmic frequency analysis Linear frequency analysis	Signal sequence (Frequency range is divided according to the characteristics of DUT to uniquely vary the setup conditions.

(1) Precautions on logarithmic frequency analysis

(a) The lowest frequency range in 4-decade mode (4-decade logarithmic frequency analysis) is 100 Hz. Therefore, if a value below 50 Hz is set, no 4-decade servo analysis is executed.

(b) Data stored in memory by the STORE key is erased from the memory when a 4-decade logarithmic frequency analysis is executed. In this case,

"RELEASED:STORED MEMORY"

is displayed (in blinking format) for several seconds in the center of the CRT screen.

(c) If 4-decade logarithmic frequency analysis is followed by

* averaging of other analytical data,
* storage of analytical data in memory,
* running zoom, or
* hold zoom,

the 4-decade logarithmic frequency data is erased from the memory. In this case,

"RELEASED:4 DECADES LOG FREQ ANALYSIS"

is displayed (in blinking mode) for several seconds in the center of the CRT screen.

(d) 4-decade logarithmic frequency analysis cannot be executed if "SAMPCLK" is set to "EXT" in the frequency range setting menu.

(e) No capabilities in the FUNCTION menu are applicable to the result of the logarithmic frequency analysis.

(f) If, for example, the AVERAGE CONTROL section STOP key is pressed in the 10 kHz range while 4-decade frequency response analysis is being executed with the frequency range set to 100 kHz, that analysis is stopped and the frequency range is switched back to 100 kHz.

If the CONT. key is then pressed to resume the analysis, that analysis is continued in the 10 kHz range.

CH. A/CH. B AVG/INST. SPECTRUM , MAG. : Input power spectrum Gaa dBMag

CH. A/CH. B AVG/INST. SPECTRUM , MAG. : Output power spectrum Gbb dBMag

AMPLITUDE OF APPLIED SIGNAL
Output time waveform and output power spectrum are observed while measuring the transfer function.

Amplitude of applied signal is too large:
Harmonics are produced because of nonlinear operation.

Amplitude of applied signal is too small:
Resulting signals derived from source signals are buried in extraneous noises.

Appropriate amplitude of applied signal:
Only resulting signals generated from source signals are observed.

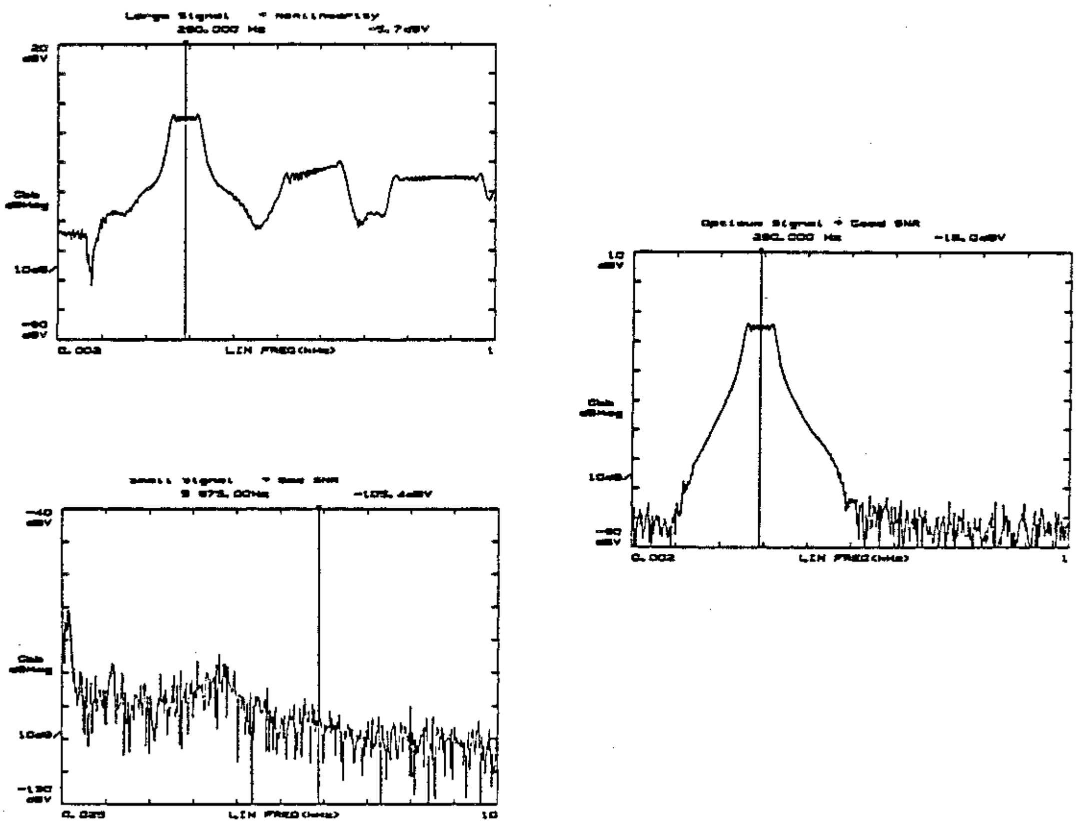
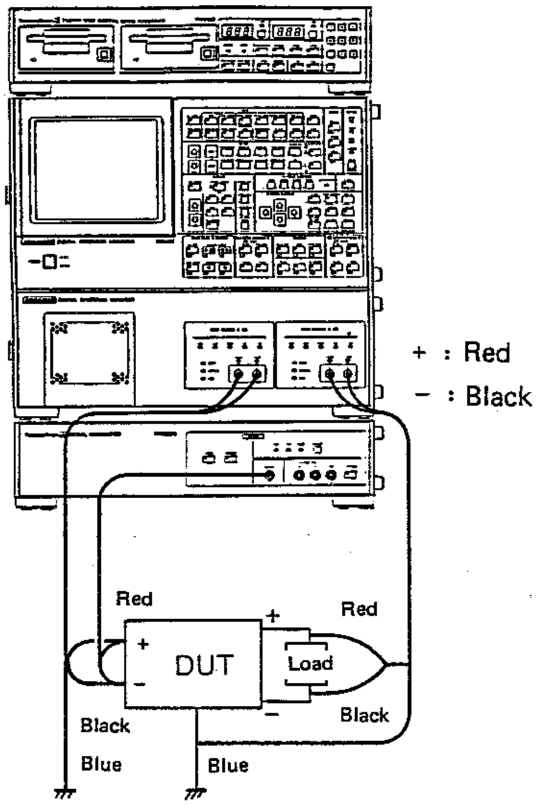


Figure 3-1 Excessively Large (Upper), Appropriate (Middle), and Excessively Small (Lower) Amplitudes of Output Power Spectrums when Swept Sine (40-line WIDTH) is Applied

(2) Linear frequency analysis with multi-sine wave

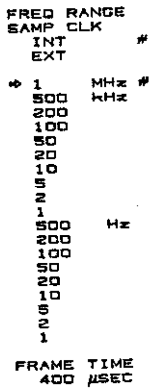


① Connect a DUT.

② Preset

a. Presettings with the panel switches: LOCAL LOCAL AVG MODE

Presettings:
Frequency range = 100 kHz
Signal generator output waveform = MULTI-SINE
AMPLITUDE = 02.0E-3Vpp
SERVO = ENABLE, ADVANCED ANALYSIS EXECUTE
ANALYSIS LINE = NORMAL
SENS CTRL = AUTO
WEIGHTING CTRL = AUTO
SG OPERATION = ON-KEY
AVG NUMBER = 8



③ Frequency range [FREQUENCY] : Displays the "FREQUENCY" menu.

④ Input coupling [AC/DC] [AC/DC] or [-GND] [as necessary]

⑤ Auto range [SENS. A] [SETUP] or [SENS. B] [SETUP] [with the "SENS" menu displayed]

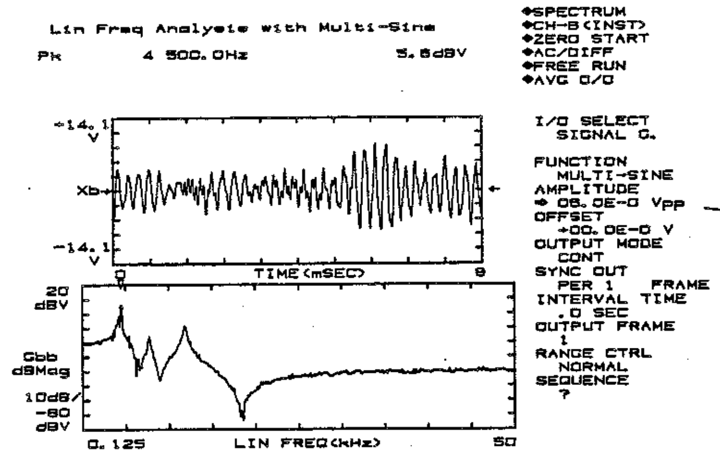
⑥ Output amplitude [I/O], [PANEL RECALL] [MEMORY STORE]: Displays the "MULTI-SINE" menu.

[OPERATE] : SG generates a signal.

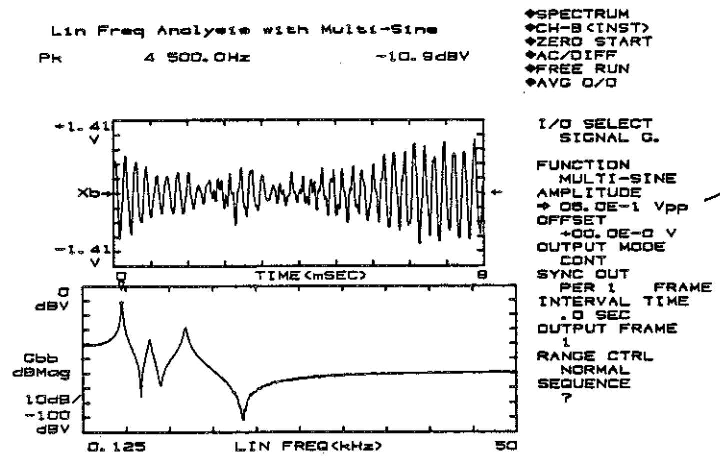
: Move the pointer (⇨) to AMPLITUDE with these keys.

Yellow : Shift a digit of a setting value with the right or left arrow key, and increment or decrement a numeral with the up or down arrow key.

(The keys with a green numeral at lower left of each key can also be used for numerical entry.)



Nonlinear operation is caused by overload with a consequent ragged output spectrum.



Proper amplitude. The output spectrum is smooth.

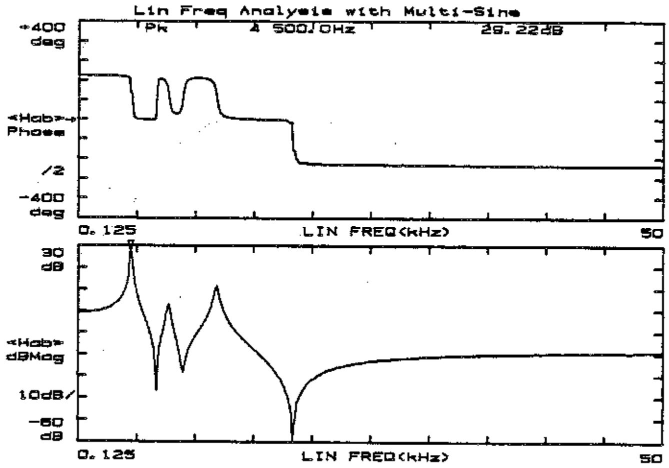
⇧ : Move the pointer (⇨) to FUNCTION.

(7) Frequency response analysis START: Measurement starts.

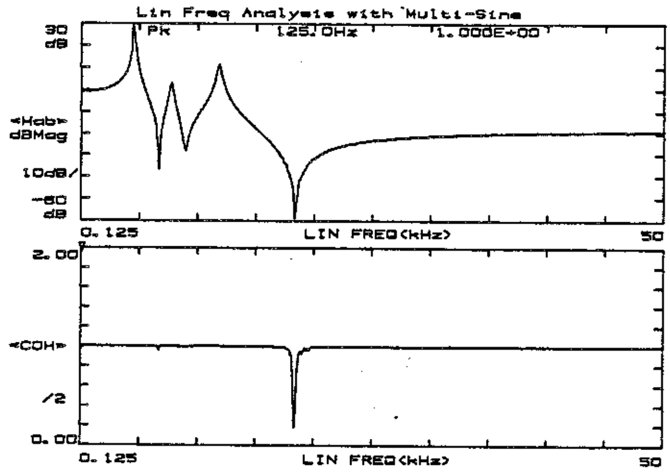
During measurement : IN PROCESS goes ON.

Measurement end : The buzzer sounds.

(8) Viewing the result of measurement



Displays a Bode diagram.
The gain and phase of the transfer function are displayed.

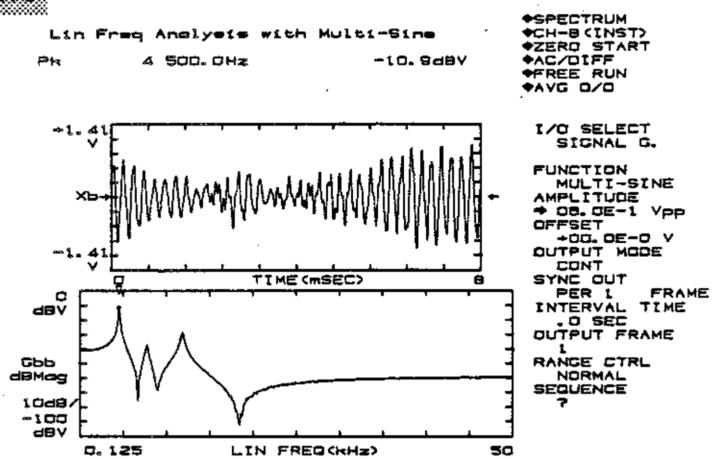


Displays the coherence function for checking the reliability of the measured transfer function.

(3) Zooming when using multi-sine wave

By using the zoom, a transfer function near a resonance point can be measured at a high resolution.

Note that the data is erased from the memory if the results of the 4-decade logarithmic frequency analysis are zoomed..



(1) Selection of the center for zooming
There are two following cases.

: Zooming with respect to the peak frequency (Auto peak search mode is entered with the vertical cursor OFF)

: Specify the center of zooming with the vertical cursor.

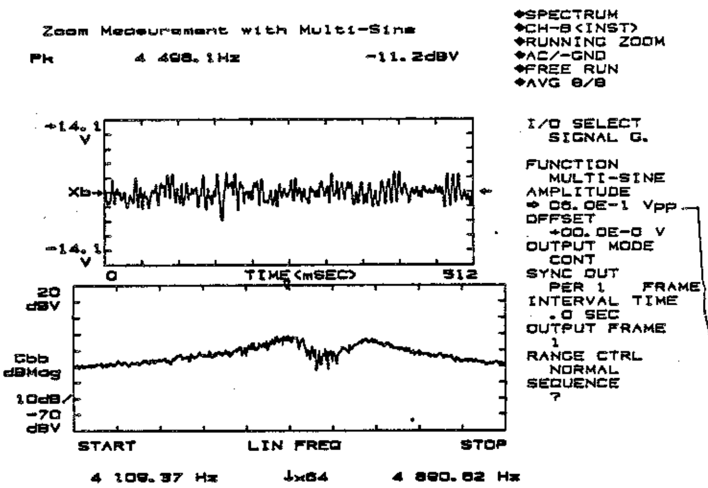
ZOOM ON/OFF

(2) ZOOM

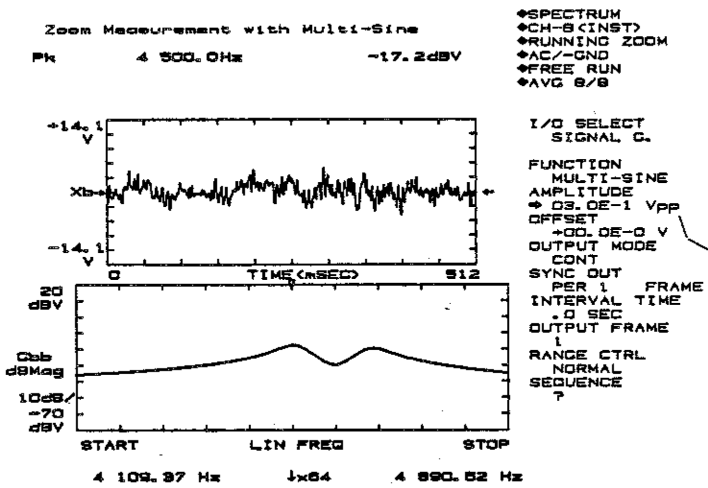
Zooming with a set zoom factor (binary step) starts. Zoom factor is displayed below the x-axis as x64 (x2 to x256 in running zoom). ↓ indicates the zoom factor for the lower screen.

(3) Output amplitude

Since the energy of the input signal is concentrated in a narrow band in the zooming mode, the output signal waveform may become ragged. Output amplitude adequately set demonstrates that the peaks are adjacent to each other.



Overload

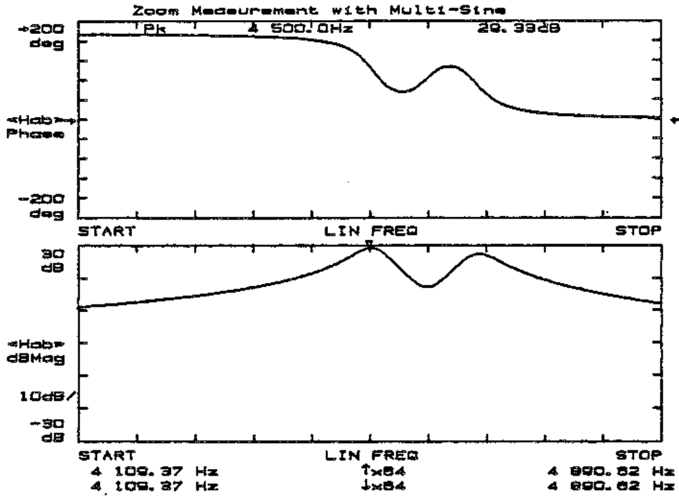


Input of a proper amplitude

(4) Frequency response analysis START : Measurement starts.

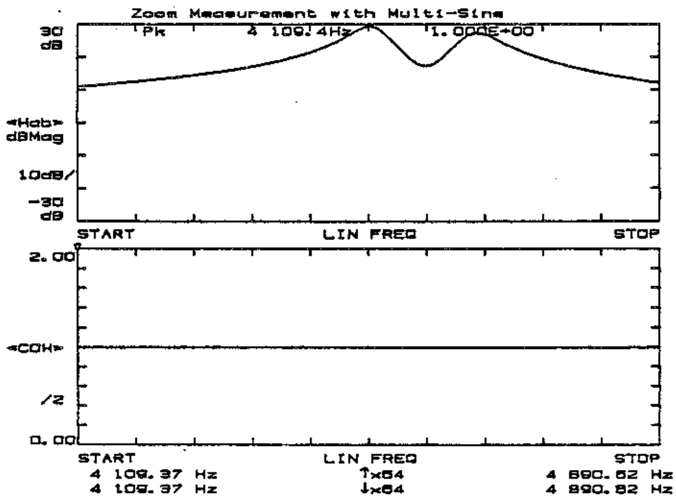
(5) Viewing the results of measurement

: Bode diagram
With a high-resolution measurement, the gain and phase vary gradually.



Start frequency, zoom factor, stop frequency for the upper screen
Start frequency, zoom factor, stop frequency for the lower screen

: Coherence function



(4) Logarithmic frequency analysis with multi-sine wave

① Connect a DUT.

② Preset

a. Presettings with the panel keys: LOCAL LOCAL B WGT/SCALING

Presettings:
Frequency range = 100 kHz
Signal generator output waveform = MULTI-SINE
AMPLITUDE = 02.0E-3Vpp
SERVO = ENABLE, ADVANCED ANALYSIS EXECUTE
ANALYSIS LINE = 4-DECADE
SENS CTRL = AUTO
WEIGHTING CTRL = AUTO
SG OPERATION = ON-KEY
AVG NUMBER = 8

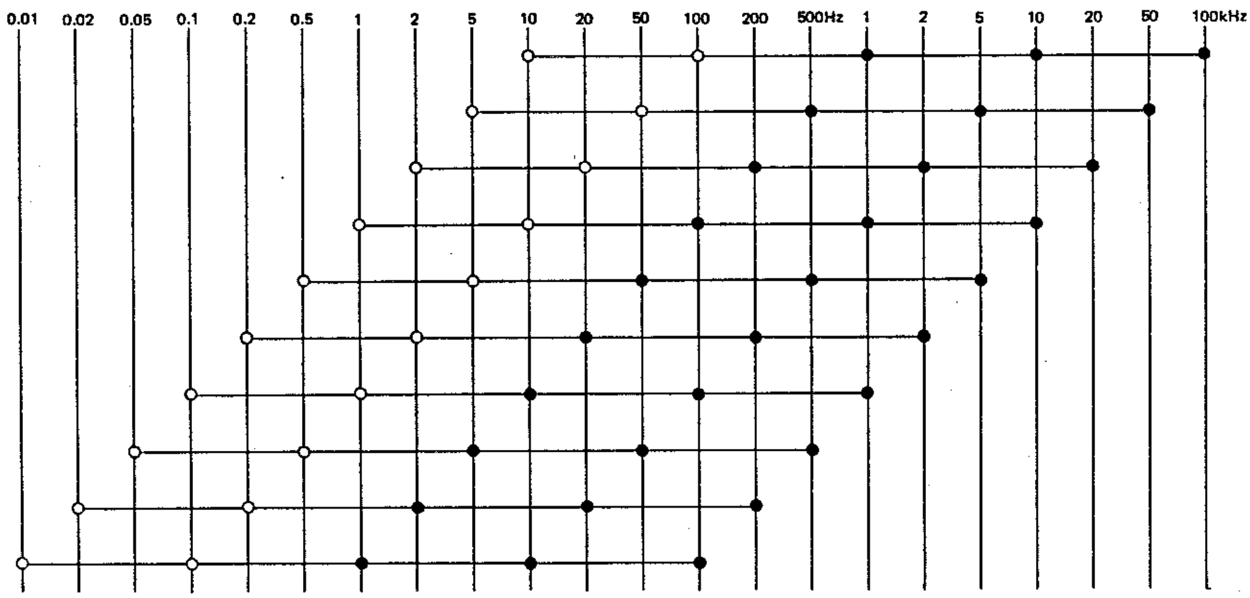


Figure 3-2 Start and Stop Ranges in the 4-decade Log Frequency Analysis

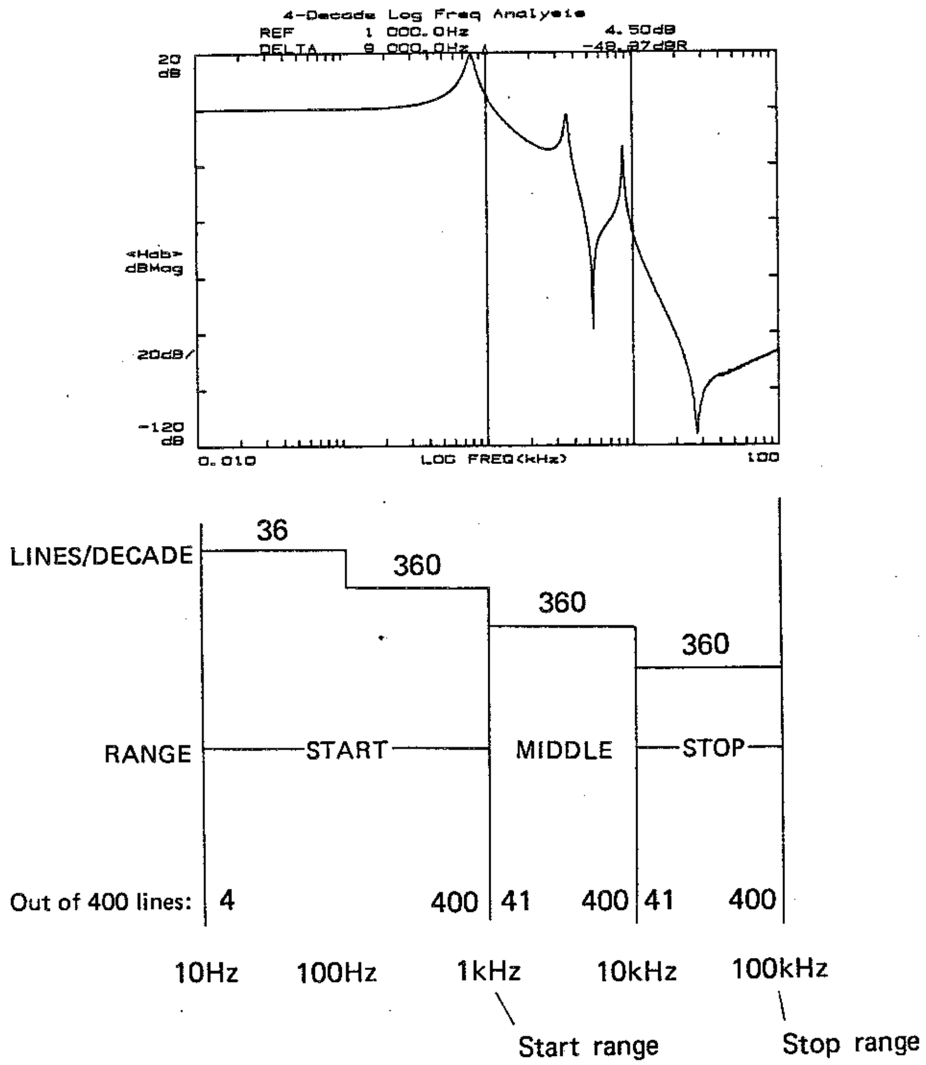


Figure 3-3 Explanation of 4-decade Log Frequency Analysis
(STOP range: 100 kHz)

4-DECADE frequency response analysis is executed by switching the frequency range into three stages.
As can be seen from the "FREQ RANGE" menu, the frequency is switched to 100 kHz, 10 kHz, 1 kHz when the frequency range is, say, 100 kHz, and a 1116-line logarithmic frequency spectrum is averaged and displayed.
And when the frequency range is set to 50, 20, 10, 5, 2, 1 (kHz), 500, 200, or 100 (Hz), the frequency is switched in 1/10ths, and a logarithmic frequency spectrum of a total of 1116 lines is averaged and displayed.

③ Frequency range FREQUENCY : Displays the "FREQUENCY" menu.

④ Input coupling AC/DC , AC/DC or -GND [as necessary]

⑤ Auto range SENS. A SETUP or SENS. B SETUP [with the "SENS" menu displayed]

⑥ Output amplitude I/O , PANEL RECALL STORE :

Displays the "MULTI-SINE" menu.

OPERATE : SG generates a signal.

: Move the pointer (⇨) to AMPLITUDE with these keys.

Yellow : Shift a digit of a setting value with the right or left arrow key, and increment or decrement a numeral with the up or down arrow key.

: Move the pointer (⇨) to FUNCTION.

⑦ Frequency response analysis START : Measurement starts.

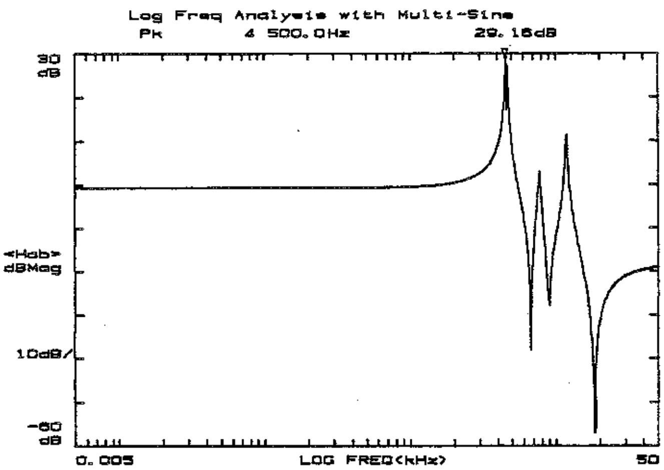
⑧ Viewing the results of measurement

The results of the logarithmic frequency analysis cannot be shown in dual display mode.

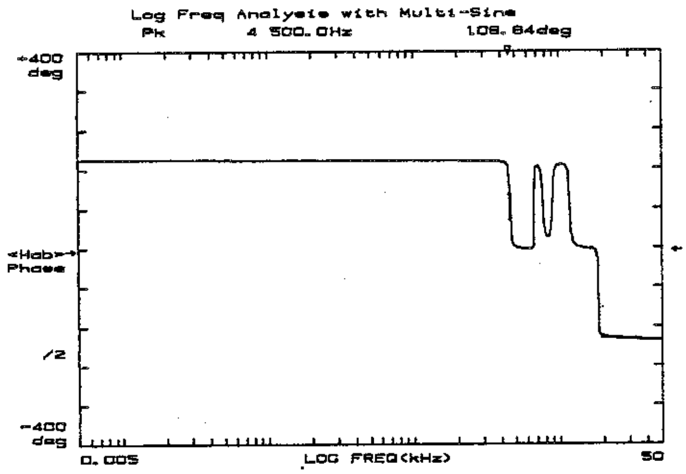
NOTE

- Logarithmic frequency analysis is always carried out in the STOP-MIDDLE-START range sequence.

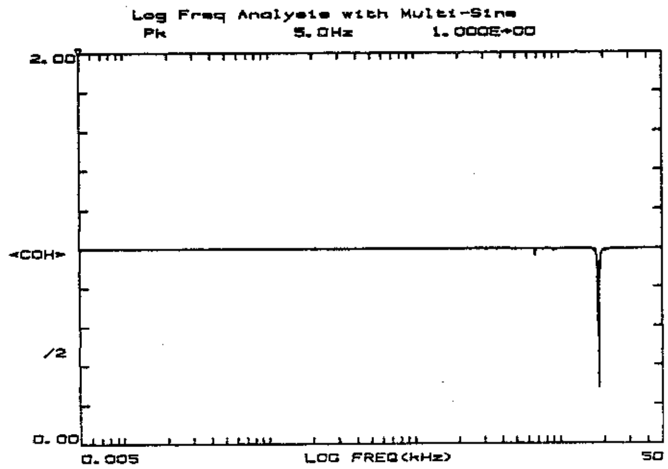
- The three ranges are each provided with the gradations of intensity on the x-axis facilitating the recognition of the boundaries between the ranges.



TRANS. FCTN MAG. : Gain of transfer function

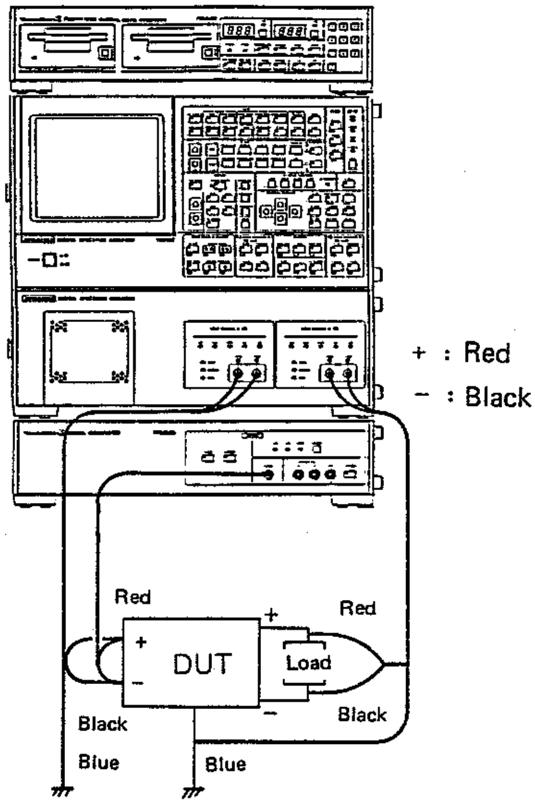


TRANS. FCTN PHASE : Phase of transfer function



COHERENCE : Coherence function

(5) Linear frequency analysis with sine wave



① Connect a DUT.

② Preset

a. Presettings with the panel switches:

LOCAL LOCAL	FUNCTION C	LIN SWEEP
	DISPLAY CTL D	LOG SWEEP

By the above key operation, the following settings are made:

Presettings:
Frequency range = 100 kHz
Signal generator output waveform = SINE
AMPLITUDE = 02.0E-3Vpp
OUTPUT MODE = LIN SWEEP
STEP = 7
(or OUTPUT MODE = LOG SWEEP
LINES = 80/decade)
SERVO = ENABLE, [ADVANCED ANALYSIS] [EXECUTE]
ANALYSIS LINE = NORMAL
SENS CTRL = AUTO
WEIGHTING CTRL = AUTO
SG OPERATION = ON-KEY
AVG NUMBER = 2

(3) Frequency range [FREQUENCY] : Displays the "FREQUENCY" menu.
[⇧] [⇩]

(4) Input coupling [−GND], [AC/DC] or [AC/DC] [as necessary]

(5) Auto range [SENS. A] [SETUP] or [SENS. B] [SETUP] [with the "SENS" menu displayed]

(6) Output amplitude

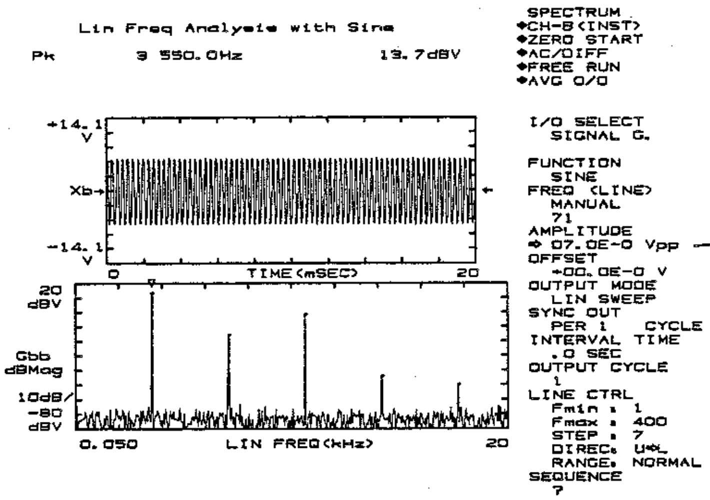
[I/O] [PANEL RECALL] [C. O. P.] : Displays the "SINE" menu.

[OPERATE] : SG generates a signal.

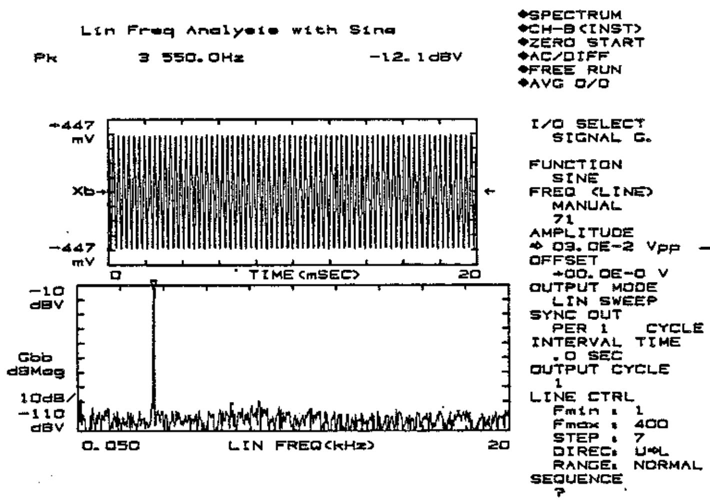
[⇩] [⇧] : Move the pointer (⇨) to AMPLITUDE with these keys.

Yellow [⇧] [⇦] [⇨] [⇩] : Shift a digit of a setting value with the right or left arrow key, and increment or decrement a numeral with the up or down arrow key.

[⇧] : Move the pointer (⇨) to FREQ (LINE).



Nonlinear operation due to overload.
Harmonics are generated.



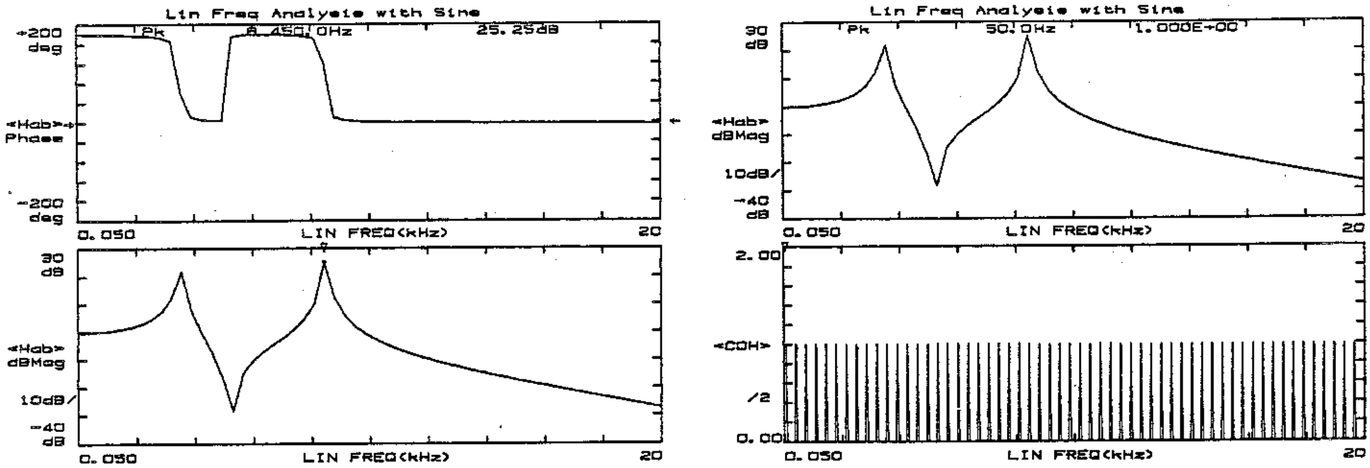
Input with a proper amplitude

(7) Frequency response analysis START: Measurement starts.

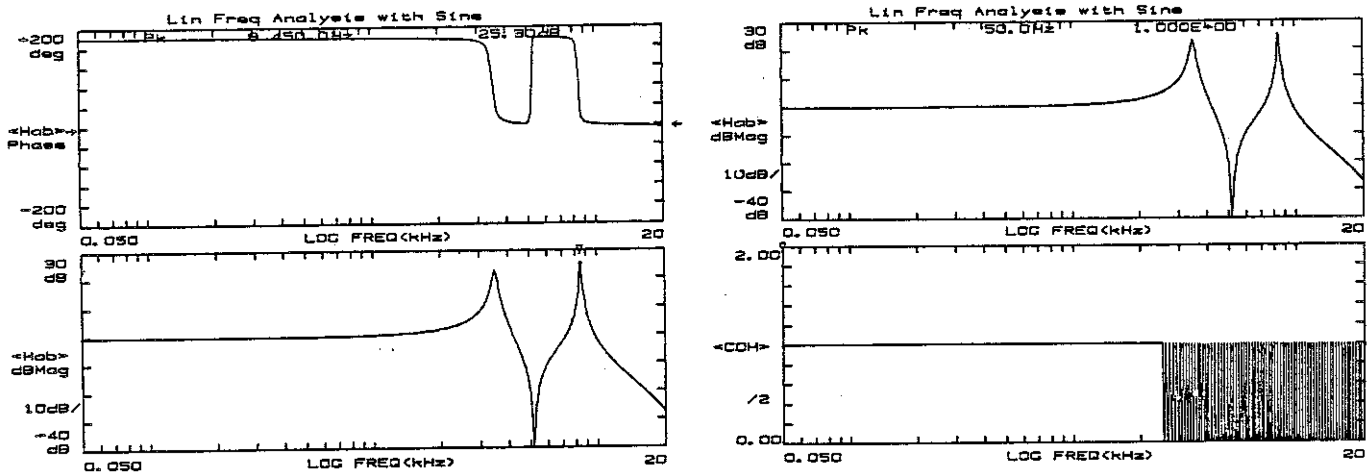
(8) Viewing the results of measurement

LOCAL LOCAL 2 +GND: Bode diagram

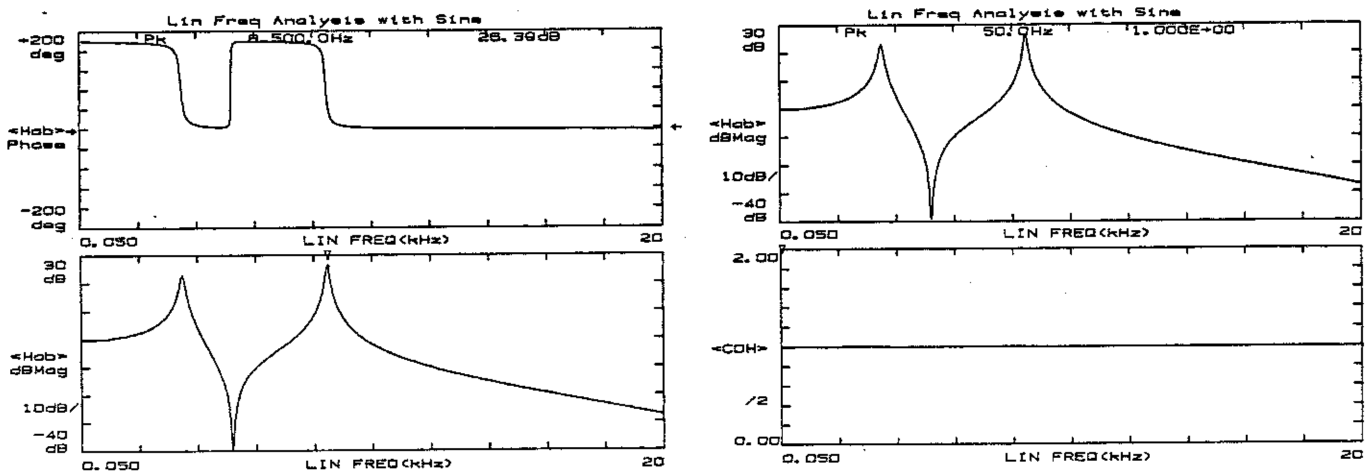
LOCAL LOCAL 3 AC/DC: Coherence function



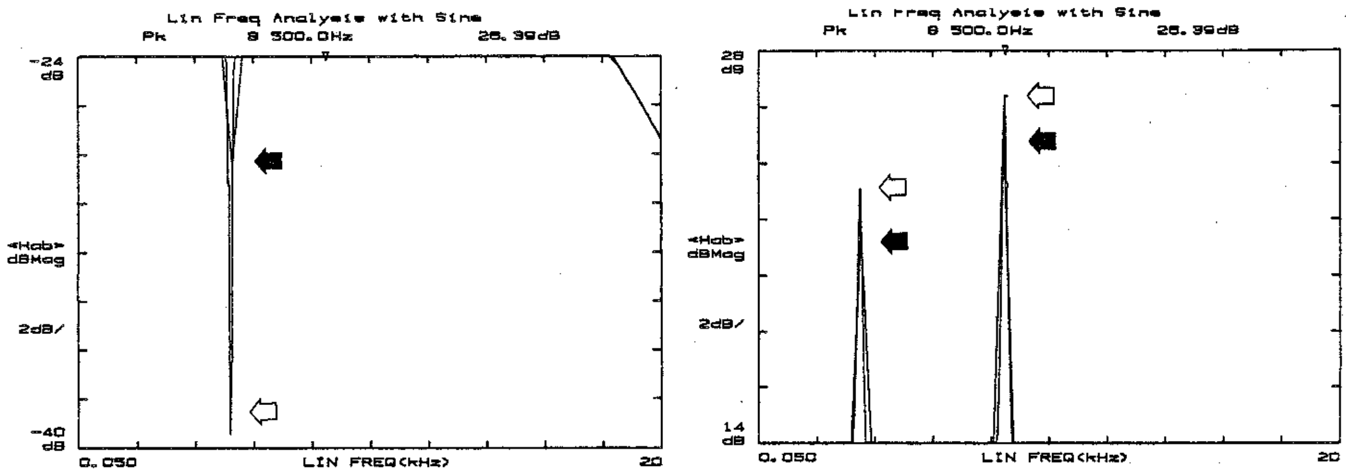
Linear Sweep (Step = 7)



Logarithmic Sweep (Lines = 80/D)



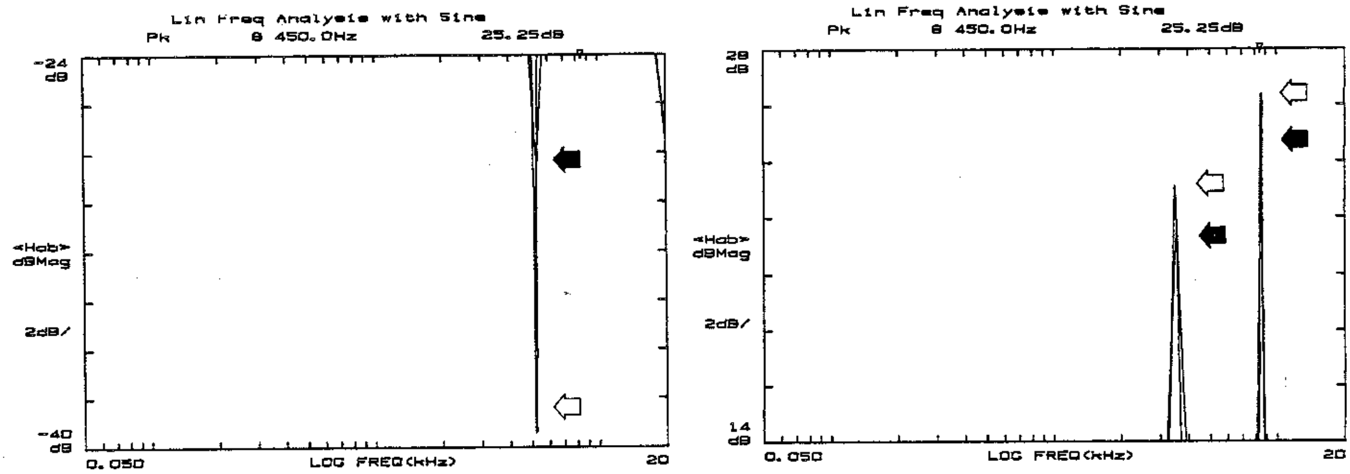
Linear Sweep (Step = 1)



Antiresonance frequency

Resonance frequency

Figure 3-4 Comparison Between Step = 1 and Step = 7 of Linear Sweep



Antiresonance frequency

Resonance frequency

Figure 3-5 Comparison Between Linear Sweep (Step = 1)
and Logarithmic Sweep (Lines = 80/D)

By sweeping with the sine wave, measurements can be made at a high resolution with the coherence function close to 1.0. Conversely, the sweeping frequency is known from the coherence function.

When a transfer function with sharp resonance and antiresonance frequencies undergoes a logarithmic sweep, for example at 80 lines/decade, the following results are expected:

At resonance frequency ..... Measured value (⇦) is smaller than true gain (⬅)

At antiresonance frequency ... Measured value (⇦) is larger than true gain (⬅)

To cope with this situation, use one of the following measures to get high-resolution and high-speed measurements.

- Sweeping with a swept sine wave about 40 lines wide

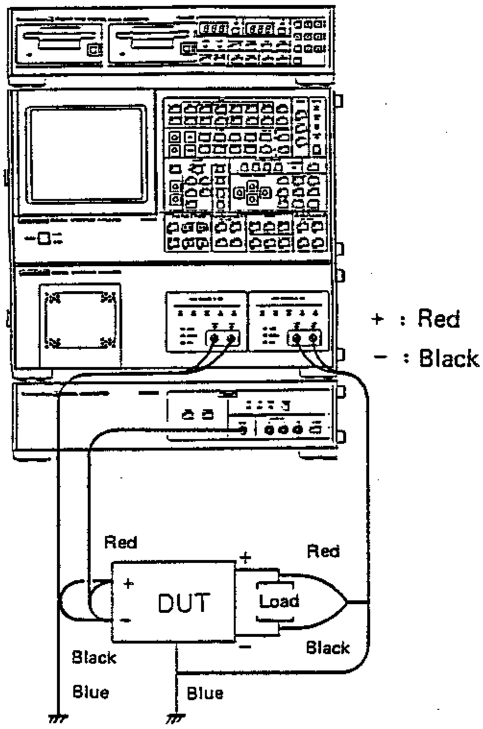
- Sweeping only near sharp resonance/antiresonance points with a sine wave using the signal sequence method

The following sweeps are effective for measuring a transfer function without a sharp dip.

- Linear sweep in arithmetic steps
- Logarithmic sweep in geometric steps

(9) When AUTO SCALE function is used
When AUTO SCALE in the DISP CTRL menu is set to ON, the frequency domain data is displayed at the appropriate gain on the CRT; the transfer function measured in combination with the sine waves (log sweep, or linear sweep in 2 steps or more) is always displayed at the gain of 140 dB.

(6) Logarithmic frequency analysis with sine wave



① Connect a DUT.

② Preset

a. Presettings with the panel switches:

LOCAL LOCAL	I/O E	LIN SWEEP
	FREQUENCY F	LOG SWEEP

By the above key operation, the following settings are made:

Presettings:
Frequency range = 100 kHz
Signal generator output waveform = SINE
AMPLITUDE = 02.0E-3Vpp
OUTPUT MODE = LIN SWEEP
STEP = 9
(or OUTPUT MODE = LOG SWEEP
LINES = 80/Decade)
SERVO = ENABLE, ADVANCED ANALYSIS EXECUTE
ANALYSIS LINE = 4-DECADE
SENS CTRL = AUTO
WEIGHTING CTRL = AUTO
SG OPERATION = ON-KEY
AVG NUMBER = 2

(3) Frequency range FREQUENCY : Displays the "FREQUENCY" menu.

(4) Input coupling AC/DC AC/DC or -GND [as necessary]

(5) Auto range SENS. A SETUP or SENS. B SETUP [with the "SENS" menu displayed]

(6) Output amplitude I/O, PANEL RECALL P C. O. P. : Displays the "SINE" menu.

OPERATE : SG generates a signal.

: Move the pointer (⇨) to AMPLITUDE with these keys.

Yellow : Shift a digit of a setting value with the right or left arrow key, and increment or decrement a numeral with the up or down arrow key.

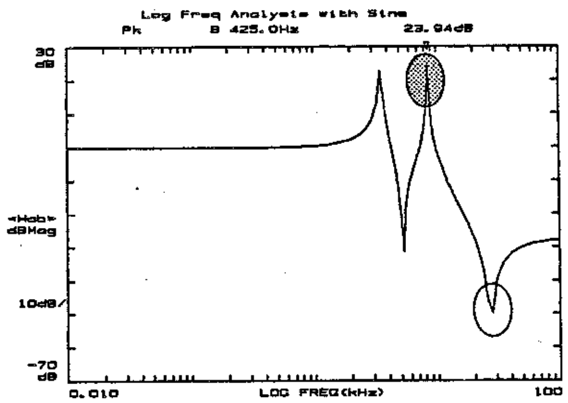
(The keys with a green numeral at lower left of each key can also be used for numerical entry.)

Move the pointer (⇨) to FREQ(LINE).

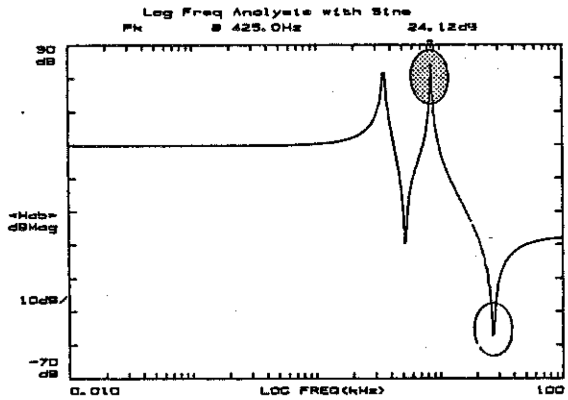
(7) Frequency response analysis START : Measurement starts.

(8) Viewing the results of measurement [TRANS. FCTN] [MAG.]:

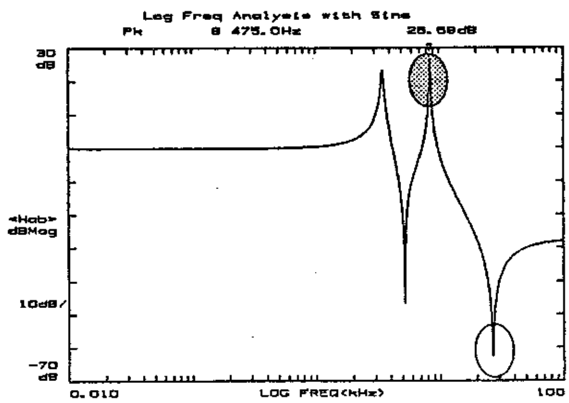
Gain of transfer function



Linear sweep (step = 9)



Log sweep (Lines = 80/D)



Linear sweep (step = 1)

When a logarithmic sweep, for example at 80 lines/decade, is performed in a logarithmic frequency analysis, the following results are obtained as was the case with the linear frequency analysis:

Measured value is smaller than true gain at resonance frequency
and
Measured value is larger than true gain at antiresonance frequency

In this case, too, high-resolution high-speed measurements are achieved by either of the following:

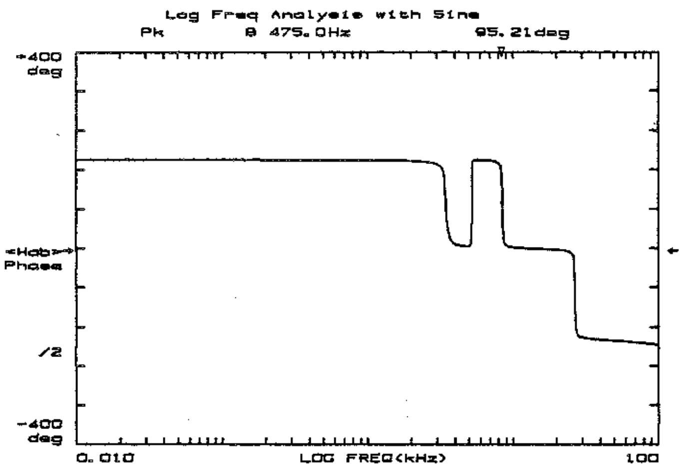
- Sweeping with a swept sine wave about 40 lines wide

- Sweeping only near sharp resonance/antiresonance points with a sine wave using the signal sequence method

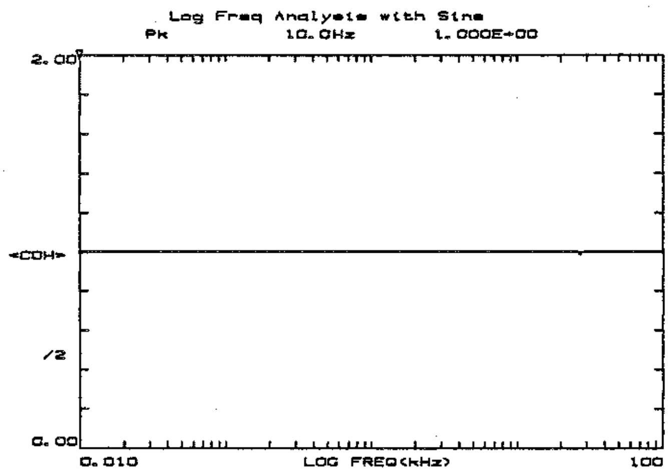
The following sweeps are effective for measuring a transfer function without a sharp dip

- Linear sweep in arithmetic steps

- Logarithmic sweep in geometric steps

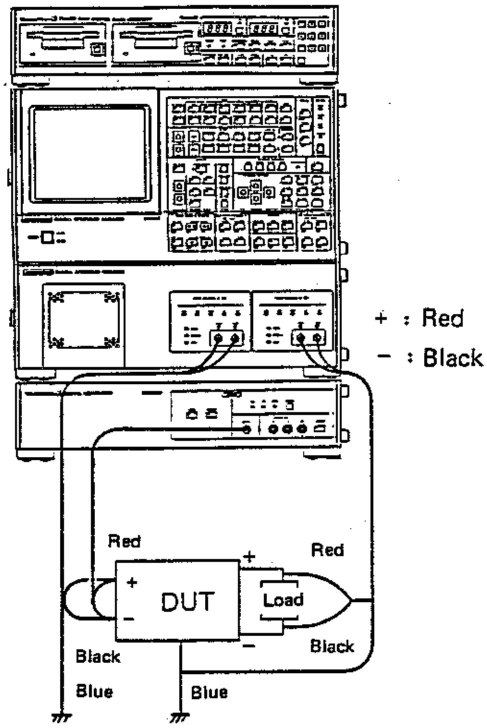


TRANS. FCTN PHASE : Phase of transfer function



COHERENCE : Coherence function

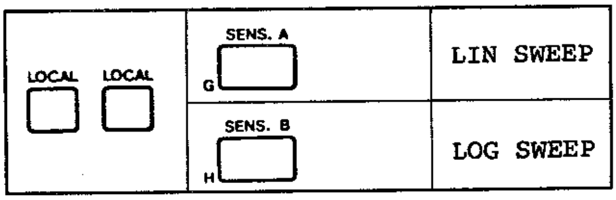
(7) Linear frequency analysis with Sweep of Swept Sine (SSS scheme)



① Connect a DUT.

② Preset

a. Presettings with the panel switches:



By the above key operation, the following settings are made:

Presettings:
Frequency range = 100 kHz
Signal generator output waveform = SWEPT SINE
AMPLITUDE = 02.0E-3Vpp
OUTPUT MODE = LIN SWEEP
WIDTH = 80
(or OUTPUT MODE = LOG SWEEP
LINES = 20/decade)
SERVO = ENABLE, ADVANCED ANALYSIS EXECUTE
ANALYSIS LINE = NORMAL
SENS CTRL = AUTO
WEIGHTING CTRL = AUTO
SG OPERATION = ON-KEY
AVG NUMBER = 4

(3) Frequency range FREQUENCY : Displays the "FREQUENCY" menu.

(4) Input coupling AC/DC AC/DC or -GND [as necessary]

(5) Auto range SENS. A SETUP or SENS. B SETUP [with the "SENS" menu displayed]

(6) Output amplitude I/O , PANEL RECALL U AUTO-CORR.

: Displays the "SWEPT-SINE" menu.

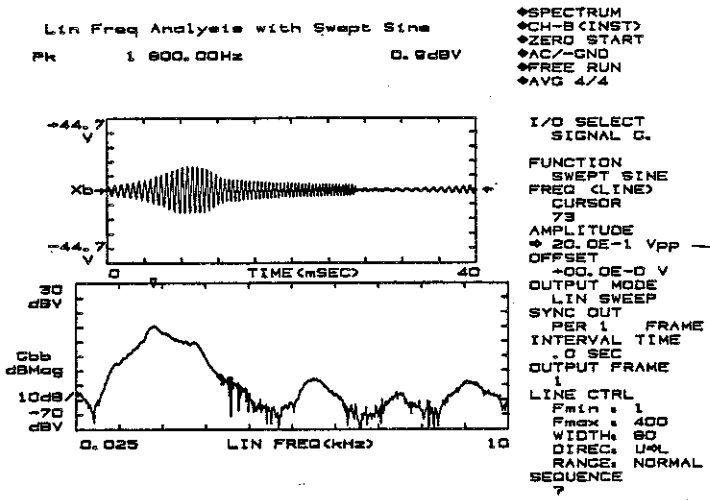
OPERATE : SG generates a signal.

: Move the pointer (⇨) to AMPLITUDE with these keys.

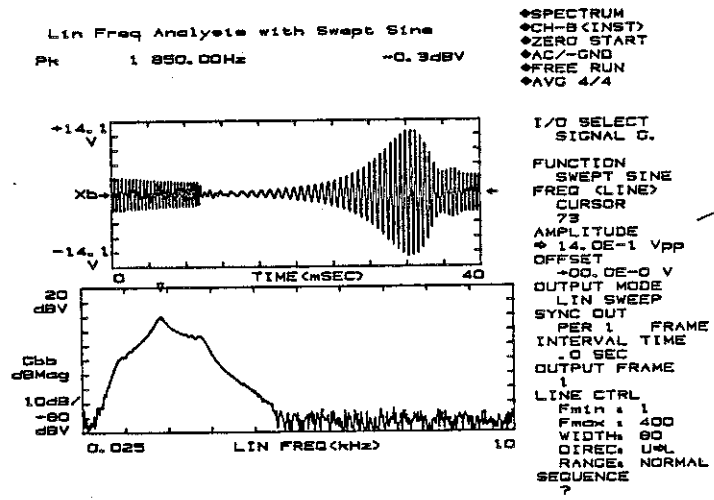
Yellow : Shift a digit of a setting value with the right or left arrow key, and increment or decrement a numeral with the up or down arrow key.

(The keys with a green numeral at lower left of each key can also be used for numerical entry.)

: Move the pointer (⇨) to FREQ(LINE).



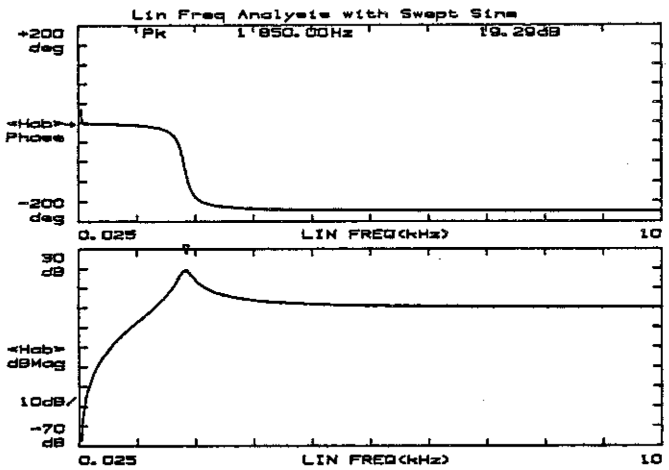
Nonlinear operation due to overload. Harmonics are generated.



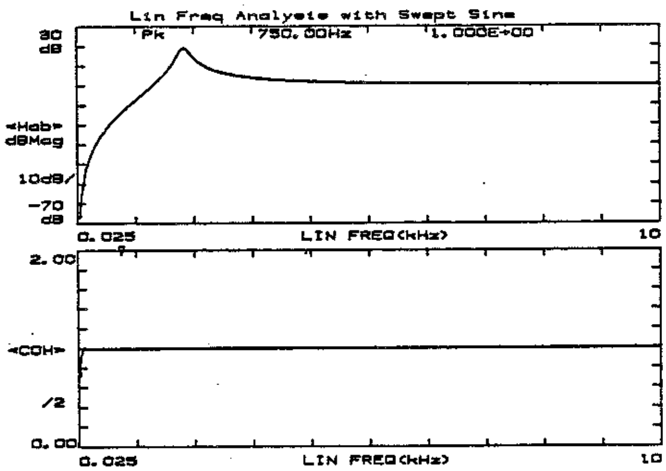
Input with a proper amplitude.

(7) Frequency response analysis [START] : Measurement starts.

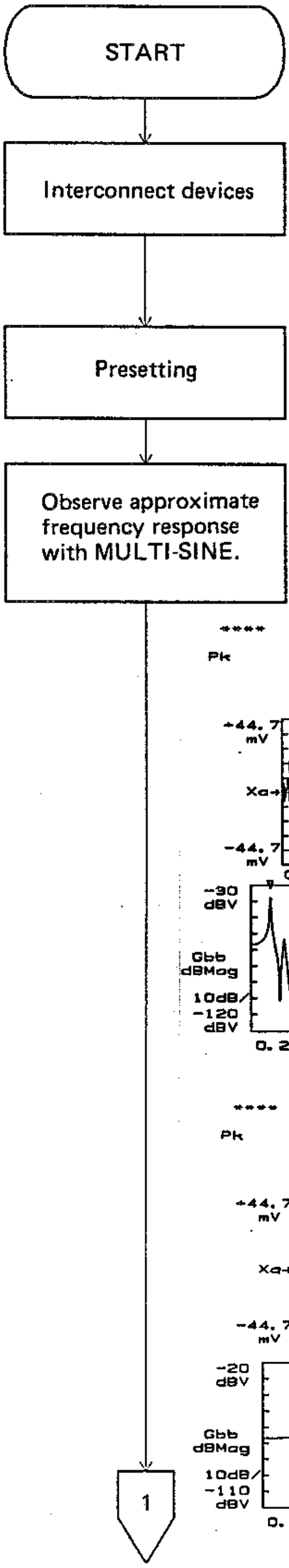
(8) Viewing the results of measurement LOCAL LOCAL 2 +GND : Bode diagram



LOCAL LOCAL 3 +GND : Coherence function



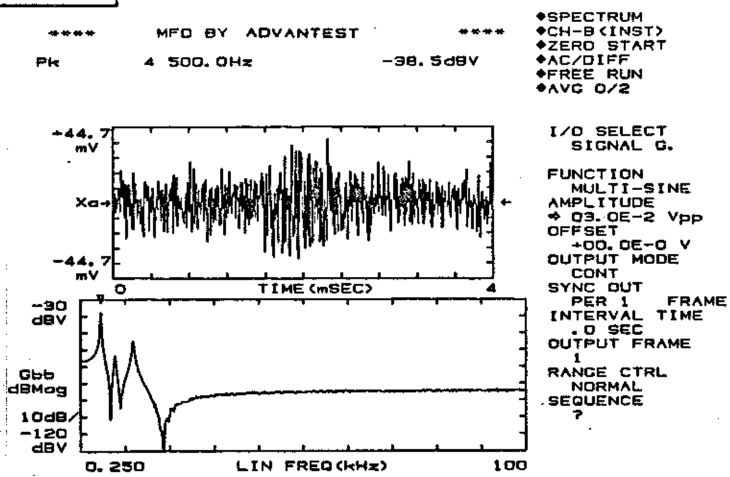
Frequency response analysis measurement example (SSS scheme)



See the setup on page 3-37.

OPERATE : Signal generator generates a signal.

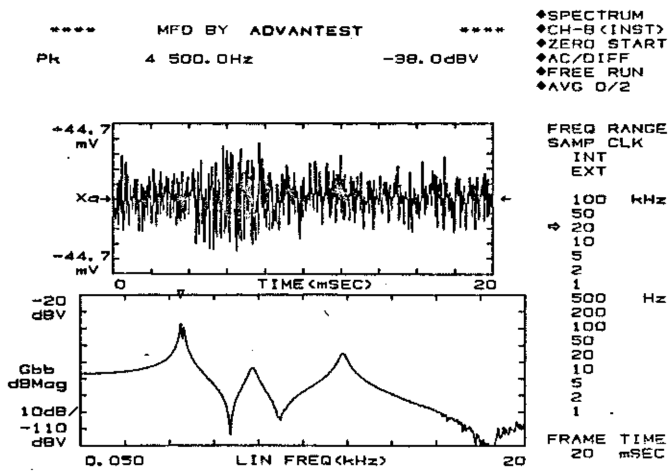
LOCAL LOCAL , AVG MODE (when TR9407 panel switches are used), the multi-sine of the following setting values is output.



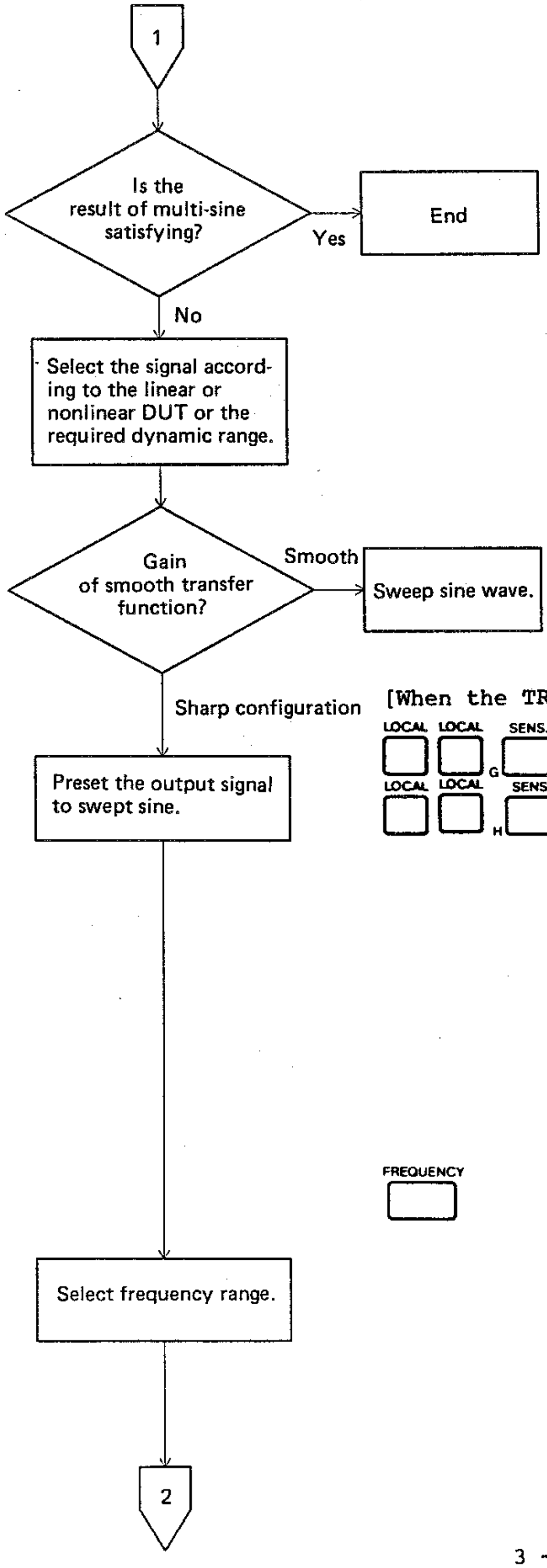
Frequency range:
100 kHz

Amplitude:
02.0E-3Vpp

SERVO: ENABLE,
EXECUTE
WEIGHTING CTRL:
AUTO
SG OPERATION: ON-KEY
ANALYSIS LINE:
NORMAL
AVG NO.: 8



Judging from the spectrum of channel B in the above figure, change the frequency range to 20 kHz.



When a MULTI-SINE does not give a clear trace by adjusting AMPLITUDE, or dynamic range is not sufficient, use SWEPT SINE or SINE.

For sine wave, all you have to do is to press LOCAL LOCAL C FUNCTION (or D DISPLAY CTL) and change frequency range and AMPLITUDE setting.

[When the TR9407 front panel switches are used]

LOCAL LOCAL G SENS. A For linear sweep

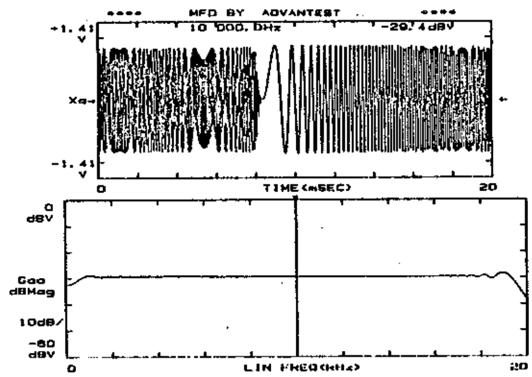
LOCAL LOCAL H SENS. B For logarithmic sweep

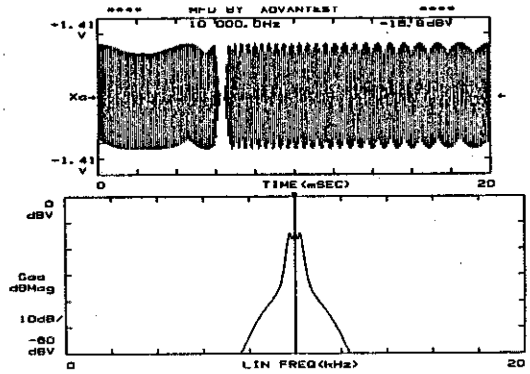
FREQUENCY Change frequency range to 20 kHz.

2

Set WIDTH.

As shown below, signals of the same amplitude in time axis produce larger level on the frequency axis when the bandwidth (WIDTH) of the signal becomes narrow. For this reason, WIDTH should be set first, before setting (via AMPLITUDE) the optimum level of signals applied to the DUT.





In the range where the transfer function has smooth frequency characteristics, apply the signal with bandwidth extended as wide as possible (to reduce measurement time), and in the range where the change is rapid and the level difference is large, set it so that the peak and notch are in different WIDTHs.

How to set up the bandwidth (WIDTH) of swept sine by cursor

WIDTH in the swept-sine menu can be set up either by DISP (or SETUP) key or cursor. Use of the cursor will facilitate setup of WIDTH, especially the configuration of spectra is characterized with the abrupt level changes.

(1) Display the frequency domain data, such as the transfer function, on the CRT.

(2) I/O, PANEL RECALL, U AUTO-CORR. Display the "SWEPT SINE" menu.

(3) ⇧ ⇩ (SETUP section) Move the pointer (⇨) to WIDTH:XXX

(4) C (↔) Activate the vertical cursor.

(5) SET REF. ON/OFF, SET REF. Set the cursor-defined frequency to the reference.

Now, the reference cursor is set.

3

3

⑥ Move the vertical cursor until the difference with the reference cursor is equal to WIDTH to be set.

⑦ [SET X]

At completion of setting,

"SET:WIDTH"

blinks at the center of the CRT for several seconds.

CAUTION

Do not measure the transfer function with the same sensitivity when the level difference is large. SENSITIVITY set to auto range complies with the peak value but not to a lower level area at the same time.

Table 3-3 WIDTH of swept sine

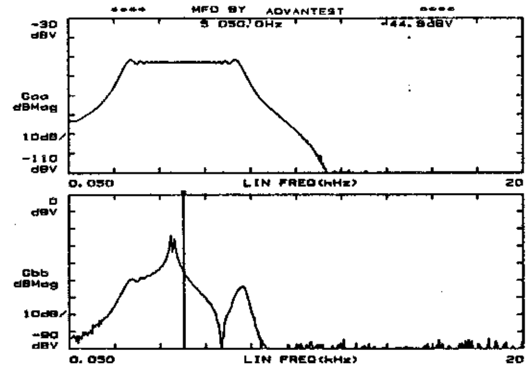
System	Measurement dynamic range	WIDTH
Linear system	Up to about 50 dB	100
	Up to about 70 dB	50
	Up to about 100 dB	25
	100 dB or more	≦10
Non-linear system	Up to about 50 dB	40
	Up to about 70 dB	25
	70 dB or more	≦10

The left table gives a general rule of thumb. In actual measurement, when there are many coherence function values of 0.8 or less, set a smaller value as WIDTH to increase reliability.

4

4

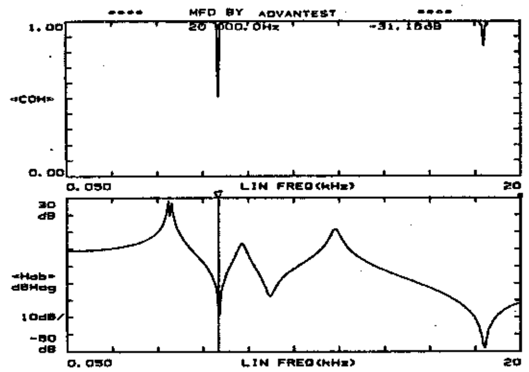
1



In frequency response analysis, perform averaging after settings and confirm the reliability of the results by the COHERENCE function.

The upper trace in 1 shows the waveform at the second sweeping with WIDTH=100. Comparing the flat portion with the input waveform of channel B in the lower trace reveals that not only the peak value near 4.5 kHz but the level at notch approximately 60 dB below the peak is measured at the same time.

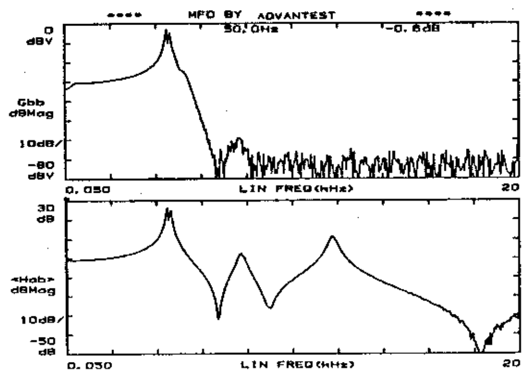
2



Consequently, as shown in 2, coherence at the anti-reasonance frequency, where the cursor is positioned, is low.

[Example when the coherence of measurement results is degraded because of a large WIDTH setting]

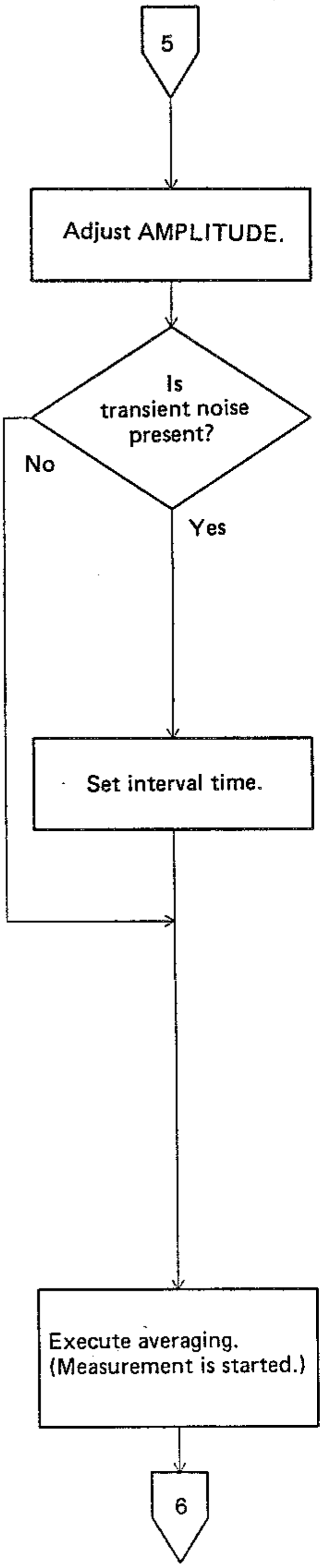
Display the power spectrum of B channel in the upper region of CRT.

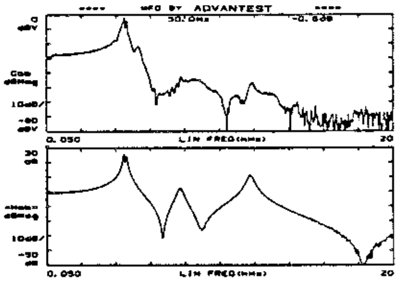


Gbb is displayed in the upper area by UPPER/LOWER CH. A/CH. B SPECTRUM.

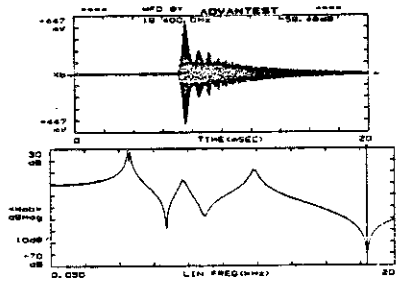
Confirm signal-to-noise ratio by monitoring the spectrum output from the DUT.

5





Determine the maximum signal level applied to DUT. (Too small an input amplitude degrades the signal-to-noise ratio.) Increase signal level gradually up to the level just before distortion appears in DUT response.



Too high level, as shown in the left figure, causes distortion at lower level, then at the higher level.

(Display the time data of channel B in the upper area for monitoring.)

Set by INTERVAL TIME (corresponding to the delay time of conventional frequency response analyzer); the time until averaging is started after frequency is switched.

[Why is an interval time necessary?]
When sweep frequency is stepped up during sweep, the output level changes rapidly, the full scale value of input level is exceeded, and overload occurs because the way the frequency is switched is not analog. At that time, auto range reduces sensitivity, however, the transient response is long, depending on the DUT, so it takes a long time to reach the stationary state. Accordingly, if averaging is started with sensitivity smaller than the optimum range for measurement, an error occurs. Then, if interval time is used, meansurement is stopped for a specified time, and measurement is automatically resumed. This is useful when a system with large time constant is measured.

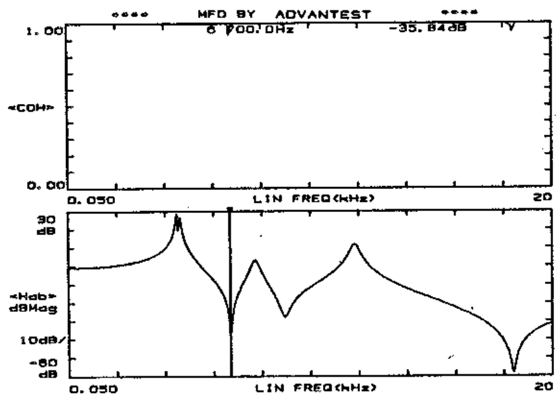
Frequency response analysis is effective only when averaging is performed. Specify 2 or more as the number of averagings. Setting to 1 always causes coherence of 1; the reliability of measurement result cannot be determined. From 4 to 16 is OK as the number of averagings STOP ERASE START.

6

Confirm the reliability of measured data by coherence.

After frequency response analysis, confirm the reliability of measurement result by coherence.

Press [UPPER/LOWER] [COHERENCE] to display coherence function in the upper screen. Data closer to 1.0 has a higher reliability.



The left figure shows coherence at 6.7 kHz and 18.3 kHz is reduced a little.

[Example of coherence function data]

OK?

No → Use swept sine or signal sequence by two or more signals.

(Fast, high-accuracy)

Yes ↓

Write data to floppy disk.

Perform another analysis as required.

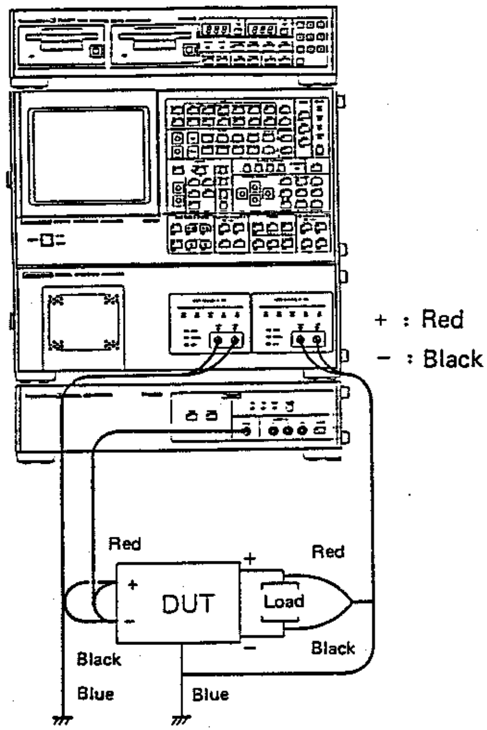
If necessary, further process measured data to get detailed data.

- Determination of stability (Nichols chart gives a better stability criterion than Nyquist diagram or Bode diagram. Use [DISPLAY CTL] switch.)
- EQUALIZE (use [FUNCTION])
- Interchannel delay
- Operation of open ↔ closed loop

} Cannot be used during 4-decade log frequency analysis.

- Unwrapped phase display [phase display without wraparound (periodicity)]
- Group delay

(8) Logarithmic frequency analysis with Sweep of Swept Sine (SSS scheme)



① Connect a DUT.

② Preset

a. Presettings with the panel switches:

LOCAL LOCAL	TRIG. MODE I	LIN SWEEP
	ADVANCED ANALYSIS J	LOG SWEEP

By the above key operation, the following settings are made:

Presettings:
Frequency range = 100 kHz
Signal generator output waveform = SWEPT SINE
AMPLITUDE = 02.0E-3Vpp
OUTPUT MODE = LIN SWEEP
WIDTH = 80
(or OUTPUT MODE = LOG SWEEP
LINES = 20/decade)
SERVO = ENABLE
ANALYSIS LINE = 4-DECADE
SENS CTRL = AUTO
WEIGHTING CTRL = AUTO
SG OPERATION = ON-KEY
AVG NUMBER = 4

(3) Frequency range FREQUENCY : Displays the "FREQUENCY" menu.

(4) Input coupling AC/DC AC/DC or -GND [as necessary]

(5) Auto range SENS. A SETUP or SENS. B SETUP [with the "SENS" menu displayed]

(6) Output amplitude I/O , PANEL RECALL U AUTO-CORR. : Displays the "SWEPT-SINE" menu.

OPERATE : SG generates a signal.

: Move the pointer (⇨) to AMPLITUDE with these keys.

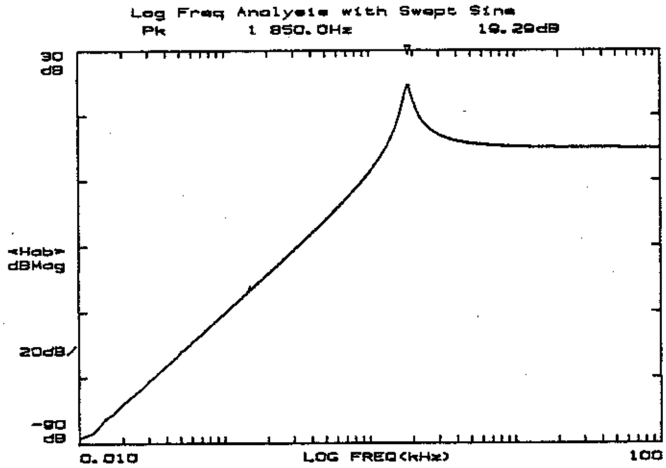
Yellow : Shift a digit of a setting value with the right or left arrow key, and increment or decrement a numeral with the up or down arrow key.

Keys with the green numerals are also usable.

: Move the pointer (⇨) to FREQ(LINE).

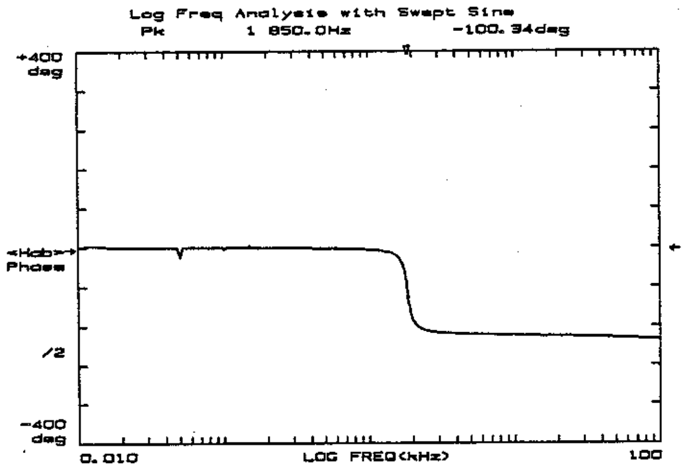
(7) Frequency response analysis START : Measurement starts.

8 Viewing the results of measurement

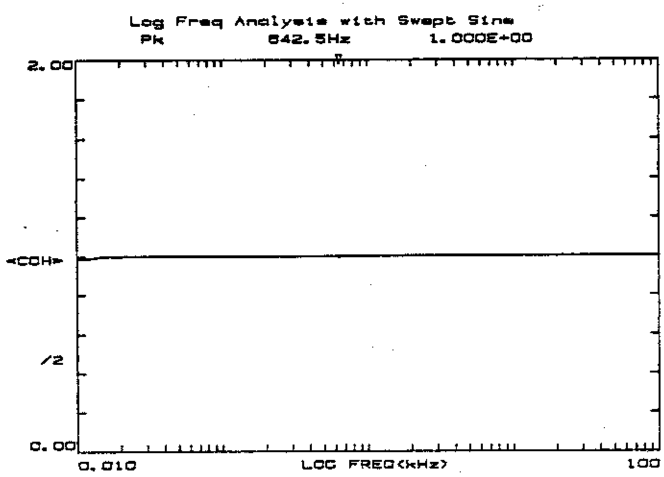


TRANS. FCTN MAG. : Gain of transfer function

The same DUT as for linear frequency analysis. The structure on the low-frequency range is measured more clearly.

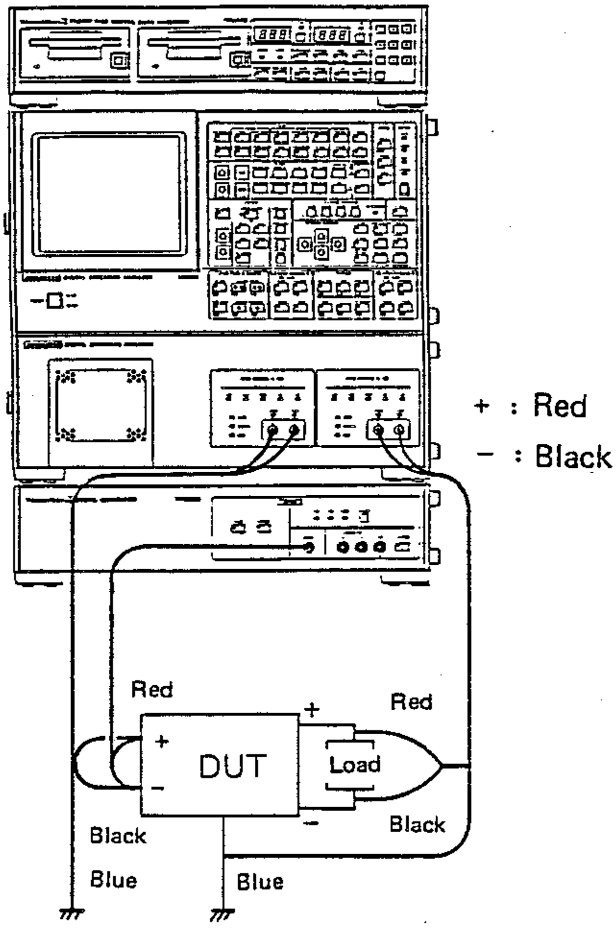


TRANS. FCTN PHASE : Phase of transfer function



COHERENCE : Coherence function

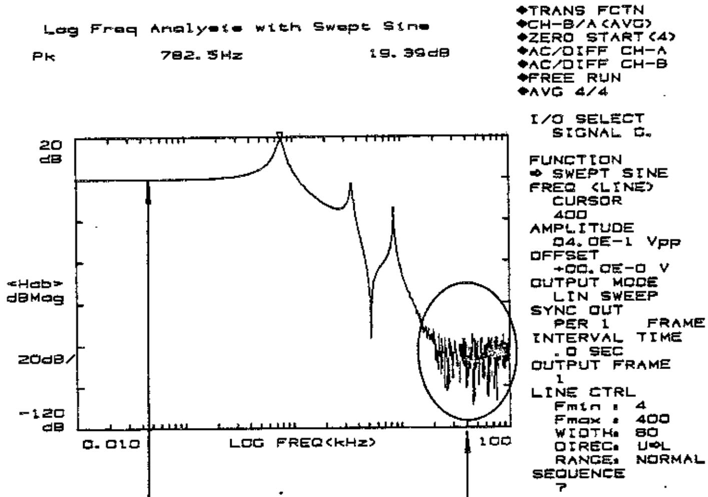
(9) Logarithmic (or linear) frequency analysis by signal sequence method



① Connect a DUT.

② Approximate frequency response of DUT

Logarithmic frequency analysis is performed by sweeping with a swept sine with an 80-line bandwidth.



In the figure on the left, the portion at -90 dB or below is not measured correctly. The method for measuring this portion must be improved.

When "RANGE: NORMAL" is set, this signal is used for all three ranges of the logarithmic frequency band.

Small AMPLITUDE of S.G. output level is enough for the high level response

Apply the signal of large amplitude to the region of low level signal. (Improvement of S/N ratio)

③ Preset

a. Presettings with the panel switches:

LOCAL LOCAL	AVG/INST. K	Linear frequency analysis
	SPECTRUM L	Logarithmic frequency analysis

By the above key operation, the following settings are made:

Preset conditions for measurement:				
Frequency range			100 kHz	
Signal sequence (A → B → C)	Sequence A: Swept-sine	Setting item	Lin. frequency analysis	Log. frequency analysis
		AMPLITUDE	02.0E-3Vpp	
		OUTPUT MODE	LIN SWEEP	
		WIDTH	80	
		(Fmin, Fmax)	(1,120)	(41,400)
		RANGE	NORMAL, L → U	STOP, U → L
	Sequence B: Swept-sine	AMPLITUDE	02.0E-3Vpp	
		OUTPUT MODE	LIN SWEEP	
		WIDTH	80	
		(Fmin,Fmax)	(121,240)	(41,400)
		RANGE	NORMAL, L → U	MIDDLE, U → L
	Sequence C: Swept-sine	AMPLITUDE	02.0E-3Vpp	
		OUTPUT MODE	LIN SWEEP	
		WIDTH	80	
		(Fmin,Fmax)	(241,400)	(4,400)
		RANGE	NORMAL, L → U	MIDDLE, U → L
SERVO menu			ENABLE	
	ANALYSIS LINE		NORMAL	4-DECADE
	SENS CTRL		AUTO	
	WEIGHTING CTRL		AUTO	
	SG OPERATION		ON-KEY	
	AVG NO.		4	

④ Frequency range FREQUENCY ⇩ ⇧ : Display the "FREQUENCY" menu.

⑤ Input connection AC/DC AC/DC or −GND [as necessary]

⑥ Output amplitude I/O PANEL RECALL CROSS SPECT. x : Display the "SEQUENCE" menu.

⇩ ⇧ : Move the pointer (⇨) to AMPLITUDE of each sequence with these keys. (The brightness is intensified.)

```
I/O SELECT
  SIGNAL G.

FUNCTION
  SEQUENCE
SEQUENCER
➡ A→B→C
A: SWEPT SINE
AMP: 04.0E-1 Vpp
MODE: LIN SWEEP
RANGE: STOP
Fmin : 41
Fmax : 400
AVG NO: 4
B: SWEPT SINE
AMP: 04.0E-1 Vpp
MODE: LIN SWEEP
RANGE: MIDDLE
Fmin : 41
Fmax : 400
AVG NO: 4
C: SWEPT SINE
AMP: 04.0E-1 Vpp
MODE: LIN SWEEP
RANGE: START
Fmin : 4
Fmax : 400
AVG NO: 4
```

Yellow ⇧ ⇦ ⇨ ⇩ : Shift a digit of a setting value with the right or left arrow key, and increment or decrement a numeral with the up or down arrow key.

Set an output amplitude here in viewing the approximate frequency response of DUT in step ②.

⑦ Changing the sequence settings

(i) Recall

I/O PANEL RECALL AUTO-CORR. U : Display the "SWEPT SINE" menu.

⇩ ⇧ : Move the pointer (⇨) to SEQUENCE in the bottom row.

PANEL RECALL AVG MODE A : Since the setting of swept sine of the stop range is changed, call sequence A from the sequence file.

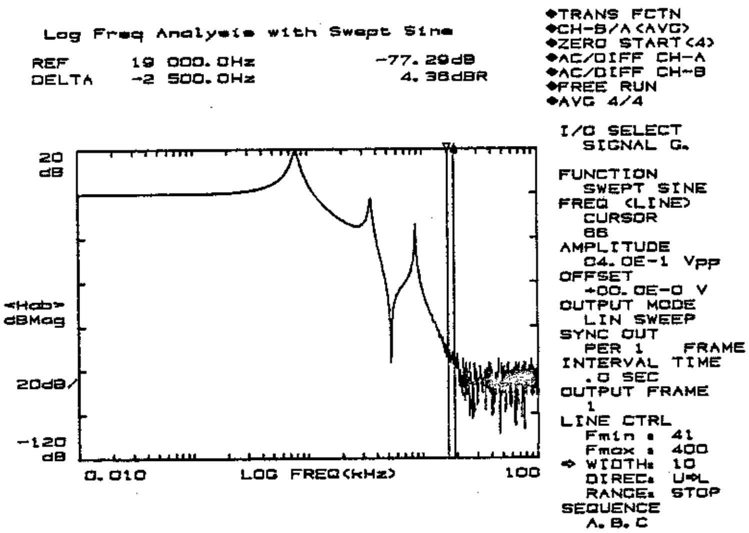
```
I/O SELECT
  SIGNAL G.

FUNCTION
  SWEPT SINE
FREQ (LINE)
  CURSOR
  41
AMPLITUDE
  02.0E-3 Vpp
OFFSET
  +00.0E-0 V
OUTPUT MODE
  LIN SWEEP
SYNC OUT
  PER 1    FRAME
INTERVAL TIME
  .0 SEC
OUTPUT FRAME
  1
LINE CTRL
  Fmin : 1
  Fmax : 400
  WIDTH: 80
  DIREC: U⇦L
  RANGE: NORMAL
SEQUENCE
⇨ A.B.C
```

Recall →

```
I/O SELECT
  SIGNAL G.

FUNCTION
  SWEPT SINE
FREQ (LINE)
  CURSOR
  68
AMPLITUDE
➡ 04.0E-1 Vpp
OFFSET
  +00.0E-0 V
OUTPUT MODE
  LIN SWEEP
SYNC OUT
  PER 1    FRAME
INTERVAL TIME
  .0 SEC
OUTPUT FRAME
  1
LINE CTRL
  Fmin : 41
  Fmax : 400
  WIDTH: 80
  DIREC: U⇦L
  RANGE: STOP
SEQUENCE
  A.B.C
```

(ii) Setting the WIDTH

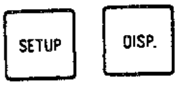
C (↔)	: Display the vertical cursor.
SET REF. ON/OFF, SET REF.	: Set the reference cursor.
Yellow ⇧ ⇩	: Move the reference cursor by the space to be set as the desired width.
⇩ ⇧	: Move the pointer (⇨) to WIDTH.
SET X	: Set the width. ("SET:WIDTH" is displayed.)
SETUP, DISP.	: Make a fine adjustment of the above set width as necessary with the menu.



SET REF. ON/OFF	: Delete the reference cursor.

(iii) Setting amplitude

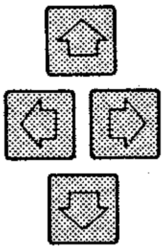
 : Move the pointer (⇨) to FREQ (LINE).



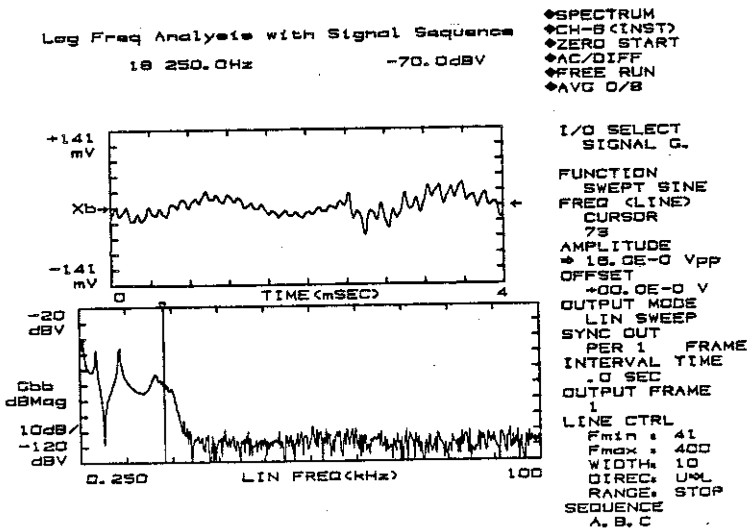
: Change MANUAL to CURSOR.

Yellow  : Move the vertical cursor to a resonance frequency to be examined.

 : Move the pointer (⇨) to AMPLITUDE.

Yellow  : Shift a digit of a setting value with the right or left arrow key, and increment or decrement a numeral with the up or down arrow key.

(The keys with a green numeral can also be used for numerical entry.)



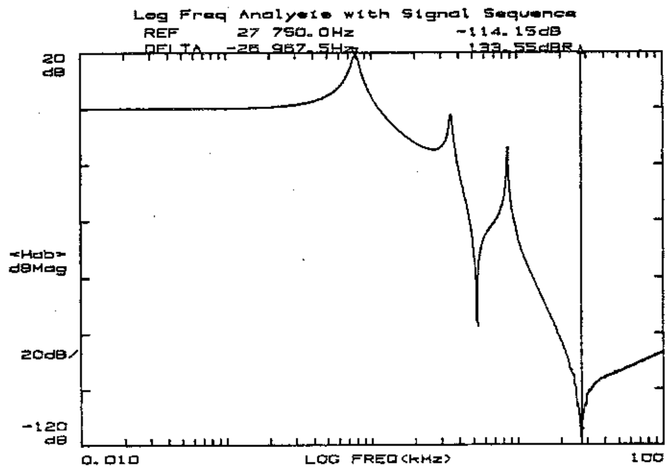
(iv) Saving altered data

[⇩] [⇧] : Move the pointer (⇨) to SEQUENCE.

AVG MODE
A [ ] : Return the altered data to the original sequence "A".

```
I/O SELECT
  SIGNAL G.
FUNCTION
  SWEPT SINE
FREQ <LINE>
  CURSOR
  73
AMPLITUDE
  16.0E-0 Vpp
OFFSET
  +00.0E-0 V
OUTPUT MODE
  LIN SWEEP
SYNC OUT
  PER 1    FRAME
INTERVAL TIME
  .0 SEC
OUTPUT FRAME
  1
LINE CTRL
  Fmin : 41
  Fmax : 400
  WIDTH: 10
  DIREC: U⇨L
  RANGE: STOP
SEQUENCE
⇨ A, B, C
```

(8) Servo analysis START [ ] : Measurement starts.



Wider dynamic range (approx. 130 dB) is achieved as compared with the result of the original measurement

⑨ Remeasurement

Measure only the antiresonance frequencies whose gain can be further improved by sweeping with the sine wave.

(i) Signal G. menu [I/O] [RECALL]P [C. O. P.] :

The "SINE" menu is displayed.

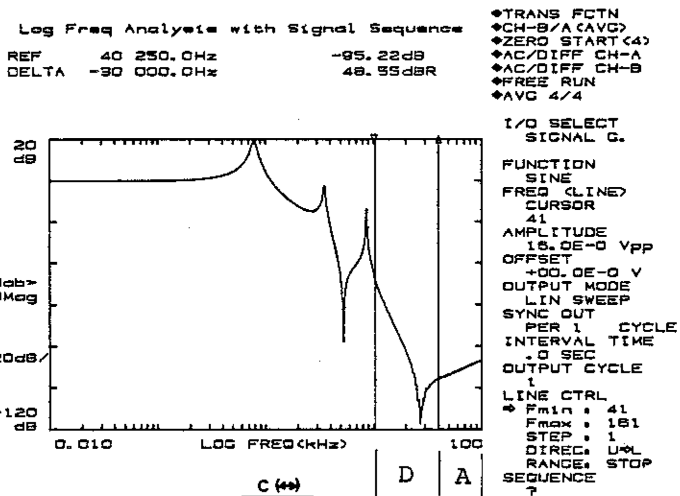
(ii) (Fmin, Fmax)

[⇩] [⇧] : Move the pointer (⇨) to FREQ (LINE) with these keys.

[SETUP] or [DISP.] : Change MANUAL to CURSOR.

[⇩] [⇧] : Move the pointer (⇨) to OUTPUT MODE.

[SETUP] or [DISP.] : Set the sweeping mode to LIN SWEEP.



A: Sequence A for the first sweep

D: Sequence D where S.G. condition has been changed for further sweep

C (↔) [■] : Display the vertical cursor.

SET REF. ON/OFF [■] SET REF. [ ] : Display the reference cursor.

Yellow [⇦] [⇨] : Move the vertical cursor.

[⇧] [⇩] : Move the reference cursor.

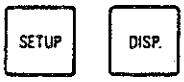
[⇩] [⇧] : Move the pointer to "Fmin:" (or "Fmax:") with these keys.

SET X [ ] : Set (Fmin, Fmax).

You can confirm the successful setup with the blinking display of

SET: Fmin
SET: Fmax

When setting is inhibited with "SAME? : FREQ RANGE" displayed, move the vertical cursor or reference cursor to set the both cursors within the same frequency range. In this case, a vertical cursor value is displayed at the FREQ (LINE) position.



: Make a fine adjustment of the setting if necessary.

: Delete the reference cursor.

(iii) Output amplitude

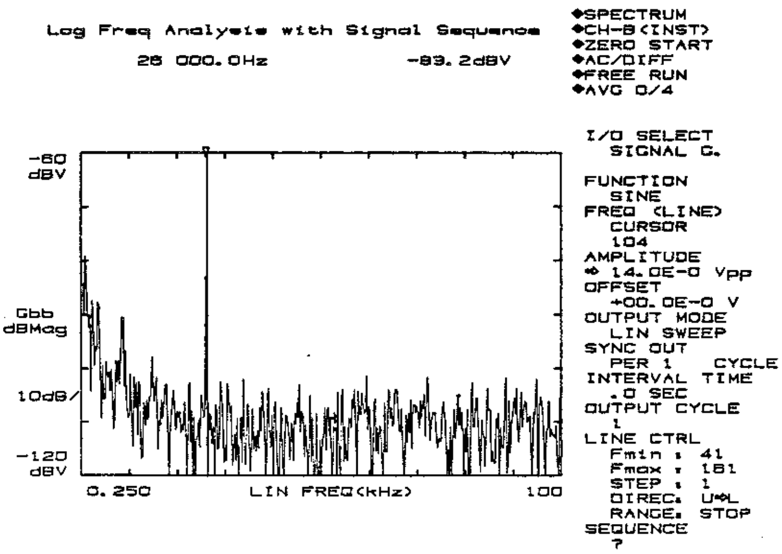
: Display the output power spectrum.

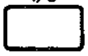
: Display the "FREQUENCY" menu.


: When the stop range is 100 kHz, select the following frequency range:

10 kHz for middle range setting

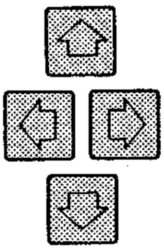
1 kHz for start range setting



I/O
 : Display the "SINE" menu.

Yellow  : Move the vertical cursor to a resonance frequency to be examined.

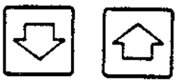
 : Move the pointer (⇨) to AMPLITUDE.

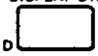
Yellow  : Shift a digit of a setting value, and increment or decrement a numeral with these keys.

Increase the AMPLITUDE to enhance the S/N ratio at the antiresonance frequencies where the signal level is low.
Maximize the amplitude level, not so much as the level of harmonics of channel B will rise.

(iv) Saving into sequence file

```
I/O SELECT
   SIGNAL G.

FUNCTION
   SINE
FREQ <LINE>
   CURSOR
   104
AMPLITUDE
   14.0E-0 Vpp
OFFSET
   +00.0E-0 V
OUTPUT MODE
   LIN SWEEP
SYNC OUT
   PER 1    CYCLE
INTERVAL TIME
   .0 SEC
OUTPUT CYCLE
   1
LINE CTRL
   Fmin : 41
   Fmax : 161
   STEP : 1
   DIREC: U⇨L
   RANGE: STOP
SEQUENCE
⇨ ?
```

 : Move the pointer (⇨) to SEQUENCE in the bottom row of the menu.

DISPLAY CTL
D  : Saving the above analysis conditions into sequence D.

 : Return the pointer (⇨) to "RANGE." (Move the pointer out of the SEQUENCE item.)

FREQUENCY
 : Press this key to display the "FREQUENCY" menu as necessary.

 : Return to the frequency range setup corresponding to the STOP range.

(v) Signal sequence

I/O, PANEL RECALL x CROSS SPECT : Display the "SIGNAL SEQUENCE" menu.

⇧ ⇩ : Move the pointer (⇨) to SEQUENCER in the top row of the menu.

SETUP DISP. : Set up the sequence A→B→C→D

⇩ ⇧ : Move the pointer to "Fmin:" of "A:".

SETUP DISP. : Set "Fmin" to "161" to prevent sweeping ranges from overlapping because the sweep range of sequence D is "41" to "160". (See Figure on P.3 - 58.)

⇩ ⇧ : Move the pointer to "AVG NO:" of "A:".

SETUP DISP. : Increase the averaging number. Also increase the averaging number of sequence B in the same way.

Placing the pointer to this position, press SETUP DISP. to scroll up or down the menu.

```
  I/O SELECT
    SIGNAL G.

  FUNCTION
    SEQUENCE
  SEQUENCER
  ⇨ A→B→C→D
  A: SWEPT SINE
O AMP: 16.0E-0 Vpp
  MODE: LIN SWEEP
O RANGE: STOP
O Fmin : 161
O Fmax : 400
O AVG NO: 8
  B: SWEPT SINE
O AMP: 04.0E-1 Vpp
  MODE: LIN SWEEP
O RANGE: MIDDLE
O Fmin : 41
O Fmax : 400
O AVG NO: 8
  C: SWEPT SINE
O AMP: 04.0E-1 Vpp
  MODE: LIN SWEEP
O RANGE: START
O Fmin : 4
O Fmax : 400
O AVG NO: 4
```

```
A: SWEPT SINE
AMP: 16.0E-0 Vpp
MODE: LIN SWEEP
RANGE: STOP
Fmin : 161
Fmax : 400
AVG NO: 8
B: SWEPT SINE
AMP: 04.0E-1 Vpp
MODE: LIN SWEEP
RANGE: MIDDLE
Fmin : 41
Fmax : 400
AVG NO: 8
C: SWEPT SINE
AMP: 04.0E-1 Vpp
MODE: LIN SWEEP
RANGE: START
Fmin : 4
Fmax : 400
AVG NO: 4
D: SINE
AMP: 14.0E-0 Vpp
MODE: LIN SWEEP
RANGE: STOP
Fmin : 41
Fmax : 160
AVG NO: 4
```

Setup for the items marked with O can be changed on this menu.

Since output signal of SINE has a good S/N ratio with its energy concentrated on a single line, a small number of averagings is enough.
Increasing the number of averages causes longer measurement time.
AVG NO. set up in the SEQUENCE menu has the highest priority over the values set up in the SERVO or AVG MODE menus.

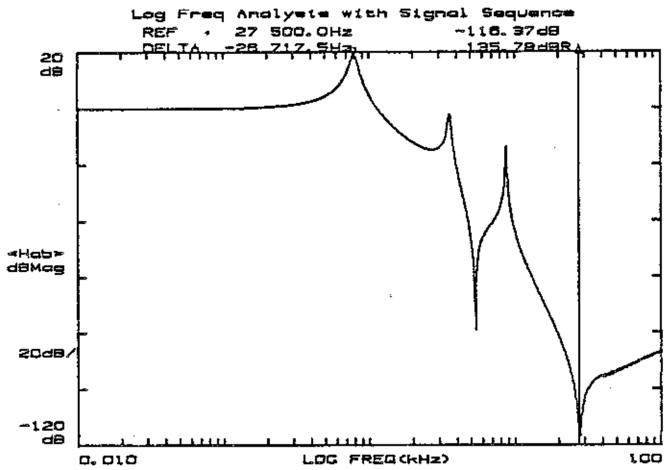
⑩ Frequency response analysis [START]: Measurement starts.

At this time, the "SIGNAL SEQUENCE" menu is always displayed.

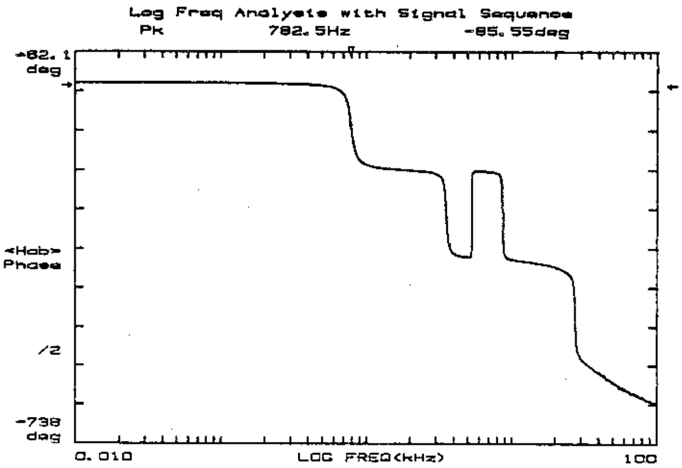
[TRANS. FCTN] [MAG.] : Gain of transfer function

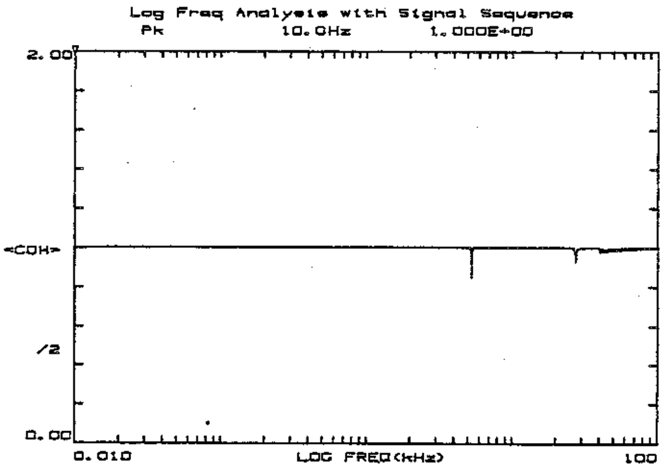
The gain at an antiresonance frequency is more precisely measured.

A wide dynamic range measurement of about 135 dB is achieved.



[TRANS. FCTN] [PHASE] : Phase of transfer function





: Coherence function

3.1.6 SENS. sequence function

For the signal sequence preset function mentioned in Section 3.1.5 (9), AUTO range is set for the input sensitivity, that is, all sequence settings are the same (nSQ mode). If the input sensitivity range is known in advance (on the factory line), the sensitivity range can be incorporated into each sequence instead of the AUTO range. Use of the sSQ mode makes the measurement time shorter, typically one-third that of the nSQ mode.

Setting input sensitivities when signal sequence technique is used:

NORMAL SEQUENCE (nSQ mode)
A fixed sensitivity or AUTO range is set for all sequences.
SENSE SEQUENCER (sSQ mode)
A sensitivity is set for each sequence block.

There are two different input methods, (4) and (5), below using the label area.

(1) Determine the input sensitivities for each signal sequence in the nSQ mode.

1. Display the transfer function and the power spectrum Gbb in the dual display mode.

2. Display the SWEPT SINE menu of the SIGNAL G. and set the FREQ (LINE) to CURSOR. (Cursor position is monitored as a line number in the menu)

3. Confirming that the signal is not overloaded by observing the power spectrum Gbb, define the sweep frequency range and input sensitivity setup values.

(2) Setting the sSQ mode

1. Display instant data.

2. Press LABEL to select the label input mode. (The LED for the LABEL 1 goes on.)

3. The beginning of the label area blinks. Enter green characters SMALL, s, SMALL, s, o, and DATA WINDOW.

Then the following will be displayed in the label area:

sSQ! TR9407 DIGITAL SPECTRUM ANALYZER **

(4) Press the LABEL key again (the LED goes off) to exit the label input

mode and set the sSQ! mode.

sSQ! <AS> 0 → 0 → 0 → 0 → 0 → 0 <BS> 0 → 0 → 0 → 0 → 0 → 0

<AS>: Indicates channel A
<BS>: Indicates channel B

The above SENS. sequence information is displayed on the instant display screen. Thus, the nSQ mode has been switched to the sSQ mode and data (code 0) representing +30 dBV range has been input in sequence blocks A to F.

Note: The sSQ information is displayed in the label area by averaging for the averaged data such as <Hab>, <Gaa>, and <Gab>.

(3) Set up the floppy disk record mode as necessary. Use the WRITE mode for the FLOPPY MODE.

(4) Modifying sensitivity information (sSQ mode) (modifying only the sensitivity condition in the sequence block)

Like GPIB codes, 0-9 displayed in the label area correspond to +30 dB to -60 dB and AUTO, and they are displayed for the data in sequence blocks.

Sequence block		A	B	C	D	E	F		A	B	C	D	E	F
Label contents	sSQ! <AS>	0 →	0 →	0 →	0 →	0 →	0	<BS>	0 →	0 →	0 →	0 →	0 →	0
Marker location at modification	a	b	c	d	e	f	g		h	i	j	k	l	m

Sensitivity range and codes (same as GPIB codes)

SENS code	Range
0	+30dBV
1	+20dBV
2	+10dBV
3	0dBV
4	-10dBV
5	-20dBV
6	-30dBV
7	-40dBV
8	-50dBV
9	-60dBV
:	AUTO

(1) Press the LABEL key to set the label input mode. (The LED goes on.)

(2) In the label mode, the market is lit. Move the marker to the desired position (a to m) corresponding to the value to be modified by

pressing the yellow key ⇦ or ⇨ (general cursor section).

- When the marker is at position "a"
  Each time DISP. or SETUP is pressed, the display changes as
  s → n → s ....

  This setting can be made by pressing the green key SMALL (for lower case and N or S keys.

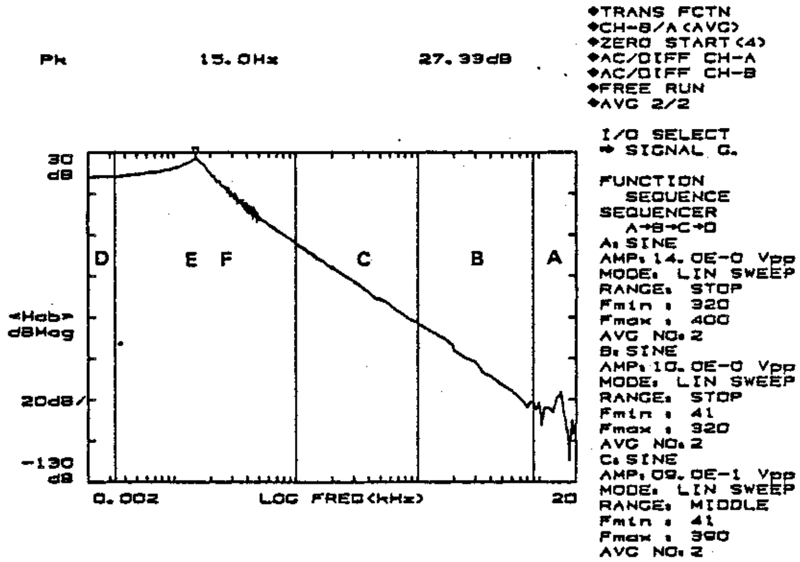
- When the marker is at a position other than "a"
  Move the marker to the desired position by pressing the yellow key
  ⇦ or ⇨.
  Every time DISP. or SETUP is pressed, the display cyclically changes: 0 → 1 → 2 ......9 → : → 0.
  A green character (0-9) and : may be input directly.

In either of these cases, the EXECUTE (I/O) and LOCAL keys can be used at this stage of procedure.

③ LABEL When the LABEL 1 LED goes on, change the display as follows:

sSQ! <AS> 1 → 2 → 2 → 5 → 1 → 1 <BS> 7 → 7 → 7 → 2 → 7 → 7

Thus, the modified sensitivity information has been set in the sequence blocks.
Correspondence between the sequence blocks and the sensitivity values set in the above is given as below.



	Sequence		A	B	C	D	E	F
Input sensitivity range settings in the sSQ mode	CH.A	(dBV)	+20	+10	+10	-20	+20	+20
		code	1	2	2	5	1	1
	CH.B	(dBV)	-40	-40	-40	+10	-40	-40
		code	7	7	7	2	7	7

(5) Modifying sensitivity information together with other sequence information

① Press LABEL to select the label input mode. (The LED goes on.)

② Enter sSQ! at the beginning of the label area.

③ Press LABEL again. (The LED goes off.) Thus, the sSQ mode has been set.

④ Press [SENS. A] to display the channel-A sensitivity menu and set a range.

⑤ Press [SENS. B] to display channel-B sensitivity menu and set a range.

⑥ Press [I/O] to display the signal generator function menu and move the pointer (⇨) to SEQUENCE at the bottom of the menu.

⑦ Press the keys (green characters A to F) corresponding to the blocks into which the sensitivity information set in steps ④ and ⑤ above is to be stored. The sequence of steps ④ to ⑥ can be taken in any order.

```
I/O SELECT
  SIGNAL G.
FUNCTION
⇨ SWEPT SINE
FREQ (LINE)
  MANUAL
  200
AMPLITUDE
  02.0E-3 Vpp
OFFSET
  +00.0E-0 V
OUTPUT MODE
  LIN SWEEP
SYNC OUT
  PER 1     FRAME
INTERVAL TIME
  .0 SEC
OUTPUT FRAME
  1
LINE CTRL
  Fmin :  1
  Fmax :  400
  WIDTH:  20
  DIREC:  L⇨U
  RANGE:  NORMAL
SEQUENCE
  D.E.F
```

(6) Start measurement

(7) Switching modes from sSQ to nSQ

① Display instant data and press [LABEL]. (The LABEL 1 LED goes on.)
Averaged data display is inhibited if [LABEL] is pressed.

② Enter four characters nSQ! at the beginning of the label area.

③ Press [LABEL] again. (The LABEL 1 LED goes off.)

The label input mode is exited, the nSQ mode is selected, and the label area for the instant data display is initialized as follows:

(Example)

** TR9407 DIGITAL SPECTRUM ANALYZER

(This processing is performed only when the sSQ mode is switched to the nSQ mode. It is not performed when the nSQ mode is switched to the sSQ mode.)

(8) Notes on nSQ mode

1. Before recalling a sequence, set the free run state. In the HOLD, ARM., or AUTO ARM state, the sensitivity information is not recalled.

2. Note that the auto range may be reset depending on the signal state if the auto range is recalled as a sense range.

3. To save sequence blocks D, E, and F, press the STORE key (the LED goes on) in the PANEL CONTROL section and press the AVG MODE A key before switching the power off.

   The information in sequence blocks D, E, and F is not saved in C-MOS (nonvolatile memory). If the power is switched on without performing the above operations, the current sensitivity range is set for the blocks D, E, and F.

Setting the sSQ mode

Press LABEL to ON.

⇩

** TR9407 DIGITAL SPECTRUM ANALYZER **

⇩

Enter sSQ! at the beginning.

⇩

sSQ!TR9407 DIGITAL SPECTRUM ANALYZER **

⇩

Press the LABEL key to OFF.

⇩

sSQ! <AS> 0 → 1 → 2 → 3 → : → 5 <BS> 6 → 5 → 4 → 3 → 0 → :

Setting the nSQ mode

Press the LABEL to OFF.

⇩

sSQ! <AS> 0 → 1 → 2 → 3 → : → 5 <BS> 6 → 5 → 4 → 3 → 0 → :

⇩

Enter nSQ! at the sSQ! position.

⇩

nSQ! <AS> 0 → 1 → 2 → 3 → : → 5 <BS> 6 → 5 → 4 → 3 → 0 → :

⇩

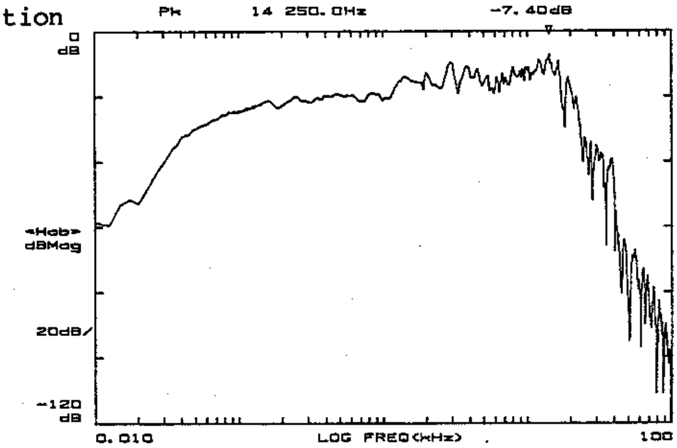
Press LABEL to OFF.

⇩

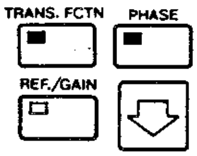
** TR9407 DIGITAL SPECTRUM ANALYZER **

3.1.7 Phase Unwrapping and Group Delay

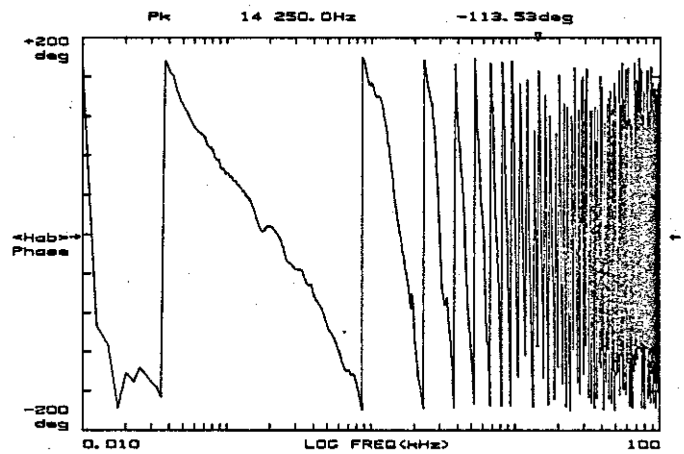
(1) Measurement of transfer function



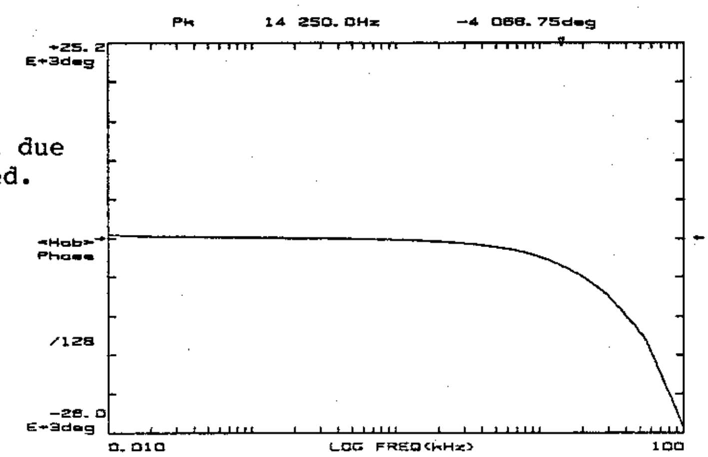
(2) Unwrapped phase display



Display the phase of the transfer function
Reduce display gain

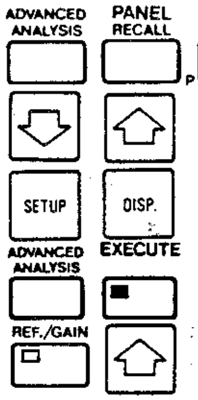


Unwrapped phase, not folded due to periodicity, is displayed.



(3) Group delay

Group delay is obtained by differentiating the phase of the transfer function Hab or the cross spectrum Gab with respect to the frequency. The group delay is uneven in the portion where the phase does not change linearly.



: Display the "G-DELAY" menu.

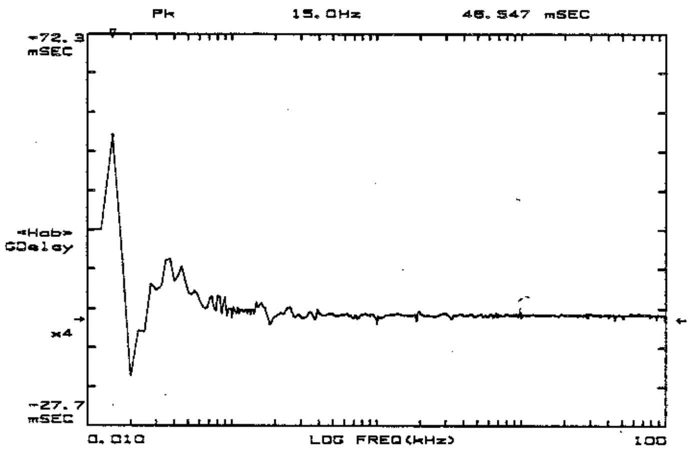
: Move the pointer (⇨) to <DISABLE>.

: Set to ENABLE .

: Group delay is computed.

: Expand the display gain appropriately.

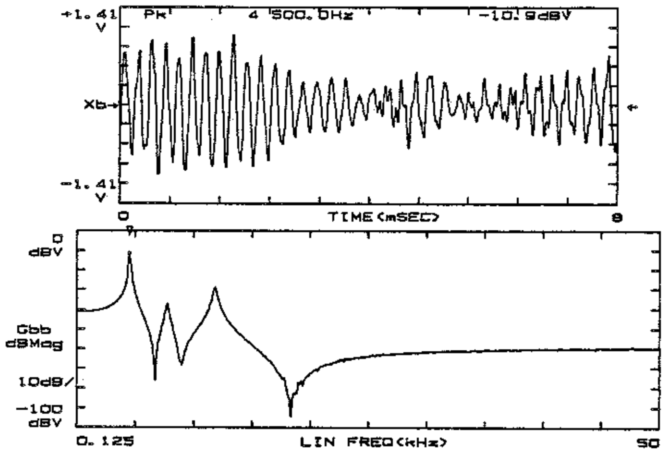
```
ADVANCED SELECT
 G-DELAY
  <ENABLE>

ADVANCED LIST
  3D DISPLAY: D
  OCTAVE    : D
  SERVO     : D
  G-DELAY   : E
  SNR       : D
  ML        : D
  SCOT      : D
  CEPSTRUM  : D
  P-ENVELOPE: D
```



3.1.8 Observation of measurement result by using the LOCAL key

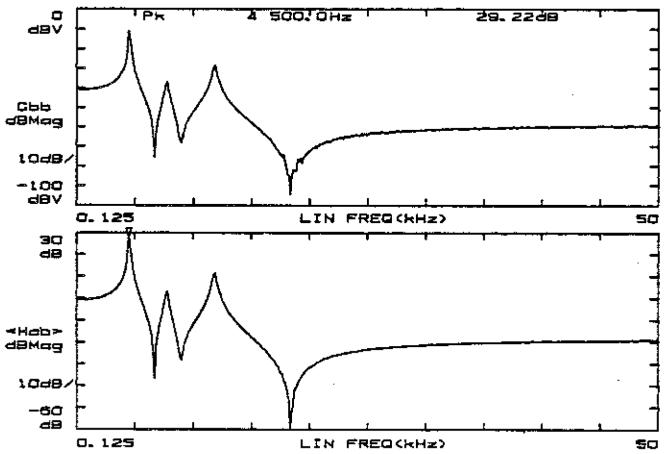
Output time waveforms and output power spectrum: 

Application: Optimization of SG amplitude (checked by Gbb)



Output power spectrum and transfer function: 

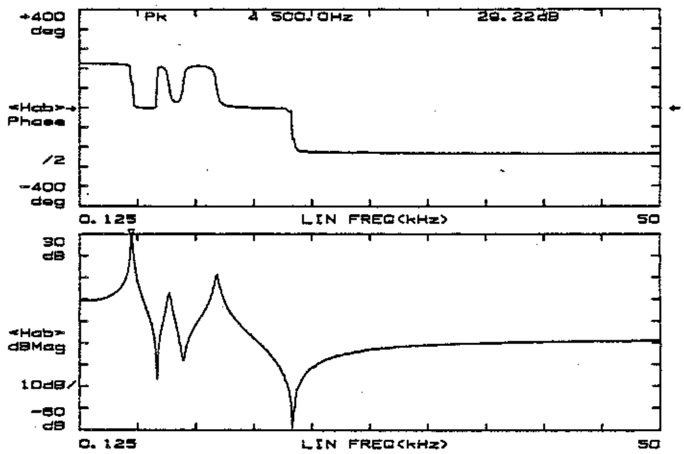
Application: The progress of sweep measurement checked by Gbb.



Bode diagram: LOCAL LOCAL 2 +GND

Application: Observation of the gain and phase of transfer function

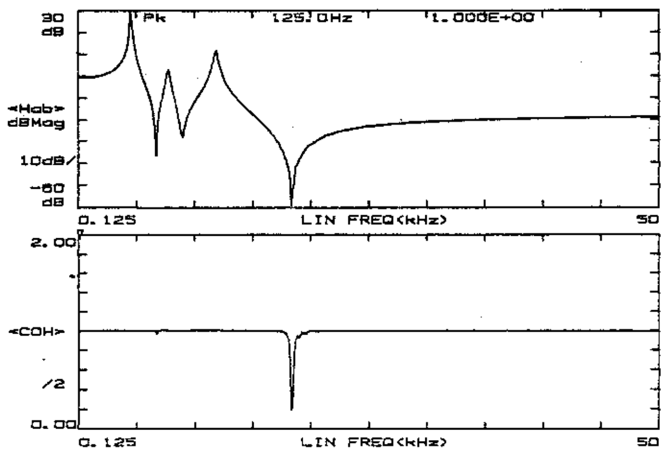
NOTE: In the logarithmic frequency analysis, only gain is observed.



Coherence function and transfer function: LOCAL LOCAL 3 AC/DC

Application: Verification of reliability of measured transfer function

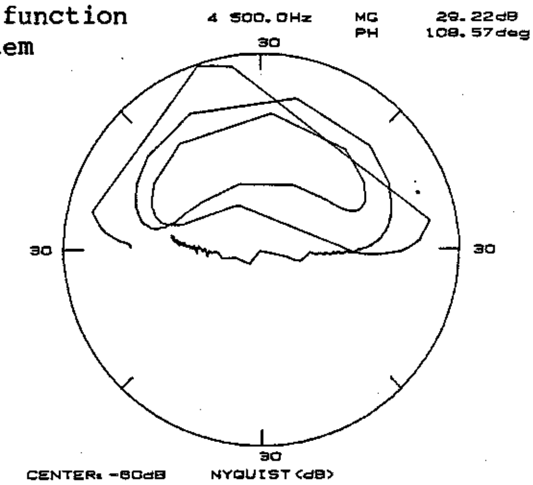
NOTE: Not used in the logarithmic frequency analysis.



Nyquist diagram of transfer function (dBMag-phase display):

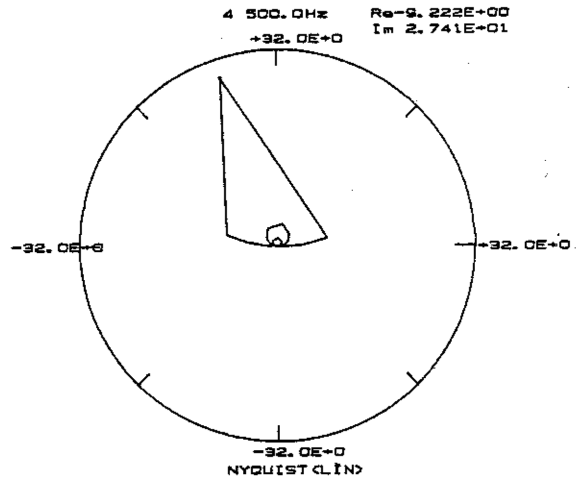
LOCAL LOCAL
[ ] [ ] 4 [ ]

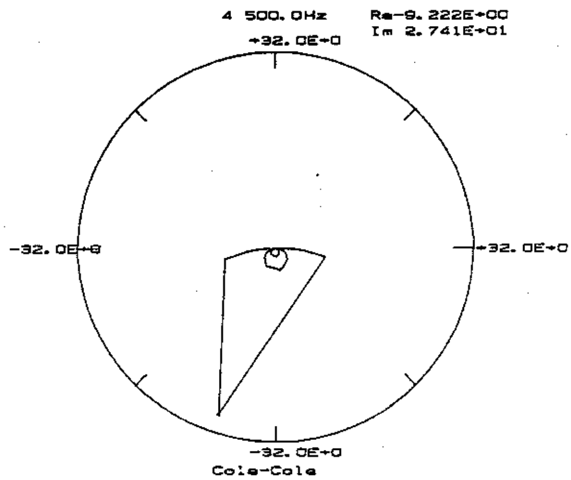
Application: Observation of transfer function in polar coordinate system



Nyquist diagram of transfer function (Real-Imaginary display):

LOCAL LOCAL HOLD/REL.
[ ] [ ] 5 [ ]



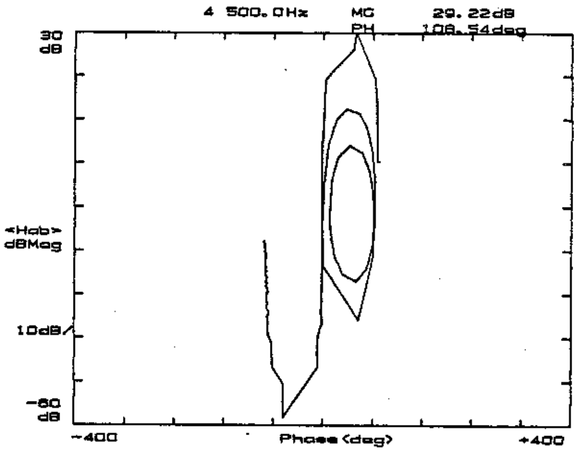


Nyquist diagram of transfer function (Real-Imaginary display)

LOCAL LOCAL ARM
[ ] [ ] 6 [ ] (Cole-Cole plot)

Nichols chart: LOCAL LOCAL, 7 +GND

Application: Stability criterion in feedback system. (Stability check of the gain whether the transfer function gain in the open loop is less than 0 dB at -180°) (when closed loop transfer function is measured from open loop)



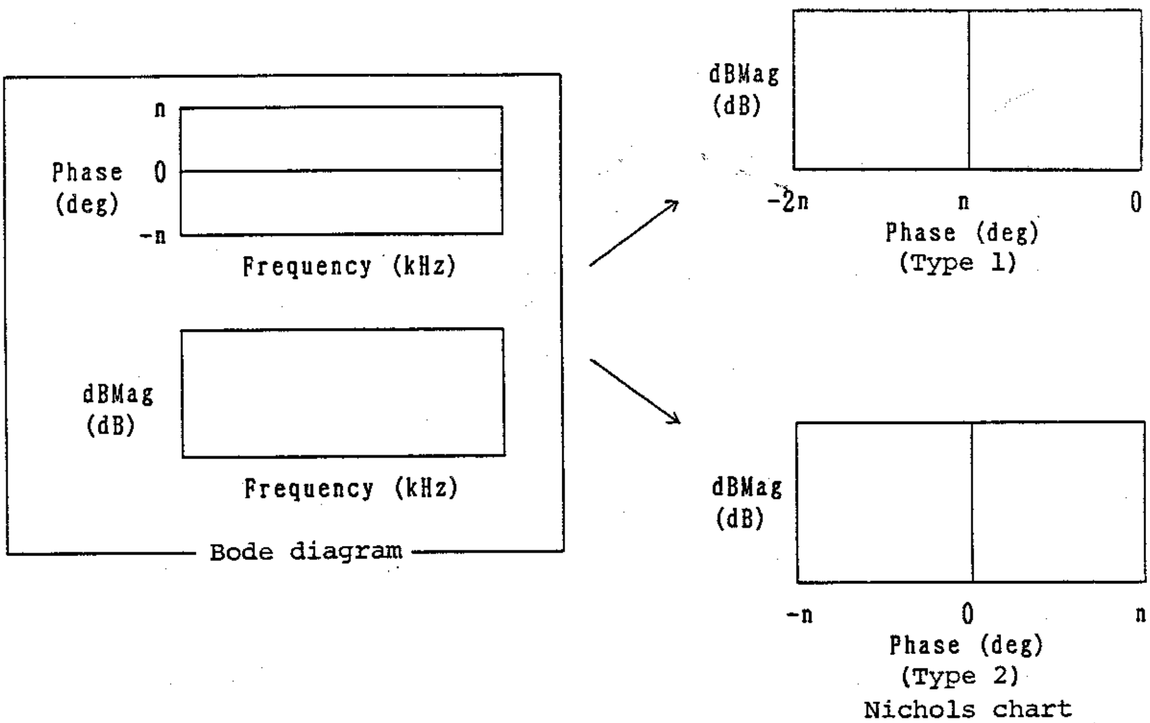
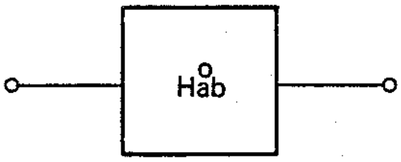


Figure 3-6 Phase Display of Nichols Chart

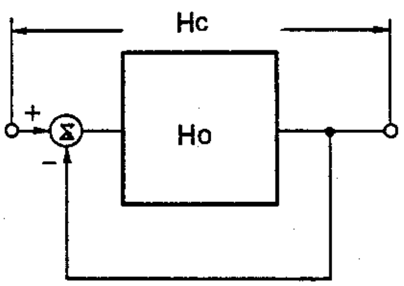
Table 3-4 Relation Between Display Range (deg) and Display Type

Display range (deg)	Gain factor of phase	Display type
-25 to +25	x 8	Type 2
-50 to +50	x 4	Type 2
-100 to +100	x 2	Type 2
-400 to 0	x 1	Type 1
-400 to +400	/ 2	Type 2
-800 to +800	/ 4	Type 2
-1600 to +1600	/ 8	Type 2

3.1.9 Feedback Control System (Transfer Function in Open Loop to Closed Loop)



Open loop system



Closed loop system

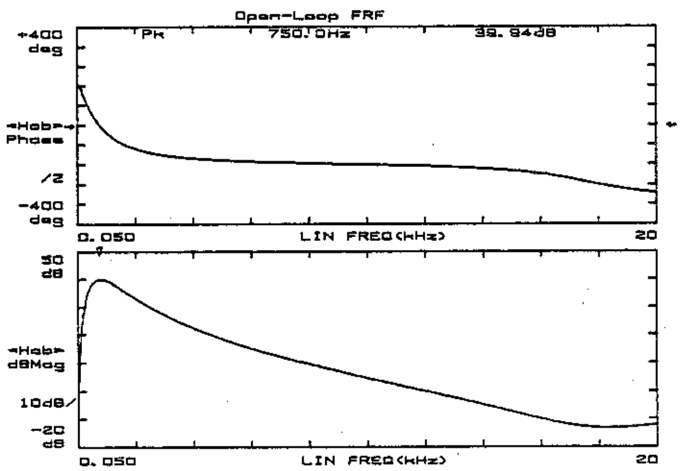
The characteristics (=Hc) of closed loop are estimated when feedback of unity gain is applied to the open loop system shown in the left figure.

Hc = Ho/(1 + Ho)
Ho = Hc/(1 - Hc)

(1) Measurement of transfer function

To measure a high-resolution transfer function, linear frequency analysis is performed by sweeping swept sine of 80 lines wide.*

: Display a Bode diagram.



* Function, Open/Closed, $(j\omega)^n$, Coherence blanking, and Equalize cannot be performed on the results of logarithmic frequency analysis.

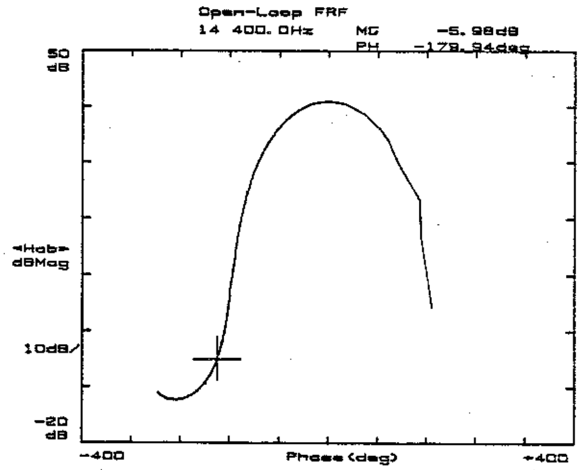
(2) Nichols chart

LOCAL LOCAL, 7 +GND : Display a Nichols chart.

C (↔) yellow ⇦ ⇨ : Display the vertical cursor. Check the gain margin near -180°.

Stability check

If open loop transfer function has gain of 0 dB or less at -180°, it is stabilized when converted to closed loop.



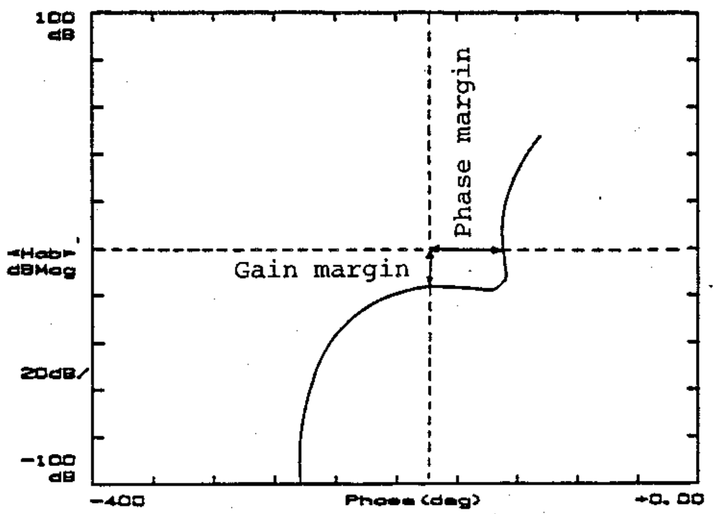
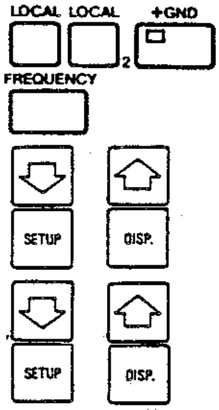


Figure 3-7 Phase Margin and Gain Margin on Nichols Chart

(3) Transfer function from open loop to closed loop



: Bode diagram

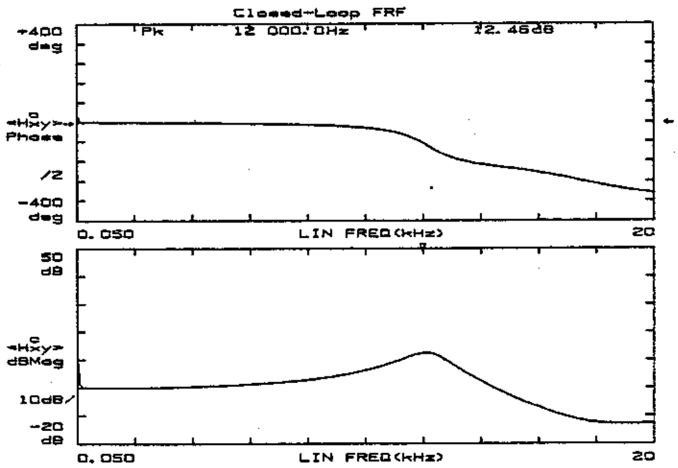
: Display the "FUNCTION" menu

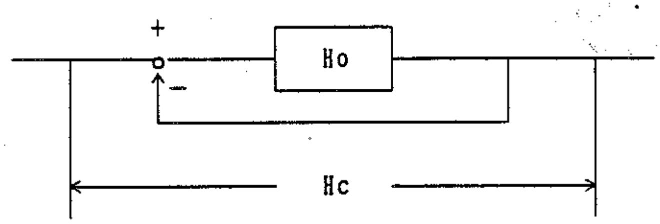
: Move the pointer (⇨) to "OPEN/CLOSED".
Select "Ho/(1 + Ho)".

: Move the pointer (⇨) to OFF.

: Set it to ON.

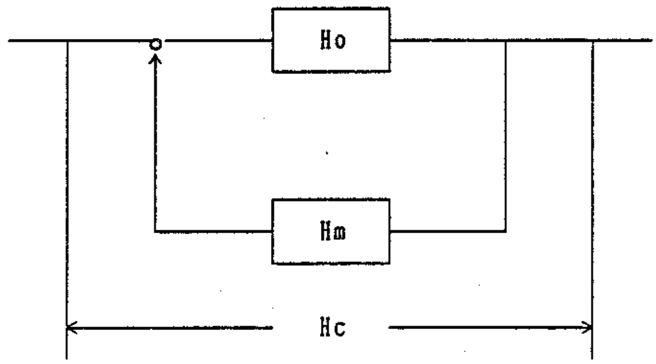
The transfer function in loop is computed and displayed.
If closed-loop transfer function Hc is obtained from the open-loop transfer function, the data is annotated with $\langle H^{C}_{xy} \rangle$ on the leftmost graticule. You can confirm with it that the complex operation has been executed.
If open-loop transfer function is derived from the closed loop, $\langle H^{O}_{xy} \rangle$ will be displayed.





Hc = Ho/ (1 + Ho) (1)
Ho = Hc/ (1 − Hc) (2)

(a) Direct-coupled feedback control system



Hc = Ho/ (1 + Ho · Hm) (3)
Ho = Hc/ (1 − Hc · Hm) (4)

(b) Feedback control system

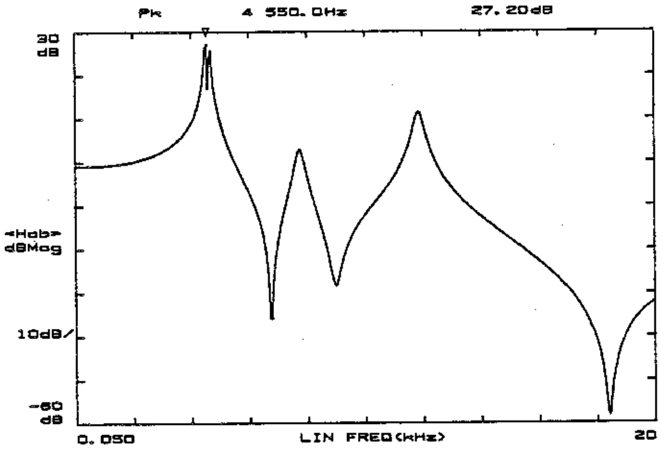
Hc: Closed-loop transfer function
Ho: Open-loop transfer function
Hm: Transfer function of feedback element

Figure 3-8 Transfer Function in Open/Closed Functions

Measurement of transfer function in the feedback control system, but not in the direct-coupled feedback control system, requires in advance the measurement of feedback element Hm and its saving into the buffer memory by pressing  in the VIEW section. Without this, complex operation will not be executed even if OPEN/CLOSED is set to "ON," with the following displays blinking:

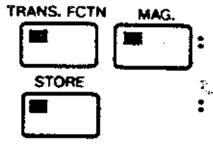
"NO TRANS FCTN IS STORED IN MEMORY"

3.1.10 Observation of Damping Factor by Pre-envelope



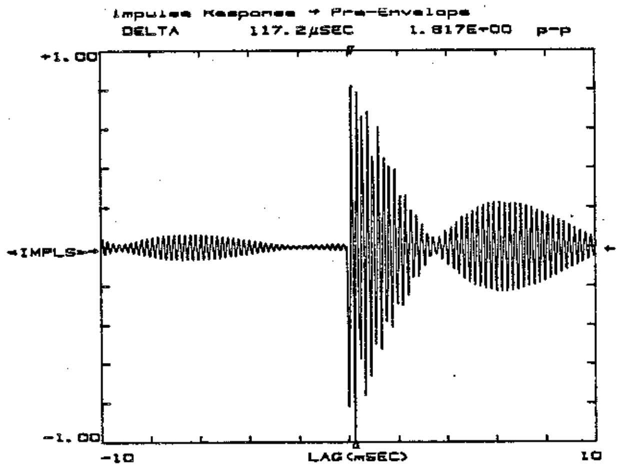
(1) Measurement of transfer function

Transfer function is measured by linear frequency analysis by sweeping sine waves or swept sine waves.



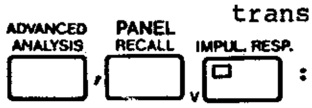
: Gain of transfer function.

: Stored in memory to set the sweep frequency range at the next measurement



(2) Damping factor of energy in the full frequency span

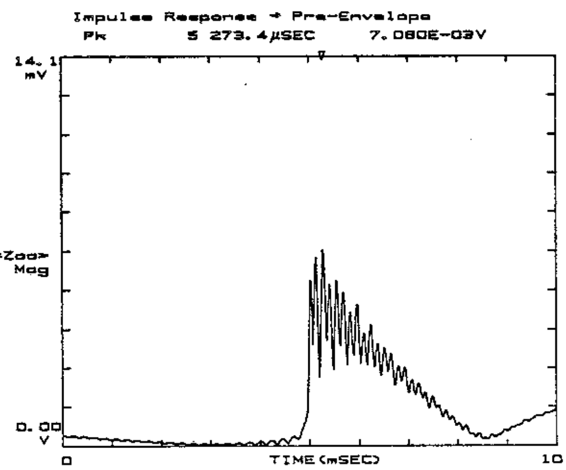
: Impulse response. Inverse Fourier transform of transfer function.

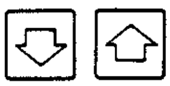


: Display the "P-ENVELOPE" menu.

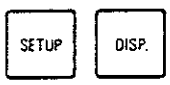
ADVANCED SELECT
→ P-ENVELOPE
<DISABLE>

ANALYSIS CHAN
CH-A
CH-B
DUAL
VIEW
DOMAIN
TIME
FREQUENCY



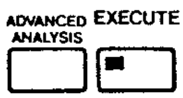


: Move the pointer (⇨) to <DISABLE>.



: Set it to <ENABLE>.

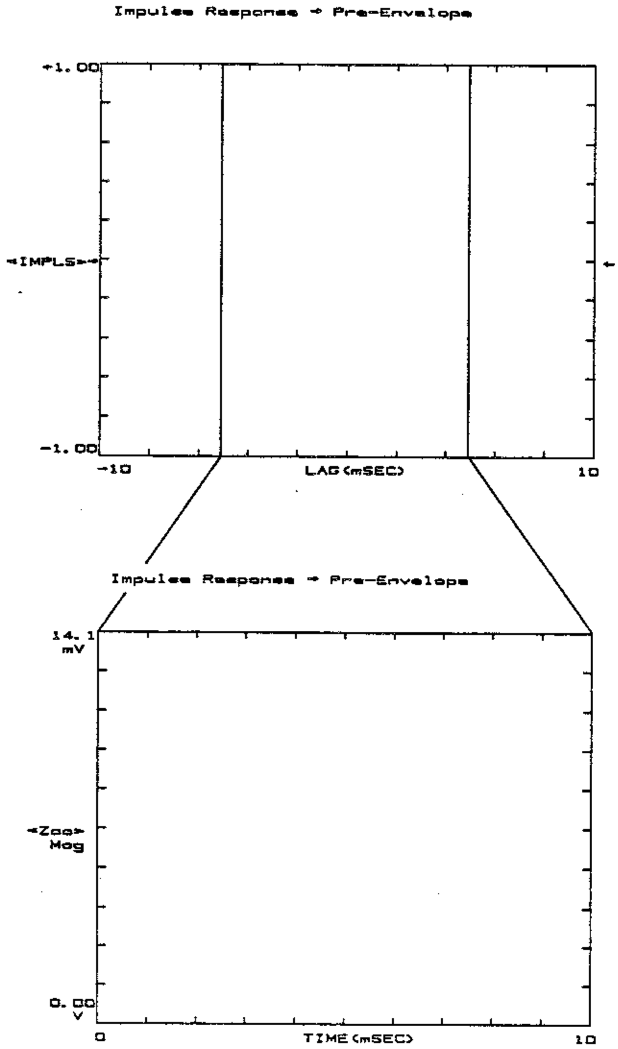
: Set "ANALYSIS CHAN" to VIEW.



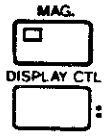
: Pre-envelope for full frequency span is displayed.

Figure 3-9 Damping Factor Over the Full Frequency Span

```
DISP CTRL
 -LOWER-
AUTO SCALE
-> ON
DISP MODE
  TIME

  Mag
  Mag²
  dBMag     L#

  NICHOLS
DISP GAIN
(dB/DIV)
  2
  5
  10        L#

DATA WINDOW
  AUTO      #
  MANUAL
STEP (D. WINDOW)
  8/1024
```



To display Mag, press the following switches.



: "DISP CTRL" menu

:

Move the pointer (⇨) to Mag of "DISP MODE".

Pre-envelope is defined as

$$Za\ (t) = Xa\ (t) + j\hat{X}a\ (t)$$

where,

Real part: Original time series. In this example, impulse response.

Imaginary part: Hilbert transform of original real time series ($Xa\ (t)$).

$$\hat{X}a\ (t) = \frac{1}{\pi} \int \frac{Xa\ (\xi)}{t - \xi}\, d\xi$$

Mag of pre-envelope, as shown below,

$$Za\ (t)^2 = Xa\ (t)^2 + \hat{X}a\ (t)^2$$

uniquely gives the energy envelope of the original time series.

Figure 3-10 How to Determine Pre-envelope

(3) Damping factor for each resonance frequency

① Measurement of transfer function

RECALL: Display on CRT the transfer function stored in memory.

C (↔) SET REF. ON/OFF SET REF. SET X: Set a sweep range using the cursors (See page 3-58).

Display the SINE or SWEPT SINE menu. Move the pointer to the "Fmin" item in the menu and place the vertical cursor to the desired position to set Fmin.
Press SET REF key to make it the reference cursor.
Move the other cursor to the Fmax position and press SET X key to define the sweep range between the Fmin and Fmax.

② Damping factor of each resonance frequency

Almost the same result is obtained in Figure 3-11 (a) as is the case of the full frequency span measurement (Figure 3-9). No great difference is seen for the impulse response between (b) and (c) in Figure 3-11 while the difference in energy damping is clarified by the pre-envelope.

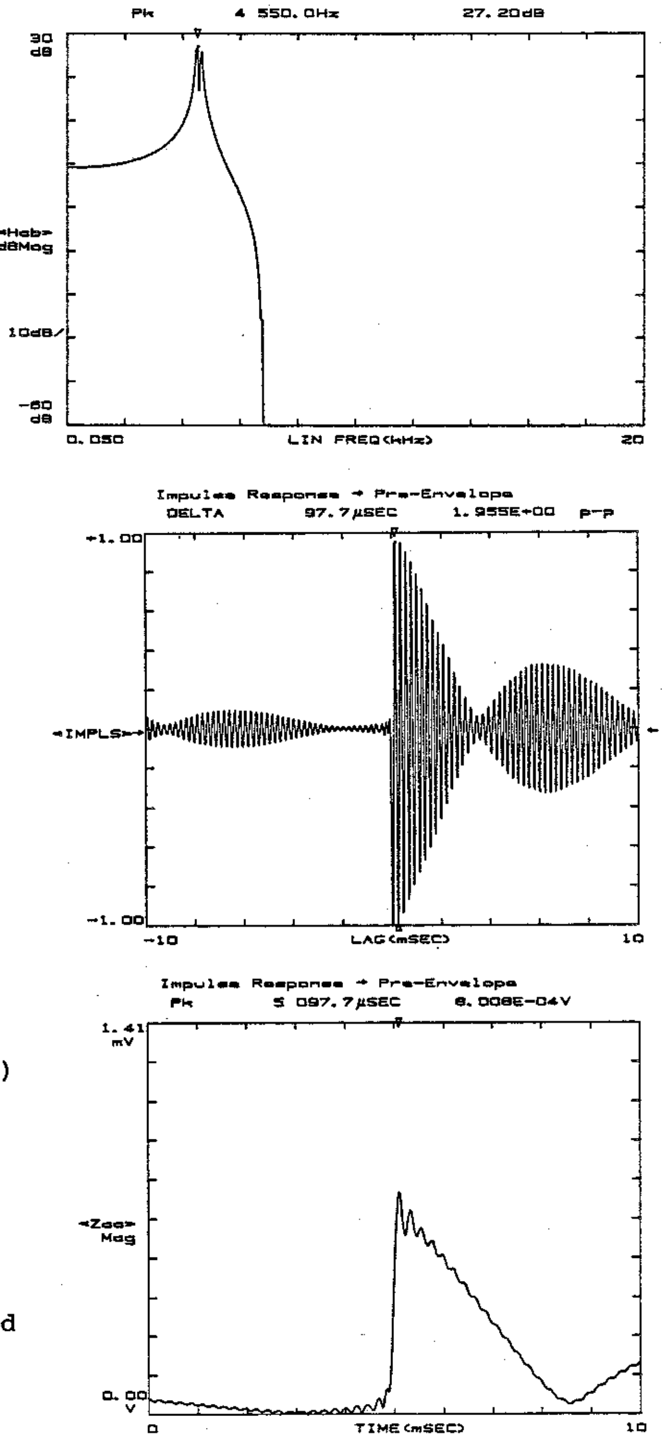


Figure 3-11 (a) Damping Factor at Resonance Frequency

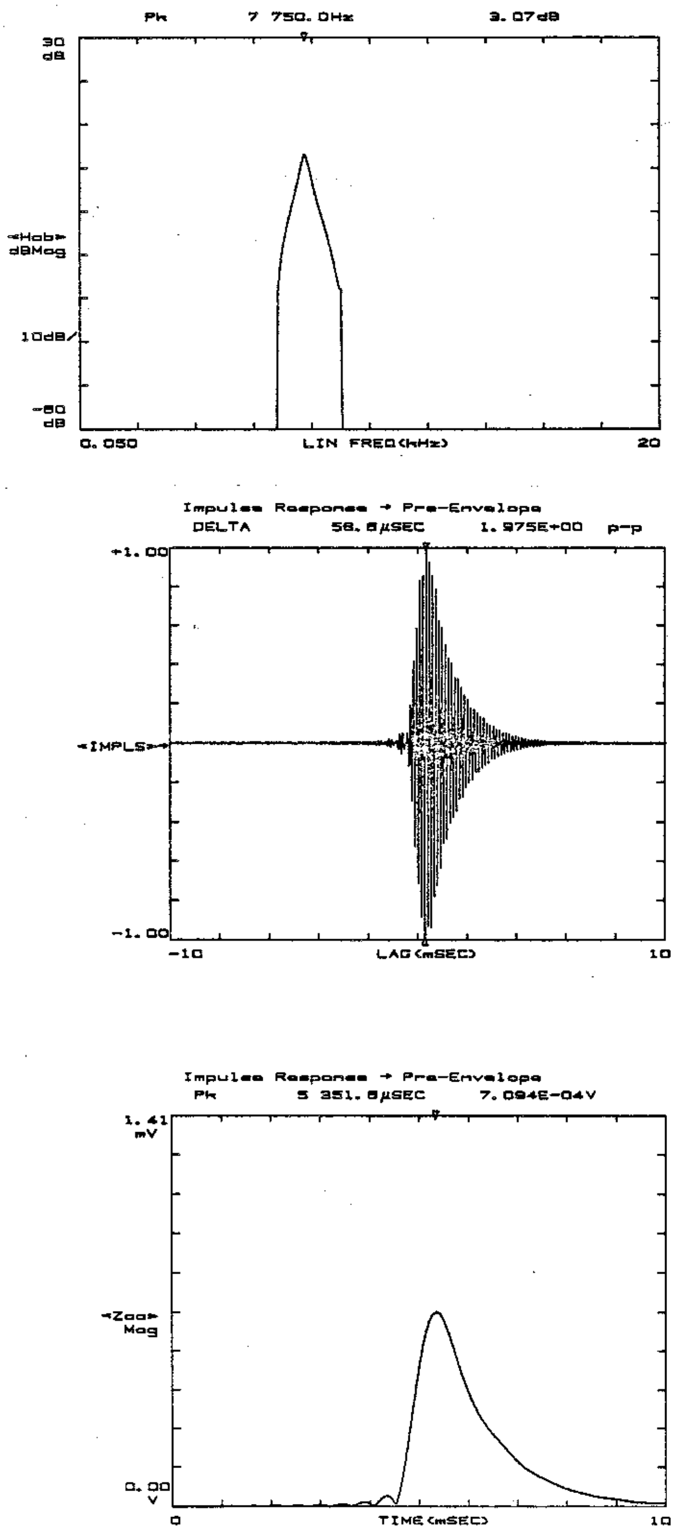


Figure 3-11 (b)

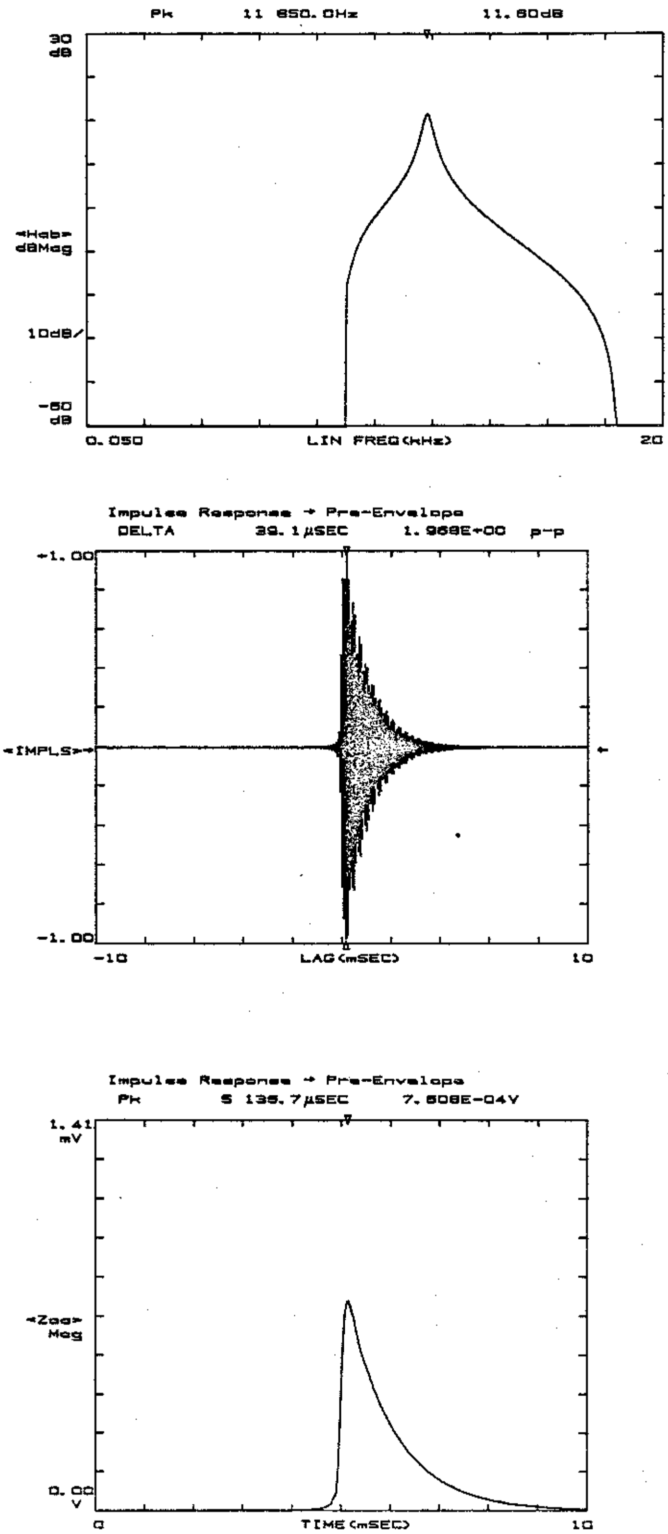


Figure 3-11 (c)

3.1.11 Amplitude Control

The AMPLITUDE CTRL function controls the amplitude of the sine wave (or swept sine wave for sweeping) from the TR98201 signal generator. By controlling the amplitude, the power spectrum being observed through a specified channel is made constant and flat.

By making the input amplitude constant, a transfer function of DUT, which is sensitive to the measuring conditions, can be observed with a good reproducibility. Also a transfer function at a specific amplitude of nonlinear DUT, which depends on the amplitude of the input signal, can be measured.

(1) Comparison of Characteristics Between Microphones

A differential gain and a differential phase between the standard microphone and a microphone to be tested are obtained. In this measurement, measure a transfer function while making the power spectrum to be observed with the standard microphone flat with AMPLITUDE CTRL.

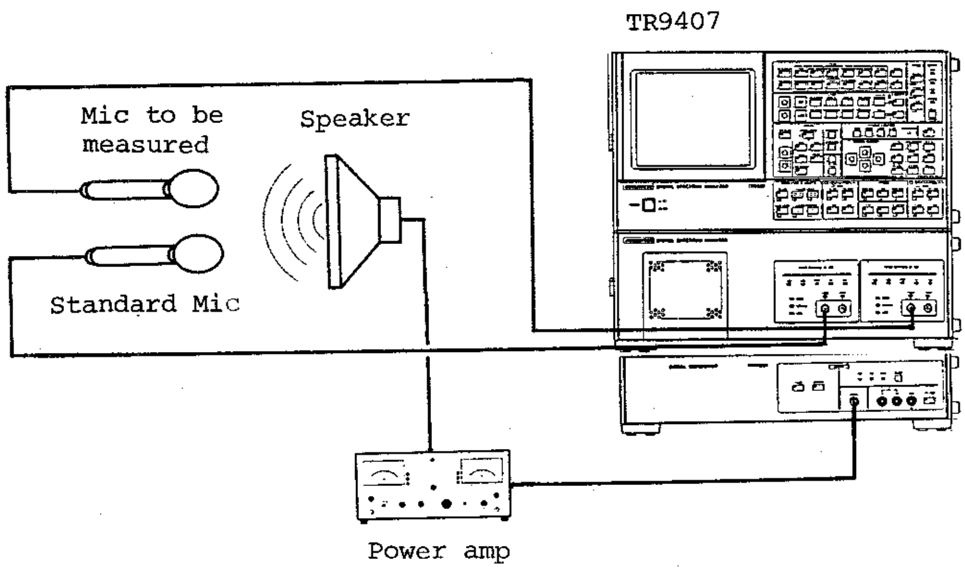
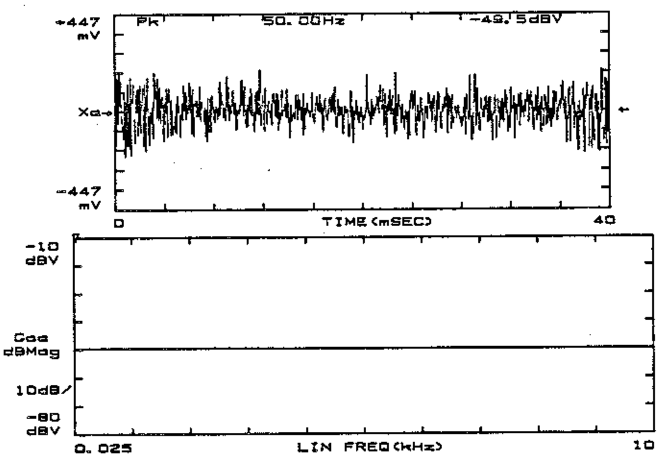


Figure 3-12 Setup for Comparison of Characteristics Between Microphones

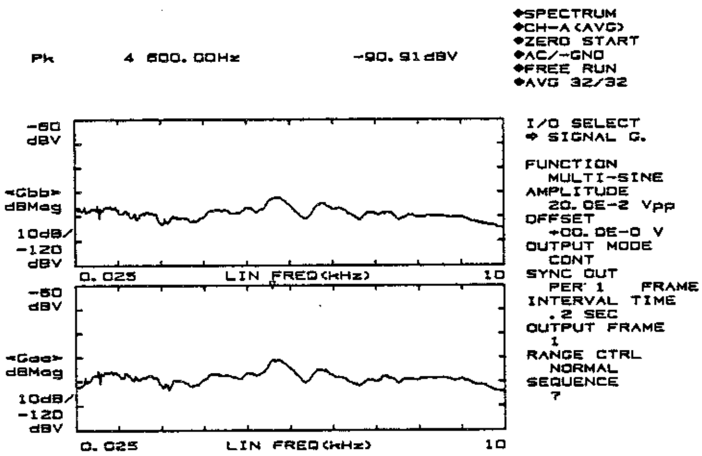
(1) Input sensitivity range

(i) Generate a multi-sine wave from the signal generator.

(ii) Determine the measuring sensitivity range by averaging.



The power spectrum of the multi-sine wave itself is almost flat.

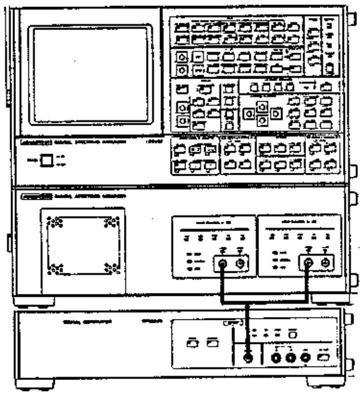


The output power spectrum from the microphones are ragged, varying by about 13 dB.

Take measurements with a sensitivity range of -60 dBV for both channels.

② Measuring the transfer function of the analyzer

To prevent the analog system of the analyzer itself from influencing the measurements, measure the transfer function of the analyzer for the later execution of EQUALIZATION.



(i) Make the connection shown on the right.

(ii) Measure the transfer function of the FFT analyzer.

(iii) [TRANS. FCTN] : Display a measured transfer function.

(iv) [STORE] (MEMORY)

: Store the measured transfer function in MEMORY.

(v) Return the connection to the original state.

③ AMPLITUDE CONTROL

(i) [ADVANCED ANALYSIS], [PANEL RECALL]₀[COHERENCE] : Display the "SERVO" menu.

(ii) [⇩] [⇧], [SETUP] [DISP.] : Set "SENS CTRL" to "MANUAL" to perform "EQUALIZE".

(iii) [⇩] [⇧], [SETUP] [DISP.] : Set "SG OPERATION" to "ON-AVG". (The signal is made to generate only during averaging to ensure quiet operation.)

```
ADVANCED SELECT
  SERVO
  <ENABLE>

ANALYSIS LINE
  NORMAL
SENS CTRL
  CH-A: MANUAL
  CH-B: MANUAL
WEIGHTING CTRL
  AUTO
SG OPERATION
  ON-AVG
NON-STOP AVG
  STOP
AVG NUMBER
  4
AVG PROCESS
  SWEEP
AMPLITUDE CTRL
→ CH-A: CONST
CTRL LEVEL(F)
  -82.0±2.0 dBV
OVER LEVEL(Vpp)
  CH-A:+02.0E-3
  CH-B:+02.0E-3
OVER & SERVICE
  SKIP
```

(iv) [⇩] [⇧], [SETUP] [DISP.] : Set "AMPLITUDE CTRL" to "CH-A:CONST".

(v) [⇩] [⇧] : Use the keys with green numerals.

Enter the following data in the frequency domain for "CTRL LEVEL(F)".

First 3 digits for Control amplitude value;

2 digits after ± for Error allowance

(vi) [⇩] [⇧] [SETUP] [DISP.] : Set "OVER & SERVICE" to "SKIP".

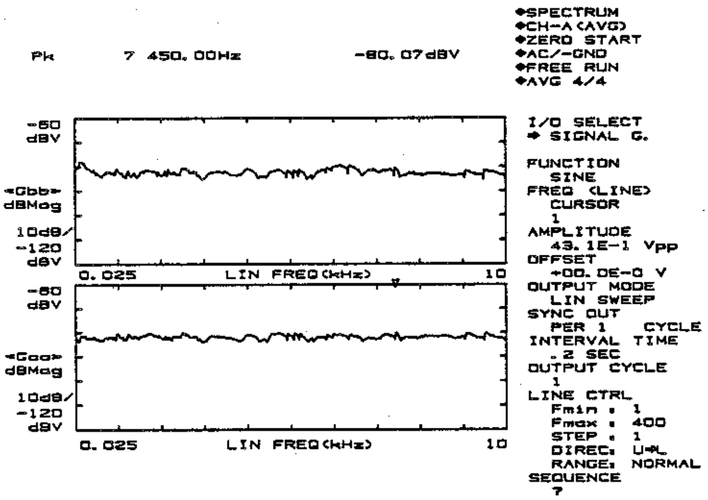
Measurement of those frequencies whose amplitude cannot be controlled is skipped.

(vii) [⇩] [⇧], [SETUP] [DISP.] : Set SERVO to <ENABLE>.

(viii) [I/O] [RECALL], [C. O. P.] : Display the "SINE" menu.

Set Fmin, Fmax, and STEP.

(ix) [ADVANCED ANALYSIS] [EXECUTE], [START] : Measurement starts.



Power spectrum of input channel is almost flat.

[DISPLAY CTL] : Display the "DISP CTRL" menu.

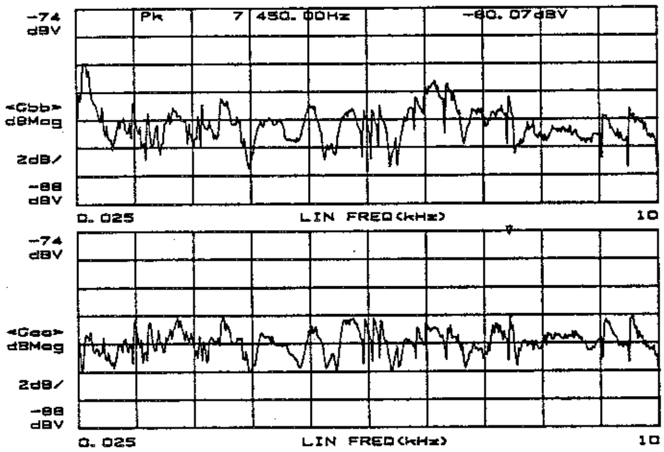
DISP CTRL
UPPER
AUTO SCALE
ON
DISP MODE
TIME
Mag
Mag²
dBMag U*
NICHOLS
DISP GAIN
<dB/DIV>
→ 2 U*
5
10
DATA WINDOW
AUTO *
MANUAL
STEP<D. WINDOW>
8/1024

[UPPER/LOWER] : Change the display gain for the lower screen

[⇧] [⇩] [SETUP] : 2 dB/div

[UPPER/LOWER] : Change the display gain for the upper screen

[SETUP] : 2 dB/div



GRATICULE

: Display the graticules to use the scale for verification.

Flat, within ± 2 dB

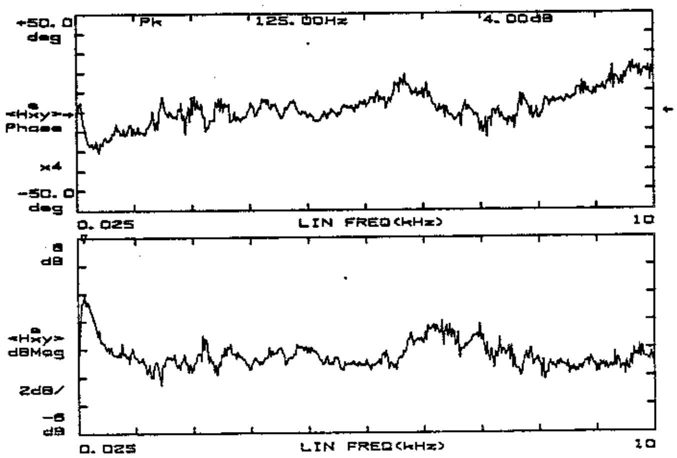
④ Equalize

(i) LOCAL LOCAL 2 +GND : Bode diagram of transfer function

(ii) FUNCTION : Display the "FUNCTION" menu.

(iii) ⇩ ⇧ SETUP : Set "EQUALIZE" to "ON".
<He xy> is displayed at the left of graticule.
The influence of the transfer function of the measuring system, which is stored in the memory, is removed from a measured transfer function.

FUNCTION
OFF
<U+L>
OPEN/CLOSED
OFF
Ha/(1+Ha)
∫Xxdt
OFF/CH-A
OFF/CH-B
dXx/dt
OFF/CH-A
OFF/CH-B
<VIEW> (jw)ⁿ
OFF
EQUALIZE
→ ON
COH BLANK
OFF
OVERALL
OFF
TREND REMOVAL
OFF/CH-A
OFF/CH-B
SMOOTHING
OFF



Difference in gain and phase between the microphones is now obtained.

3.1.12 Use of Memory Function of the Signal Generator

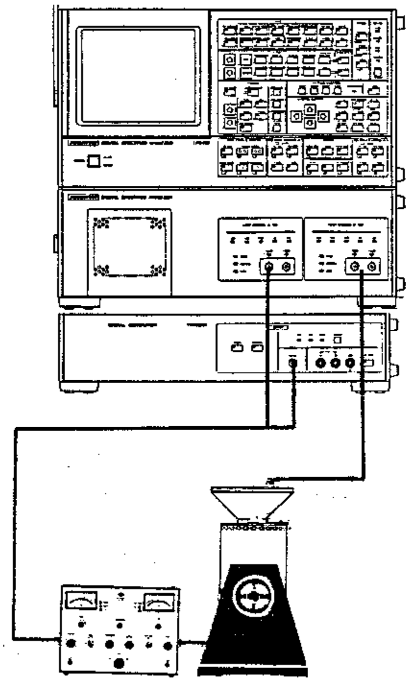
As an example of using the memory of the signal generator (TR98201), this section describes equalizing the frequency response of an exciter. For the generation of signals computed in the computer, see GPIB programming example in Section 7.

(1) Equalization of an Exciter

① Measurement of transfer function

The frequency response of transfer function of an exciter is not flat.

Apply the input reverse in response to keep the transfer function of the exciter flat.



Channel A: Input to the exciter

Channel B: Excitation power

Figure 3-13 Measurement of the Transfer Function of the Exciter

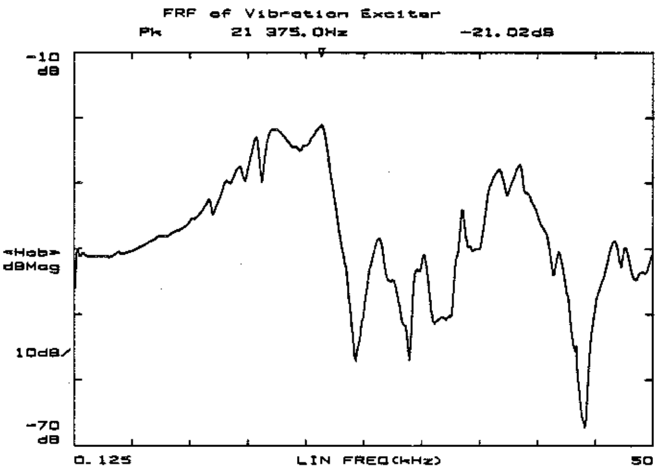


Figure 3-14 Transfer Function of Vibration Exciter

② Equalization

(i) Output multi-sine wave via the signal generator.

(ii) [BOTH]: Dual display

(iii) [DISPLAY UPPER/LOWER], [CH. A/CH. B] [AVG MODE] [SPECTRUM], [REAL]:

Upper screen: Real part of input spectrum

(iv) [UPPER/LOWER], [TRANS. FCTN], [MAG.]:

Lower screen: Gain of transfer function

(v) [FUNCTION]: "FUNCTION" menu is displayed.

(vi) [⇩] [⇧], [SETUP] [DISP.]:

Move the pointer (⇨) to "FUNCTION". Select <U/L>.
Sx is displayed to the left of y-axis as a result of operation of (complex spectrum Sa)/(Transfer function <Hab>).

(vii) [⇧] [⇩], [SETUP] [DISP.]:

Change "FUNCTION" from "OFF" to "ON".

FUNCTION
◆ ON
◄U/L►
OPEN/CLOSED
OFF
Ha/(1+Ha)
◆∫Xxdt◆
OFF/CH-A
OFF/CH-B
◆dXx/dt◆
OFF/CH-A
OFF/CH-B
◆<VIEW> (jw)ⁿ ◆
OFF
EQUALIZE
OFF
COH BLANK
OFF
OVERALL
OFF
TREND REMOVAL
OFF/CH-A
OFF/CH-B
SMOOTHING
OFF

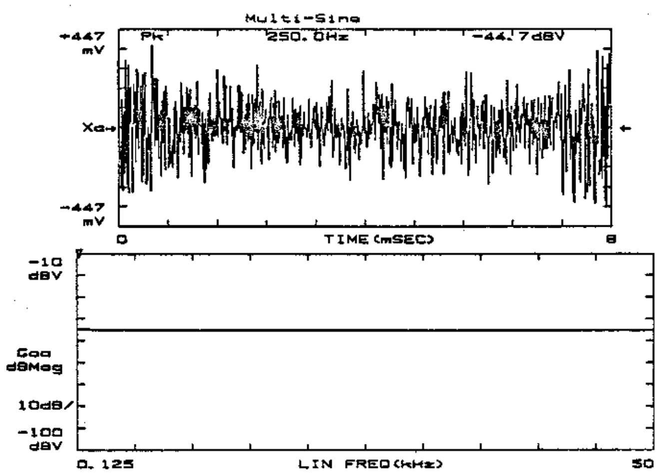
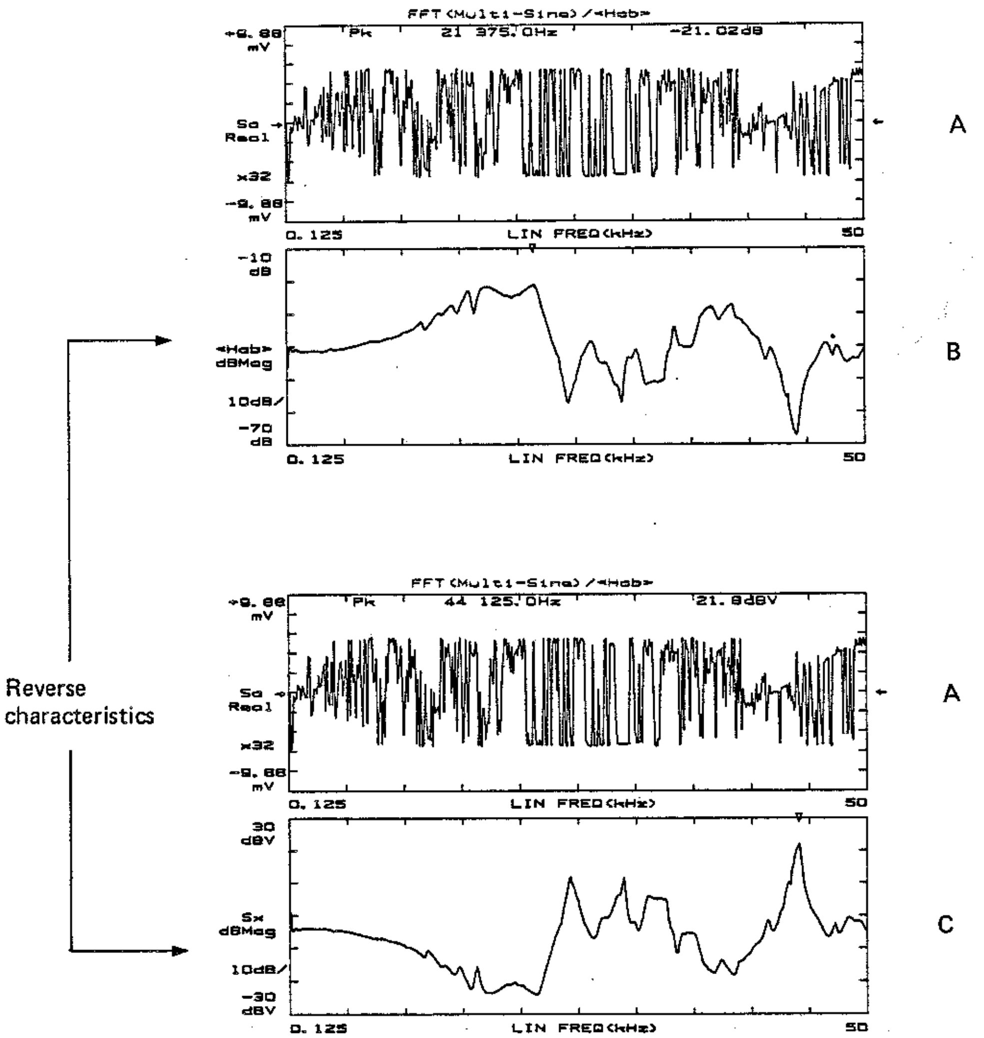


Figure 3-15 Multi-Sine Time Waveform and Spectrum



C = A/B

Figure 3-16 Computed Result of (COMPLEX SPECT)/(TRANS.FCTN)

(viii) STORE Store the data in memory

③ Inverse Fourier transform

To recall the data from memory and transfer it to memory in the signal generator, it must be converted to time domain data for display.

(i) [RECALL] (MEMORY): Display the data stored in memory.

(ii) [DISPLAY CTL] : Display the "DISP CTRL" menu.

(iii) [⇩] [⇧], [SETUP] [DISP.] : Set "DISP MODE" to TIME.

DISP CTRL
LOWER
AUTO SCALE
ON
DISP MODE
➡ TIME L
Mag
Mag²
dBMag #
NICHOLS
DISP GAIN
(dB/DIV)
2
5
10 L#
DATA WINDOW
AUTO #
MANUAL
STEP (D. WINDOW)
1024/1024

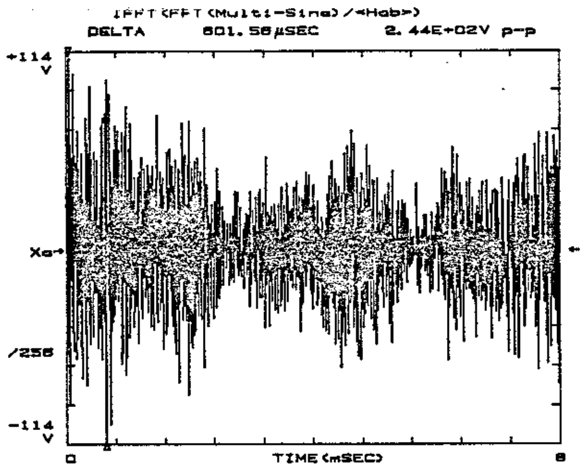


Figure 3-17 IFFT of the Frequency Domain Data Recalled from Memory

NOTE

If complex spectra Sa and Sb are to be stored in memory, and then recalled from memory for an inverse Fourier transform, the data stored in memory must be real part, imaginary part, or phase data. If magnitude (Mag) data from a magnitude (Mag) display (in the lower display if in dual display mode) is stored in memory, inverse Fourier transforms cannot be performed on the corresponding frequency data recalled from the memory. In <Hab>, Gab, or <Gab>, the data stored in memory may be real part, imaginary part, phase, or magnitude data. If an inverse Fourier transform is to be executed on frequency domain data <Sa> or <Sb>, it is necessary to first set the averaging mode to "COMPLEX SPECT" and execute averaging.

I/O SELECT
SIGNAL G.
FUNCTION
→MEMORY
AMPLITUDE
03.5E-1 Vpp
OFFSET
+00.0E-0 V
OUTPUT MODE
CONT
SYNC OUT
PER 1 FRAME
INTERVAL TIME
.0 SEC
OUTPUT FRAME
1
READ/WRITE
→WRITE
FILTER
OFF
RANGE CTRL
NORMAL
SEQUENCE
?

④ Transfer to memory in the signal generator

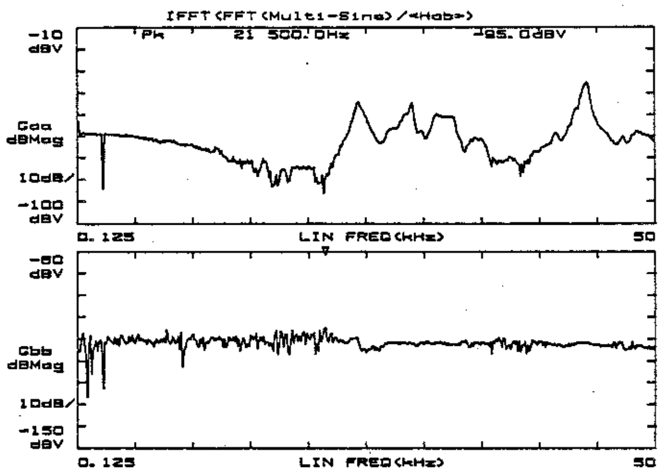
(i) [I/O], [PANEL RECALL] w[TRANS. FCTN] : "MEMORY" menu is displayed.

(ii) [⇩] [⇧], [SETUP] [DISP.] : Set "READ/WRITE" to WRITE.

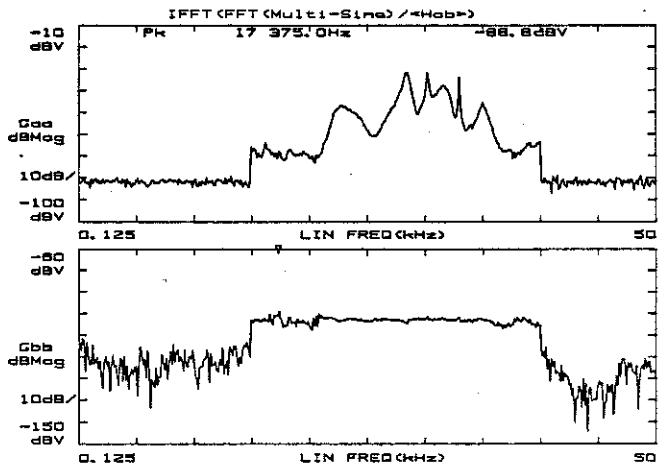
(iii) I/O [EXECUTE] : Transfer

⑤ Generation of signal

[OPERATE] : Start to generate signals transferred to the memory.
Gbb: Exciter output is almost flat.



Using transfer function sweeping only in the narrow band increases the degree of flatness.



⑥ Application of excitation to DUT

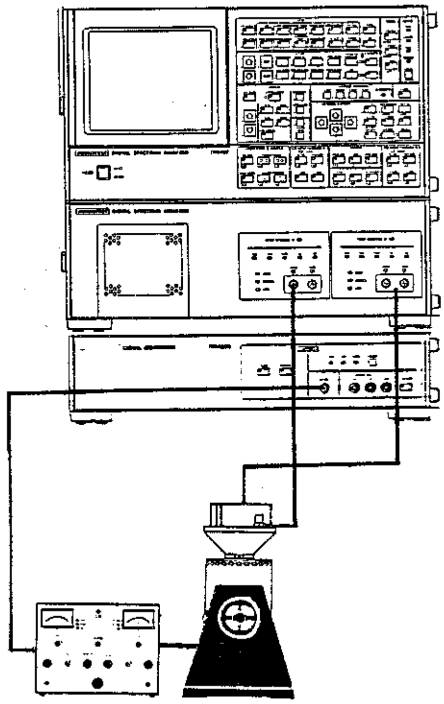


Figure 3-18 Application of Excitation to DUT

3.2 TRANSFER FUNCTION MEASUREMENT BY IMPULSE METHOD

START

↓

Preparation for measurement
(Setup of equipment: See below)

↓

Set frequency range

↓

Set input sensitivity

↓

Set trigger conditions

↓

See averaging conditions

↓

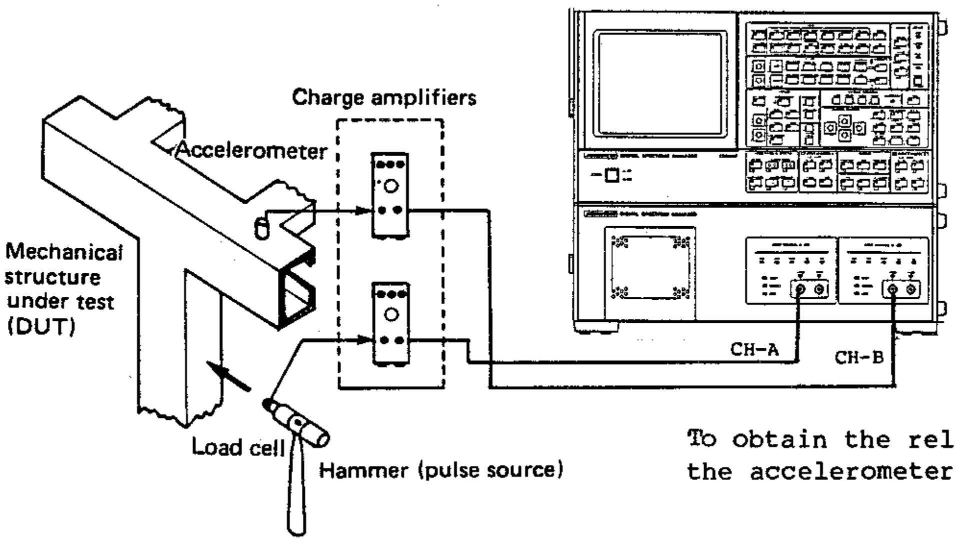
Start averaging with AUTO ARM

↓

Execute averaging by applying impulses with hammer

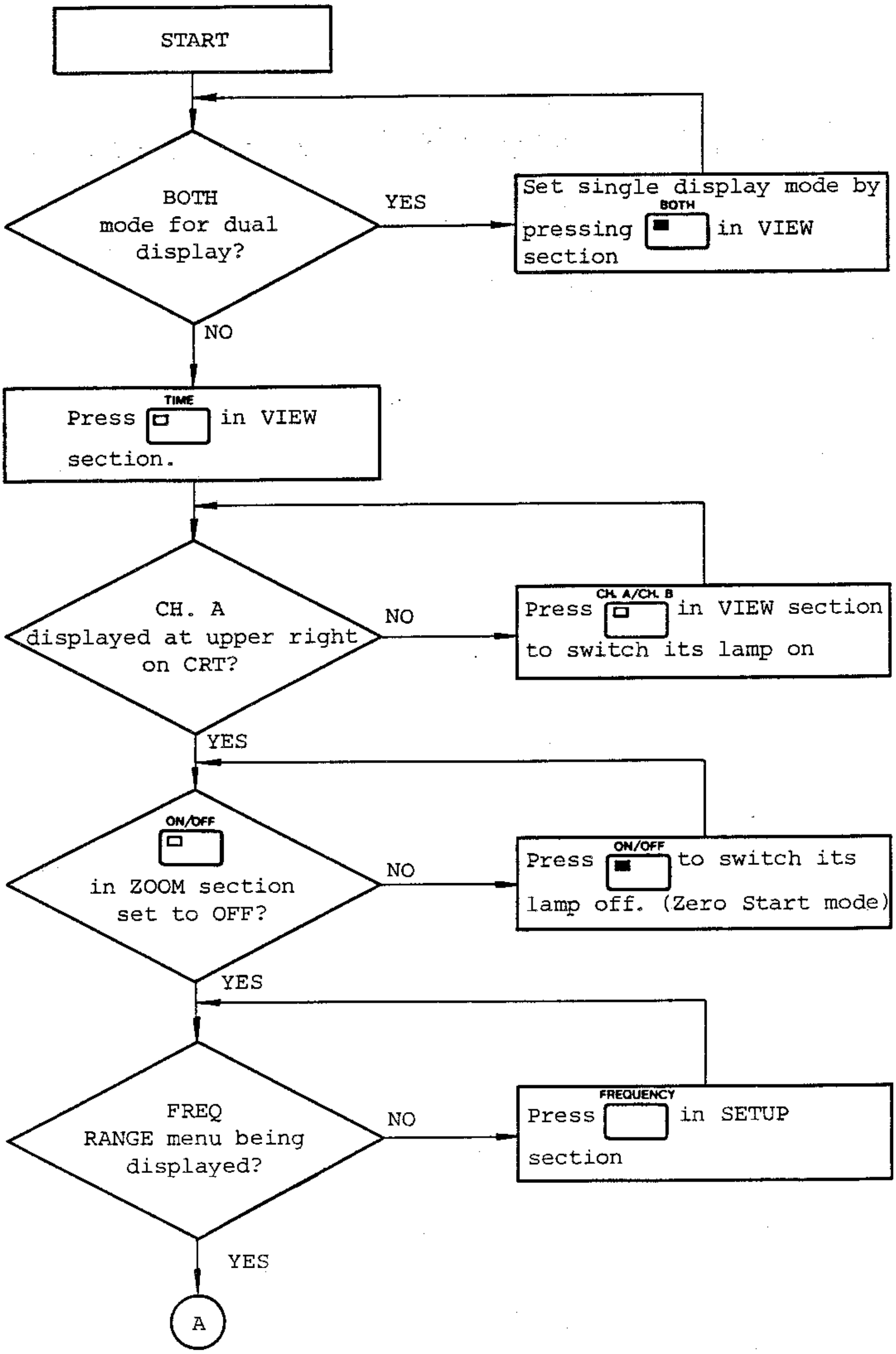
↓

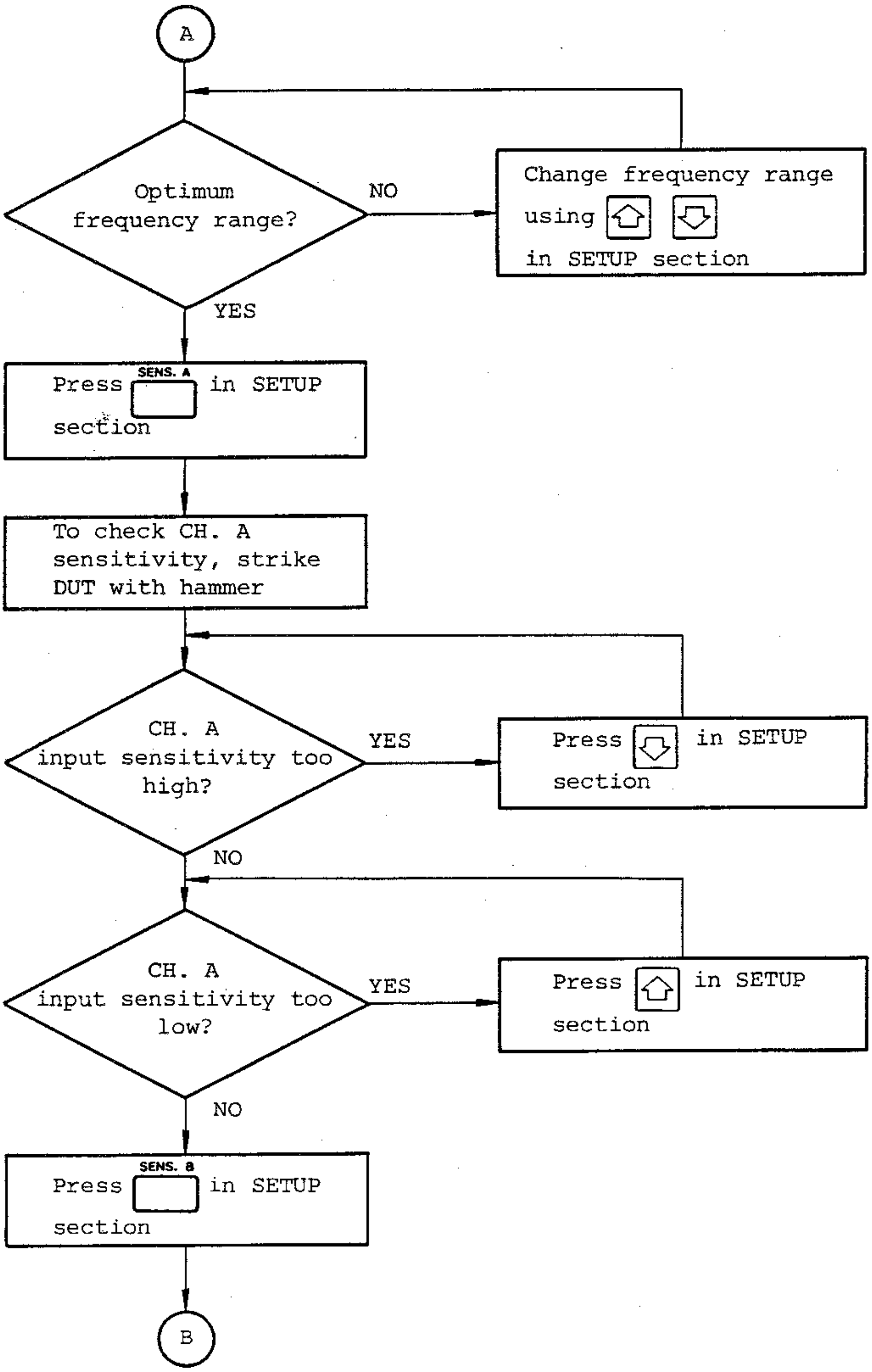
END

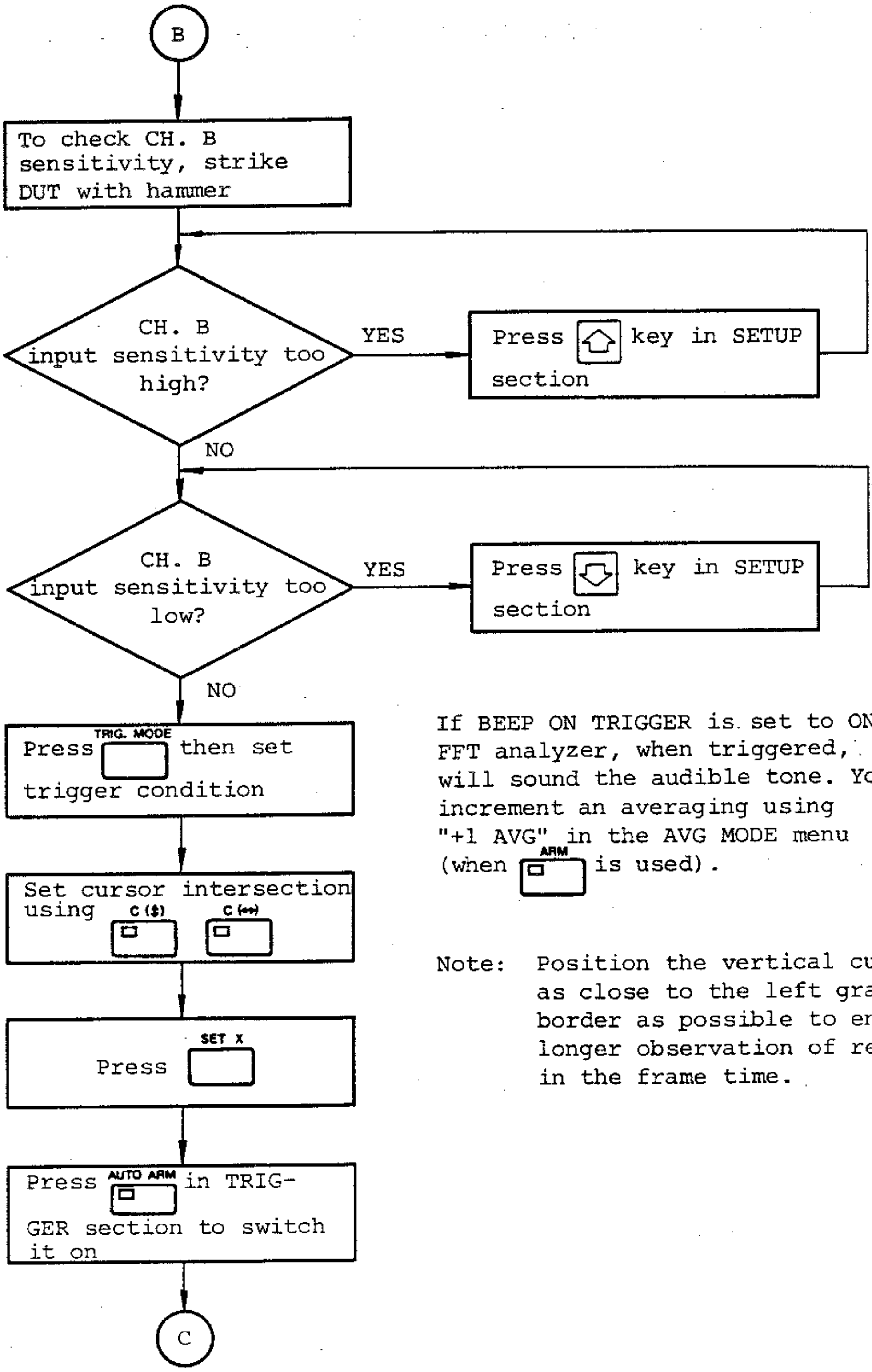


To obtain the reliable data, fix the accelerometer accurately.

Figure 3-19 Transfer Function Measurement by Hammering

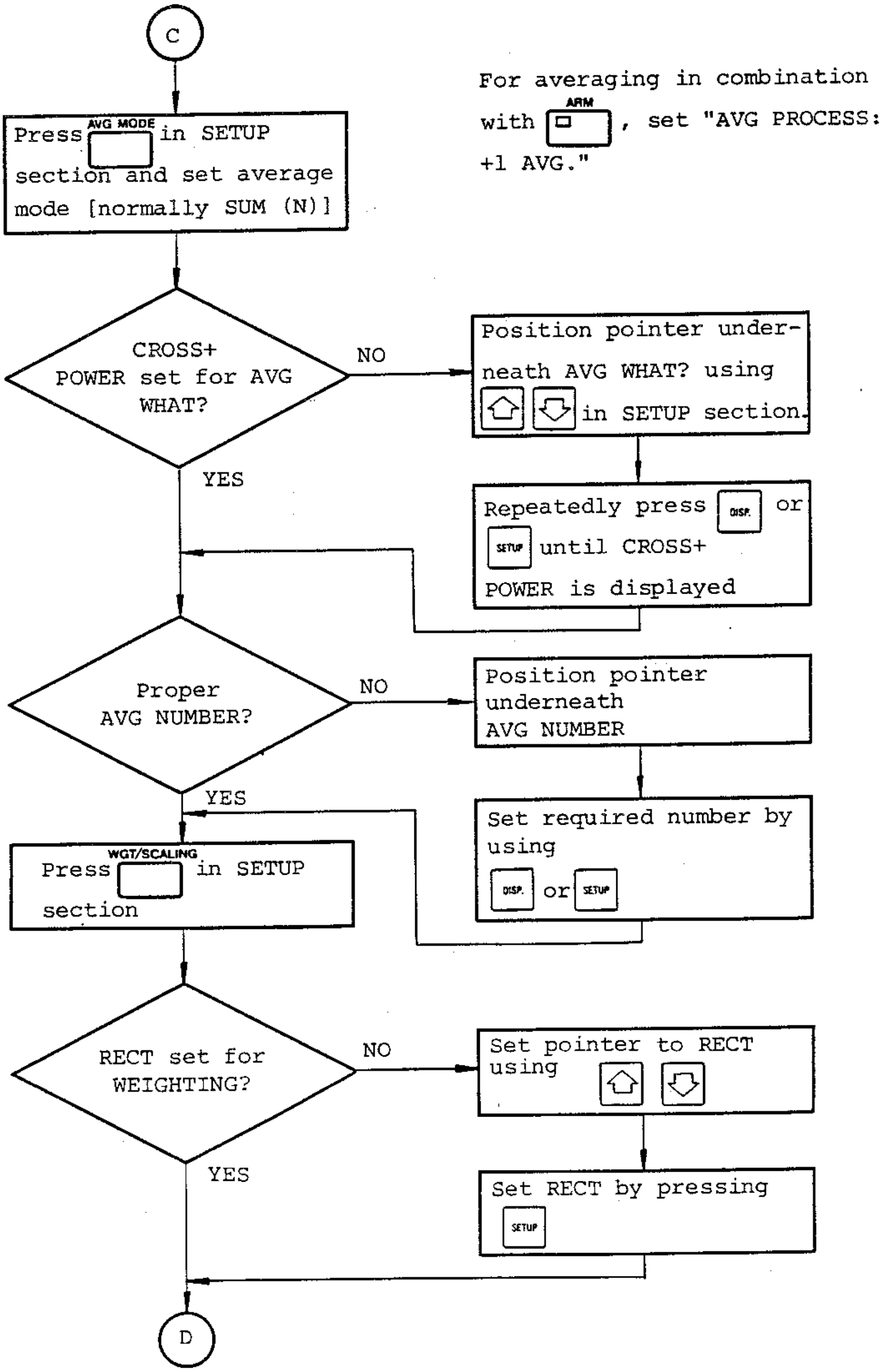

START
BOTH mode for dual display?
YES
Set single display mode by pressing BOTH in VIEW section
NO
Press TIME in VIEW section.
CH. A displayed at upper right on CRT?
NO
Press CH. A/CH. B in VIEW section to switch its lamp on
YES
ON/OFF in ZOOM section set to OFF?
NO
Press ON/OFF to switch its lamp off. (Zero Start mode)
YES
FREQ RANGE menu being displayed?
NO
Press FREQUENCY in SETUP section
YES
A


A
Optimum frequency range?
NO
Change frequency range using in SETUP section
YES
SENS. A
Press in SETUP section
To check CH. A sensitivity, strike DUT with hammer
CH. A input sensitivity too high?
YES
Press in SETUP section
NO
CH. A input sensitivity too low?
YES
Press in SETUP section
NO
SENS. B
Press in SETUP section
B



If BEEP ON TRIGGER is set to ON, FFT analyzer, when triggered, will sound the audible tone. You can increment an averaging using "+1 AVG" in the AVG MODE menu (when ARM is used).

Note: Position the vertical cursor as close to the left graticule border as possible to enable longer observation of response in the frame time.


C
Press AVG MODE in SETUP section and set average mode [normally SUM (N)]
For averaging in combination with ARM, set "AVG PROCESS: +1 AVG."
CROSS+ POWER set for AVG WHAT?
NO
Position pointer underneath AVG WHAT? using in SETUP section.
Repeatedly press DISP. or SETUP until CROSS+ POWER is displayed
YES
Proper AVG NUMBER?
NO
Position pointer underneath AVG NUMBER
Set required number by using DISP. or SETUP
YES
Press WGT/SCALING in SETUP section
RECT set for WEIGHTING?
NO
Set pointer to RECT using
Set RECT by pressing SETUP
YES
D

D

Start averaging by pressing ERASE START in AVERAGE CONTROL section

Averaging ended (for example, AVG 64/64 displayed)?

NO

YES

Press TRANS. FCTN in VIEW section

Press BOTH in VIEW section

Press MAG. in DISPLAY section (magnitude is selected for display on lowerhalf screen)

Press UPPER /LOWER in DISPLAY section (UPPER ON)

Press TRANS. FCTN in VIEW section

Press PHASE in DISPLAY section (phase is selected for display on upper-half screen)

END

SAVING DATA ON FLOPPY

Use the following procedure to repeat the measurements in loops in which averaging is started with AUTO ARM and, each time the averaging is ended, the transfer function is written to the floppy, and the averaging is started again.

1. Set up floppy menu.
   MODE: WRITE
   WRITE MODE: ORIGIN
   WRITE TRIG: AVGED
2. AUTO ARM
   TRANS. FCTN Display transfer function.
3. Setup on the floppy disk recorder.
4. START START averaging.
5. Strike DUT with a hammer.
   AUTO START/STOP WRITE

LOCAL LOCAL +GND 2 Bode diagram display.

3.3 TRANSFER FUNCTION MEASUREMENT BY USE OF IMPULSE WAVEFORM

① AC / DC, −GND — Select DC coupling for both channels A and B

② WGT/SCALING — Move the pointer to RECT (for rectangular), then select the rectangular weighting function by pressing the SETUP key.

③ TIME — Move the pointer to CH.A (for channel A) under TRIGGER SOURCE, then press the SETUP key.

④ TRIG. MODE — Also, set SLOPE to <+>.

⑤ C (⇕), C (⇔) — Display the horizontal cursor and vertical cursor on the CRT.

Move the two cursors to the proper trigger level and trigger position by manipulating the four arrow-marked keys in the GENERAL CURSOR section.

⑥ SET X — Set the cursor trigger values (The cursor intersection represents the trigger point.)

⑦ Apply a pulse, taking note of the pulse width (width equivalent to 1 to 2 points in the time data) determined by the frequency range (see the table on the right.)

Frequency range	Pulse width (T)
1 MHz	500 ns
500 kHz	1 µs
200 kHz	2.5 µs
100 kHz	5 µs
50 kHz	10 µs
20 kHz	25 µs
10 kHz	50 µs
5 kHz	100 µs
2 kHz	250 µs
1 kHz	500 µs
500 Hz	1 ms
200 Hz	2.5 ms
100 Hz	5 ms
50 Hz	10 ms
20 Hz	25 ms

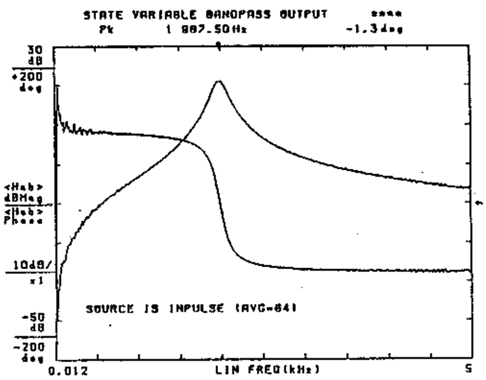
Pulse width having 1/2 T (Hz) band

⑧ AUTO ARM (or ARM if "+1 AVG" mode has been set)

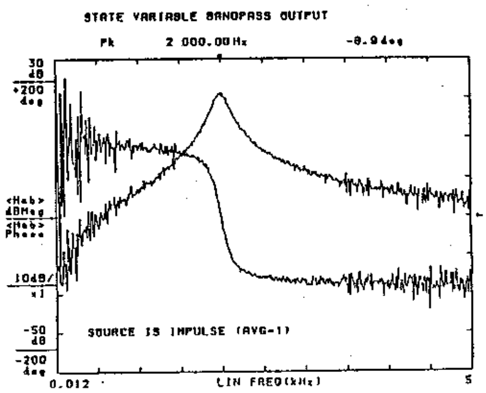
⑨ AVG MODE — Select CROSS + POWER for AVG WHAT?, and CROSS for AVG CHANNEL.

⑩ START — Start averaging.

⑪ TRANS. FCTN — Display the transfer function.



Transfer function display by application of one pulse (magnitude and phase are superimposed.)



Transfer function display after 64 ensemble averages

Figure 3-20 Transfer Function Measurement by Impulse Method

3.4 ZOOMING MODE FOR TRANSFER FUNCTION MEASUREMENT

A complicated structure has various resonances and antiresonances. By use of the zooming mode, transfer function of high resolution can be measured with the resonance frequency being centered, which has been identified by cursor in "Zero-Start" measurement.

1 With ZOOM set to OFF, make 16 averages (CROSS + POWER) and measure the transfer function of the entire frequency range. (Set the BOTH mode to display the magnitude on the top trace and the phase on the bottom trace.) (See the plots on the following page.)

2 SPECTRUM — Present spectrum display

3 C (↔) UPPER /LOWER ⇦ ⇨ — Let the vertical cursor appear on the upper half of the screen and move it to the peak of the spectrum. (If the cursor key is off, the peak is automatically searched.)

4 TRIG. MODE — Set trigger condition as ARM LENGTH

5 AVG MODE — AVG WHAT?: CROSS + POWER
AVG CHANNEL: CROSS

6 ZOOM ON. The vertical cursor is positioned at the center of the CRT.

7 EXPAND WIDTH ⇨⇦ (/) ⇦⇨ — Set the zoom factor, for example, to x4; the resolution is expanded four-fold on both sides of the cursor.

8 START — Start averaging.

9 TRANS. FCTN

10 ZOOM OFF

11 Set the vertical cursor on the upper half of the screen to the minimum gain of the waveform (in the same way as explained in step 3).

12 SPECTRUM

13 Set ZOOM to ON, then set the proper zoom factor.

14 AUTO ARM

15 START — Perform averaging.

16 TRANS. FCTN

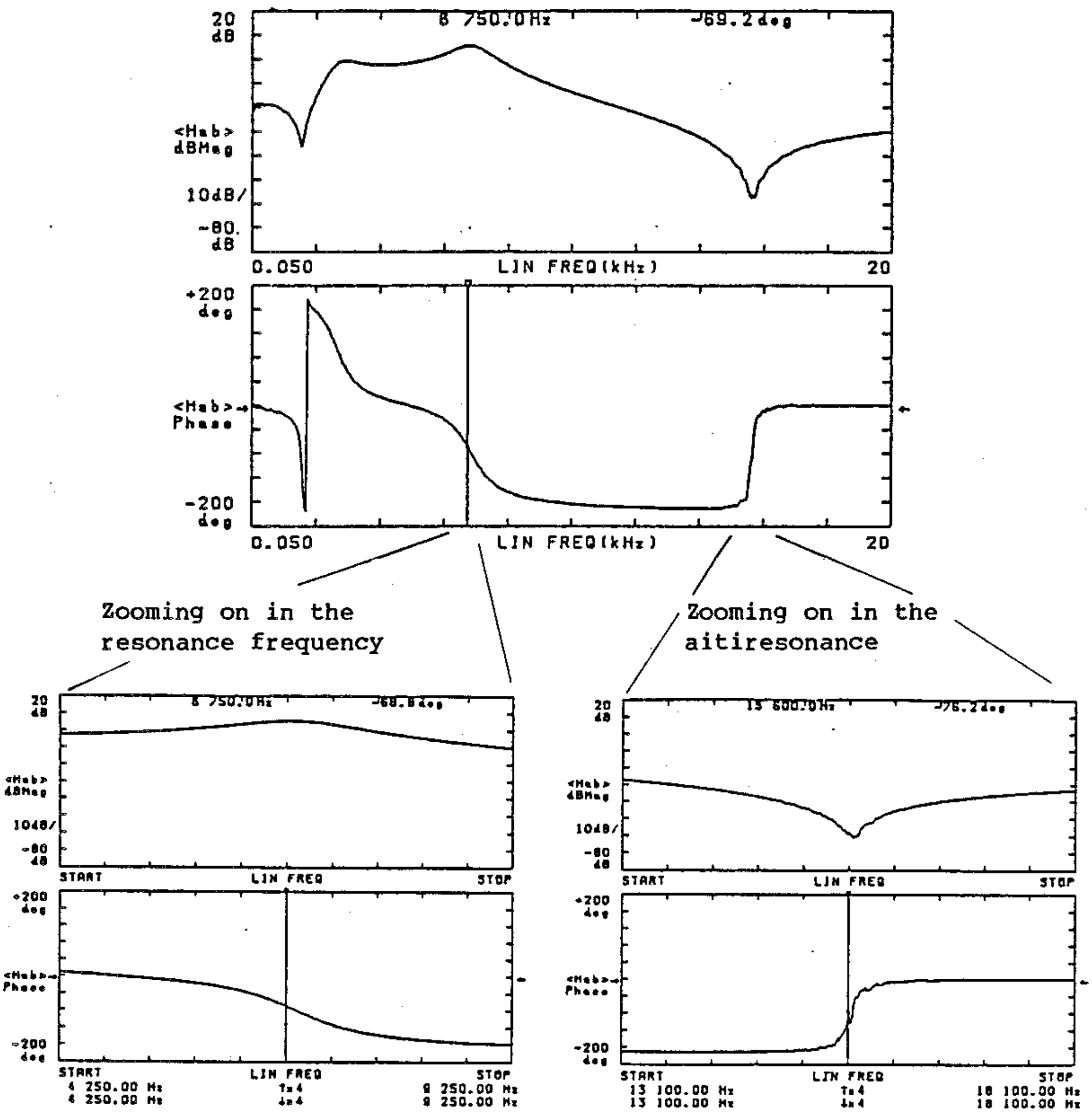


Figure 3-21 High Resolution Measurement of Transfer Function

3.5 INTERCHANNEL DELAY COMPENSATION FOR TRANSFER FUNCTION MEASUREMENT

If there is a time lag between the input and output signals, a portion of each signal corresponds to data in the other signal outside the frame time, resulting in an erroneously low estimate of the coherence function and random error in transfer function measurement becomes large. To correct such a time lag and make accurate transfer function measurement, shift one of the signals in time domain by proper interchannel delay.

AUTO-CORR. or IMPUL. RESP. or CROSS SPECT.

SET X

Normally, because the waveform peak value is set as the interchannel delay, press this key with the cursor off (which assumes the auto peak search mode). To set a different value than a peak value, switch the vertical cursor on, move it as desired time lag, then press SET X.

If the frequency analysis range is changed, the interchannel delay is reset to 0.

Interchannel delay can also be set up by the "INTERCHAN DELAY" in the TRIG MODE menu.

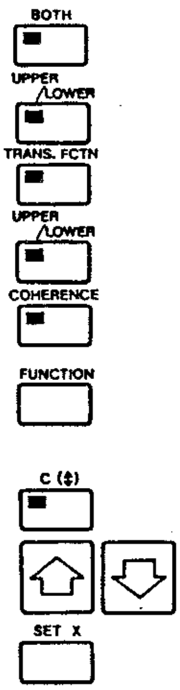
Use DISP. or SETUP to set the values between the points -1024 to 1024.

3.6 COHERENCE FUNCTION AND COHERENCE BLANKING

When measuring a transfer function, it is important to check the coherence function as well. Coherence function is a value lying between 0 and 1.0 that gives an unambiguous indication of the cause-and-effect relationship between input and output.

The coherence function is particularly useful when investigating cause-and-effect relationships in multiple-input systems. It gives a measure of how much output power at a frequency can be attributed to each input source.

A value of 1.0 indicates a perfectly linear relation uncontaminated by noise between input and output.



(1) Set the BOTH mode

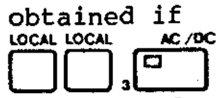
(2)

(3) Display the transfer function on the top trace

(4)

(5) Display the coherence function on the bottom trace.

The same display is obtained if

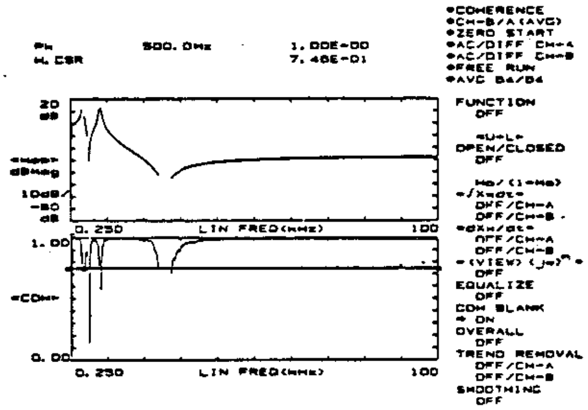


are pressed.

(6) Display the FUNCTION menu, move the pointer to COH BLANK (the pointer blinks), then press the SETUP or DISP key to set the COH BLANK mode.

(7) Let the horizontal cursor appear on the CRT, then move it to the value where coherence blanking is to be made.

(8) Press this key to set the coherence blanking value; the portions of trace under coherence function blanking value are eliminated from the display.



Coherence blanking is started
Only the transfer function portions above the coherence of 0.746 are displayed with the lower-coherence portions eliminated (top trace).

Coherence function with portions not higher than 0.746 eliminated (bottom trace).

Figure 3-22 Coherence Blanking

MEMO

TABLE OF CONTENTS

4. 2-CHANNEL MEASUREMENTS

4.1 TONE BURST

Two conventional methods for evaluating the transient characteristics of acoustic devices such as speakers are:

(1) Tone burst
(2) Cumulative spectrum

These methods have several drawbacks. Generating the tone burst is not simple and measurement is ambiguous because of the relativity of wave positions for determining rise and fall characteristics; the cumulative spectrum method is poor in reproducibility and difficult in quantitative analysis.

(3) New measurement method by tone burst and pre-envelope

Sine waves are applied to the speaker from the signal generator and pre-envelope is determined from the output waveforms. The energy envelope uniquely determined from the pre-envelope information is self-explanatory like the power spectrum, easy to obtain, and its rise and fall characteristics are clearly definable.

In the production line, the energy envelope can also be checked for predetermined frequencies.

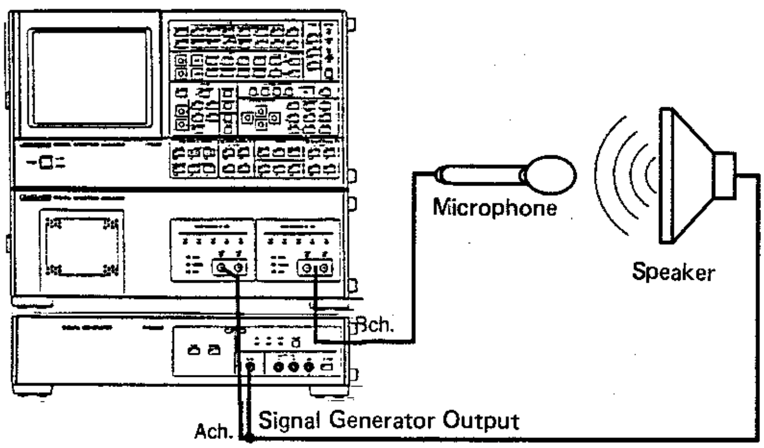
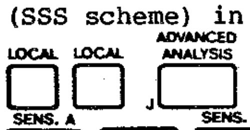
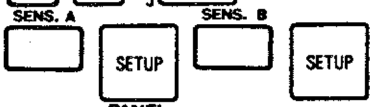


Figure 4-1 Transient response characteristics test of a speaker

(1) Perform 4-decade logarithmic frequency analysis by sweeping swept sine (SSS scheme) in the narrow band.



(For logarithmic sweep) [3.1.5 (8)]



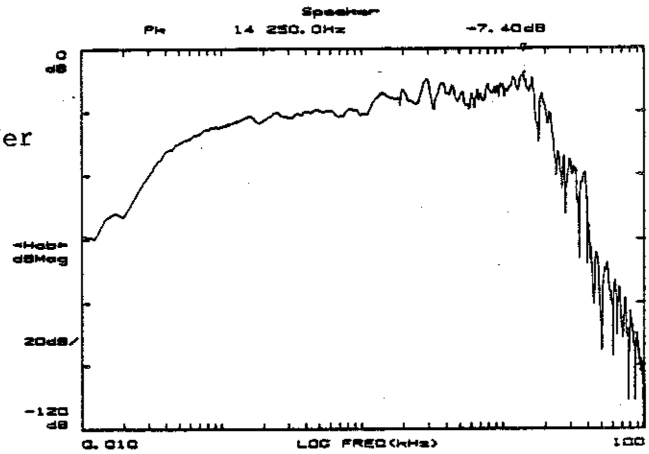
Set to auto range.

Set up amplitude.

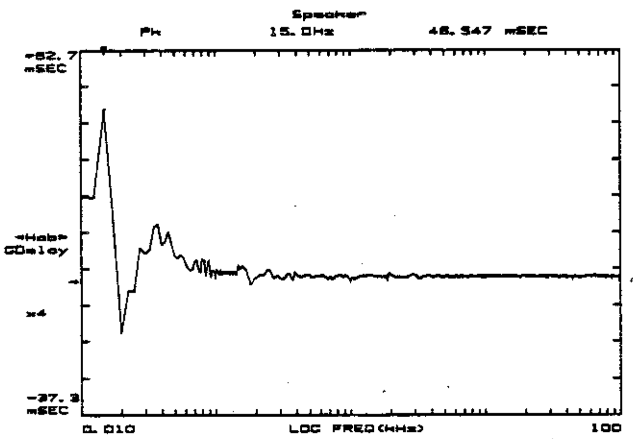
Measurement is started.

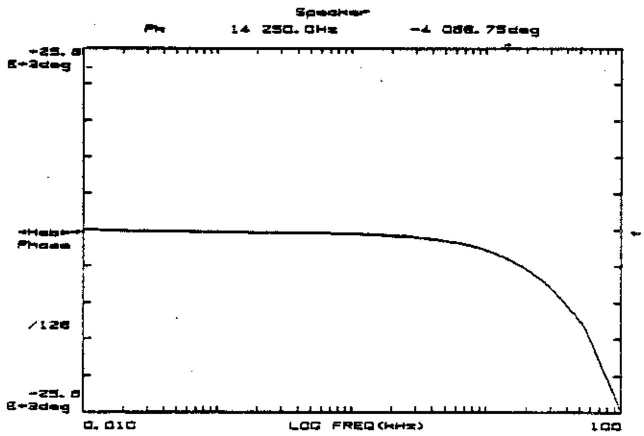
(a) through (c) shows the transfer function of the speaker.

Group delay is important since an abrupt change of phase exerting a large affect on sound quality can be detected.

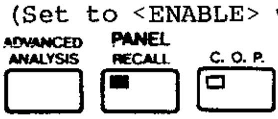


(a) Amplitude characteristics



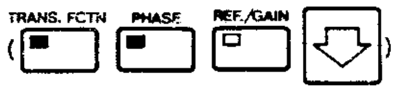


(b) Group delay
(Set to <ENABLE> with

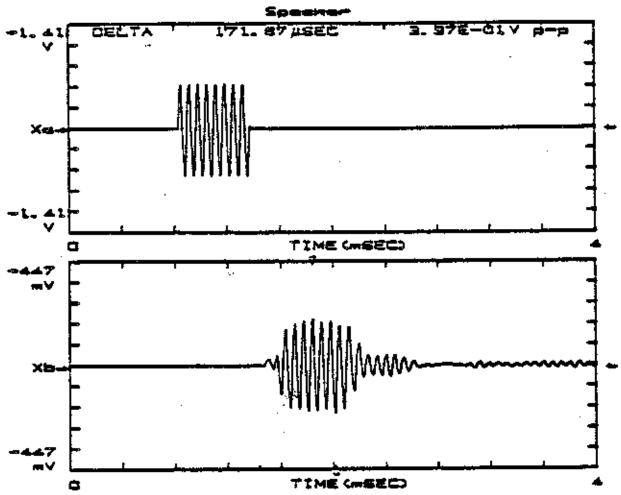


and execute.)

(c) Unwrapped phase



(2) Generate tone burst



(i) I/O, PANEL RECALL, C.O.P.

Display the sine menu.

(ii) Set frequency range and amplitude.

(iii) PHASE : OUTPUT MODE: MANUAL
Set start and stop phases.

(iv) ARM or AUTO ARM

Set trigger conditions by the cursors.

(v) Set output cycle (8 in this case).

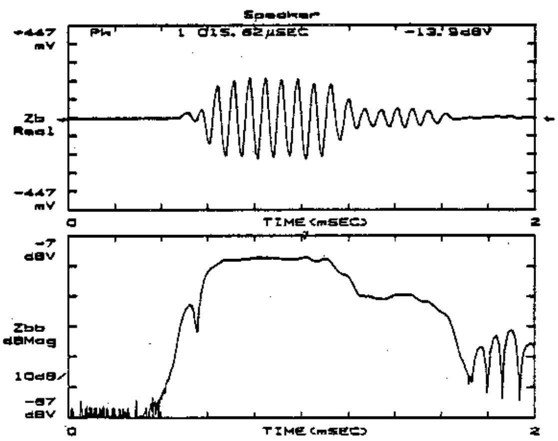
(vi) PAUSE Pressing the PAUSE switch in the signal generator outputs sine waves of the specified cycle. The upper figure shows the input waveforms of a tone burst and the lower shows the output waveforms.

(3) Determining pre-envelope from the above waveform gives the damping time and distribution of energy in the time domain.

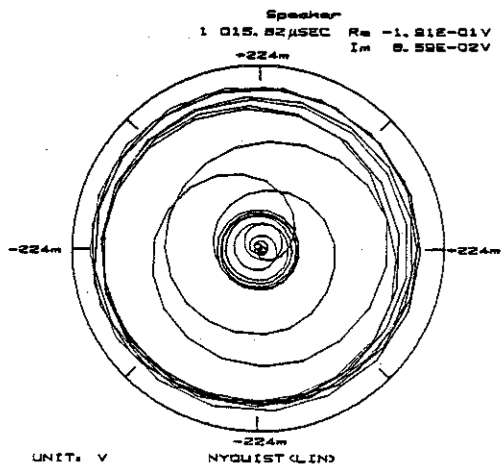
(i) ADVANCED ANALYSIS, PANEL RECALL, IMPUL. RESP. Displays P-ENVELOPE menu.

(ii) Set ANALYSIS CHAN to CH-B and <DISABLE> to <ENABLE>.

(iii) Press the EXECUTE switch of ADVANCED ANALYSIS.



Pre-envelope



Nyquist display of pre-envelope

4.2 PCM TRANSMIT/RECEIVE FILTER

In telephone line, the voice of analog quantity passes through a transmit filter (band-pass filter), then it is converted into PCM codes by the encoder (A/D conversion) of codec and transmitted. The received PCM code is D/A converted into analog signals via the decoder of codec and returned to voice signals through a receive filter (low-pass filter).

The transmit filter is a bandpass filter comprising of a low-pass filter providing the anti-aliasing capability necessary for the 8 kHz sampling system and a high-pass filter eliminating the ham components of 50/60 Hz.

The receive filter is a low-pass filter for smoothing the decoder output (PAM output of D/A converter) of codec.

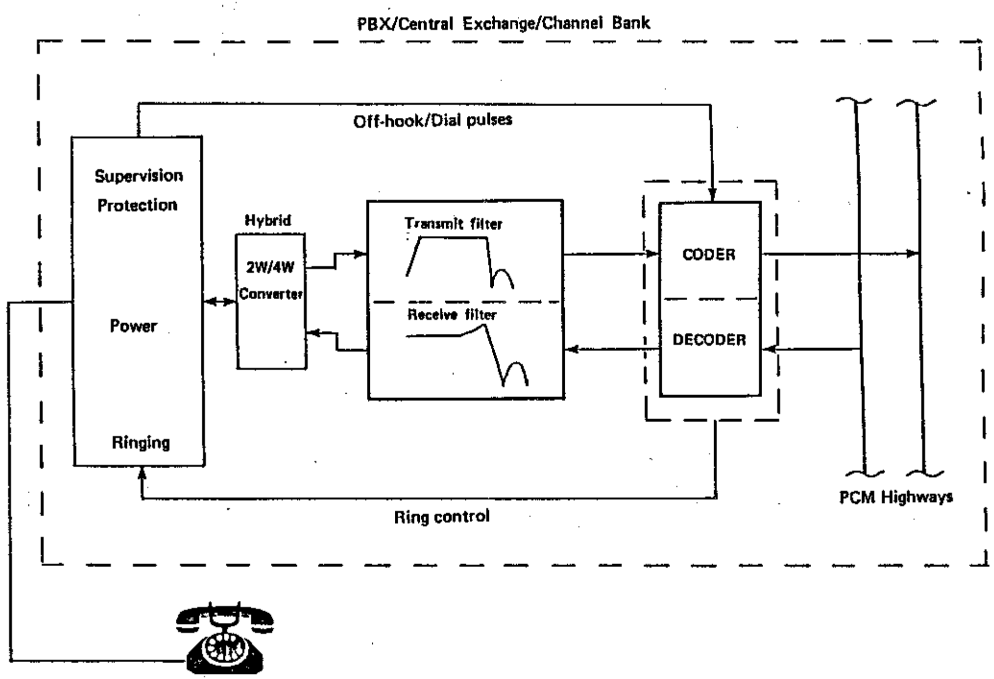


Figure 4-2 Typical Application of Codec and Filter

Figure 4-3 shows the transfer characteristics of transmit filter. For a bandpass filter whose pass band is 300 to 3200 Hz, the gain values relative to gain at 1 kHz are given.

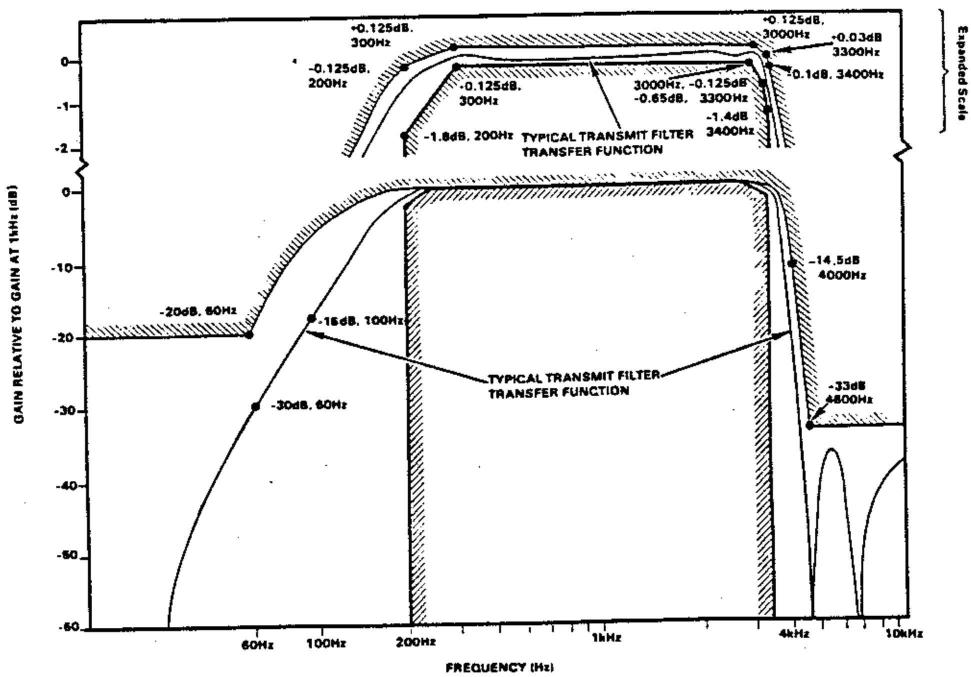


Figure 4-3 Transmit Filter Transfer Characteristics

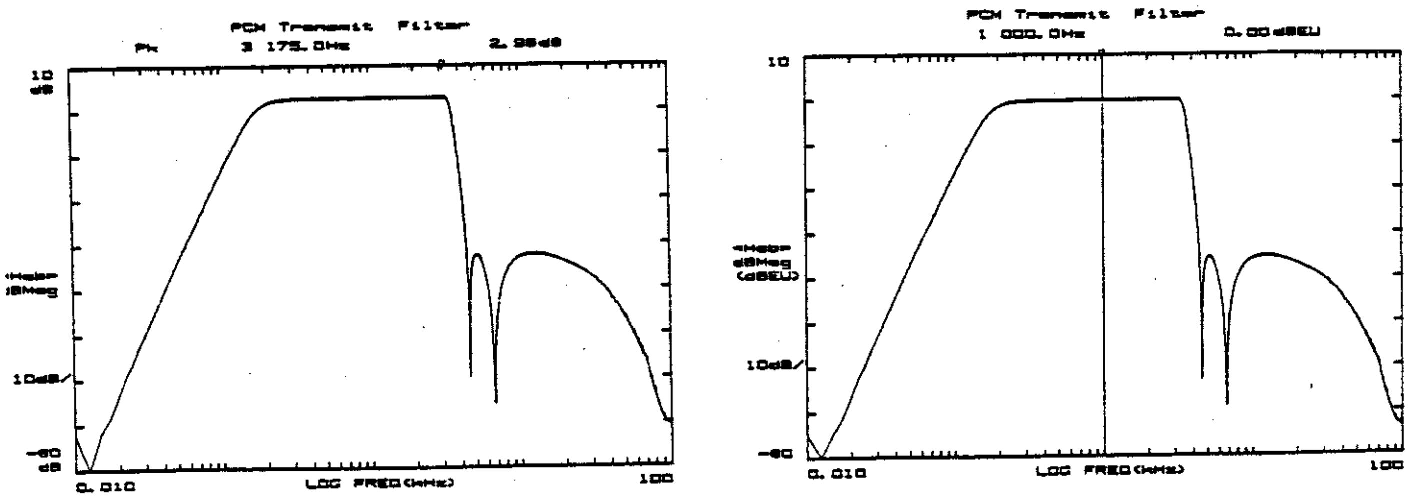


Figure 4-4 Transmit Filter Transfer Function by Swept Sine Sweep

Figure 4-4 shows the transfer function the transmit filter measured by sweeping swept sine wave.

① Set the engineering unit so that the gain value at 1 kHz is 0 dBEU.

C (↔) Position the vertical cursor at 1 kHz.

DISPLAY CTL Set DISP MODE to dBMag.

WGT/SCALING Set to the CURSOR mode.
Move the pointer (⇨) to CURSOR = and set 000.0 dBEU. Set CURSOR OFF to CURSOR ON. (Figure 4-4)

② SET REF. ON/OFF Move the cursor to the frequency of (frequency, gain value) in Figure 4-3 from the high-frequency side and set it to reference with SET REF.

③ LIST List the relative values for gain value at 1 kHz. (Figure 4-5)
Figure 4-6 shows the phase display (unwrapped phase) and group delay of the same transfer function.

TR9407 DIGITAL SPECTRUM ANALYZER

		Frequency Hz	TRANS FCTN dBMag dBEU
SET NO.	1	60.0	-31.49
	2	100.0	-16.55
	3	200.0	-1.28
	4	300.0	-0.09
	5	3000.0	0.02
	6	3300.0	-0.05
	7	3400.0	-0.45
	8	4000.0	-15.02
	9	4600.0	-62.63

Figure 4-5 Relative Values for Gain Value at 1 kHz

④ Press LOCK CLR to all clear the set references (with the state of SET REF. ON/OFF).

Figure 4-7 shows the transfer function of receive filter.

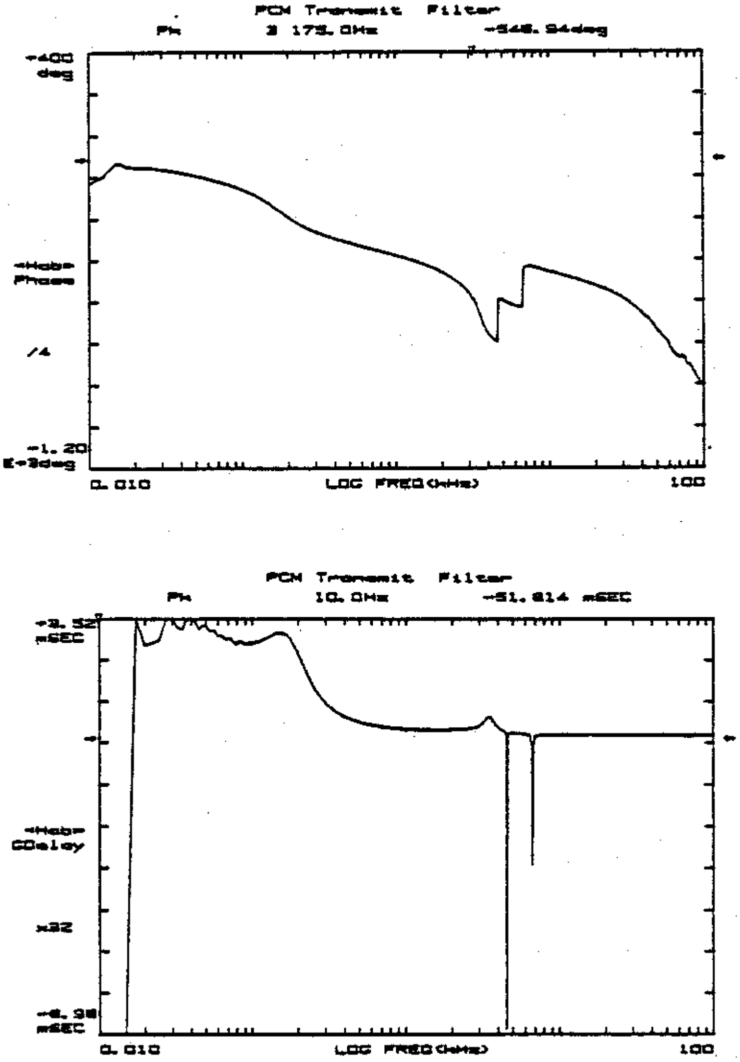


Figure 4-6 Phase and Group Delay of PCM Transmit Filter

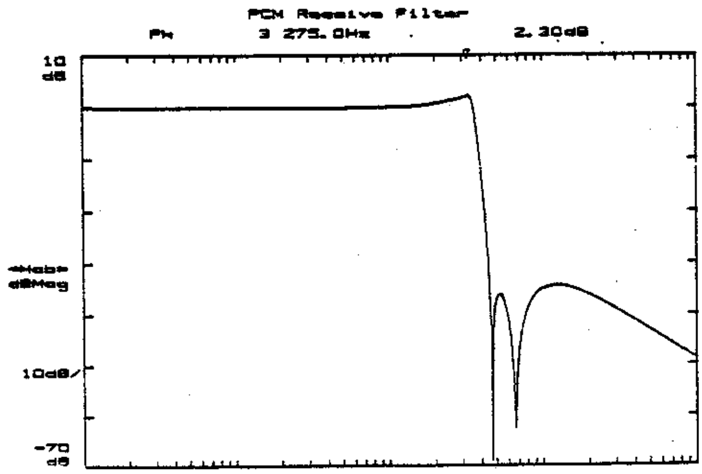
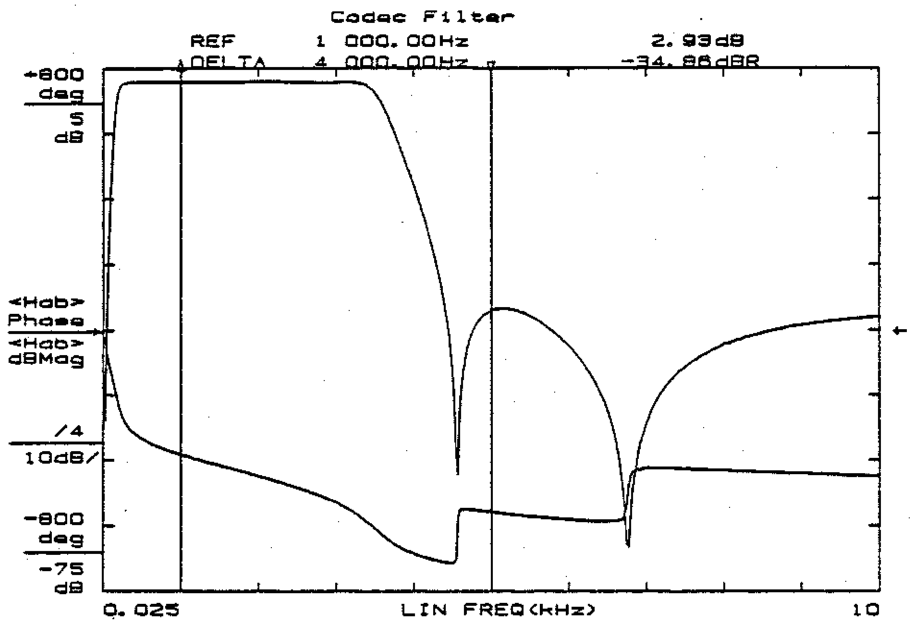


Figure 4-7 Transfer Function of PCM Receive Filter

Press BOTH to display both amplitude and phase of the transfer function of Codec filter and press SUPERIMPOSE to superimpose them. Dual list display will be obtained by following the above procedure with LIST.



Codec Filter

		Frequency Hz	TRANS FCTN dBMag dB	TRANS FCTN Phase deg
SET NO.	1	1 000.00	2.93	-383.4
	2	1 500.00	2.95	-416.6
	3	2 000.00	2.99	-448.9
	4	2 500.00	2.95	-484.8
	5	3 000.00	2.92	-529.4
	6	3 500.00	1.33	-608.2
	7	4 000.00	-12.75	-685.8
	8	4 500.00	-40.62	-714.6
	9	5 000.00	-31.96	-557.6
	10	5 500.00	-32.79	-570.5
	11	6 000.00	-37.33	-580.0
	12	6 500.00	-47.38	-585.8
	13	7 000.00	-49.39	-423.0
	14	7 500.00	-40.52	-425.7
	15	8 000.00	-37.12	-429.4
	16	8 500.00	-35.32	-435.3
	17	9 000.00	-34.17	-439.7
	18	9 500.00	-33.41	-443.9
	19	10 000.00	-32.94	-447.6

Figure 4-8 Dual List Mode Display

4.2.1 Measurement of Filter's bandwidth

When the horizontal cursor is displayed, the two closest points to the intersection between the horizontal cursor and the data to the right of the vertical cursor position of the peak indicated by the "∇" mark are detected and intensified by ".". The procedure for finding filter bandwidth using this function is described below.

① Suppose transfer function dBMag is displayed on the CRT.

② Press the [C (↔)] key (LED lamp goes off) to set peak search mode. Read the maximum value of the bandwidth gain. (See Figure 4-9).

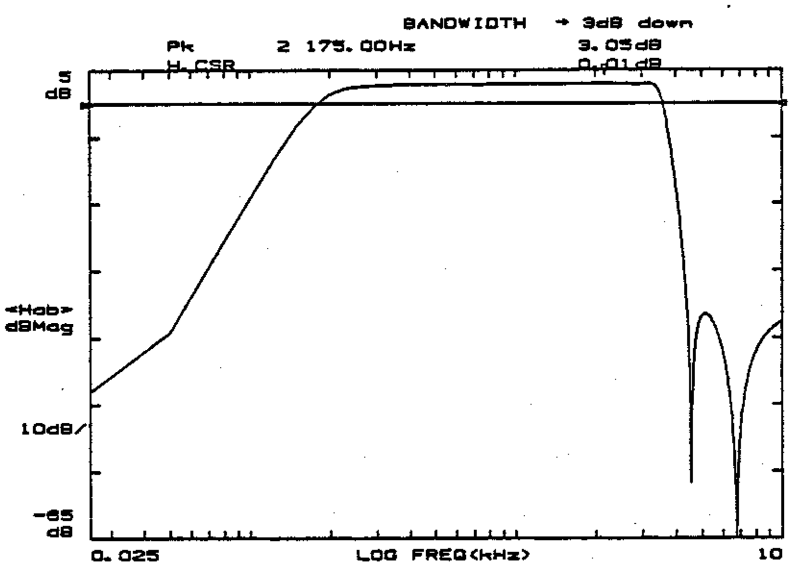


Figure 4-9 Peak Value Readout with Vertical Cursor off

③ Press the [C (↕)] key (lamp comes on) to display the horizontal cursor.

④ Press the [⇧] or [⇩] key to move the horizontal cursor.

Stop the cursor when the
  H.CSR   x.xx dB
display on the CRT screen reaches value 3 dB below the maximum value of the bandwidth gain.

⑤ Press the [C (↔)] key (lamp comes on) to display the vertical cursor.

(6) Press the [⇦] or [⇨] key to move the vertical cursor to the left of the "first intersection between the display data and the horizontal cursor".

(7) Press the [SET REF. ON/OFF] key (lamp comes on) to switch to reference mode.

The bandwidth is displayed on the CRT screen as:
  H. CSR   xx.xx Hz   x.xx dB
(See Figure 4-10).

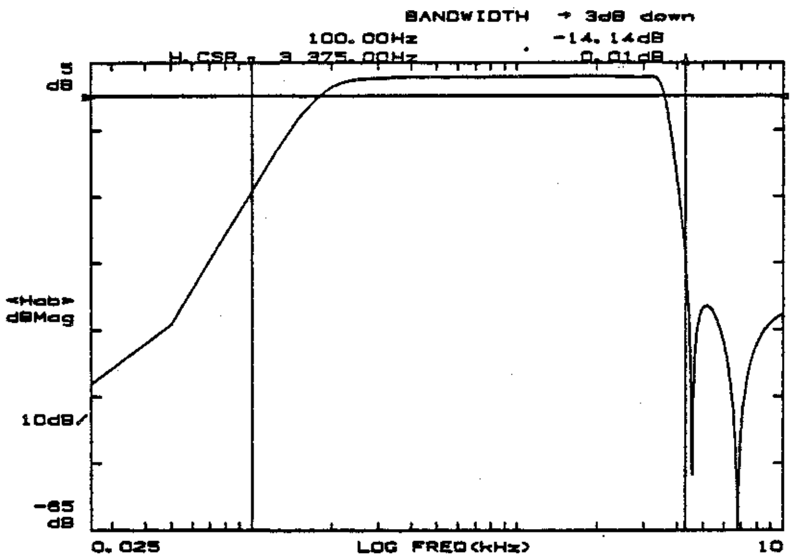
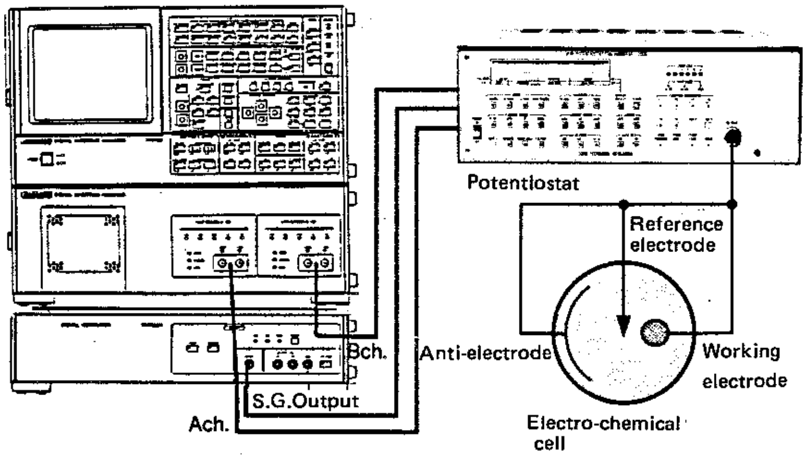


Figure 4-10 Filter's Bandwidth Value Readout

4.3 CHEMICAL IMPEDANCE MEASUREMENT

Since the TR9407 permits high-speed, high-accuracy measurement, measurement can be done quickly before any chemical change takes place.

(1) Connection of devices



The lithium cell yields better frequency response than the mercury cell.

Figure 4-11 Chemical Impedance Measurement Example

(2) Setting

a. Potentiostat
MODE: P-STAT
SETTING: Set INT and EXT2 to ON.

CURRENT RANGE: Select the○○.○○mA range with △ ▽.

EDITOR: Set the INT SET voltage to the voltage of the measuring cell or to a slightly higher voltage with △ ▽ ◁ ▷.

FUNCTION: Connect the cell and set OFF to TO CELL. Make sure that the OVERLOAD lamp does not light. If this lamp lights, reset the CURRENT RANGE value again.

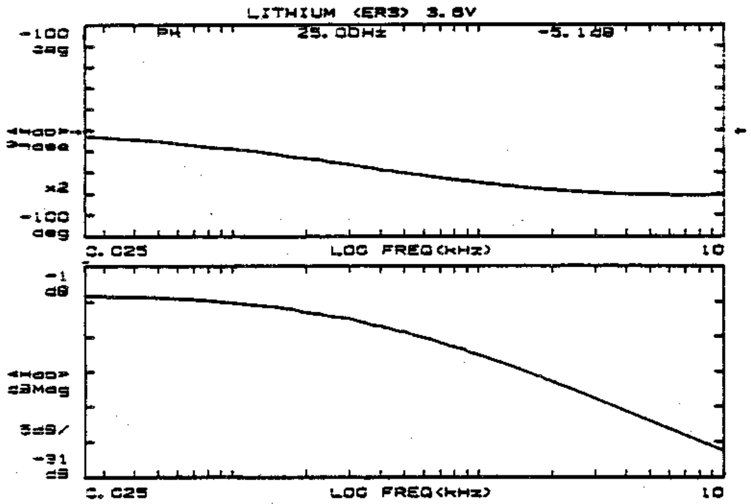
b. Setup in the measurement section
Frequency: 20 kHz
S.G. function: Multi-sine
Amplitude: 0.2 Vp-p
Offset: 0V
AVG number: 16

(3) Measurement

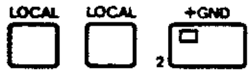
a. Press START [ ] to start measurement.

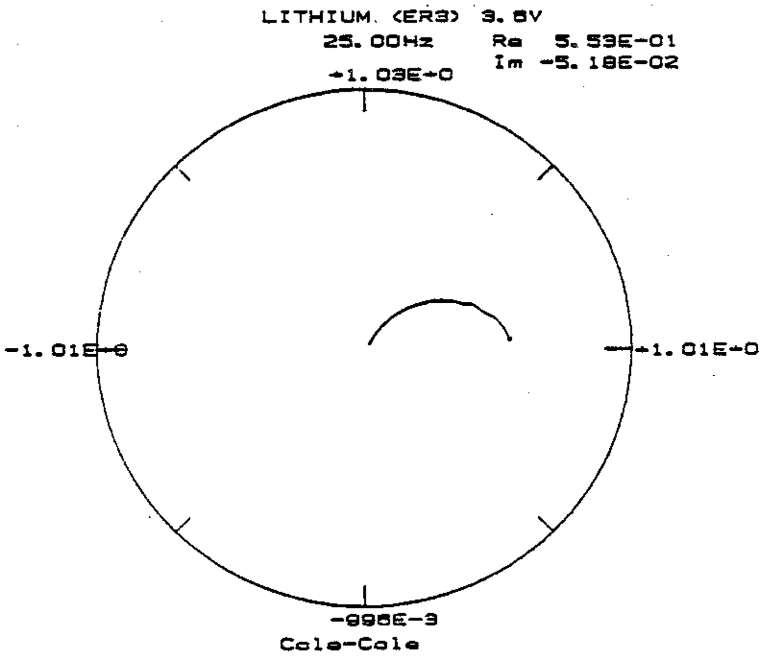
During measurement, the IN PROCESS lamp is lit. When measurement is completed, the audible tone sounds.

b. Observing the measurement result
Display of Bode diagram.



Gain and phase of transfer function are displayed.





Cole-Cole plot (real, -imaginary display)

4.3.1 Application of Chemical Impedance Measurement

(1) Evaluating metal corrosion

Time-varying evaluation of metal corrosion under the film (coating) (detection of correction).

(a) First step (measuring impedance)
The system containing the TR9407, TR98201, and P-STAT is used to measure the impedance to evaluate the corrosion of the coated metal.

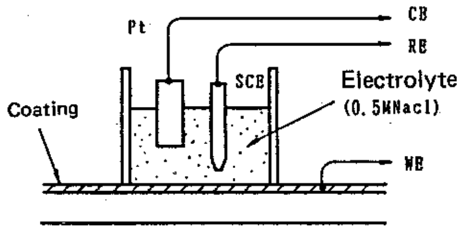


Figure 4-12 Impedance Measurement of Metal Corrosion Under Film

Figure 4-13 shows Cole-Cole plots indicating the impedance measurement results.

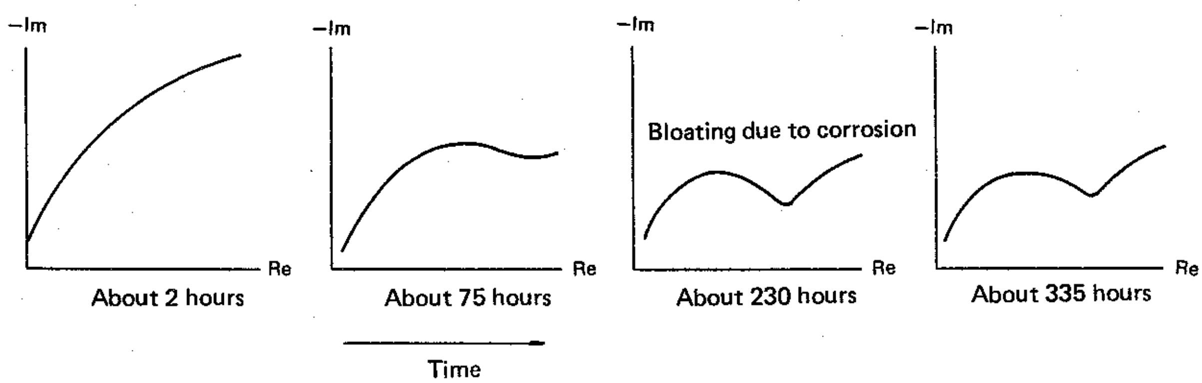
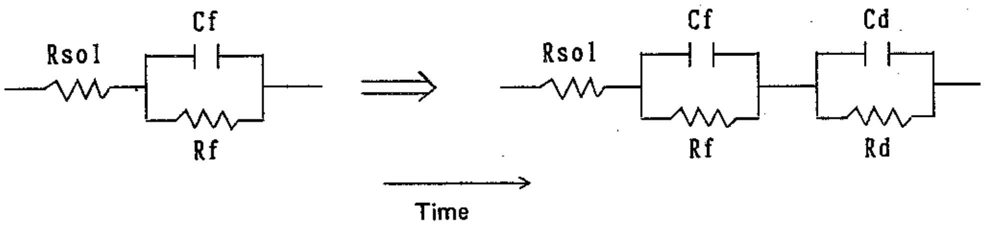


Figure 4-13 Cole-Cole Plot Change with Time (Metal Corrosion)

(b) Second step (presuming the equivalent circuit)
The following equivalent circuit is presumed as a result of the first step.



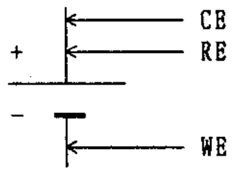
(c) Third step (physical correspondence with actual DUT)
Rsol: Solution resistance
Cd: Capacity of electric double layer when corrosion occurs
Cf: Film capacity
Rd: Corrosion reactive resistance
Df: Film resistance

(d) Fourth step (obtaining the desired result of analysis)
Metal is not corroded at first, so the normal film resistance and film capacity are obtained. As time lapses, corrosion is caused and a semicircular impedance curve is displayed in the low-frequency range.
As corrosion progresses, the film resistance is reduced.
Therefore, corrosion can be found by checking the semicircular impedance curve in the low-frequency range.

(2) Evaluation of the cell

1 Cell change over time (constant load continuous discharge characteristic)

(a) First step (measuring the impedance)
When a constant load (10 kΩ) is connected to the cell (lithium/manganese dioxide cell), the impedance change with time is measured using the following connection.



The system including the TR9407, TR98201, and Potentiostat is used for this measurement.

Figure 4-14 shows the Cole-Cole plots indicating the above measurement results.

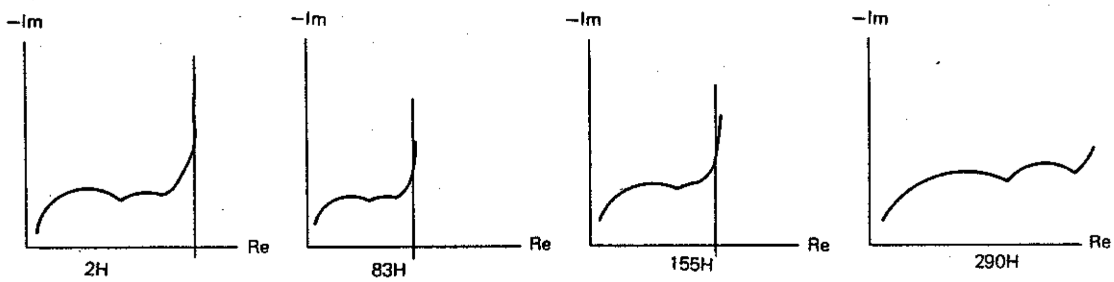
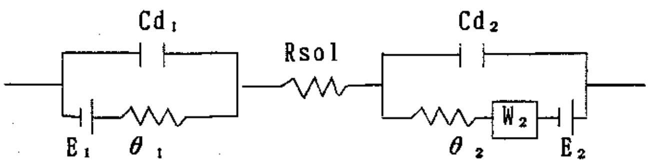


Figure 4-14 Cole-Cole Plot Change Over Time (Cell)

(b) Second step (presuming the equivalent circuit)
It is presumed that the circuit is equivalent to basic electrode reactions connected in series (positive/negative electrodes).
The Walburg impedance of the negative electrode is omitted because the result of the first step indicates that the influence by negative electrode diffusion is negligible.



(c) Third step (Physical relationship with actual DUT)
The circuit is equivalent to the basic electrode reaction.
Cd_1, Cd_2: Electric double layer capacities of negative and positive electrodes
θ_1, θ_2: Charge migration resistance
W_2: Walburg impedance of positive electrode
Rsol: Solution resistance
R_L: Limit resistance (Resistance component of Walburg impedance at low-frequency range at finite diffusion)

(d) Fourth step (analysis result)
Figure 4-15 shows the changes of Rsol, θ_1, θ_2, and R_L plotted together with the cell's constant load discharge curve.
θ_1, θ_2, and R_L are constant during the middle of discharge, but they start increasing at the end of discharge.
The Cole-Cole plot shows, a large vector locus in the beginning of discharge, shows a small constant locus in the middle of discharge, and shows a locus greatly shifted to the right at the end of discharge.
According to the above changes, it is possible to estimate the life of the cell.

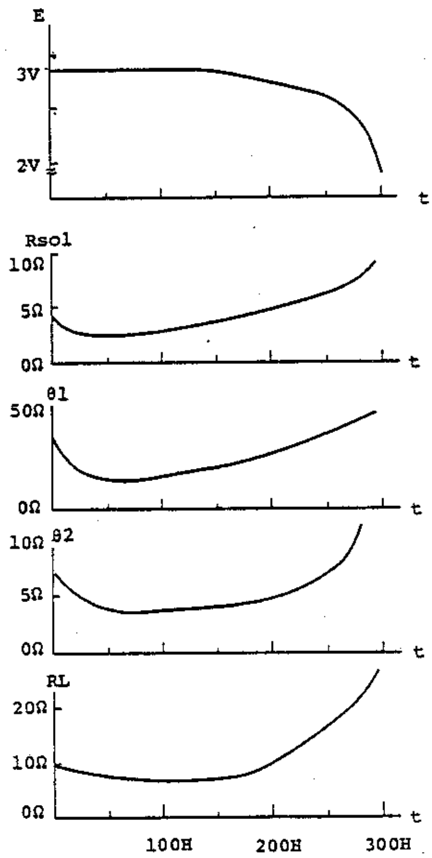
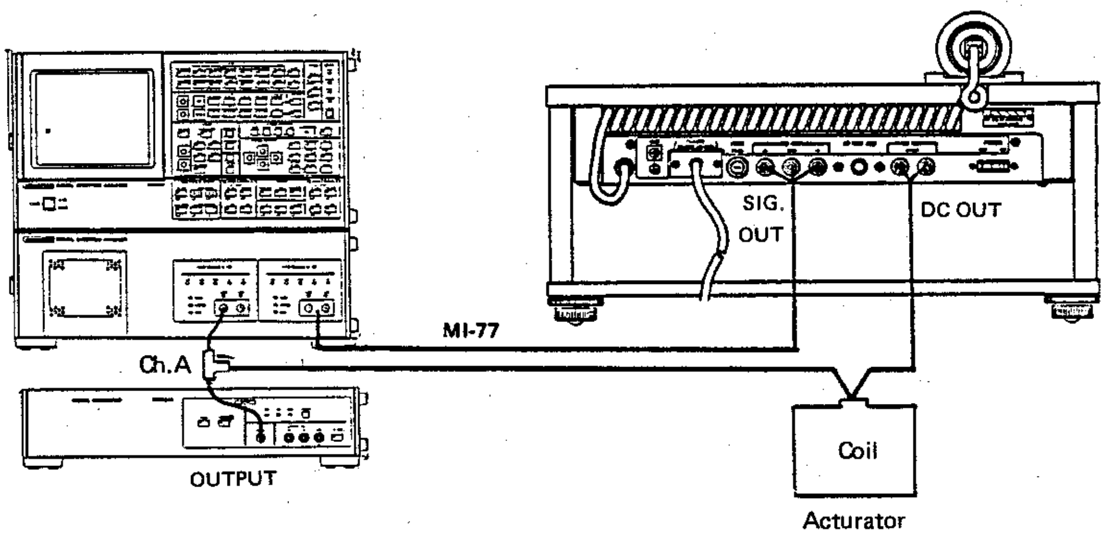


Figure 4-15 Constant Load Continuous Discharge Curve

4.4 MEASUREMENT OF DISPLACEMENT
(DIRECT READING WITH SCALING FUNCTION)

TR9407, if combined with the TQ88091 optical Actuator Test Head and the TR98201 Signal Generator, gives a wide dynamic range measurement of the magnitude of response or displacement (4 mm to 0.0014 µm; 130 dB) of the vibrating body whose DC to 50 kHz displacement being converted into voltage.

2ch FFT analyzer and the signal generator TQ88091



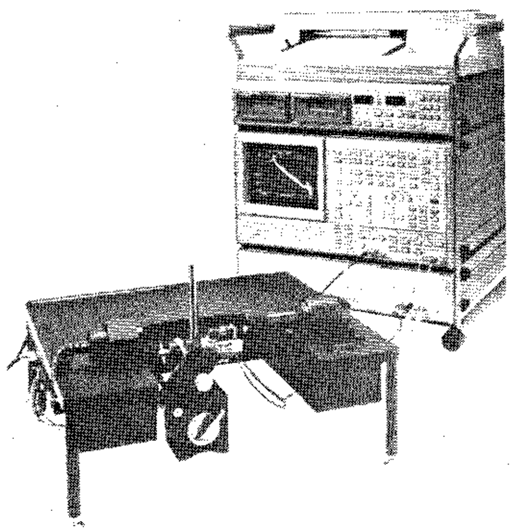
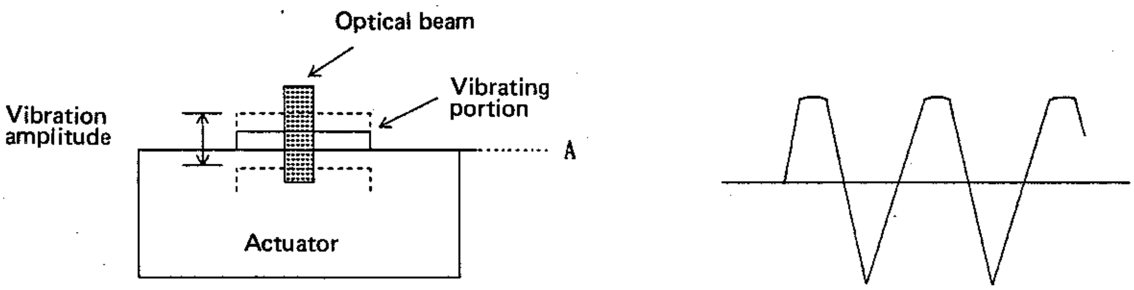


Figure 4-16 Connection the FFT Analyzer with the TQ88091

(1) Connect the TR9407 with the TQ88091 and the signal generator.

(2) Determine signal level applied to the actuator coil

① Set the mode selector to the MEAS position.
② Generate and apply about 0.5 V_{p-p} signals from the frequency response analyzer (signal generator) with the actuator frequency at about the first resonance point. (The level varies with the actuator.)
③ Observe the signal level for the channel B (TQ88091 output) (<Gbb>) by using the frequency response analyzer.
④ Alter the signal frequency to search for the frequency of the maximum output in channel B.
⑤ Adjust the signal level from the frequency response analyzer so that the channel B output level ranges from 2 to 8 dBV (magnitude of displacement is between 1.4 and 3.0 mm).
⑥ At this time, observe the channel B signals in the time domain and confirm that the upper or lower portion of waveforms are not clipped or distorted. For focus direction measurement, especially, if the applied direct bias from TQ88091 is improper (insufficient), the channel B output waveform will be distorted as illustrated in Figure 4-17. Apply the direct bias voltage so that the vibration amplitude range always goes over the section A as shown in (a) of Figure 4-17.



(a) Insufficeient forcus bias

(b) Waveform distortion due to insufficient bias

Figure 4-17 Output Waveforms When Direct bias is insufficient

(3) Measurement with signal sequences

The previous subsection described how the signal level to be applied to the actuator could be specified. The characteristics required for the actuator are depicted in Figure 4-18. From Figure 4-18, it can be seen that the larger the signal frequency is, the smaller the response level becomes. When the frequency is 5 kHz or more, the response will be below the system noise level. For the measurement of the actuator, therefore, in wide dynamic ranges from 120 to 130 dB, use the signal sequence method of the TR9407.

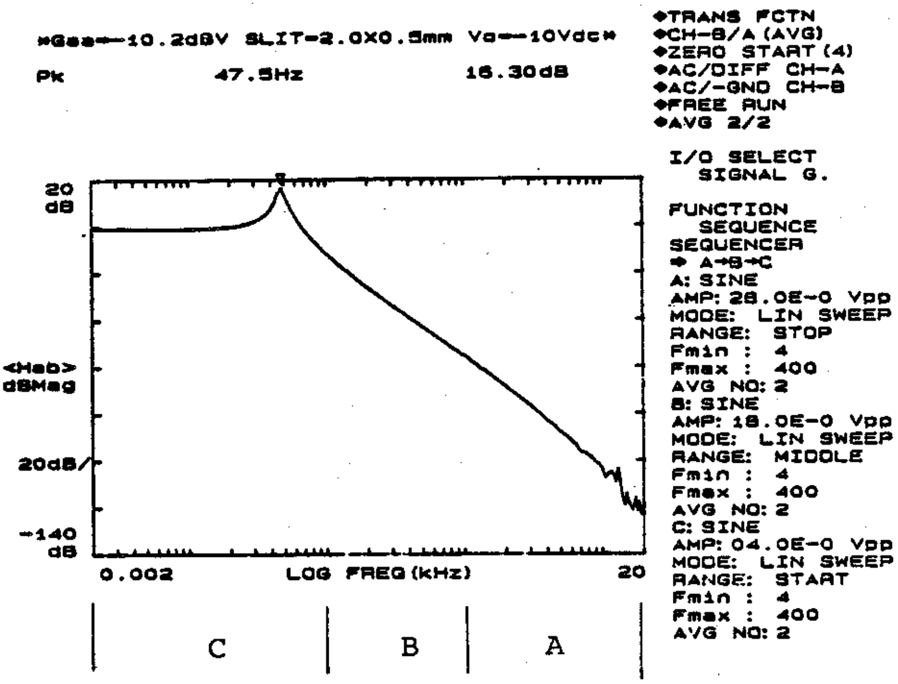


Figure 4-18 Characteristics of Actuator

When the analysis range is between 2 and 20 kHz (4 decades)

① Low frequency range (2 to 200 Hz) level
Apply the signal level (reference level) determined in 5 in subsection (2). When there is a considerable amount of light disturbance, divide the frequency range into more regions, say, 2 to 100 Hz, and 100 to 200 Hz. If the response decreases for the 100 to 200 Hz range, apply a signal level which is four to five times higher than the reference level.

② Middle frequency range (200 to 2 kHz) level
Apply a signal level which is approx. 10 to 20 times higher than the reference level.

③ High frequency range (2 to 20 kHz) level
Apply a signal level which is approx. 20 to 40 times higher than the reference level.

(4) Converting measurement results into displacement values
Shown in Figure 4-19 is a plot of the frequency response (transfer function) of the actuator yielded by the TQ88091 and the TR9407.
The transfer function is expressed by the output Fourier spectrum <Sb> ratio against the input Fourier spectrum <Sa> as follows:

$$\langle Hab \rangle = \langle Sb/Sa \rangle$$

or

$$\langle Hab \rangle = \left\langle \frac{Sb \cdot Sa^*}{Sa \cdot Sa^*} \right\rangle = \frac{\langle Gab \rangle}{\langle Gaa \rangle}$$

That is, the transfer function can be expressed by the cross spectrum ratio against the input power spectrum.
Since the measurement is performed when the coherence function is "1" (the transfer function is the least susceptible to noise), this function can also be expressed as follows:

$$\left| \langle Hab \rangle \right|^2 = \frac{\langle Gbb \rangle}{\langle Gaa \rangle}$$

By testing the actual input level applied to the actuator, output level Gbb for each frequency can be obtained as follows:

$$\langle Gbb \rangle = \left| \langle Hab \rangle \right|^2 \cdot \langle Gaa \rangle$$

Levels in the low frequency range applied from the signal generator to the actuator are displayed on menu C: of the signal sequence in Figure 4-18. This value incorporates a load of 50 Ω. Since the actual value applied to the actuator varies according to the actuator, measure the actual value of Gaa .

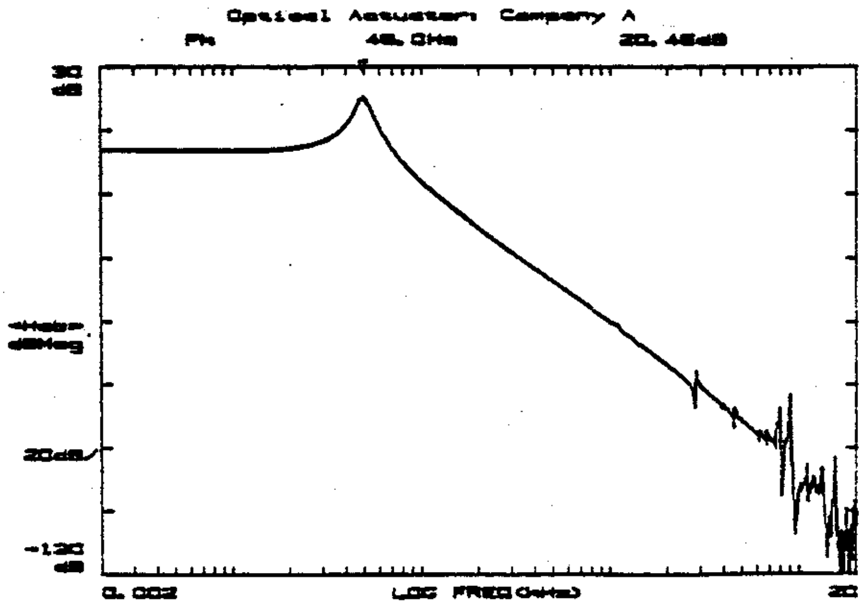


Figure 4-19 An Example of Actuator Transfer Function

A practical example of scaling

Try actual scaling by using the measurement data shown in Figure 4-18. Suppose the <Gaa> measurement value in low frequency range "C" is -10.2 dBV. Since the actuator value of |<Hab>| at the frequency of 47.5 Hz is 10.3 dB, then:

$$\langle Gbb \rangle = 10.3 + (-10.2) = 0.1 \text{ (dBV)}$$

Where voltage gain = 0.1 dBV = 20log X. This can be linearly expressed as

$$\langle Gbb \rangle = 1.01 \text{ Vrms} = 2.86 \text{ V}_{p-p}$$

The basic sensitivity of TQ88091 is 0.4 µm/mV$_{p-p}$, therefore, the magnitude of displacement amplitude is 1.14 mm. This is illustrated in figure 4-20. To perform scaling, the scaling factor must be entered with the WEIGHTING menu of the analyzer. This is described as follows:

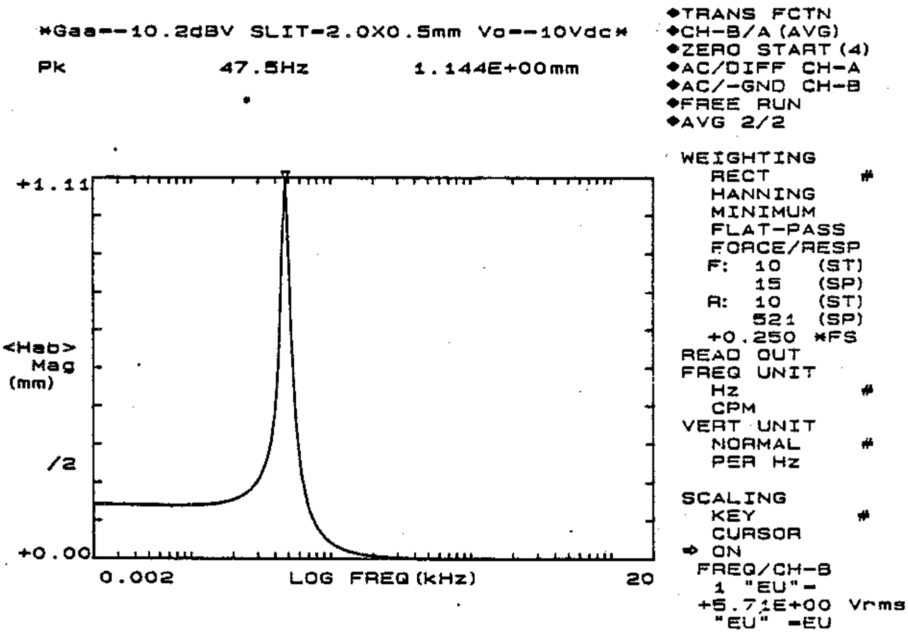


Figure 4-20 A Scaling Example of Actuator Characteristic

Operating the TR9407 on scaling

① TRANS. FCTN — Display the transfer function.

② DISPLAY CTRL — Display the DISPLAY CTRL menu to display the amplitude in MAG (linear display).

```
DISP CTRL
 *LOWER*
AUTO SCALE
  ON
DISP MODE
  TIME

⇨ Mag        L#
  Mag²
  dBMag
  NICHOLS
DISP GAIN
<dB/DIV>
  2
  5
  10         L#

DATA WINDOW
  AUTO
STEP<D. WINDOW>
   15/1024

RE-SAMPLING
  UNIFORM
LEVEL MONITOR
  OFF
  CURSOR
```

Figure 4-21 DISPLAY CTRL Menu

③ WGT/SCALING — Displays the scaling menu to perform scaling. Set SCALING:KEY (move the pointer (⇨) to the KEY position, and press SETUP.)

④ CH. A/CH. B — CH-B is displayed on the scaling factor display field in the menu. Calculate the linear value for input corresponding to 20 dB to key in.

<Gbb> = 14 dB + (-10.2) dBV = 3.8 dBV

As X = 1.55 is obtained by substituting 3.8 dBV = 20logX for the above equation, then:

3.8 dBV = 1.55 Vrms = 4.37 V_{p-p}

Since the TQ88091 basic sensitivity is 0.4 μm/mV_{p-p}, the displacement value becomes 1748 μm. Accordingly, 1.75 mm corresponds to 20 dB. That is,

20 dB ..... 10 Vrms ..... 1.75 mm

Where 0 dB = 1 Vrms.
Therefore, 10/1.75 = 5.71 Vrms/mm is obtained. Finally, 1EU = 5.71E + 00 Vrms can be entered (refer to the menu display in Figure 4-20.) as the scaling factor for CH. B.

⑤ CH. A/CH. B Set channel A to display CH-A in the menu of the scaling factor. Then, enter EU = mm. The channel A value does not need to be changed from its initialization value:

1EU = 1.00E00 Vrms

⑥ Move the pointer (⇨) SCALING OFF position and set SCALING ON by the SETUP key.

4.5 MODAL ANALYSIS

As an applied example of the measurements with the TR9407, this section describes modal analysis of the swing arm in combination with the TQ88091.

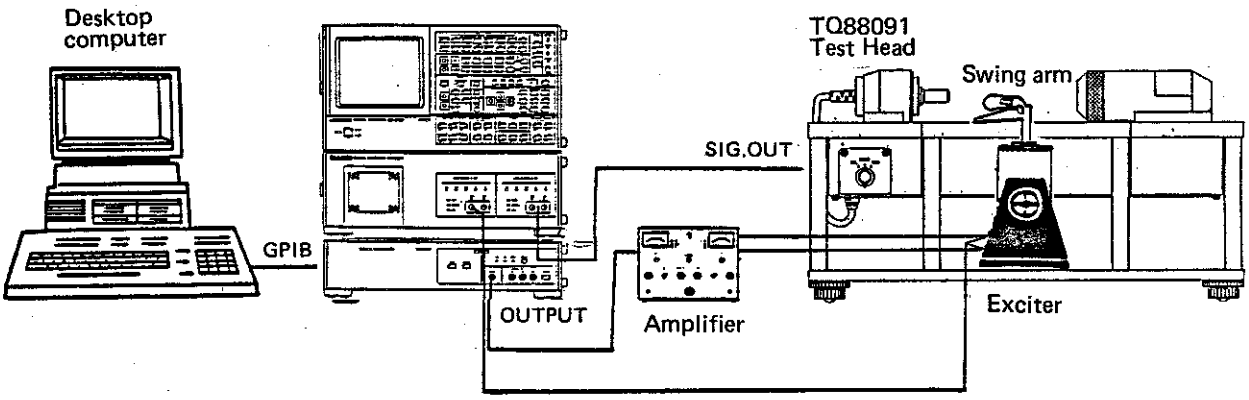


Figure 4-22 Connection of Equipment

Note: In setting up the system, be sure to use the differential input method for the TR9407 channel B. Also, do not mistake the polarities of the exciter and channel B.

(1) General procedure for measurement

① You expose the paper sealed on the arm edge to the optical beam to measure the magnitude of displacement of the swing arm. To do this, first confirm that the paper has no influence on the measurement.
② Next, measure the transfer function at each test point on the arm delimited into equal interval segments. Note that the transfer function of the reference point at which the swing arm vibration is the least should also be measured. Then, store the test results on the floppy disk using ORIGIN mode.
③ Set up the coordinate points according to the scale of the test points, and enter the display sequence to the computer.
④ Store the reference point transfer function, and equalize it with each test point transfer function read out from the floppy disk.
⑤ Enter these data to the computer to perform modal analysis. For details, refer to the modal analysis reference manual.

4.5.1 Measurement of Transfer Function of Paper

Check the frequency response of the paper (the aluminum foil label is useful) to be used for the measurement of the swing arm displacement to confirm that it is flat.

(1) Fixing the arm to the exciter
Pick out the section of arm of the least vibration as a reference point, and fix it to the exciter. Move the fixed section (reference point) to be left in the beam.

(2) Measure the transfer function of the reference point and store it on the floppy disk with the WRITE MODE:ORIGIN (See Figure 4-23.)

$$\langle Hab \rangle = \frac{\text{Exciter vibration (displacement)}}{\text{Input to exciter}} \quad \text{----------} \quad (1)$$

```
I/O SELECT
  FLOPPY

FLOPPY MODE
  READ         *
=> WRITE
  EDIT
  CATALOGUE

DISPLAY SOURCE
  FLOPPY       *
  PANEL

DATA OUT
  CRT

OVERLAY NUMBER
  0
```

Figure 4-23 Floppy WRITE Menu

(3) Attach the paper to the edge of the fixed point of the arm. Seal it at a suitable position where it blocks 50% of the beam in the focus direction. (Figure 4-17)

(4) Measure the transfer function of paper, and store the result to the floppy disk.

$$\langle Hab \rangle = \frac{\text{Paper vibration (displacement)}}{\text{Input to exciter}} \quad \text{----------} \quad (2)$$

(5) Read the reference point transfer function from the floppy disk to store the value to the analyzer memory.

(6) Read the transfer function of paper from the floppy disk.

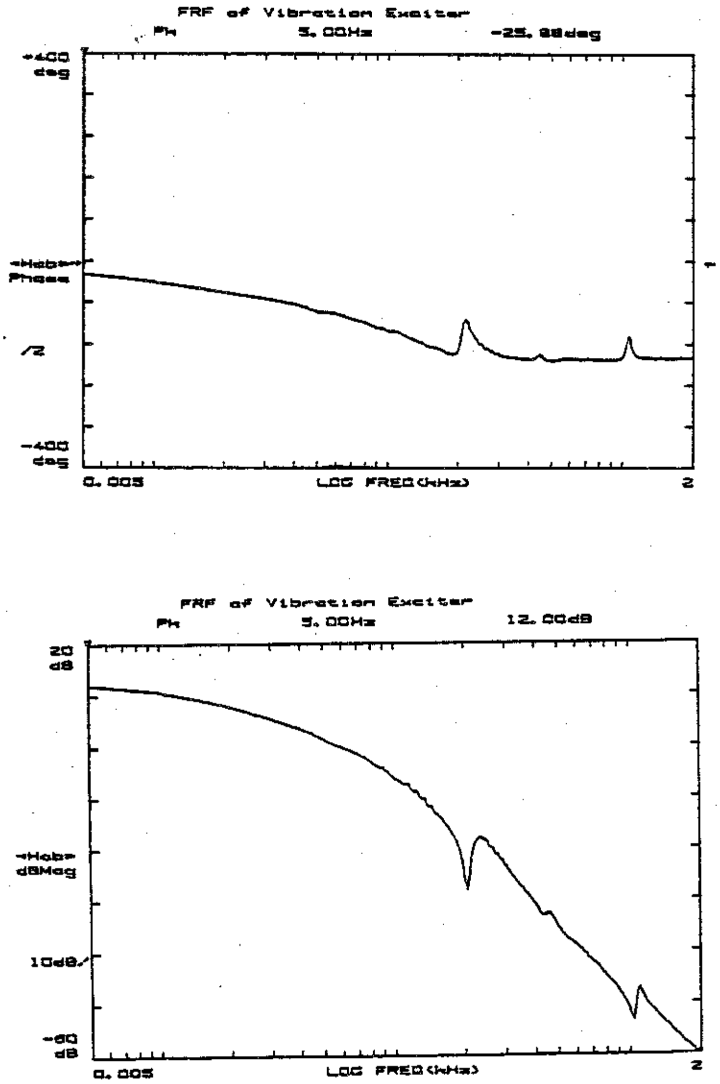


Figure 4-24 Transfer Function of Exciter

7. Display the menu by pressing the FUNCTION key. Then, set EQUALIZE function from OFF to ON with the SETUP key. This equalized transfer function corresponds to the following equations:

$$\langle Hab \rangle = \frac{\text{Equation (2)}}{\text{Equation (1)}} = \frac{\text{Paper displacement}}{\text{Input to exciter}} \Big/ \frac{\text{Exciter displacement}}{\text{Input to exciter}}$$
$$= \frac{\text{Paper displacement}}{\text{Exciter displacement}}$$

With these equations, only the characteristics of paper (removing the influence from the exciter) can be obtained as illustrated in Figure 4-26. $\langle Hxy \rangle^{e}$ in the leftmost position of the figure indicates that transfer function is being equalized. Figure 4-26 shows the paper characteristics is almost flat.
Use lighter paper with strong adhesive capability.

In normal measurement using an exciter and an accelerometer, data may fluctuate according to how the accelerometer is installed. This fluctuation may cause unreliable measurement result. This method, on the other hand, using paper lighter than accelerometer, enhances reliability on top of high precision of the TQ88091.

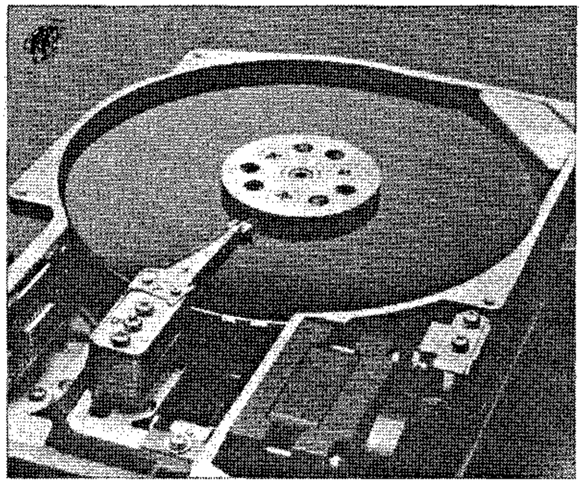


Figure 4-25 Magnetic Disk Swing Arm

NOTE

Analysis resolution in Modal analysis uses 400 lines. Set the ANALYSIS LINE: NORMAL to set the servo menu.

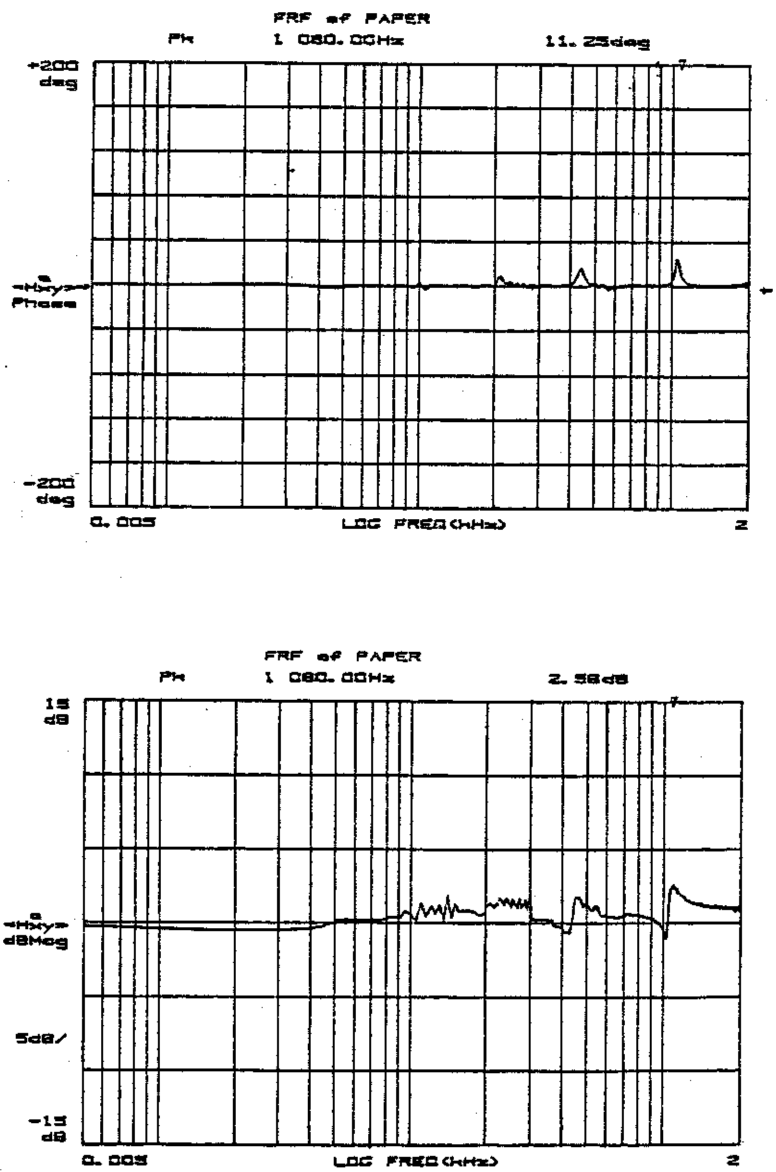


Figure 4-26 Frequency Response of Paper

4.5.2 Measurement of Displacement at Each Point on the Arm

(1) Marking a scale
To set the coordinate for the object to be tested, modal analysis requires data to be read at equal intervals. Therefore, mark the arm at equal intervals (1 cm in this example) to seal paper on each point before measuring the transfer function in order.

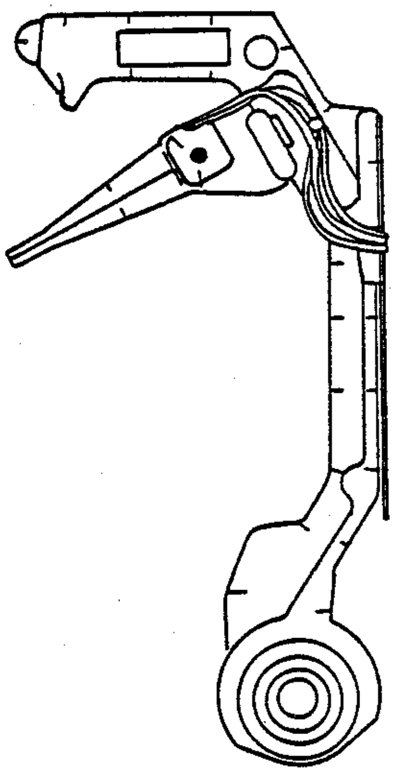


Figure 4-27 Notching the Arm (Actual Size)

(2) Measurement at test point
First, check the whole transfer function, and adjust the signal generator output amplitude if necessary. Second, observe the spectrum of output spectrum Gbb to set the appropriate amplitude in the signal generator menu to prevent burial of signal in noise. Use the signal sequence at the most complicated configuration of trace. Store the data on the floppy disk at each test point. For a reliable data acquisition to the floppy disk, press the WRITE key twice to obtain two screens of data.

(3) Setting signal sequence

Figure 4-28 illustrates the swing arm magnetic head characteristics. Signal sequence in this example divides the frequency band into four regions of A, B, C, and D. Each region is tested on different conditions.

After setting the conditions with each menu (a) through (d), set the pointer (⇨) to SEQUENCE in the bottom line, and press each key A through D. This setting stores the signal sequence to the sequence file as shown in (e). Conversely by setting the pointer to SEQUENCE and, for example pressing the PANEL RECALL key and A (AVG MODE key), the signal sequence from the sequence file A is recalled.

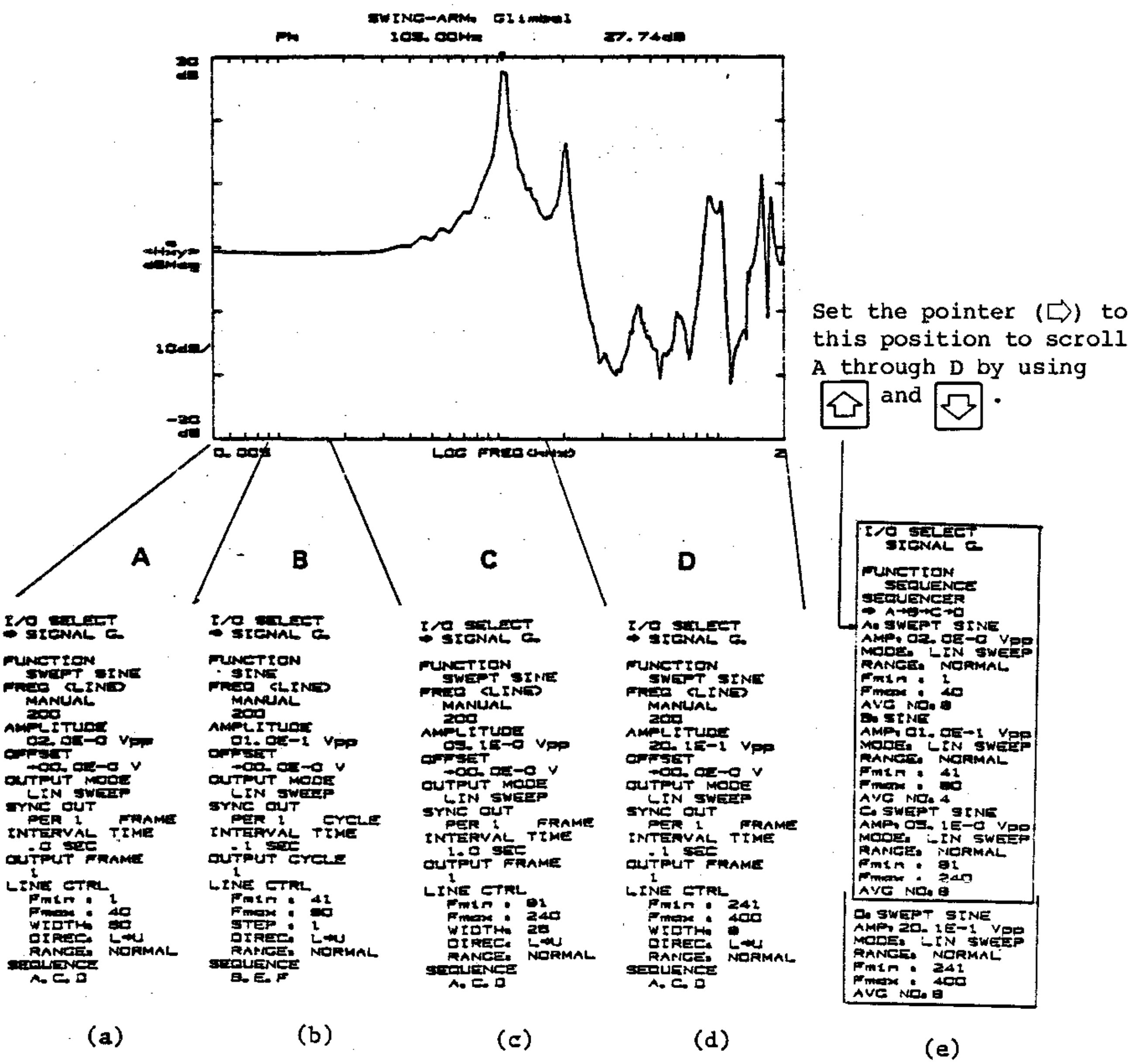


Figure 4-28 Setup Example of Signal Sequence

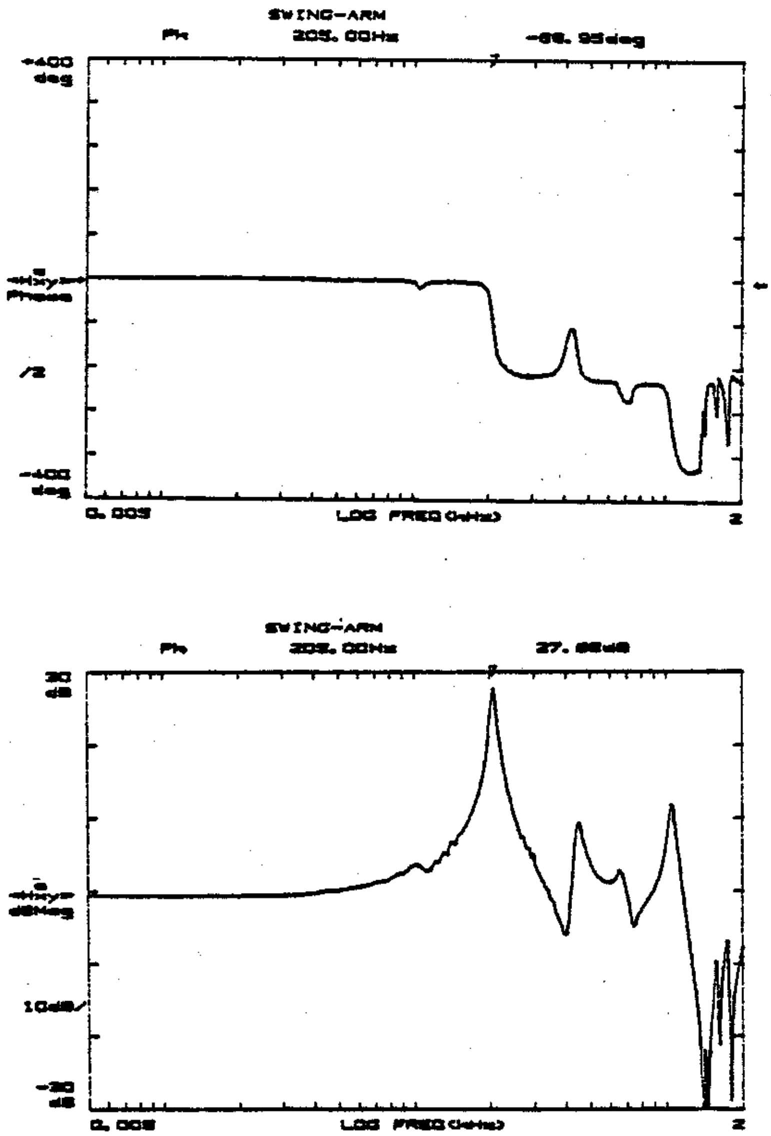


Figure 4-29 Characteristics of a Swing Arm Tip

4.5.3 Modal Analysis

Modal analysis is performed after each test point data on the arm is stored on the floppy disk. The data is analyzed on the desk-top computer using MODAL 3.0 software.

Enter CHART in the desk-top computer to display the procedural menu. Press ENTER in order from top to bottom for each row to execute the = marked items as follows.

(1) Determine the coordinate of each measurement point and input the data into the desk-top computer.

(2) Define and input the display sequence for the measurement points referred to in the above.

(3) Equalizing each measurement point data with reference point data
To remove the influence of the exciter from the test results for each measurement point data, equalize the data recalled from the floppy disk. Note that no equalized data can be stored on the floppy disk.

① Read the reference point transfer function data, and then store it to the analyzer memory.
② Set the DISPLAY SOURCE of floppy READ menu to PANEL. Setting conditions at the time of reproduction are made to conform to the panel setting conditions at the time of reproduction.
Since input sensitivities (SENS.A, SENS.B) have been cancelled with the equalize function, set both channels A and B to 0 dB.

(4) Perform analysis on the computer

① Transfer data from the analyzer to the computer.
② Curve-fit the transfer function.
③ Perform animation display for the swing arm mode shape.

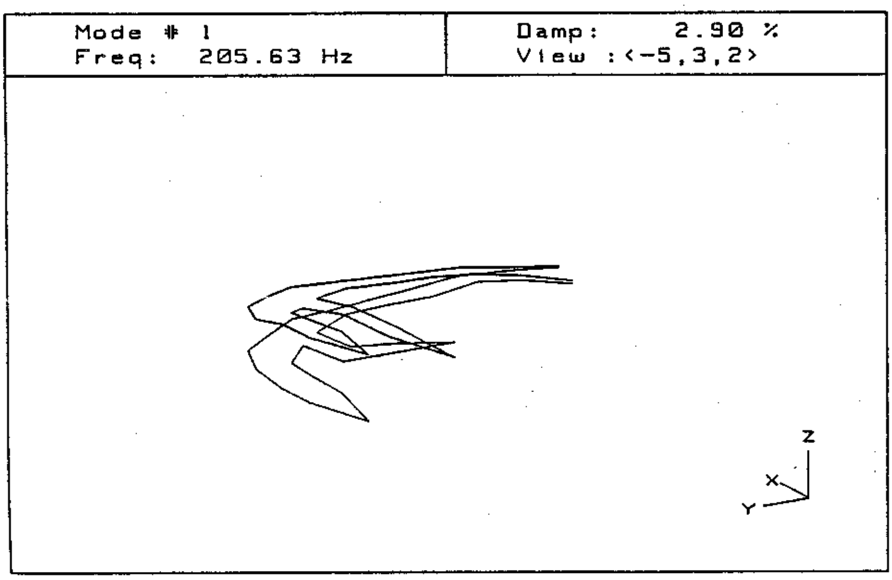
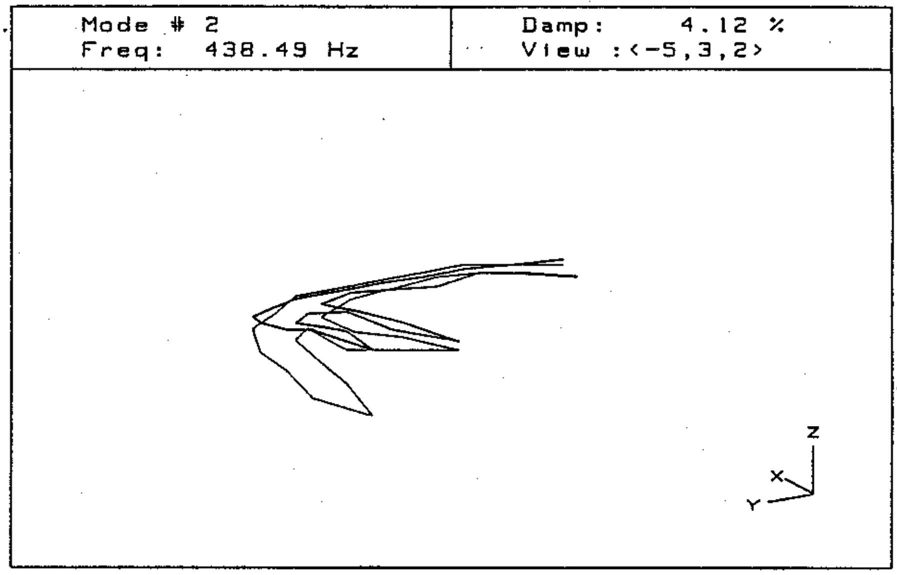


Figure 4-30 Mode Shape of Swing Arm (Animation Display) (1)



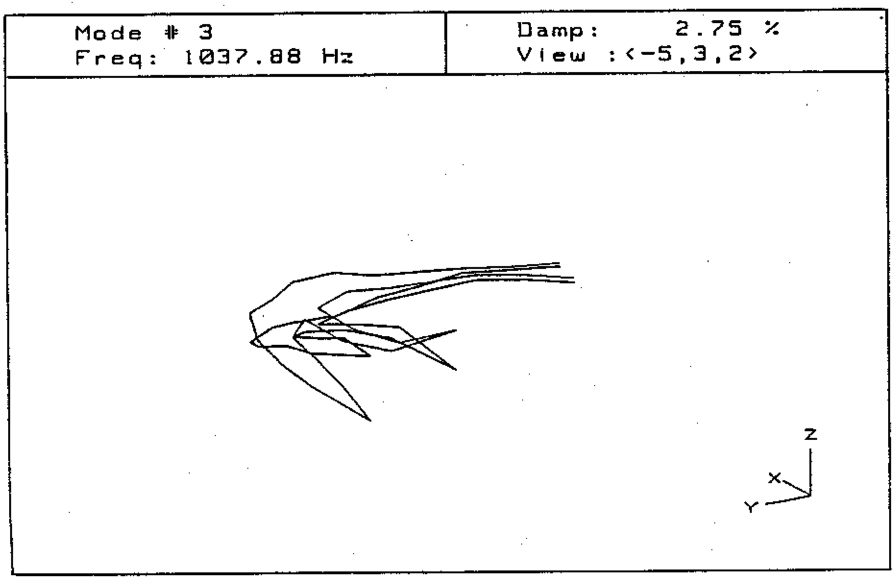


Figure 4-31 Mode Shape of Swing Arm (Animation Display) (2)

4.6 ACOUSTIC INTENSITY

Acoustic intensity is the vector quantity indicating the magnitude of energy and direction of the sound that passes through the unit area at the specified place within the unit time. It is expressed by the time average obtained from (acoustic pressure) x (particle velocity). The acoustic pressure can be measured with ease; however, it is difficult to measure the particle (air) velocity. With the progress in digital conversion technology and availability of high-precision microphones, employment of fast Fourier transform (FFT) realized approximate acoustic intensity to be obtained from the imaginary part of the cross spectrum. That is, analysis using an FFT analyzer and dedicated software are enabled without using unique equipment. Refer to "Acoustic Intensity Analysis Software Manual" for further details.

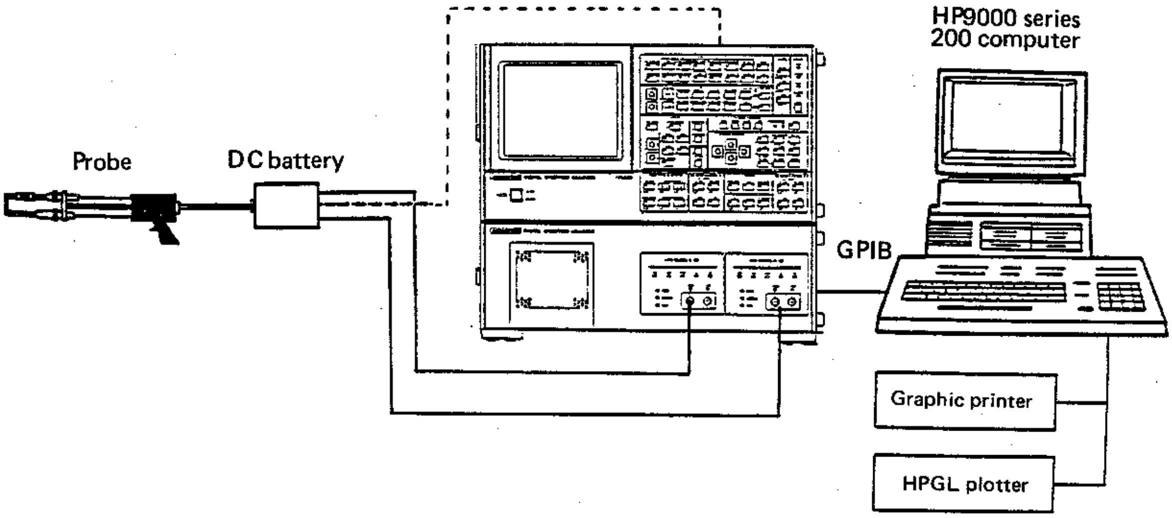


Figure 4-32 Setup for Measuring Acoustic Intensity

4.6.1 Measurement Procedure

(1) Setting measurement conditions with the computer
Store the following conditions in the computer tables.

(a) Creating a SYSTEM table
Set the GPIB addresses for the FFT analyzer, plotter, and printer.

(b) Creating a MIC table
Specify the types, sensitivities, and spacer length of two microphones.

(c) Creating a MESH table
Specify the numbers of mesh points arranged in X- and Y-directions on the acoustic intensity measuring plane, the width and length of each mesh (Δx and Δy in Figure 4-33), and the measurement direction (X, Y or Z).

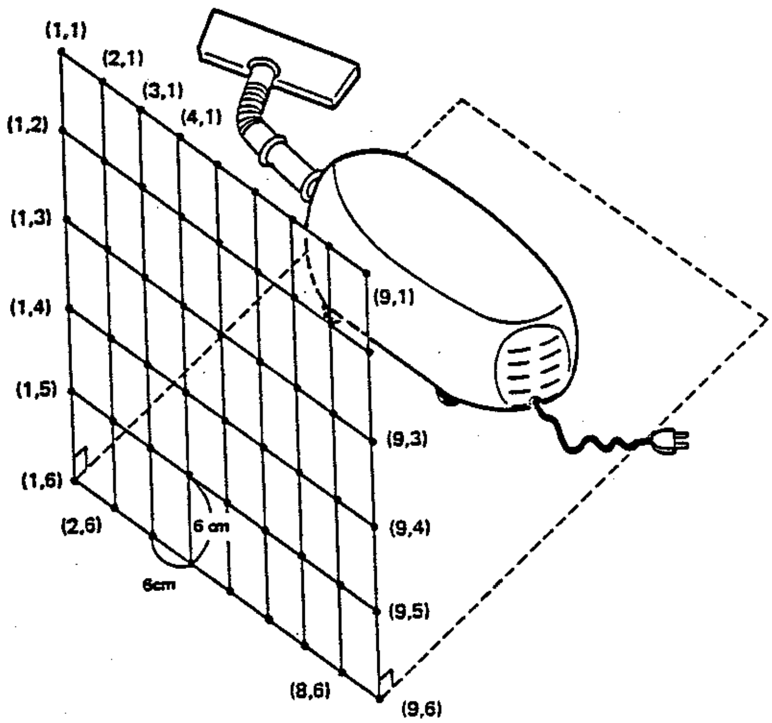


Figure 4-33 Measuring Acoustic Intensity of Electric Cleaner

(2) Determining the mesh size (n x m)
Specify the number of meshes (9 x 6 in Figure 4-33) and the size of each mesh (6 cm x 6 cm in Figure 4-33).

(3) FREQUENCY Setting the Frequency range

The relationships between frequency ranges, microphone sizes (inch), and spacer lengths (cm) are listed in the following table. Select the optimum microphone.

Table 4-1 Frequency Range, Microphone Sizes, and Spacer Lengths

Frequency range (Hz)	Microphone size (inches)	Spacer length (cm)
200 - 10 k	1/4	0.6
100 - 5 k	1/4	1.2
100 - 5 k	1/2	1.2
20 - 1 k	1/2	5

FREQ RANGE
SAMP CLK
INT #
EXT
⇨ 1 MHz #
500 kHz
200
100
50
20
10
5
2
1
500 Hz
200
100
50
20
10
5
2
1
FRAME TIME
400 µSEC

(4) TIME SENS. A , and SENS. B Setting input sensitivities.

The outputs from the microphones are connected to channels A and B of the FFT analyzer. Display two pieces of time domain data (Xa and Xb) of channels A and B on the dual screen and set up the input sensitivities.
Slowly move microphones over all measuring points (shown in Figure 4-33) to set optimum sensitivities that will not cause overload.

SENSITIVITY
MAX INPUT
A: ± 44.7 V
B: ± 44.7 V

CH-B
NORMAL B#
INVERT

ACTIVATE

AUTO
(dBV)
⇨ +30 B#
+20
+10
0
-10
-20
-30
-40
-50
-60

(5) [AVG MODE] Setting the Average number

```
AVG MODE
➡ SUM (N)   #
  SUM (L)
  DIFF
  EXP
  PEAK
  SUM (T)
AVG WHAT ?
  CROSS+POWER
AVG NUMBER
  2
AVG CHANNEL
  CH-A
  CH-B
  DUAL
  CROSS    #
AVG PROCESS
  NORMAL
  +1 AVG
  SWEEP    #
OVERLAP
  0 %      #
  50%
DISPLAY
  ALL      #
  1/2
  END
```

(6) Measurement of the intensity distribution

① Insert the floppy disk (for storing the measurement data) in the disk drive selected as a data disk, then enter the measurement execution command MEASURE (which can be abbreviated as MES) from the keyboard.

MES/INT/KEY filename [ENTER]

- /KEY — Start measurement with the key on the computer keyboard or FFT analyzer. (If this qualifier is not specified, measurement will be started with the trigger switch on the microphone probe.)
- /INT — Measurement of intensity (= INTENS)

② Executing measurement
Place two microphones at right angles to the measuring plane.

(a) Press the key on the computer keyboard (softkey K5 for start) or the [START] (average start) of the FFT analyzer (when /KEY is specified).

(b) Press the trigger switch on the microphone probe (when /KEY is not specified).

Start measurement with either of the above methods and repeat measurement for all measuring points.

Upon completion of measurement at all measuring points, press the soft key K9 (for exit) on the computer keyboard to exit from the measurement mode. From the measurement data, a contour, intensity ratio, vector, and three-dimensional (3D) maps can be displayed.

CONTOUR MAP

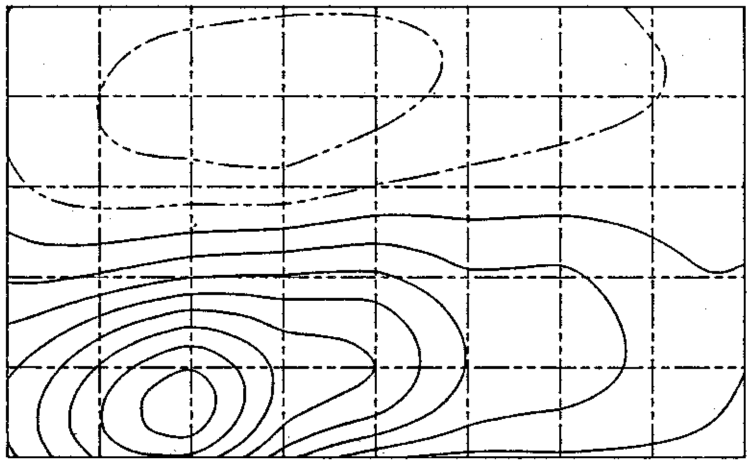


Figure 4-34 Contour Map Display (sound source: electric cleaner)

MESH MAP

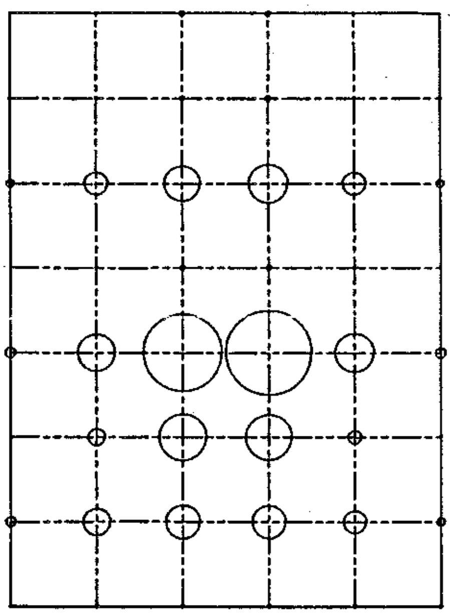


Figure 4-35 Intensity Ratio Represented by Circles (sound source: speaker)

VECTOR MAP

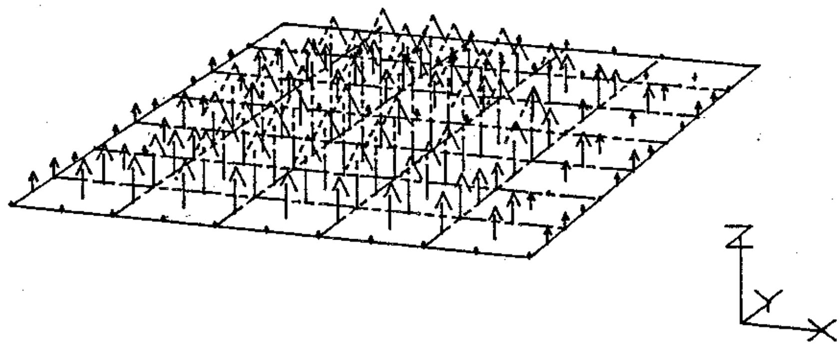


Figure 4-36 Vector Display (interpolated once)

VECTOR MAP

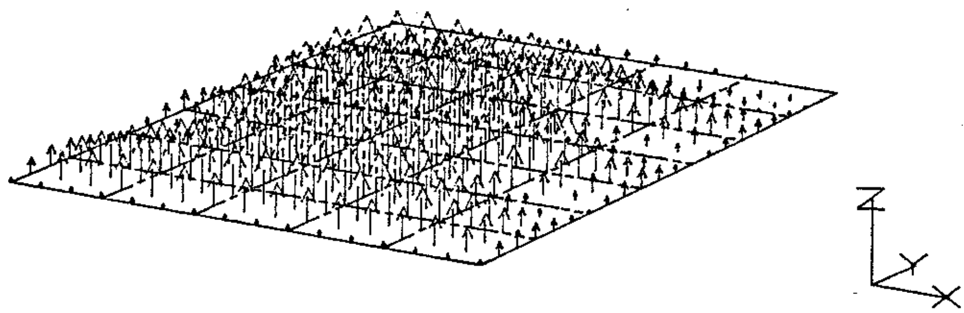


Figure 4-37 Vector Display (interpolated twice)

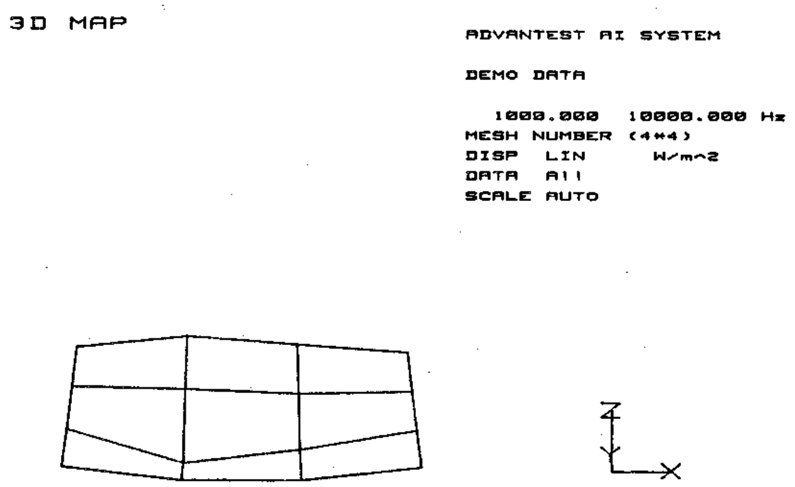


Figure 4-38 3D Display before Viewpoint Change (annotation display)

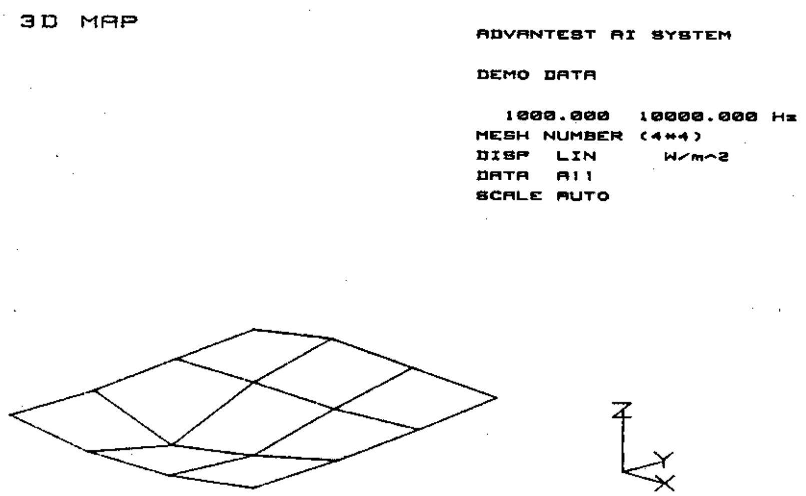
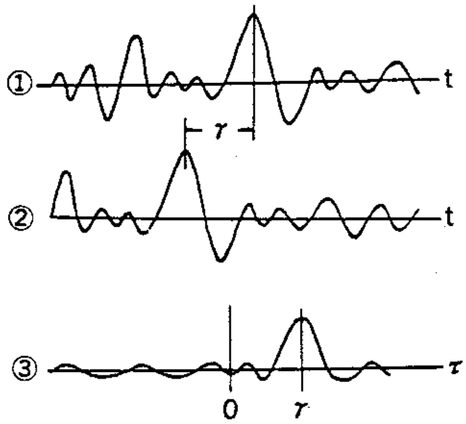


Figure 4-39 3D Display After Viewpoint Change
(45° rotation with reference to Z-axis)

4.7 TIME DELAY MEASUREMENT BASED ON CROSS-CORRELATION FUNCTION AND IMPULSE RESPONSE

The cross-correlation function provides time delay between input and output for the measurement of relationship and causality.

For the special case where input = output, the cross-correlation function is equivalent to autocorrelation function. Typically, the argument τ that maximizes cross-correlation function provides an estimate of time delay. Suppose the two signals are uncorrelated with each other, then the cross-correlation function nears zero. The impulse response is given by the inverse Fourier transform of the transfer function and linear time-invariant system is completely characterized by its impulse response.



1 2 : Input signal
3 : Cross-correlation function

Improved resolution of correlation peaks can often be achieved by using an impulse response measurement rather than direct cross-correlation analysis especially in multiple path problems, where input signal can propagate through several possible paths to yield an output signal.

① 

AC coupling is preferable for cross-correlation measurement.

② 

(Press this key to make cross-correlation measurement.)

(Press this key to make impulse response measurement.)

③ 

AVG WHAT?: CROSS-CORR (for cross-correlation)
AVG WHAT?: CROSS + POWER (for impulse response)

④ 

Start averaging.

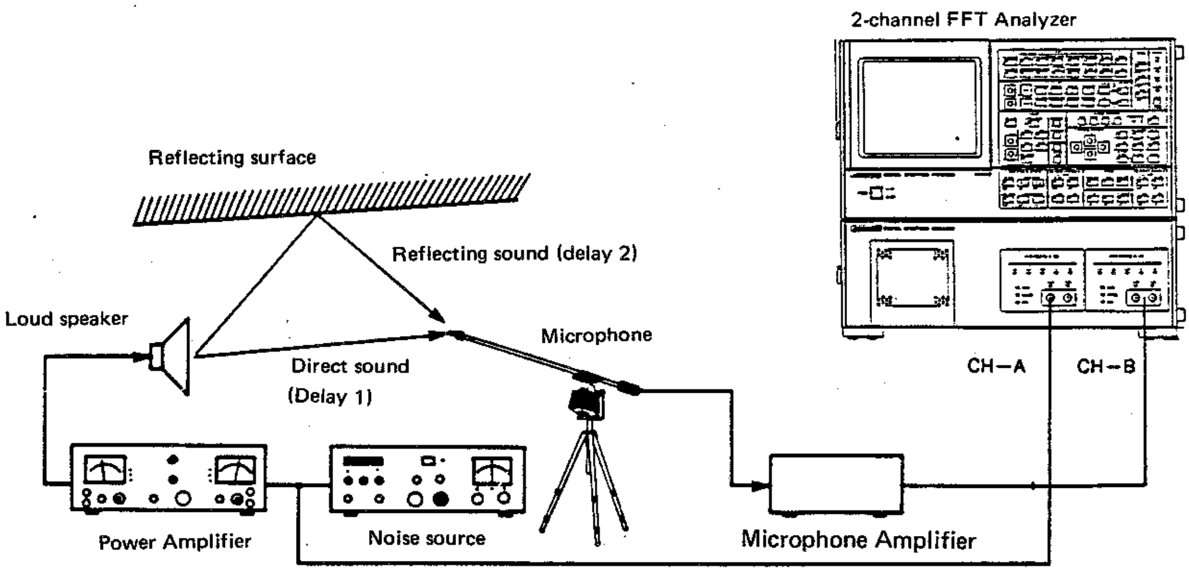


Figure 4-40 Time-Delay Measurement of Two Signals

Cross-correlation function for time delay measurement (AVG WHAT: CROSS-CORRELATION; number of averages: 64) (Two correlation peaks at 5.859 ms and 28.125 ms are observed. SET REF. was used.)

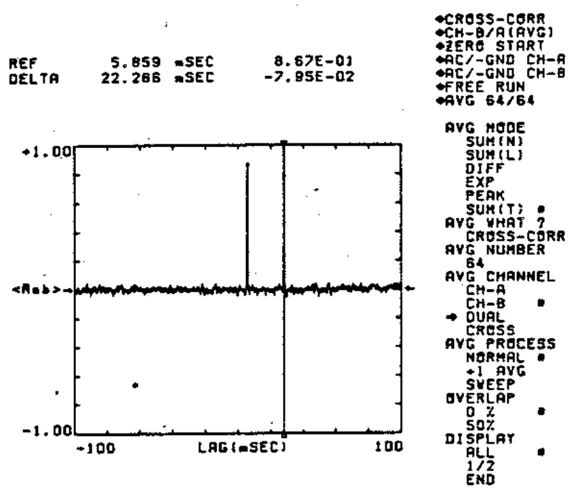


Figure 4-41 Time Delay Measurement by Cross-Correlation Function

Impulse response for time delay measurement (AVGWHAT: CROSS + POWER CORR; number of average: 64) It can be seen that the characteristic obtained is the same as that measured by the cross-correlation function, but the averages are normalized in the impulse response measurement.)

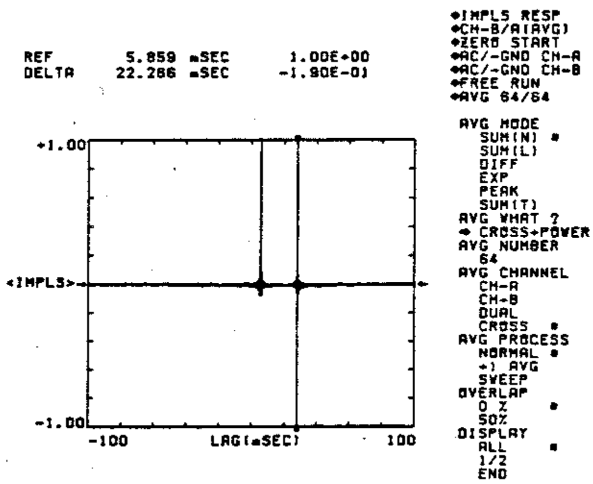


Figure 4-42 Time Delay Measurement by Impulse Response

TABLE OF CONTENTS

5. 1-CHANNEL MEASUREMENTS

5.1 ACOUSTIC EMISSION

5.1.1 General

Generally, a non-destructive inspection method is used as an effective means for assuring safety of a construction. Typical non-destructive inspection methods are: acoustic emission (AE) and ultrasonic inspection methods.

When a substance is deformed or destroyed, the internal breakage produces energy and elastic (ultrasonic) waves. The AE method is a dynamic passive inspection method, that is, the elastic waves are received with a sensor to detect the destruction itself.

Conversely, the ultrasonic inspection is a static active inspection method, that is, ultrasonic waves are sent into the material and reflected waves are received.

The advantage of the AE method is that the dynamic change of microscopic crack inside the substance can be detected instantaneously (real-time). The AE method is the only method available.

5.1.2 Setting Up for Measurement

(1) Mounting a pulser and AE sensor

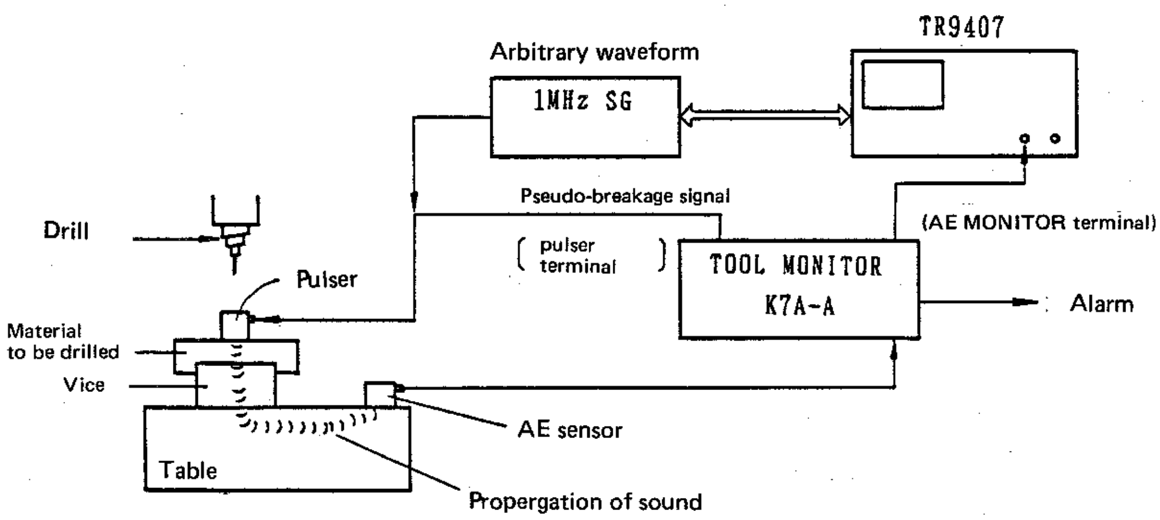


Figure 5-1 Setting Up the Monitor for Drilling

If the inside of a drill is abnormal on drilling a substance, a frequency different from that during drilling is generated. Ideal pseudo-breakage sound to be fed into a pulser is made available by feeding the AE wave monitored on the FFT analyzer to the 1 MHz arbitrary wave generator.

1. Attach the pulser to the substance to be drilled.
2. Generate from the tool monitor a false signal whose level is set according to the drill gauge.

Drill gauge	Pulser level setup value
$\phi 1$	06
$\phi 2$	13
$\phi 3$	29

(No cutting oil)

3. Attach the AE sensor with a magnetic bracket where the breakage artificial sound from the pulser can be accurately detected, then finely adjust this position.
4. After the above adjustment, fix the AE sensor with dedicated screws. (Unless the AE sensor is fixed by a pressure greater than 4 kg, the contact impedance will increase.)

(2) Measuring frequency characteristics of the AE sensor
Measure the frequency characteristics of the AE sensor with the TR9407. Even if the frequency response is not flat, the original waveform of the AE can be obtained because the transfer function of the measurement system is cancelled for compensation.

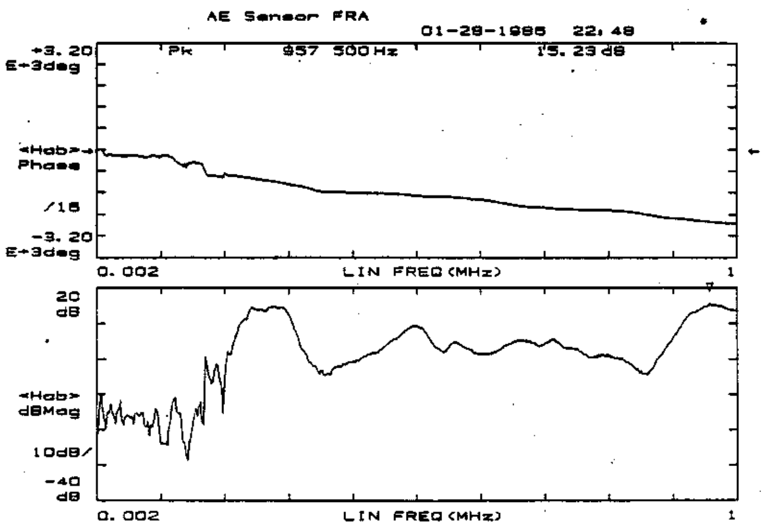


Figure 5-2 AE Sensor Frequency Characteristics

(3) Setting the tool monitor sensitivity

1. Adjust the amplifier gain with the SENSITIVITY switch of the tool monitor so that the damping of AE sound can be detected accurately (while observing the AE MONITOR level indicator lamp).

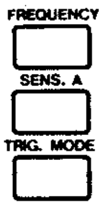
   Note: When two or more types of drill gauges are used, do not change the AE sensor mounting position. Use the AE SENSITIVITY switch.
   The AE SENSITIVITY switch accurately reamplifies the elastic wave signal at drill breakage or pulser signal which damp as passing through the material being cut, the vice, and table in that order.

2. After the above settings, remove the pulser from the material to be cut, then start drilling.

5.1.3 Analyzing AE Waveform in Time Domain

In the 1-channel measurement mode (Select DEACTIVATE instead of ACTIVATE on the SENSITIVITY menu), the TR9407 has a 512K-word memory and the AE signal can be continuously measured for about 20 ms.

(1) Setting trigger conditions



Set the frequency range to 1 MHz (frame time = 0.4 ms).

-20 dBV range (depending on the actual trigger level)

ARM MODE: ADVANCE
ARM LENGTH: 64K or more (128K or 256K)
BLOCK NUMBER: Depends on the ARM LENGTH.

ARM LENGTH	CH-A (256K)	CH-B (256K)	CH-A or B (512K)
8K or less	0-31 blocks	0-31 blocks	0-31 blocks
16K	0-15	0-15	0-31
32K	0-7	0-7	0-15
64K	0-3	0-3	0-7
128K	0,1	0,1	0-3
256K	0	0	0,1
512K			0

C (↔)
C (↕)

Activate vertical and horizontal cursors, and move them to the trigger point to be set using the yellow arrow keys in the general cursor section, then press the [SET X].

SET: TRIGGER will be displayed for confirmation.

AUTO ARM

On completion of the above settings, start drilling.

When the incoming signal meets the trigger conditions, the data displayed on the screen is held ([HOLD/REL.]).

(The data has been stored in the buffer memory, so the screen data will not change if the input cable is disconnected)

(2) Compressed display of time data

BOTH — Select the dual screen mode.

UPPER /LOWER — TIME — Display the same data on the upper screen as the held data on the lower screen.

DISPLAY CTL — RESAMPLING: Set the UNIFORM.

UPPER /LOWER — Display the time-compressed data on the lower screen. This technique allows the display of not only one frame but the entire memory.

ON/OFF — (ZOOM)

Every time this key is pressed, ↓/2, ↓/4, ↓/8..., and ↓/256 are displayed on the bottom of the screen and the time axis is decimated to expand the display range. /2 indicates that sampling is carried out every 2 points (of 1024 points) in the 2-channel mode. /4 indicates that sampling is carried out every 4 points.
The upper screen in Figure 5-3 shows ordinary waveforms, and the lower the decimated waveforms.

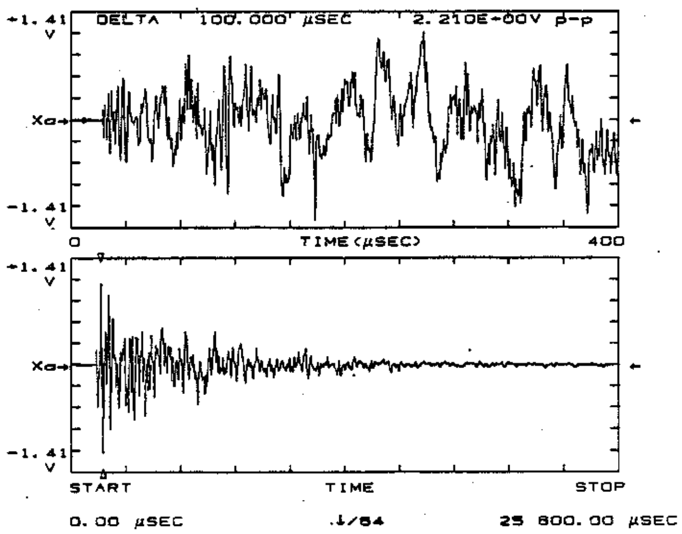
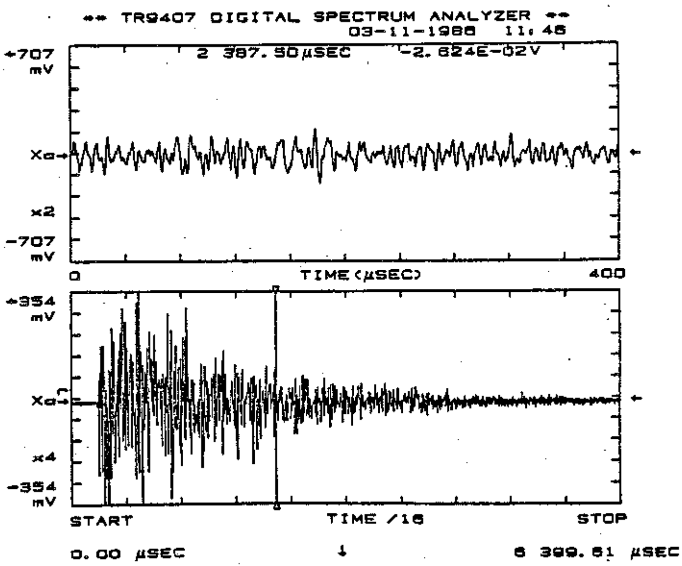


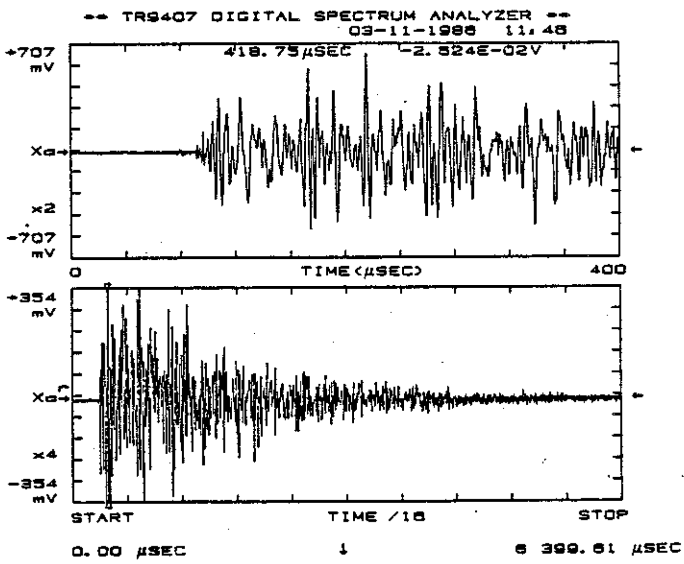
Figure 5-3 Compressed Display of Time Data

UPPER /LOWER — C (↔) — Display a vertical cursor on the lower screen and move it with yellow keys or . The upper waveform corresponding to the cursor position also moves. Thus, the waveforms of interest can be found in the whole AE wafeforms.



← The entire time data is not grasped from this display.

← Time-compressed display by sampling 1 point out of every 16 points (of 1024 points).



The waveforms equivalent to 1K words on both sides of the lower cursor are displayed in the upper screen. Decimated data will be annotated with "r" (resampled) at the extreme left of the CRT display.

Figure 5-4 Exaplanation of Time Data Compression

Select the ZOOM OFF mode and press BOTH [■] (the LED goes off). Then, the time data will be displayed on a single screen. Since this data is stored in the memory (HOLD/REL [■]) , a spectrum is displayed simply by pressing SPECTRUM [□] with a Fourier transform.

CAUTION

The data held at triggering must be saved on a floppy disk or output to a plotter because pressing the [HOLD/REL.] (the LED goes off) will destroy the displayed data and set the ordinary instant display mode.

5.1.4 Cepstral Analysis

The cepstrum is obtained as the logarithm of the power spectrum (Gaa) is inverse Fourier transformed. It can extract the fundamental frequency of the AE wave.

① Display the power spectrum whose cepstrum is to be obtained.

② [ADVANCED ANALYSIS] [PANEL RECALL] [AUTO-CORR. U] Display the cepstrum menu.

```
ADVANCED SELECT
➡ CEPSTRUM
  <DISABLE>

ANALYSIS CHAN
  CH-A          #
  CH-B
  DUAL
  VIEW
DOMAIN
  QUEFRENCY     #
  FREQUENCY
THRESHOLD
  OFF

  -774   dBFS
LIFTERING
  SHORTPASS     #
  LONGPASS
  MEMORY (A/B)

   0/511
```

③ [SETUP] or [DISP.] CEPSTRUM: Change <DISABLE> to <ENABLE>.

④ ANALYSIS CHAN: Select VIEW.

⑤ DOMAIN: Select QUEFRENCY (Ca or Caa display for cepstrum).
Select FREQUENCY to display the liftered spectrum (Gaa^{c})

⑥ Set the threshold for specifying the data to be used for the cepstrum.

[C (↔)] Move the cursor to the threshold setting position. (Set the level readout at the intersection with the waveform.)

[SET X] The above intersection is set.

[SETUP] SET: THRESHOLD is displayed.
THRESHOLD: Change OFF to ON.

If the power spectrum value at a given frequency is less than the threshold value set here, log (Gaa) = 0.

⑦ [EXECUTE] (adjacent to ADVANCED ANALYSIS key) Display the cepstrum data.

[REAL] (or [IMAG.]): Display the cepstrum.

[MAG.] : Display the power spectrum.

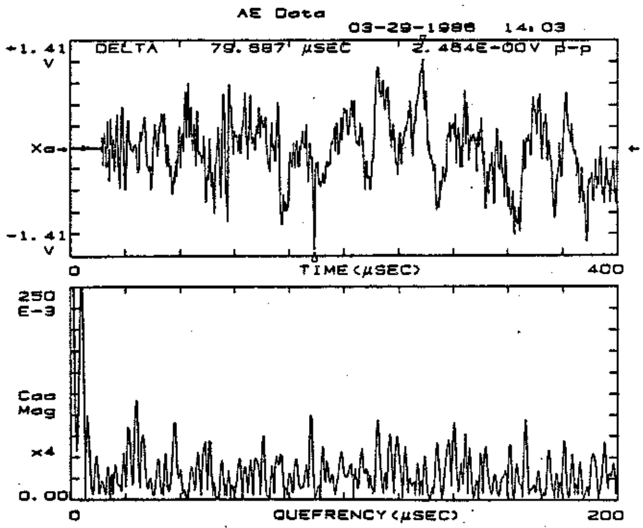


Figure 5-5 Cepstrum of AE Wave

(8) Lifter the cepstrum data to obtain the liftered spectrum G_{aa}^{c}

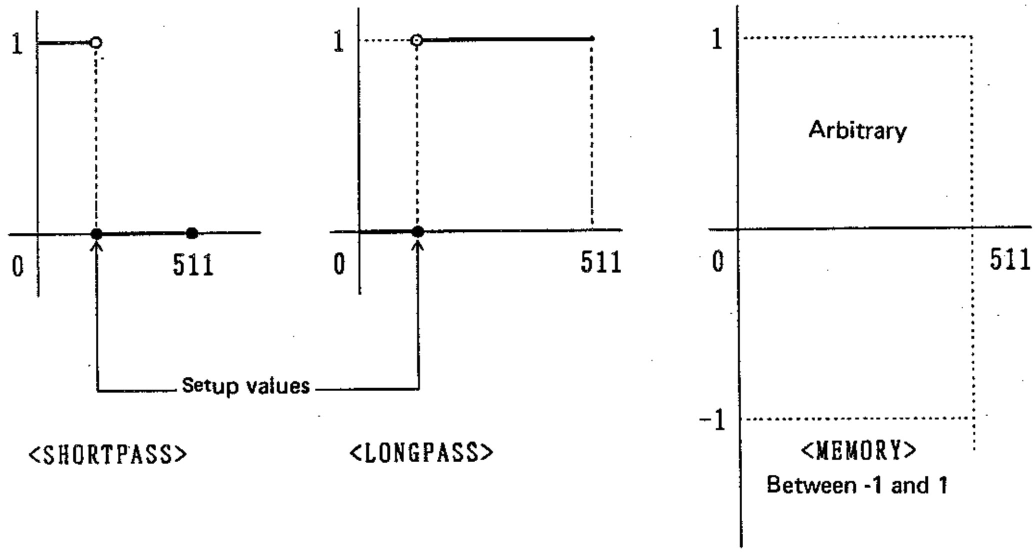
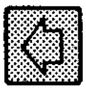
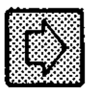


Figure 5-6 Lifter Types

Display the cepstrum (Ca) or power spectrum (Gaa), press the 

to display the vertical cursor, and move the cursor to the desired position by pressing  or , then press 

.

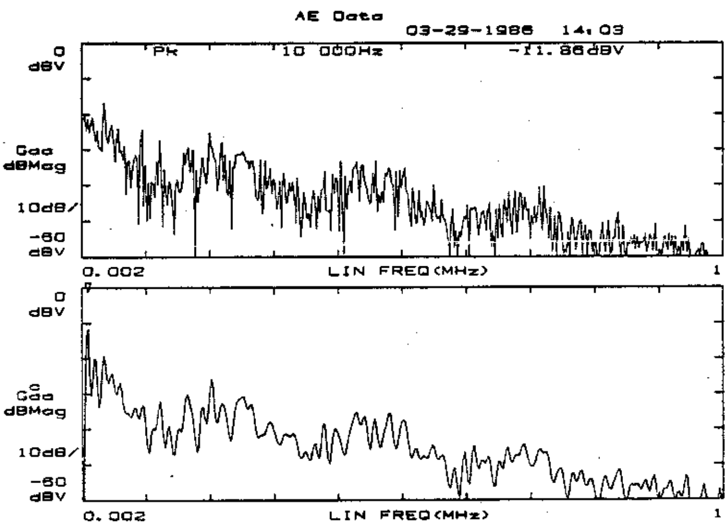


Figure 5-7 Liftered Spectrum of AE Waveform

5.1.5 Preenvelope Analysis

The AE energy damping time and the degree of energy concentration in the time domain can be known by obtaining the preenvelope of the AE waveform.

① Display the time data of the AE waveform whose preenvelope is to be obtained at the center of the screen. (Since the preenvelope is obtained from the central portion of the original time series data, trigger conditions be set up so that the waveform is displayed at the center of the screen, or select the dual screen mode and move the vertical cursor so that the waveform is displayed at the center of the compressed time data display screen.)

② Display the P-ENVELOPE menu.

ADVANCED ANALYSIS PANEL RECALL IMPUL. RESP.

```
ADVANCED SELECT
→ P-ENVELOPE
  <DISABLE>

ANALYSIS CHAN
  CH-A          #
  CH-B
  DUAL
  VIEW
DOMAIN
  TIME          #
  FREQUENCY
```

③ Press SETUP or DISP. to change DISABLE to ENABLE .

④ Set the analysis channel.
CH-A: Preenvelope of time data of channel A (Xa)
CH-B: Preenvelope fo time data of channel B (Xb)
DUAL: Preenvelopes of time data Xa and Xb of channels A and B (Xa, Xb)
VIEW: Preenvelope of displayed time data (In the dual screen mode, time data displayed on the lower screen)

⑤ Set the domain
TIME: Display the preenvelope.
FREQUENCY: Display the result of FFT of the preenvelope.

⑥ Display the preenvelope or the result of FFT

EXECUTE (Adjacent to ADVANCED ANALYSIS key)

DOMAIN: TIME is selected.
- REAL : Display the real part of the preenvelope.
- IMAG. : Display the imaginary part of the preenvelope.
- MAG. : Display the envelope.

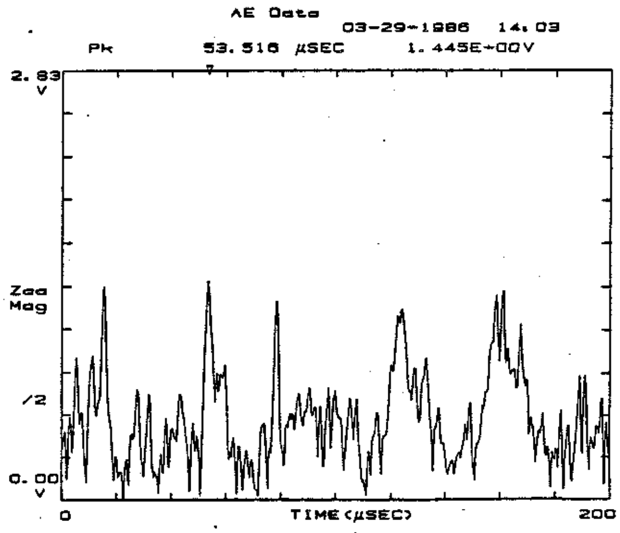


Figure 5-8 Preenvelope of AE Waveform

5.1.6 AE System Modeling and Original Waveform Analysis

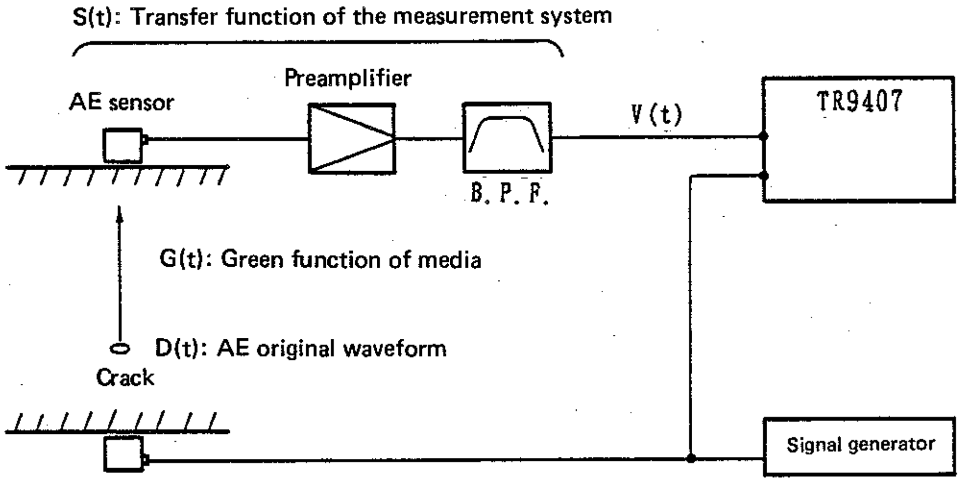


Figure 5-9 AE Measurement System Model

Measurement waveform V(t) is obtained from:
V(t) = D(t)*G(t)*S(t)
Therefore, AE original waveform D(t) can be obtained if the AE system transfer function, G(t)*S(t), can be measured.

① Output a simulated sound from the signal generator as a pseudo-sound source to measure the transfer function with the TR9407. The result is R(t).

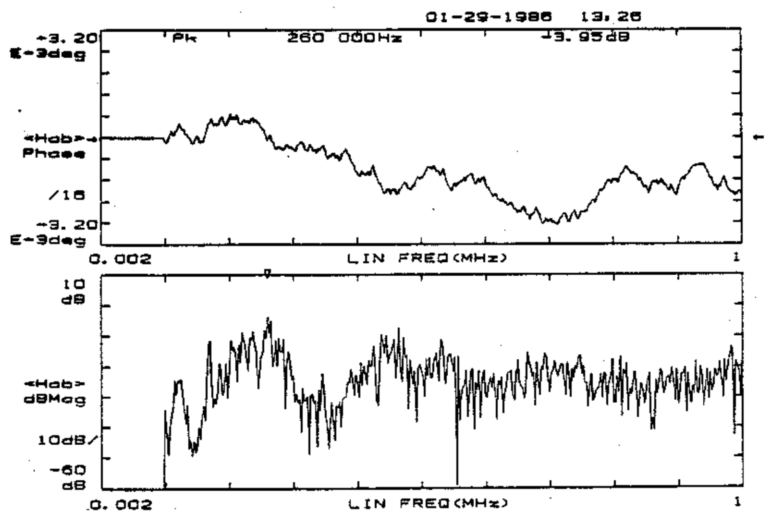


Figure 5-10 Transfer Function of AE System

(2) Obtain the complex spectrum (Sa) of the AE waveform V(t).

Xa → (FFT) → Sa

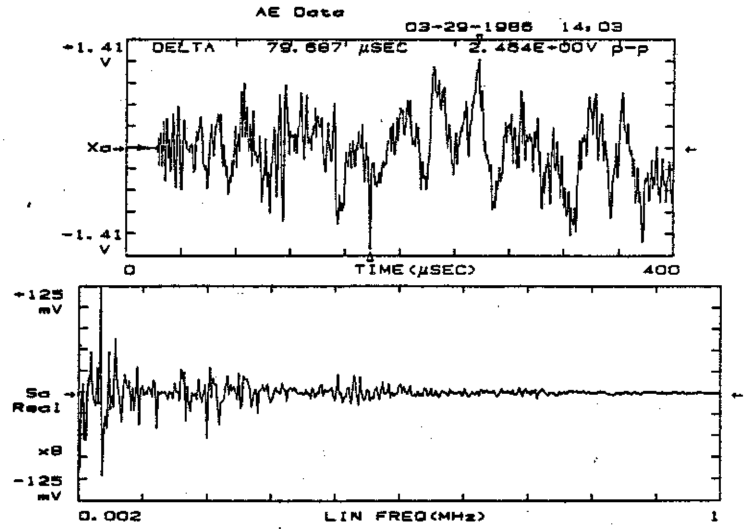


Figure 5-11 Complex Spectrum of AE Waveform

3. Select the dual display mode to display a complex spectrum in the upper screen, and the transfer function (see Figure 5-10) in the lower screen.

Press the FUNCTION key to obtain $\frac{V\ (t)}{R\ (t)}$ and select <U/L> in the FUNCTION menu.

Press the DISP. or SETUP and change FUNCTION OFF to FUNCTION ON.

Then, $\frac{V\ (t)}{R\ (t)}$ will be obtained and <Hab> at the vertical axis in the lower trace will change to Sx.

If $\frac{\text{TRANS.FCTN (upper)}}{\text{COMPLEX SPECT (lower)}}$ is tried, the operation is disabled.

$$Sa\ (f) = \frac{Sb\ (f)}{\langle Hab\rangle\ (f)} \Leftrightarrow Xa\ (t)$$

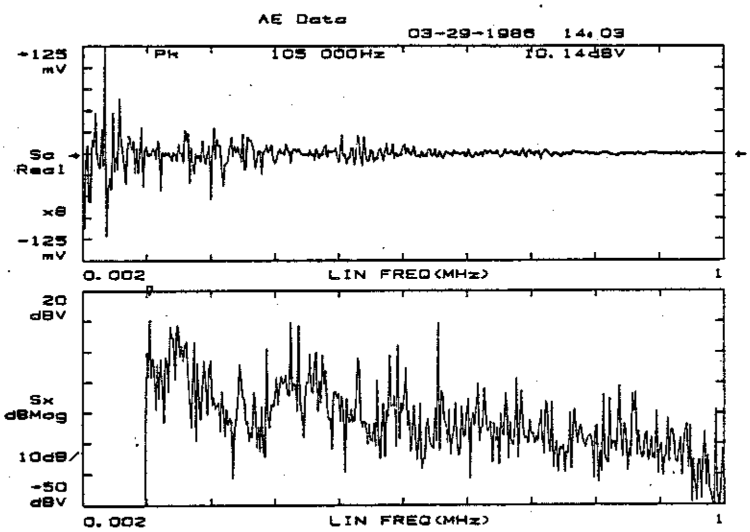


Figure 5-12 Result of Operation of $\frac{Sb}{\langle Hab\rangle}$

4) Perform inverse Fourier transform on the above result. Then, D (t) will be obtained.

In the TR9407, the result of inverse Fourier transform of memory recalled or averaged <Hab>, Sa, Sb, <Sa>, <Sb>, Gab, or <Gab> can be observed in the time domain.

DISPLAY CTL
[ ] Display the DISPLAY CTRL menu.

Move the pointer (⇨) to TIME, then press [SETUP].

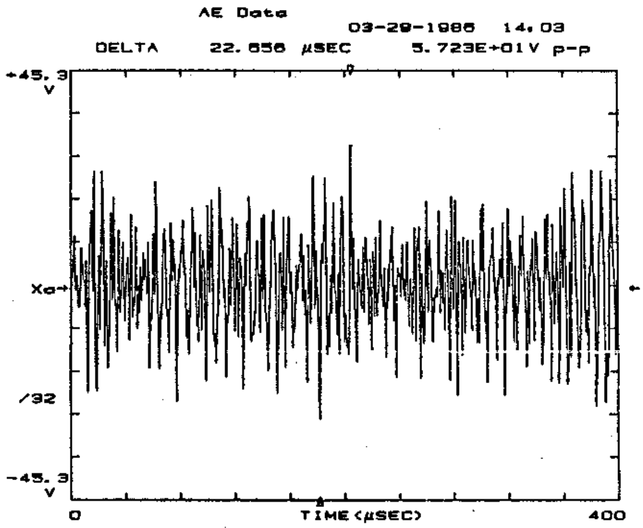


Figure 5-13 AE Original Waveform

5.2 MEASURING PILOT SIGNALS (8 mm VIDEO)

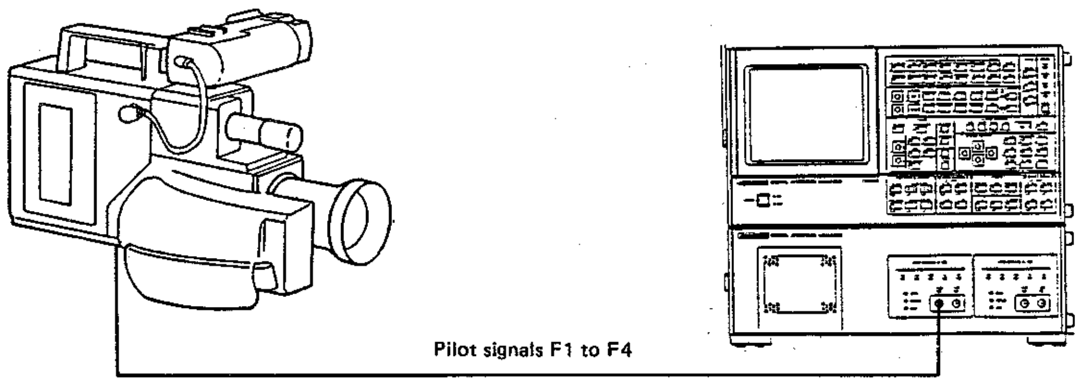


Figure 5-14 Measurement of 8 mm Video Pilot Signals

The surface of 8 mm video tape is divided into tracks as shown in Figure 5-15. Each track records a pilot signal, chromaticity signal, voice signal, brightness signal with multirecording frequencies.
Four pilot signals recorded on track are used to define the video track position. These four signals are sequentially multiplexed into the video signal (FM) and recorded in the order of f1 → f2 → f3 → f4 → f1 ...

The head covers three tracks. The power spectrum level difference sensed by the head is used to compensate the horizontal deviation of the head from the normal tracking position.

Since one track is equivalent to 1/60 second (approximately 17 ms), at least 8.5-frame (8.5K words in the 2-channel mode) continuous data are needed per track. Because the TR9407 has a 512K-word data memory in the 1-channel mode, it can record continuously signals of 60 tracks.

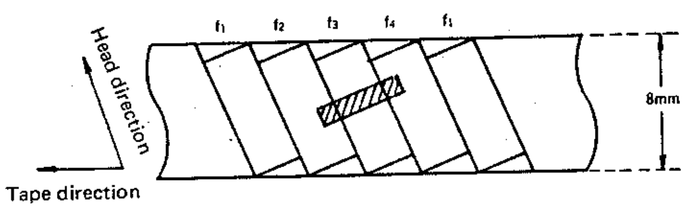


Figure 5-15 Pilot Signal Recording Pattern

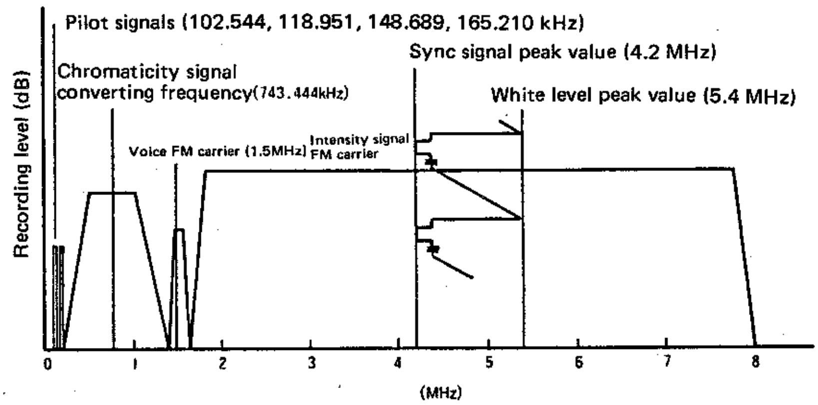


Figure 5-16 Multirecording Frequency Spectrum

① FREQUENCY — Frequency range: 200 kHz

SENS. A — Input sensitivity: -50 dBV

② Setting trigger conditions

TIME

C (↔) — Display the vertical cursor.

C (↕) — Display the horizontal cursor.

(←) (↑) (↓) (→) — Move the cursor to the trigger position.

SET X — SET: TRIGGER is displayed to indicate that the trigger position and trigger level have been set.

TRIG. MODE — Display the trigger condition setting menu. For LEVEL and POSITION, the states set by the cursor have already been set. (These states can also be set in this menu.)
ARM MODE: ADVANCE
ARM LENGTH: 1K

```
AUTO CAL
   ON
EXT GATE
   OFF

TRIGGER
SOURCE
   CH-A
SLOPE
   <+>
LEVEL
   +0.078 *FS
POSITION
   +200.00 %
BEEP ON TRIGGER
   OFF
MARKER
   OFF

ARM MODE
   NORMAL
ARM LENGTH
⇒ 256K
BLOCK NO.
    0
INTERCHAN DELAY
    0/1024
```

Each time incoming signal meets the trigger conditions, the 

LED goes on and data is fetched into data memory blocks 0-31.

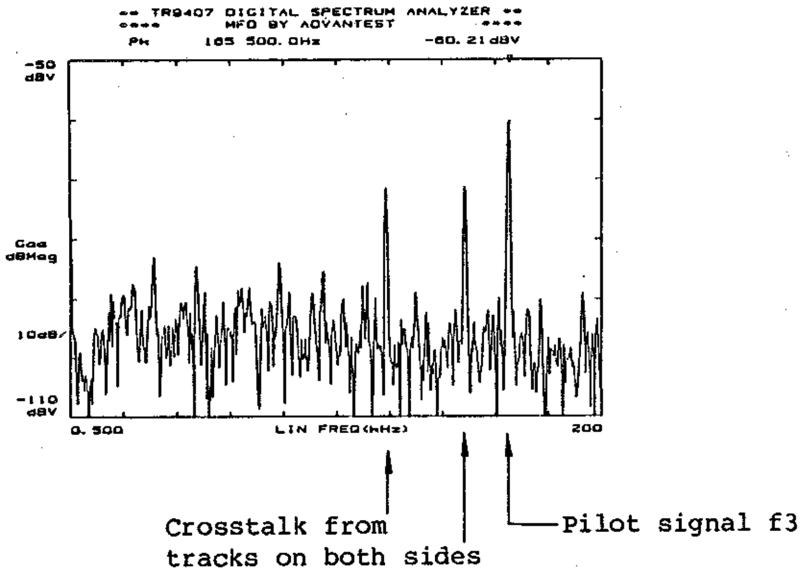


Figure 5-17 Pilot Signal

5.3 MEASUREMENT OF CROSSTALK

The crosstalk and noise of the communication line can be measured using the TR9407's 1-MHz measurement range. For the digital communication line, 300 kHz or less noise components are important. In the future, noise components up to 500-600 kHz range will be important.

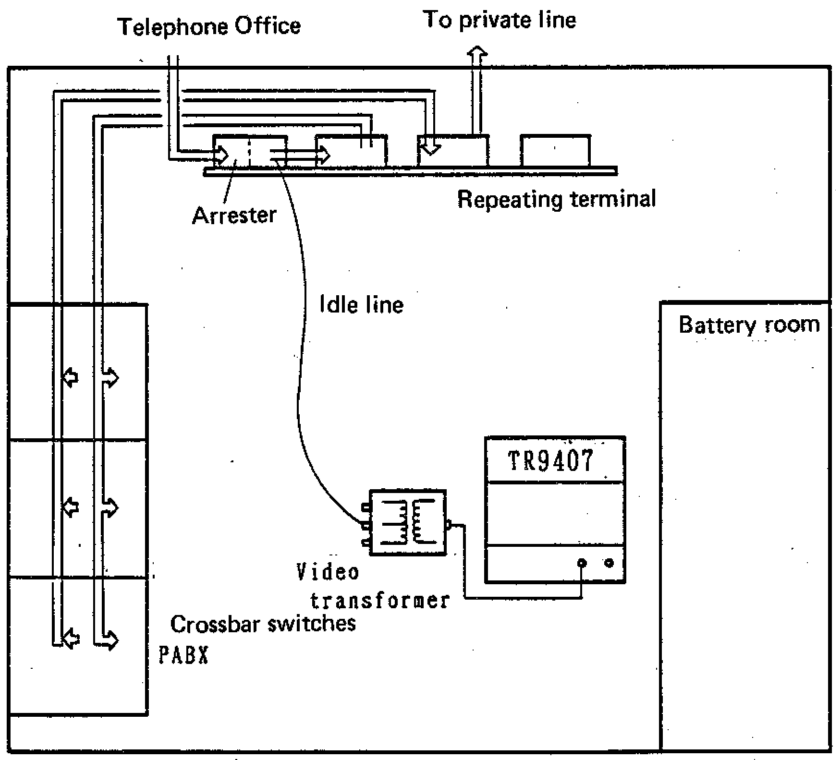


Figure 5-18 Measurement of Crosstalk of Telephone Line in Operating Room

① Frequency range: 1 MHz
Input sensitivity (SENS.A): -30 dBV

② C (↔) — Display the vertical cursor.

C (↕) — Display the horizontal cursor.

SET X — Set the trigger point at the intersection of cursors, then press the SET X key. "SET: TRIGGER" will be displayed.

(3) Setting trigger conditions.

[TRIG. MODE] Display the trigger setting menu.

ARM MODE: ADVANCE
ARM LENGTH: 2K

```
AUTO CAL
   ON
EXT GATE
   OFF

TRIGGER
SOURCE
   CH-A
SLOPE
   <+>
LEVEL
   +0.578 *FS
POSITION
   +010.94 %
BEEP ON TRIGGER
   OFF
MARKER
   OFF

ARM MODE
   ADVANCE
ARM LENGTH
=> 256K
BLOCK NO.
   0
INTERCHAN DELAY
   0/1024
```

(4) [AUTO ARM]

Whenever the incoming signal activates the trigger circuit, the lamp within the [HOLD/REL.] key goes on, and data is fetched into blocks 0-31. Data in each block is displayed on the CRT every time [RECALL] in the PANEL section is pressed as shown below.

DATA BLOCK IS RECALLED: 3

The number of the block to be read can be specified by moving the pointer (⇨) to the corresponding block number in the menu and pressing [DISP.] (to increment) or [SETUP] (to decrement) .

(In this case, [RECALL] need not be pressed.)

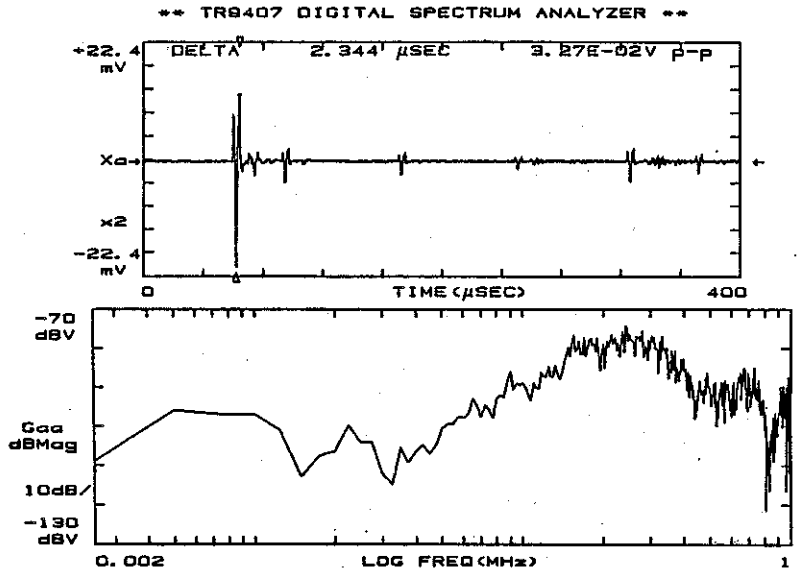


Figure 5-19 Crosstalk Time Waveforms and Spectrum

5.3.1 Setting Force Weighting Function

The impulse power is low and susceptible to noise, so signals other than impulse are replaced with their mean value.

(1) Setting the force weighting function with a cursor.

① 

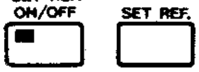
Display the WEIGHTING menu and move the pointer (⇨) to either one of the following:
F: xx (ST)
xx (SP)

② Display the time data to apply the weighting function.

③ 

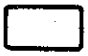
Display the vertical cursor.

④ 
Move the vertical cursor to the start point.

⑤ 

Set the reference cursor.

⑥ 
Move the vertical cursor to the stop point.

⑦ 

Thus, start and stop points have been set. "SET: FORCE" blinks for several seconds to indicate completion of the setting.

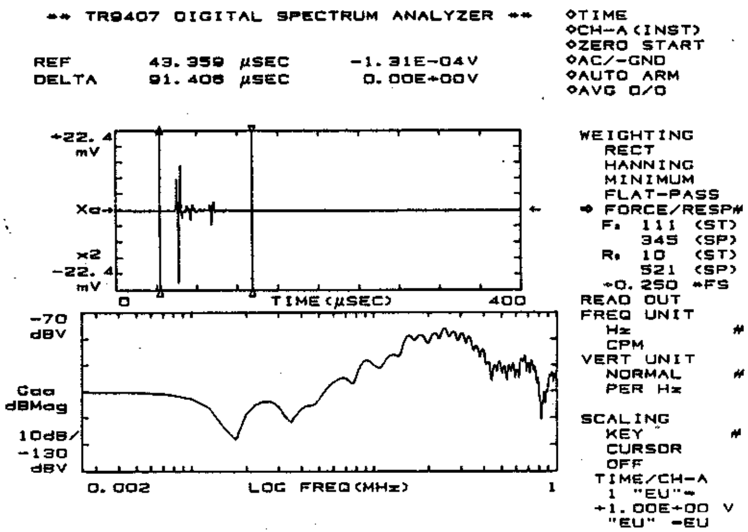


Figure 5-20 Use of Force Weighting Function

5.3.2 Automatic Data Acquisition using Both AUTO ARM and Floppy Disk

Every time the data is automatically acquired by AUTO ARM via the trigger conditions data are made to be automatically recorded on the floppy disk without human intervention. Moreover, the TR9407's CRT screen is provided with a timer to record the date and time of data recording.

1. Set the frequency range, input sensitivity, trigger and average conditions.

2. I/O RECALL HIST. N — Display the FLOPPY menu and set the following:

FLOPPY MODE: WRITE
WRITE MODE: ORIGIN
WRITE TRIG: DATE
AUTO ARM
CH-A

```
I/O SELECT
➔ FLOPPY

FLOPPY MODE
  READ
  WRITE            *
  EDIT
  CATALOGUE

WRITE MODE
  ORIGIN           *
  FIXED
  MASS TIME
  GRAPHICS
  PANEL

WRITE TRIG.
  DATA
  AUTO ARM
    CH-A

M. TIME FCTN
  OFF
  K→1.00
```

3. TIME AUTO ARM

4. Set the sequential number on the TR98102 and press AUTO and WRITE .

5. START/STOP

6. Apply input signals to channel A.

5.4 VOICE ANALYSIS

The cepstrum analysis is an effective voice analysis method like the linear prediction and filter bank methods. It is used to predict the fundamental frequency of voiced sound and to extract the envelope of the spectra.

5.4.1 Acquisition of Voice Signals

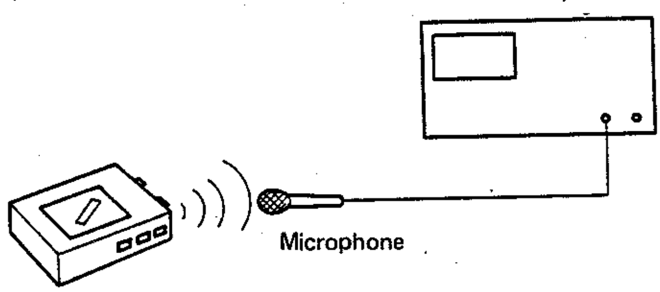


Figure 5-21 Voice Analysis Example

(1) Setting trigger conditions

FREQUENCY — Frequency range: 2 kHz or 5 kHz

SENS. A — Input sensitivity: -30 dBV (44.7 mV) to -40 dBV (14.1 mV)

TIME CH. A/CH. B

Set trigger conditions with the intersection of cursors.

C (↔) — Display the vertical cursor.

C (↕) — Display the horizontal cursor.

SET X — Set the trigger point.

TRIG. MODE — TRIGGER SOURCE: CH-A
ARM MODE: ADVANCE
ARM LENGTH: 8K or more (depending on DUT)

AUTO ARM

Connect a microphone to channel A of the TR9407, then input a human voice straightforward or a voice pre-recorded on the tape.
If a trigger takes place and a voice is captured, the lamp within HOLD/REL. goes on (the data is held).

While the lamp within HOLD/REL. is on, the frequency range or input sensitivity cannot be changed.

(2) Recording on floppy disk (mass time file)
The TR9407 provides 256K-byte data memory in the 2-channel mode and a 512K-byte data memory in the 1-channel mode. If a mass time file is used when writing data onto the floppy disk, not only all data can be recorded, but such capabilities as FUNCTION (see menu), data window, zooming, and arming functions can also be used for the reproduced data.

```
I/O SELECT
  FLOPPY

FLOPPY MODE
  READ
→ WRITE        #
  EDIT
  CATALOGUE

WRITE MODE
  ORIGIN
  FIXED
  MASS TIME    #
  GRAPHICS
  PANEL

WRITE TRIG.
  DATA
  ARM
  DATA WINDOW

M. TIME FCTN
  OFF
  K→1.00
```

① I/O RECALL N HIST. Display the floppy menu.

FLOPPY MODE: WRITE
WRITE MODE: MASS TIME.

② Insert a floppy disk in drive 0 and key in the sequential number 000 from the ten-key pad.
WRITE START/STOP

③ The sequential number is incremented by 5. Four media are required to record all 512K words. However, only one medium is required here because the recording conditions are set as follows:
ARM LENGTH = 16K
ARM MODE = NORMAL
When the sequential number changes from 0 to 360 through 200, press the START/STOP (the LED goes off) and press the MANUAL to terminate WRITE.

④ CATALOGUE mode

Select CATALOGUE as a FLOPPY MODE, then press the SETUP . And the following will be displayed:

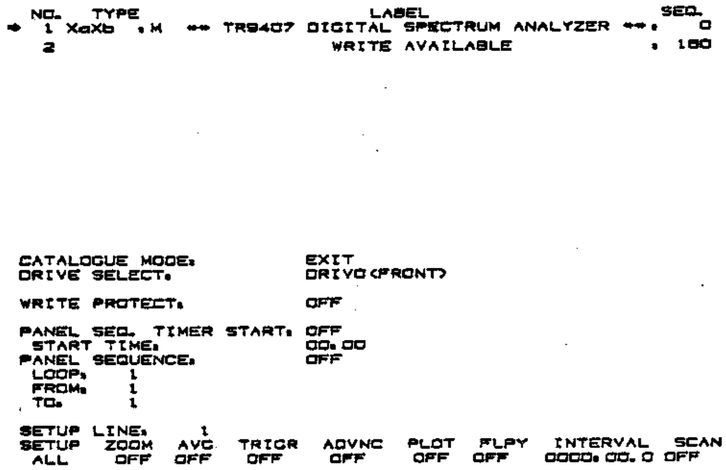


Figure 5-22 Display in CATALOGUE Mode

(3) Reproducing a mass time file
Use of a CATALOGUE mode permits reproduction of a file.

① FLOPPY MODE: Select CATALOGUE.

② Set the pointer mark (⇨) to the number of the file to be reproduced, then press SETUP .

③ The reproduced file is displayed on the screen, sequential numbers are incremented by 5, and the file contents are transferred to the TR9407 memory.

④ When the sequential number becomes 360, the following message is displayed:

INSERT NEXT DISK, PLEASE!

In this case, since all of 16K x 32 blocks (= 512K) are not used, press START/STOP (the LED goes off) and press MANUAL (the lamp of AUTO automatically goes off) when reproduction of the file contents on only one disk is completed.

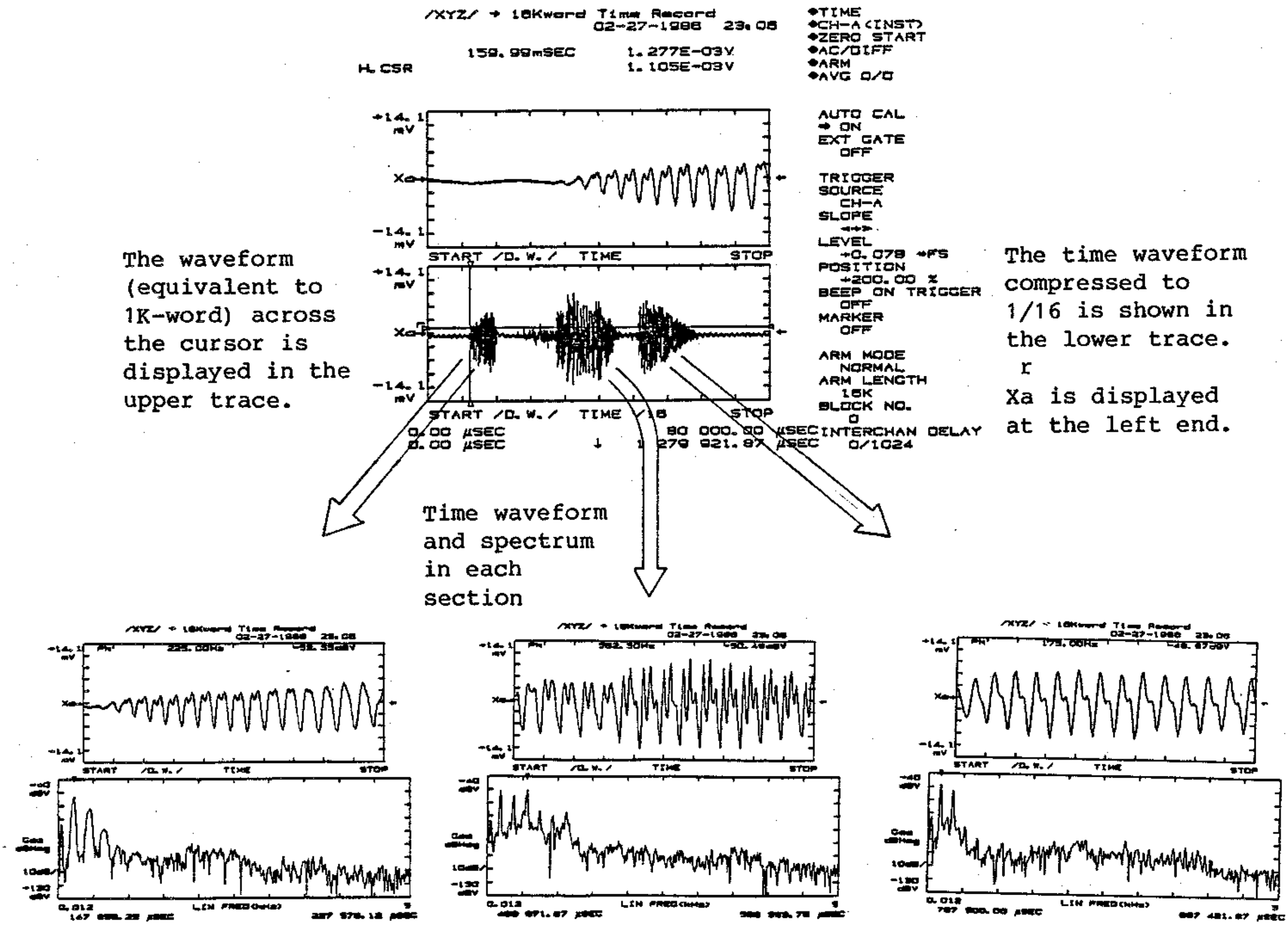


Figure 5-23 Time Compression (Record of Pronounced "XYZ")

DISP CTRL
LOWER
AUTO SCALE
ON
DISP MODE
TIME
Mag
Mag²
dBMag L#
NICHOLS
DISP GAIN
(dB/DIV)
2
5
10 L#
DATA WINDOW
AUTO
STEP(D. WINDOW)
15/1024
RE-SAMPLING
* UNIFORM
LEVEL MONITOR
OFF
CURSOR

5.4.2 Displaying a Compressed Time Waveform

Change ACTIVE to DEACTIVE in the SENS.B menu to select the 1-channel mode. Select 512K in the ARM LENGTH item. For example, a 2-kHz range (frame time: 200 ms) enables long-time analysis lasting approximately 100 seconds.
The whole contents of the memory, however, cannot be observed at a time because of physical restrictions of the 1K or 2K data window.

Select the RESAMPLING function from the DISP CTRL menu to resample, or decimate, and display the time data at the rate set by the EXPAND WIDTH key (ZOOM ON). Thus, the overall view at a glance of long data can be obtained.

① Select the following in the RESAMPLING item (press DISPLAY CTL [ ])

- UNIFORM: Data is decimated uniformly.
- PEAK: Data is sampled for every peak out of 2 points, 4 points ... of data whose compressioin rate being set up by EXPAND WIDTH key.

② When the ON/OFF [■] (ZOOM) is pressed, a compression rate (/2, /4, /8, ... /256) is displayed at the bottom of the screen each time [⇨⇦] is pressed.

r
Xa is displayed at the left end of the graticule border to indicate that this data is resampled data.
In Figure 5-23, the upper trace shows the data resampled at a compression rate of /16. The frame time of the upper trace is 80 ms, while that of the lower trace is 16 times longer.

③ When the BOTH (dual) mode is selected, the time waveform corresponding to the cursor position on the compression data can be displayed. (See Figure 5-23).

5.4.3 Observing Transition of the Spectrum (level monitor function)

The transition of the overall and peak values of the spectrum in the specified frequency range is traced for up to 1024 points. Up to two frequency ranges can be specified with the SET REF. function.

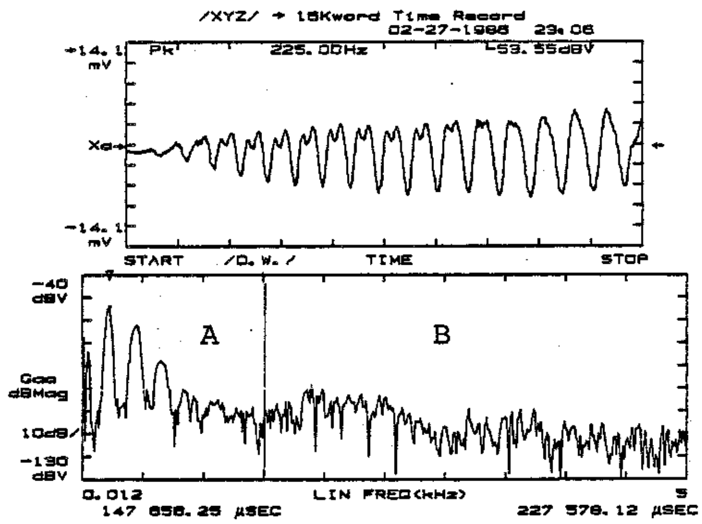


Figure 5-24 Setting the Level Monitor Range

Time-varying transition of the overall values corresponding to spectra A and B will be observed.

To monitor the transition of the peak values of spectra A and B, select CURSOR in the LEVEL MONITOR item in (4).

(1) Clearing the previous SET REF. values.

Press the [SET REF. ON/OFF] and [LIST] to display the list. If the previous values remain, clear them by pressing [LOCK / CLR].

Press [LIST] to turn off the lamp, resuming the Gaa display.

(2) Setting the range with the SET REF. function.

Press [C (↔)] to display the vertical cursor with [SET REF.] turned on).

Move the cursor to the desired frequency value and press [SET REF.] to set the reference point. Set the following four points to specify the range:

12.50 Hz
1.5 kHz } Range A

1.5 kHz
5 kHz } Range B

Move the vertical cursor to these four points and press [SET REF.] each time. Then, press [LIST] to check the setting contents. The following data will be displayed.

TR9407 DIGITAL SPECTRUM ANALYZER
02-27-1986 23:06

	Frequency Hz	SPECTRUM dBMag dBV
1	5000.00	-114.09
2	1500.00	-95.33
3	1500.00	-95.33
4	12.50	-66.38

Figure 5-25 Displaying SET REF. Set Values

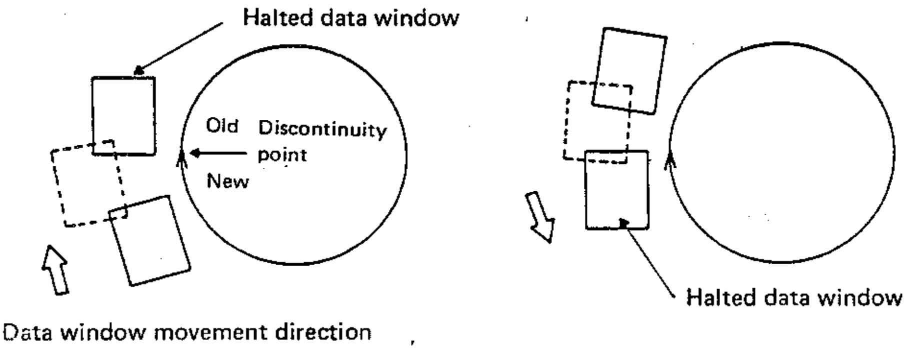
(3) Setting the data window step width

Press [DISPLAY CTL] to display the menu and set the data window movement step width.

When [(set ARM LENGTH) - 1] is set, the data window moves through the data memory without discontinuity.

[DATA WINDOW]

```
DISP CTRL
 *LOWER*
AUTO SCALE
   ON
DISP MODE
   TIME

   Mag
   Mag²
   dBMag      L#
   NICHOLS
DISP GAIN
(dB/DIV)
   2
   5
   10         L#

DATA WINDOW
   AUTO
STEP(D. WINDOW)
 →  15/1024

RE-SAMPLING
   PEAK
LEVEL MONITOR
   OFF
   OVERALL
```



When data window moves through the circular memory, there is a discontinuous point between the most recent data and oldest data. Accordingly, the data window goes past the discontinuous point and stops.

Figure 5-26 Data Window Movement

④ Change OFF to ON in the LEVEL MONITOR item.
Move the pointer (⇨) to OFF in the LEVEL MONITOR item and press [SET REF. ON/OFF L] or [SETUP] (the [DISP.] is still on). Gaa will be displayed at the left end.

⑤ To monitor two types of levels at the same time, select the dual screen mode.

[UPSCALING] If the menu is not deleted, the dual screen will not be displayed because of the limitation of memory size.

[BOTH]

⑥ [C (↔)] [⇨] (yellow arrow key) When vertical cursor is cleared and the data window starts moving, the level monitor function is executed to display the overall values of each frame for 1024 points on the Gaa screen as the time-varying data.

Lower trace in Figure 5-27 shows the level change in the range defined by No.1 and No.2 SET REF. value list and the upper trace shows the level change defined by No.3 and No.4 in the SET REF. list (see Figure 5-25)

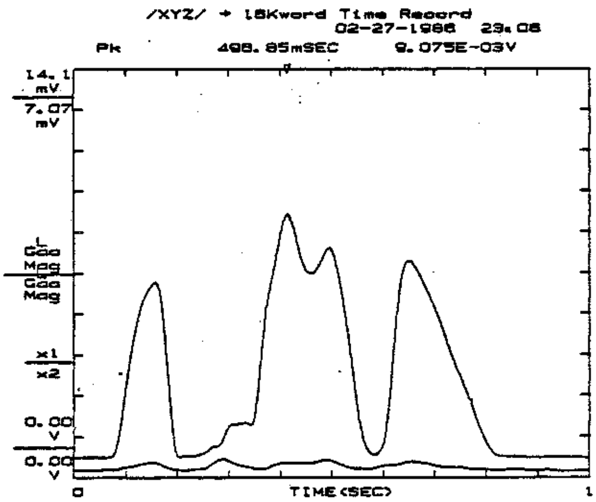


Figure 5-27 Level Monitor Display (two screens superimposed)

The waveform (the upper waveform) traced between 0 and 1.5 kHz after level monitoring (in Figure 5-27) is very similar to the compressed time waveform (in Figure 5-23), which means that pronunciation "XYZ" depends on energy below 1.5 kHz.

⑦ To terminate or restart level monitor, press SET X .

If this key is pressed during operation, the operation stops and the following is displayed:

STOP: LEVEL MONITOR

If this key is pressed again, the operation restarts and the following is displayed:

CONT: LEVEL MONITOR

⑧ When the data window goes around the circular memory and stops, level monitor also stops and the following is displayed on the screen:
STOP: LEVEL MONITOR

NOTE

During level monitor, neither the VIEW mode (except SPECTRUM and TIME) nor the data window step width can be changed.

⑨ LEVEL MONITOR: CURSOR
There are three conceivable situations for the above setup.

a. SET REF. ON/OFF C (↔) Level monitor for screen peak value

b. SET REF. ON/OFF C (↔) Level monitor of cursor position

c. SET REF. ON/OFF C (↔) Level monitor of peak value between cursors

5.4.4 Cepstrum analysis

Cepstrum is obtained by performing inverse Fourier transform for the logarithm of the power spectrum (Gaa or Gbb). Thus, a change in magnitude within a small range can be clearly indicated.

Cepstrum is used for measuring delay time and period. Generally, two channels are used to evaluate crosscorrelation. Use of cepstrum permits this evaluation with only one channel (output signal only).

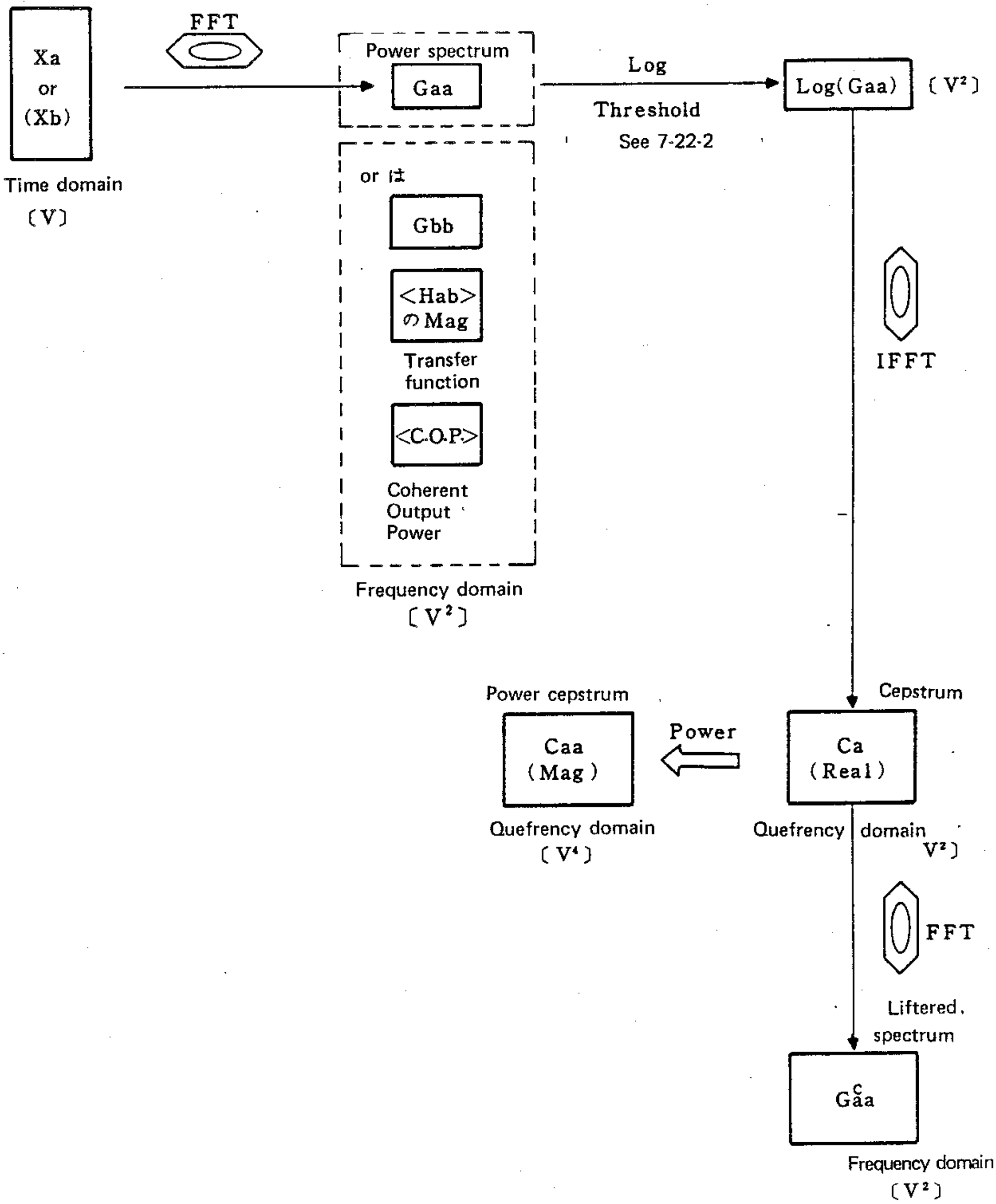


Figure 5-28 Obtaining Cepstrum

```
ADVANCED SELECT
➡ CEPSTRUM
  <DISABLE>

ANALYSIS CHAN
  CH-A           #
  CH-B
  DUAL
  VIEW
DOMAIN
  QUEFRENCY      #
  FREQUENCY
THRESHOLD
  OFF

  -774   dBFS
LIFTERING
  SHORTPASS      #
  LONGPASS

   0/511
```

(1) Obtaining cepstrum (Ca or Caa)

① Display the cepstrum menu.

[ADVANCED ANALYSIS] [PANEL RECALL] [AUTO-CORR.]

② Move the pointer (⇨) to <DISABLE>, then press [SETUP] or [DISP.] to select <ENABLE>.

③ Change CH-A or VIEW (for obtaining the cepstrum of the displayed power spectrum) in the ANALYSIS CHAN item.

④ To obtain Ca (or Caa), select QUEFRENCY in the DOMAIN item.

⑤ Press [SPECTRUM] to display the power spectrum whose cepstrum is to be obtained, then set the threshold value. Press [C (↔)], move the vertical cursor to the desired position to set the threshold, move the pointer (⇨) to OFF, then press [SET X]; SET:THRESHOLD will blink for several seconds. Press [SETUP] to change OFF to ON.

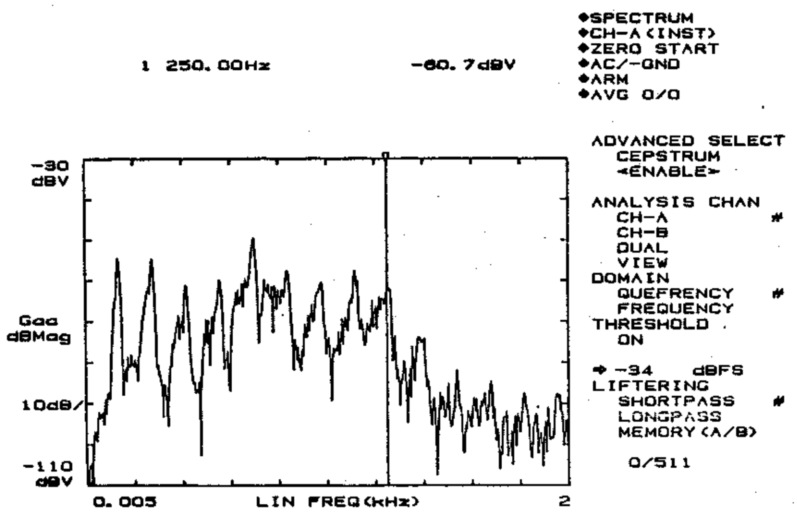


Figure 5-29 Setting the Threshold

In Figure 5-29, the logarithm becomes 0 if the power spectrum goes lower than -60.7 dBV where the cursor crosses with the spectrum. This is effective in eliminating the influence of noise.

Figure 5-30 shows the time domain (upper trace) and quefrency domain (lower trace) for a pronounced sound "a".

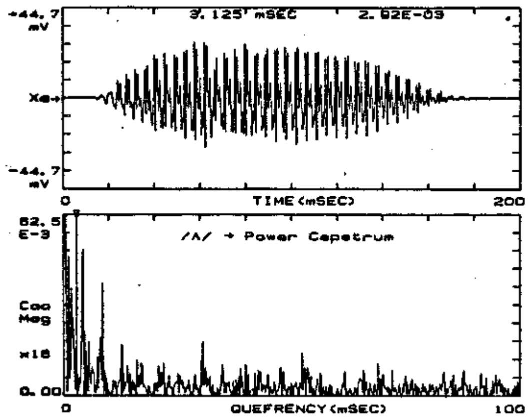


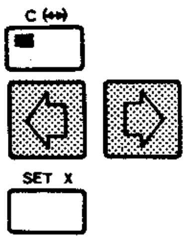
Figure 5-30 Displaying a Power Cepstrum (Caa) of "a" (lower trace)

(2) Obtaining a liftered spectrum

A liftered spectrum (G^{c}_{aa}) can be obtained by applying a lifter (see Figure 5-6) to a cepstrum or power cepstrum.

1. Select a lifter. Press [SETUP] .

2. Set the liftering value.



Display a cepstrum (Ca) or power spectrum (Caa) and move the cursor to the setting position.

SET:LIFTERING will blink in the center of the screen.

When MEMORY is selected in the LIFTERING item, the time domain data (Xa, Xb) or real cepstrum (Ca, Cb) stored in the memory is used as a lifter, and an arbitrary lifter value (-1 to +1) is specified for 0-511 points.

Table 5-1 Frequency- and quefrency domain data correspondence

Frequency domain	Quefrency domain
Spectrum	Cepstrum
Frequency	Quefrency
Filter	Lifter
Low pass filter	Short pass filter
High pass filter	Long pass filter

③ Select FREQUENCY in the DOMAIN item and display liftered spectrum G^{c}_{aa}.

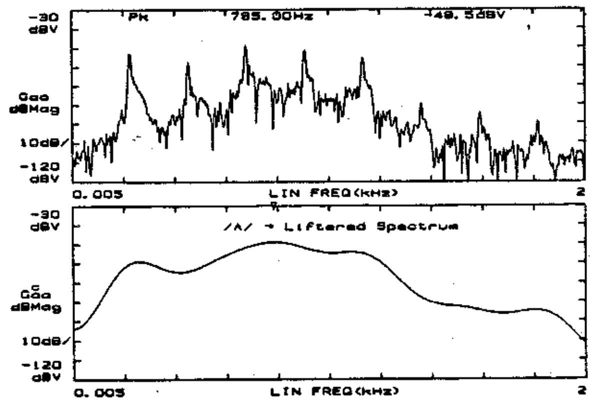


Figure 5-31 Spectrum and Liftered Spectrum of Voiced "a"

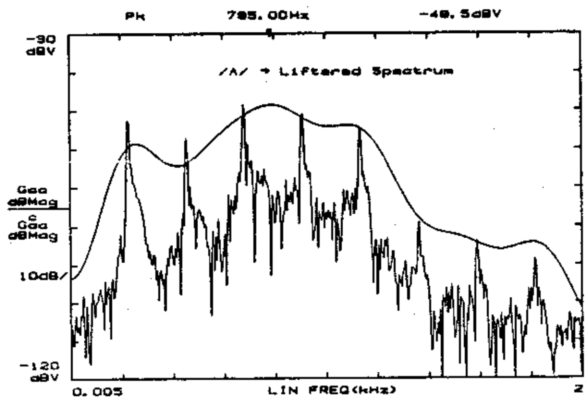
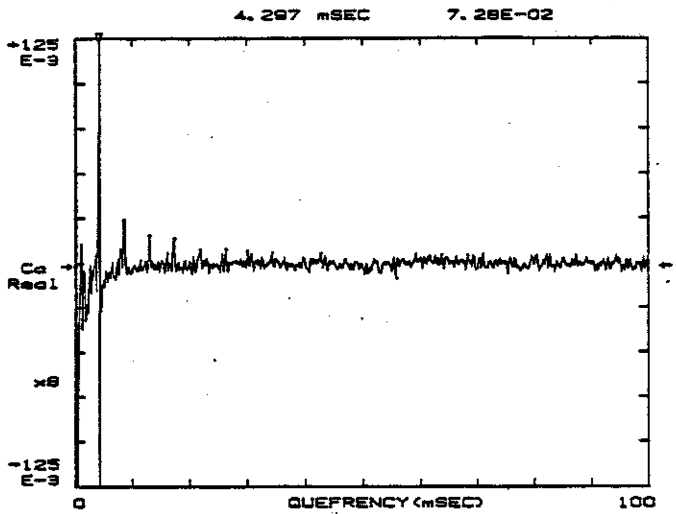
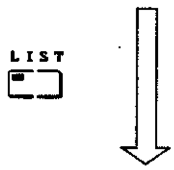


Figure 5-32 Superimposing Spectrum and Liftered Spectrum
(The upper and lower traces in Figure 5-31 are superimposed.)



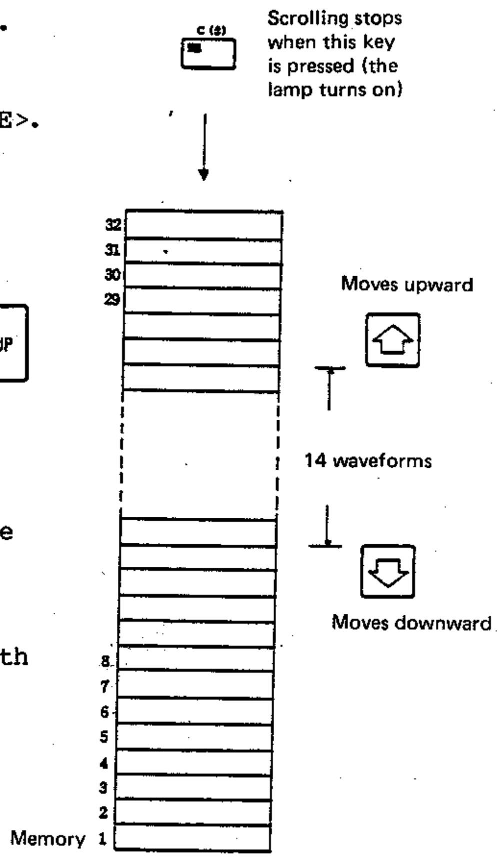


		Quefrency mSEC	CEPSTRUM Real
FUNDAMENTAL		4.297	7.28E-02
HARMONICS	2	8.594	2.42E-02
	3	13.086	1.56E-02
	4	17.383	1.38E-02
	5	21.875	7.89E-03
	6	26.367	7.63E-03
	7	30.078	6.81E-03
	8	34.375	5.86E-03
	9	38.281	-3.81E-03
	10	42.773	5.58E-03
	11	47.852	-3.33E-03
	12	50.977	-5.40E-03
	13	55.859	-6.61E-03
	14	59.180	4.76E-03
	15	63.867	4.79E-03
	16	68.359	4.61E-03
	17	71.484	-2.87E-03
	18	77.539	-4.43E-03

Figure 5-33 Rahmonic List for Cepstrum

5.4.5 Three-Dimensional (3D) Display

The 3D display function is used to display the waveforms displayed on the TR9407 CRT (waveforms in the lower screen when the dual screen mode is selected) with the lapse of time.



1. [ADVANCED ANALYSIS] [RECALL] [CROSS-CORR. M] Display the 3D menu.
2. [DISP.] [SETUP] Change <DISABLE> to <ENABLE>.
3. [SETUP] 3D DISP TRIG: AUTOMATIC

   (Selection of 3D display timing)
4. To make a 3D display, press [DISP.] or [SETUP]

   and set the start line number. (1/32 to 19/32)
   Arbitrary 14 lines out of 32 lines of waveforms stored in memory can be displayed by scrolling one line at a time

   with [⇧] [⇩].

   Scrolling is activated or deactivated with

   [C (↔)].

   [C (↔)] (lamp on) scrolling is ready.

   [C (↔)] (lamp off) scrolling deactivated.
5. Press [DISP.] or [SETUP] and set the angle factor.

   When data is output to a plotter or hard copy unit, the angle depends on the stack line number as outlined in Table 5-2.

6. Select a 3D DISPLAY SOURCE.
   SYSTEM: The screen data is displayed in the 3D mode.
   FLOPPY: The data read from the floppy disk into the TR9407 is displayed in the 3D mode.
7. Select CRT or HARD COPY from the 3D DISP OUTPUT item.
8. When HARD COPY is selected in 7 above, select 16, 32, 64, or 128 in the STACK LINE NO. item. When CRT is selected, the stack line number cannot be selected because it is fixed to 14.
9. If it is necessary to display other ADVANCED ANALYSIS menu function(s) in the 3D mode, change <DISABLE> to <ENABLE> for these menus, too.

Table 5-2 3D Display Angles

Stack line No.	Angle factor	Actual angle (degree)
16	0	90
	1	81
	2	77
	3	73
	4	69
	5	66
	6	62
	7	59
32	0	90
	1	86
	2	84
	3	81
	4	79
	5	77
	6	75
	7	73
64	0	90
	1	88
	2	86
	3	84
	4	81
	5	81
	6	81
	7	81
128	0	90
	1	88
	2	86
	3	86
	4	86
	5	86
	6	86
	7	86

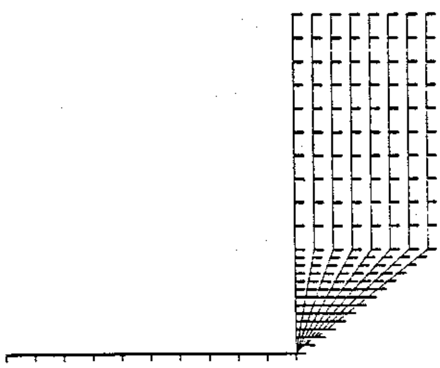


Figure 5-34 3D Display Angle

(10) Press [EXECUTE] to execute 3D display. Pressing this key again (the LED will go off) will cancel the 3D display mode.

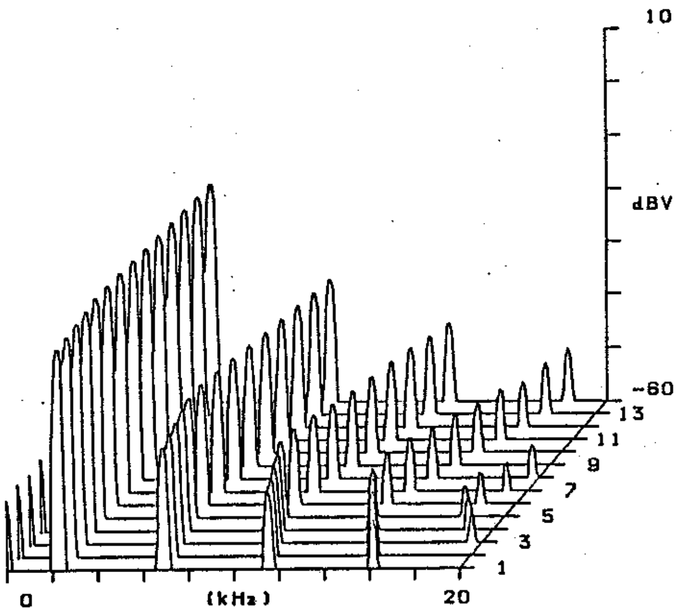


Figure 5-35 3D Display on CRT Screen

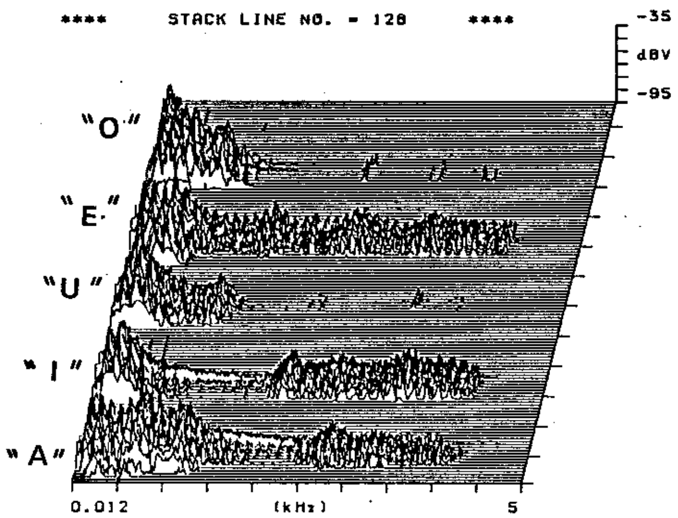


Figure 5-36 Examples of 3D Display Output to Plotter

Table 5-3 Outputting 3D Display to Plotter (or XY recorder)

3D setting menu	When set to 3D DISP OUTPUT=CRT	When set to 3D DISP OUTPUT=HARD COPY
Features of plot	Fourteen waveforms (each waveform is decimated to 200 points) are output to the external output device. (The number of data points is fixed to 200 points irrespective of the display domain.)	Waveforms are displayed without decimation. The resolution (number of points) is the same as that on the CRT screen.
I/O SELECT menu	Set to PLOTTER or XY-RCDR (When PLOTTER is selected, also select the plotter type.)	
Stack line number setting ADVANCED ANALYSIS [ ]	Unusable (the number of waveforms displayed in the 3D mode is fixed to 14.) Press the EXECUTE key to execute 3D display on the CRT screen.	Stacking display depending on the preset number (16, 32, 64, or 128) Press the EXECUTE key to execute 3D display and start plotting.
I/O [ ]	Press the EXECUTE key to start plotting.	The EXECUTE LED lamp goes on.
Plotting stop	Press the EXECUTE key (I/O [ ]).	

5.5 NOISE MEASUREMENT

5.5.1 Measuring a Sound Level Using a Sound Level Meter

With the analysis by an FFT analyzer, the frequency range is changed as required while a sound level meter measures the square means of input signals without identifying frequencies. The sound level may be represented in dBV notation only if the spectrum relative level is required; if the sound pressure absolute level is required, however, the EU value must be set so that the FFT analyzer overall value agrees with the sound level meter readout. (Calibration of the FFT analyzer with CAL signal of sound level meter.)

① Calibrate the sound level meter with a pistonphone.
② Measure the sound level meter CAL signal.

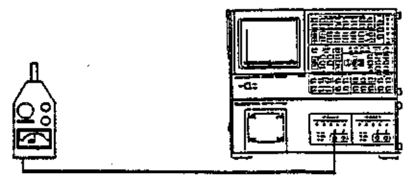


Figure 5-37 Measuring a Sound Level Meter CAL Signal

FREQUENCY — Set the frequency range to 20 kHz (audible range for humans).

SPECTRUM

SENS. A — Set the maximum sensitivity (which will not cause overload) to maximize the resolution of the A-D converter.

AC/DC — AC coupling

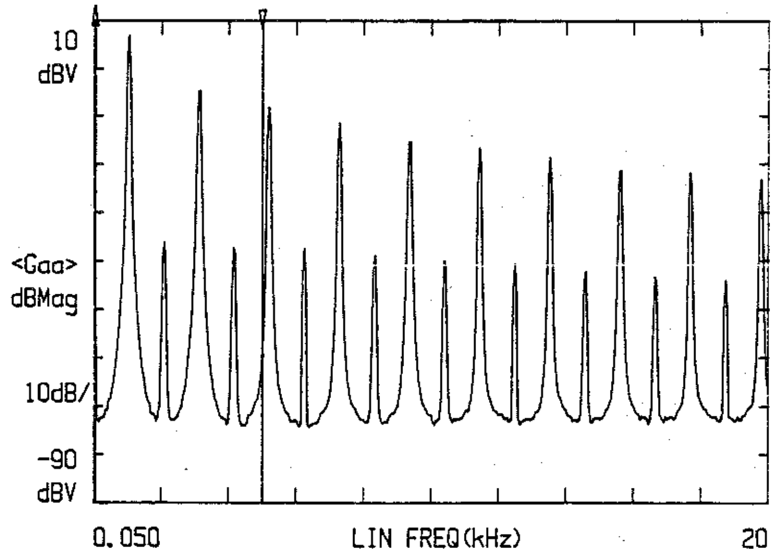


Figure 5-38 Sound Level Meter CAL Signal

FUNCTION

Measure the CAL signal overall value in the 20 kHz range.

When the overall value is measured, selection of the weighting function is arbitrary because it is internally compensated.

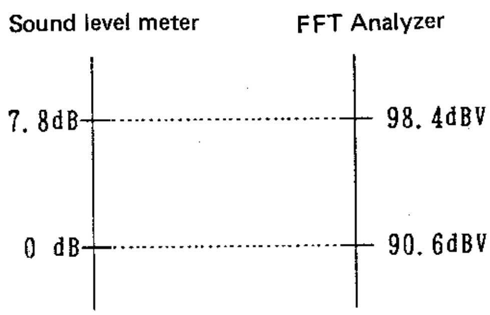
SETUP

Move the pointer (⇨) to ALL in the OVERALL.

DISPLAY CTL

Display the DISP CTRL menu and select dBMag in the DISP MODE.

The overall value of the sound level meter CAL signal (1.05 kHz) is 98.4 dBV. In this case, the sound level meter readout is 7.8 dB. Therefore, the level value can be read directly if the value displayed by the TR9407 is shifted to 90.6 dB.



FUNCTION
 OFF

 <U+L>
OPEN/CLOSED
 OFF

 Ho/(1+Ho)
∫Xxdt
 OFF/CH-A
 OFF/CH-B
dXx/dt
 OFF/CH-A
 OFF/CH-B
* <VIEW> <jw> *
 OFF
EQUALIZE
 OFF
COH BLANK
 OFF
OVERALL
⇨ ALL
TREND REMOVAL
 OFF/CH-A
 OFF/CH-B
SMOOTHING
 OFF

③ Scaling

WGT/SCALING

Move the pointer (⇨) to KEY in the SCALING.

Enter 0 dBEU=090.6dBV
EU=␣A
with numerical keys.

Move the pointer (⇨) to OFF and press SETUP

to change SCALING OFF to SCALING ON.

```
WEIGHTING
  RECT
  HANNING      #
  MINIMUM
  FLAT-PASS
  FORCE/RESP.
  F: 10   <ST>
     15   <SP>
  R: 10   <ST>
     521  <SP>
  -0.500 -FS
READ OUT
FREQ UNIT
  Hz           #
  CPM
VERT UNIT
  NORMAL       #
  PER Hz

SCALING
-> KEY         #
  CURSOR
  OFF
 FREQ/CH-A
  0 dBEU=
  000.0 dBV
  EU =EU
```

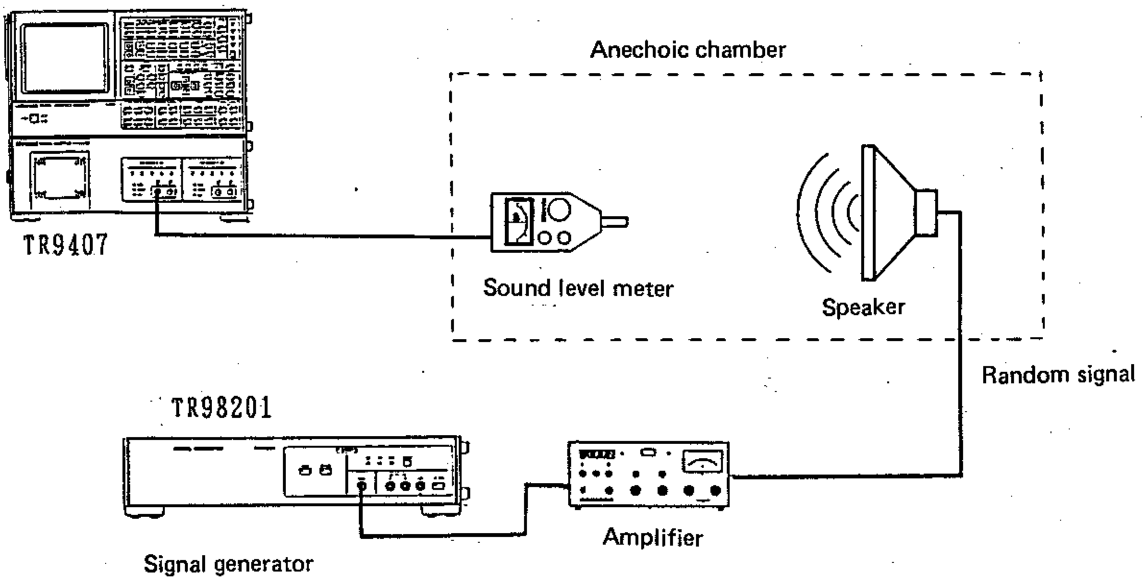


Figure 5-39 Setting Up the Noise Measurement System

④ Measuring a sound level (20-kHz range)
The FFT analyzer has been calibrated with the sound level meter CAL signal. Figure 5-39 shows an example of sound level measurement when the speaker is driven by random noise.
Measure the sound level in the same manner as ② above.

OPERATE

Output a signal from the TR98201.

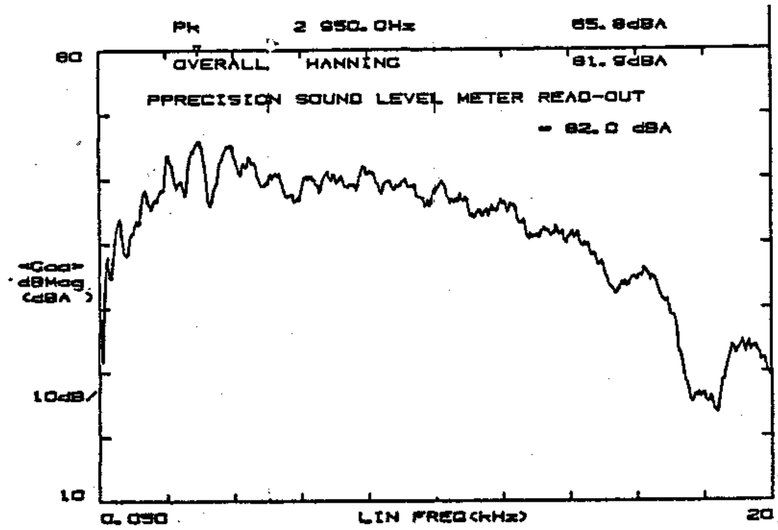


Figure 5-40 Overall Value Measured in 20-kHz Range

(5) Measuring a sound level in the 10-kHz range.
When the frequency range is lowered to half, the overall value is reduced by 3 dB. Change the scaling factor for compensation.

FREQUENCY — Set the 10-kHz range.

WGT/SCALING — Enter 0 dBEU=087.6dBV.

(6) Measuring the sound level in the 5-kHz range.
If the frequency range is lowered to quarter, the overall value is reduced by 6 dB as compared with the 20-kHz range.

FREQUENCY — Set the 5-kHz range.

WGT/SCALING — Enter 0 dBEU=084.6dBV.

5.5.2 Third Octave and Full Octave Analysis

A narrow-band spectrum is converted to thirty 1/3 octave filter outputs after operation and composition.

When the 1/3 octave mode is selected, the spectrum consisting of 1200 lines in three frequency ranges (400 lines/range) is converted (through operation and composition) according to the analyzing frequency setting within the range from 1/3 octave band center frequency 1.6 Hz to 80 kHz.

The 1/1 octave is analyzed by processing the result of the 1/3 octave analysis. It can be displayed either during or after the analysis.

(1) 1/3 and 1/1 octave analysis procedure

① [FREQUENCY] Set a frequency range (2 kHz to 100 kHz) (when the STATIONARY mode is selected).

② [SPECTRUM] Display the spectrum of the channel subject to octave analysis.

③ [ON/OFF] ZOOM OFF.

[DATA WINDOW] DATA WINDOW OFF.

④ [ADVANCED ANALYSIS] [RECALL] [HIST.] Display the octave analysis menu.

⑤ [SETUP] or [DISP.] Change <DISABLE> to <ENABLE>.

```
ADVANCED SELECT
  OCTAVE
  <ENABLE>

OCT MODE
  STATIONARY
  TRANSIENT
➜ VIEW POWER    #

ANALYSIS CHAN
  CH-A          #
  CH-B
  DUAL

BANDWIDTH
  1/3 OCT       #
  1/1 OCT

A-WEIGHTING
  OFF
```

⑥ Set the OCT mode.

STATIONARY: Octave analysis is made during free running. (Frequency range is switched.)

TRANSIENT: The AUTO ARM mode can be selected together with the ARM mode. (Frequency range is not switched.)

VIEW POWER: Octave analysis is made for the power spectrum (Gaa, Gbb, <Gaa>, <Gbb>, <C.O.P>).

⑦ Specify the channel subject to analysis, select 1/3 or 1/1 octave, and specify whether the A-weighting frequency values are to be compensated.

⑧ [EXECUTE] ([ADVANCED ANALYSIS]) Start octave analysis.

To stop octave analysis, press this EXECUTE key again.

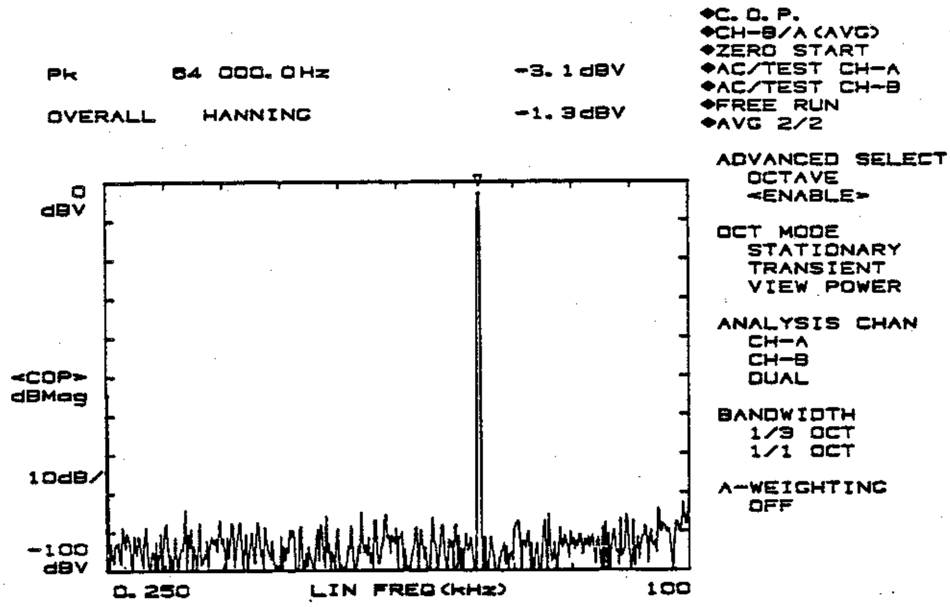


Figure 5-41 <C.O.P.>Display Example

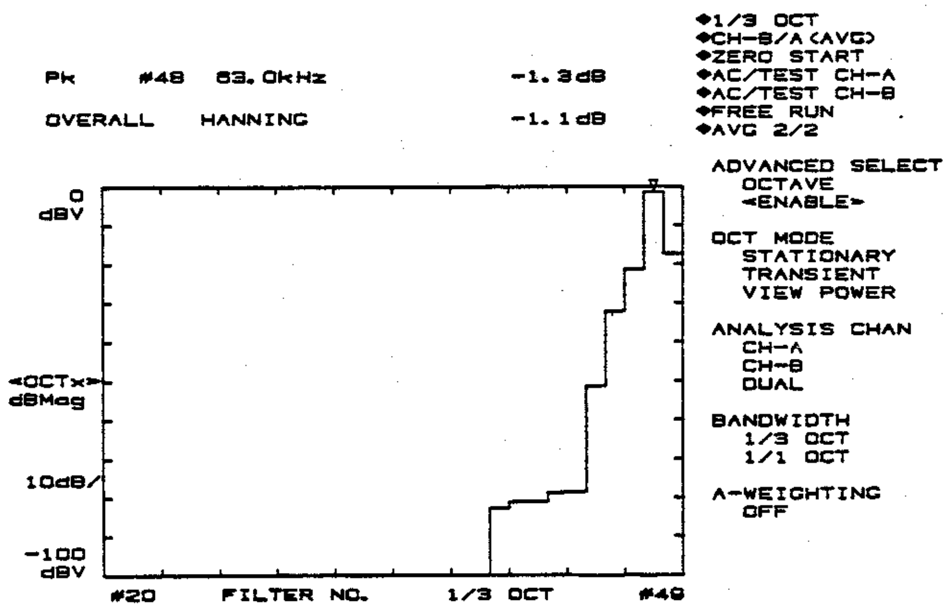


Figure 5-42 Result of Octave Analysis of the Data in the above Figure (VIEW POWER mode)

⑨ Display the averaging data (in STATIONARY or TRANSIENT mode).

Select the AVG MODE and select POWER SPECT (automatically selected) in the AVG WHAT.
Set up AVG NUMBER.

Start averaging.

(Do not press ERASE when DIFF is selected in the AVG MODE.)

If averaging is executed during VIEW POWER mode, averaging for the octave analysis is not executed but ordinary averaging is executed.

NOTES

- Octave analysis cannot be done for the power spectrum (Gab or <Gab>) of the cross spectrum.

- When octave analysis is done for the result of math operation of the power spectra in the FUNCTION ON state, temporarily store the operation result in the memory, and press the RECALL key to display it in the lower screen, then execute VIEW POWER octave analysis.

- If power spectrum Gbb is displayed after VIEW POWER octave analysis for power spectrum Gaa and octave display on the CRT screen, VIEW power octave analysis for Gaa is not executed. In this case, press the ADVANCED ANALYSIS-EXECUTE key to terminate Gaa octave analysis, then press the EXECUTE key again to restart Gaa octave analysis.

(2) The following functions are inhibited during octave analysis:

- ZOOM (RUNNING ZOOM and HOLD ZOOM)
- ARM and AUTO-ARM in STATIONARY mode
- 1-channel mode
- Auto range
- Frequency setting
- Instant correlation
- Horizontal axis log display (H-LOG)
- Harmonics search
- Data window

(3) Octave analysis test method
The best way to check the octave analysis is by feeding white noise (flat). In the 1/1 octave analysis mode, each bandwidth is increased doubly, that is, the amplitude level is increased by 3 dB for each filter. In the 1/3 octave analysis mode, the amplitude is increased by 1 dB.

Figure 5-43 shows the input signal (white noise). Figure 5-44 ((a) and (b)) shows the result of 1/3 octave analysis for white noise.

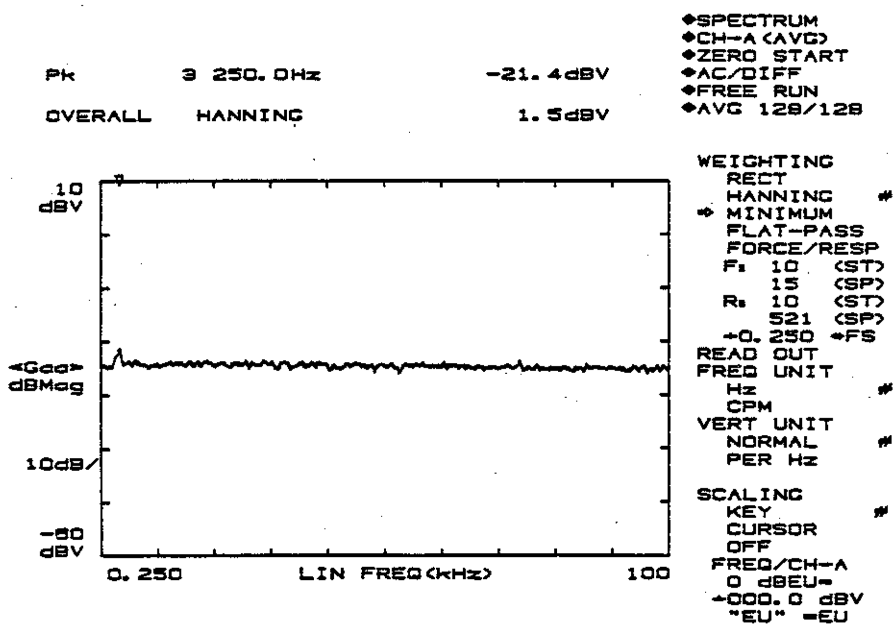
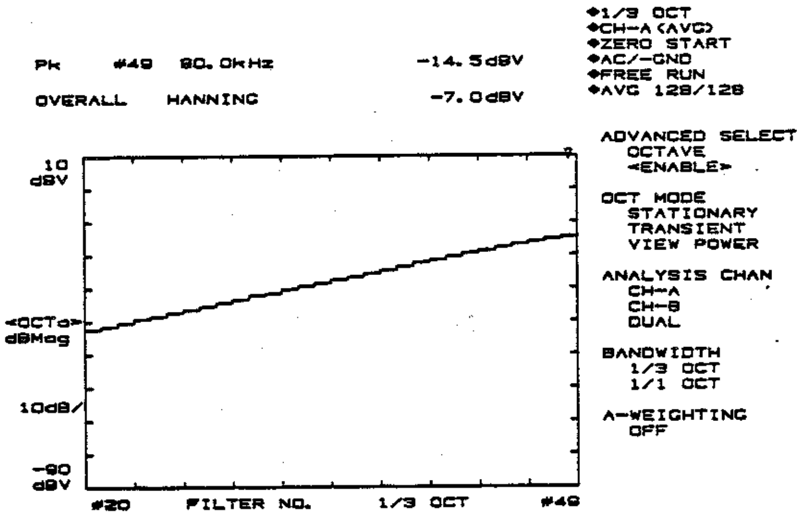


Figure 5-43 Input Signal (white noise)

(a)



(b)

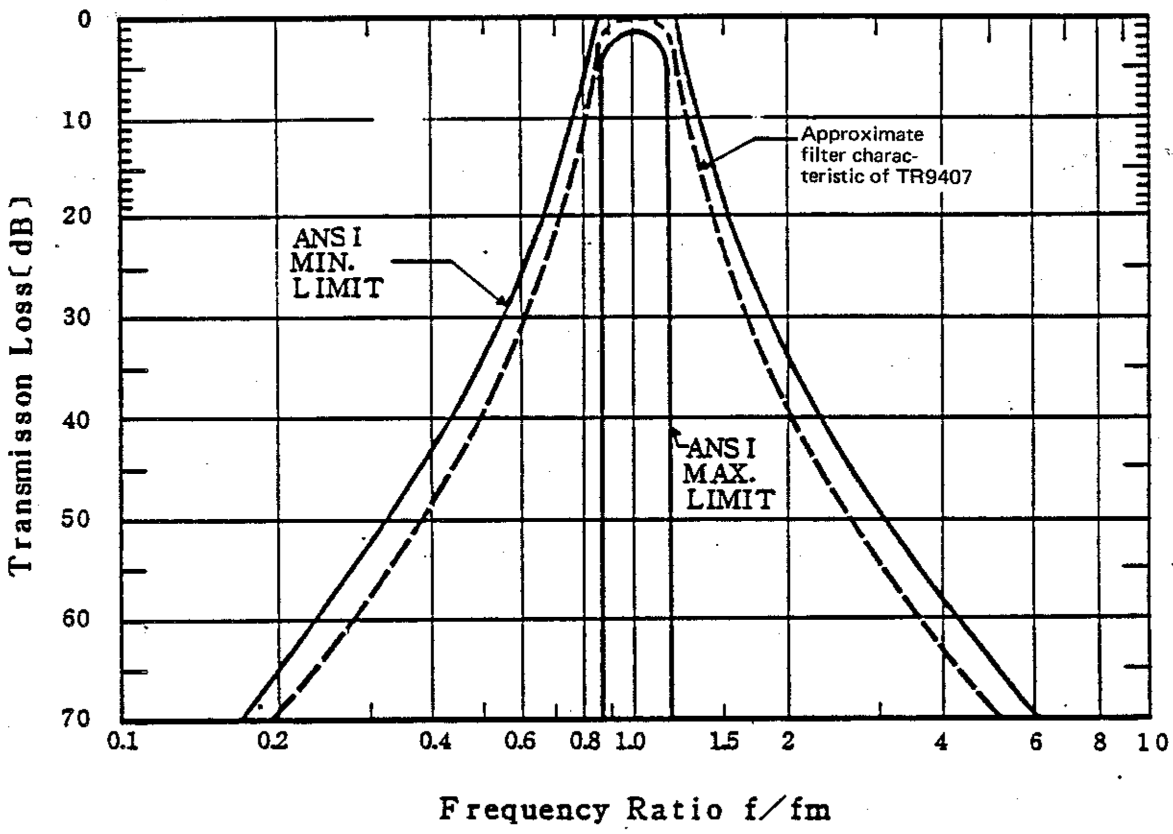
1/3 OCTAVE LIST : A-WEIGHT OFF
WINDOW HANNING
OVERALL -7.0 dBV

FILTER NO.	CENTER FREQ.	LEVEL dBV	FILTER NO.	CENTER FREQ.	LEVEL dBV
#20	100 Hz	-42.3	#35	3.15kHz	-27.3
#21	125	-41.5	#36	4.0k	-26.5
#22	160	-40.5	#37	5.0k	-25.5
#23	200	-39.2	#38	6.3k	-24.5
#24	250	-38.4	#39	8.0k	-23.4
#25	315	-37.3	#40	10.0k	-22.2
#26	400	-36.4	#41	12.5k	-21.5
#27	500	-35.4	#42	16.0k	-20.4
#28	630	-34.3	#43	20.0k	-19.4
#29	800	-33.3	#44	25.0k	-18.6
#30	1.0k	-32.1	#45	31.5k	-17.6
#31	1.25k	-31.5	#46	40.0k	-16.6
#32	1.6k	-30.2	#47	50.0k	-15.8
#33	2.0k	-29.2	#48	63.0k	-15.1
#34	2.5k	-28.4	#49	80.0k	-14.5

Figure 5-44 1/3 Octave Analysis of White Noise

Table 5-4 Relationship between Filter Numbers, Center Frequencies, and Set Frequency Ranges

Filter No.	Center frequency	OCTAVE		Setup Frequency ranges											
				STATIONARY (right) and TRANSIENT/VIEW POWER (left)						TRANSIENT/VIEW POWER					
	Hz	1/1	1/3	100k	50k	20k	10k	5k	2k	1k	500	200	100	50	20
49	80 k		←	↑ ↑											
48	63 k	←	←												
47	50 k		←												
46	40 k		←												
45	31.5 k	←	←		↑ ↑										
44	25 k		←												
43	20 k		←												
42	16 k	←	←			↑ ↑									
41	12.5 k		←												
40	10 k		←	↓			↑ ↑								
39	8 k	←	←												
38	6.3 k		←												
37	5 k		←		↓			↑ ↑							
36	4 k	←	←												
35	3.15k		←												
34	2.5 k		←			↓									
33	2 k	←	←												
32	1.6 k		←						↑						
31	1.25k		←				↓		↑						
30	1 k	←	←							↑					
29	800		←												
28	630		←					↓							
27	500	←	←								↑				
26	400		←												
25	315		←												
24	250	←	←												
23	200		←												
22	160		←						↓						
21	125	←	←							↓		↑			
20	100		←	↓									↑		
19	80		←												
18	63	←	←								↓				
17	50		←		↓									↑	
16	40		←												
15	31.5	←	←												
14	25		←			↓									
13	20		←												
12	16	←	←									↓			
11	12.5		←				↓						↓		↑
10	10		←												
9	8	←	←												
8	6.3		←					↓						↓	
7	5		←												
6	4	←	←												
5	3.15		←												
4	2.5		←												
3	2.0	←	←												
2	1.6		←						↓						↓



Transmission loss limits third-octave band filter, ANSI S1.11-1966

Figure 5-45 1/3 Octave Band Filter Characteristics

```
************************
*  A-WEIGHTING CURVE  *
************************
```

80 kHz	Filter-no(49)	-35.0 [dBV]
63	Filter-no(48)	-25.7 [dBV]
50	Filter-no(47)	-21.5 [dBV]
40	Filter-no(46)	-18.0 [dBV]
31.5	Filter-no(45)	-14.5 [dBV]
25	Filter-no(44)	-11.8 [dBV]
20	Filter-no(43)	-8.7 [dBV]
16	Filter-no(42)	-6.5 [dBV]
12.5	Filter-no(41)	-4.3 [dBV]
10	Filter-no(40)	-2.5 [dBV]
8	Filter-no(39)	-1.1 [dBV]
6.3	Filter-no(38)	-0.1 [dBV]
5	Filter-no(37)	0.5 [dBV]
4	Filter-no(36)	1.0 [dBV]
3.15	Filter-no(35)	1.2 [dBV]
2.5	Filter-no(34)	1.3 [dBV]
2	Filter-no(33)	1.2 [dBV]
1.6	Filter-no(32)	1.0 [dBV]
1.25	Filter-no(31)	0.6 [dBV]
1	Filter-no(30)	0.0 [dBV]
800 Hz	Filter-no(29)	-0.8 [dBV]
630	Filter-no(28)	-1.9 [dBV]
500	Filter-no(27)	-3.2 [dBV]
400	Filter-no(26)	-4.8 [dBV]
315	Filter-no(25)	-6.6 [dBV]
250	Filter-no(24)	-8.6 [dBV]
200	Filter-no(23)	-10.9 [dBV]
160	Filter-no(22)	-13.4 [dBV]
125	Filter-no(21)	-16.1 [dBV]
100	Filter-no(20)	-19.1 [dBV]
80	Filter-no(19)	-22.5 [dBV]
63	Filter-no(18)	-26.2 [dBV]
50	Filter-no(17)	-30.2 [dBV]
40	Filter-no(16)	-34.6 [dBV]
31.5	Filter-no(15)	-39.4 [dBV]
25	Filter-no(14)	-44.7 [dBV]
20	Filter-no(13)	-50.5 [dBV]
16	Filter-no(12)	-56.5 [dBV]
12.5	Filter-no(11)	-64.0 [dBV]
10	Filter-no(10)	-72.5 [dBV]
8	Filter-no(9)	-90.0 [dBV]
6.3	Filter-no(8)	-90.0 [dBV]
5	Filter-no(7)	-90.0 [dBV]
4	Filter-no(6)	-90.0 [dBV]
3.15	Filter-no(5)	-90.0 [dBV]
2.5	Filter-no(4)	-90.0 [dBV]
2	Filter-no(3)	-90.0 [dBV]
1.6	Filter-no(2)	-90.0 [dBV]

Figure 5-46 A-Weighting Compensation Values

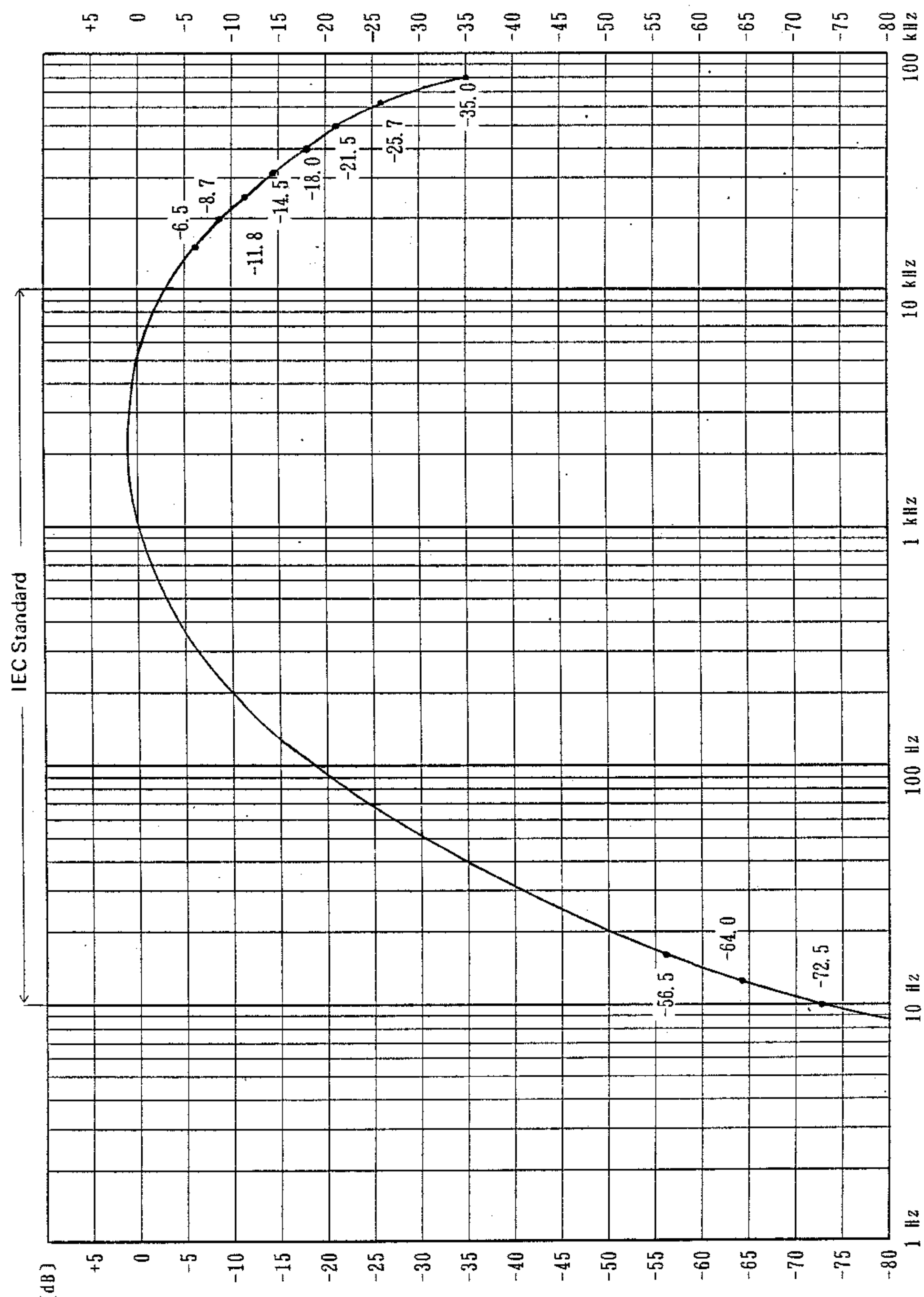


Figure 5-47 A-Weighting Compensation Value
(frequency compensation characteristics)

5.6 DISTORTION MEASUREMENT

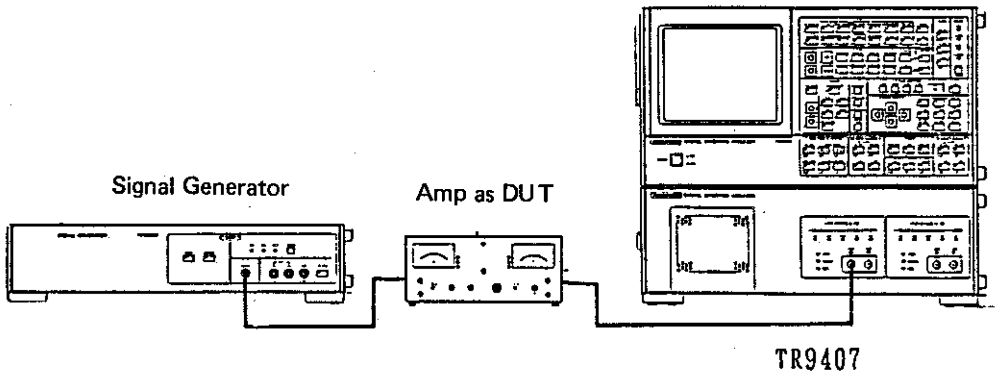


Figure 5-48 Connections for Measuring Distortion

(1) Connect the output terminal of the signal generator to the input terminal of the amplifier to be tested.

(2) Connect the output terminal of the amplifier to CH-A of the TR9407.

(3) FREQUENCY — Set the frequency range to 100 kHz.

SENS. A — Input sensitivity: AUTO;

SPECTRUM, MAG. — Raise the frequency resolution in the 1-channel mode by changing ACTIVATE into DEACTIVATE.

WGT/SCALING — Use flat pass weighting function having a good amplitude accuracy (tradeoff with low frequency resolution for harmonic analysis).

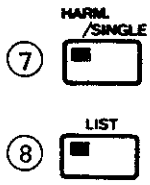
(4) When the TR98201 is used as a signal generator

I/O, PANEL RECALL, C. O. P. — Display the sine menu.
AMPLITUDE: Set a desired amplitude.
(Move the blinking digit with ⇦ or ⇨ and enter the value with numeric keys.)
(OUTPUT MODE: SWEEP

(5) OPERATE — Generate a signal from the TR98201.

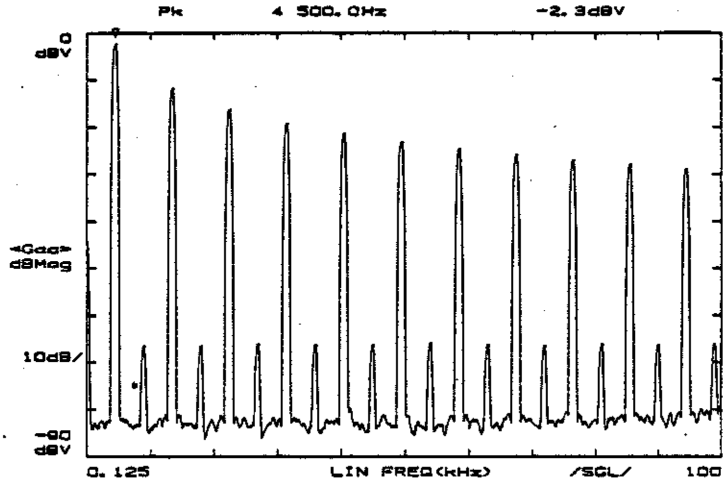
(6) C (↔), ⇦, ⇨ — Move the vertical cursor to the fundamental of the signal.

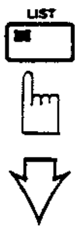
```
WEIGHTING
   RECT
   HANNING
   MINIMUM
➡  FLAT-PASS    #
   FORCE/RESP
   F1  10    <ST>
       15    <SP>
   R1  10    <ST>
       521   <SP>
  +0.250  *FS
READ OUT
FREQ UNIT
   Hz           #
   CPM
VERT UNIT
   NORMAL       #
   PER Hz

SCALING
   KEY          #
   CURSOR
   OFF
 FREQ/CH-A
   0 dBEU=
  +000.0 dBV
   "EU" =EU
```



The harmonics for the fundamental are marked. (In the CURSOR OFF mode where the auto peak search function is performed, the harmonics for the peak are marked.)
Fundamental and the level, harmonic numbers and the frequencies, level differences, distortions and total harmonics rms with reference to fundamental, and total harmonic distortion are
computed and listed.

If REAL, IMAG. or PHASE is displayed instead of MAG. in ③ above, a harmonic list is displayed instead of the harmonic distortion list.





FUNDAMENTAL		Hz	dBV	
		4 500.0	-2.3	
HARMONICS			DELTA dBR	DIST. %
	2	9 000.0	-64.2	0.062
	3	13 500.0	-9.5	33.307
	4	18 000.0	-64.3	0.061
	5	22 500.0	-14.0	20.002
	6	27 000.0	-64.0	0.063
	7	31 500.0	-16.9	14.265
	8	36 000.0	-64.1	0.062
	9	40 500.0	-19.1	11.069
	10	45 000.0	-64.0	0.063
	11	49 500.0	-20.9	9.056
	12	54 000.0	-63.7	0.065
	13	58 500.0	-22.3	7.665
	14	63 000.0	-64.0	0.063
	15	67 500.0	-23.5	6.660
	16	72 000.0	-64.2	0.062
	17	76 500.0	-24.6	5.858
	18	81 000.0	-63.9	0.064
	19	85 500.0	-25.6	5.248
	20	90 000.0	-64.0	0.063

TOTAL HARMONIC RMS , FLAT-PASS -9.1 dBV
TOTAL HARMONIC DISTORTION 45.639 %

Figure 5-49 Harmonic Distortion List

5.7 WOW-FLUTTER MEASUREMENT (WITH WOW-FLUTTER METER)

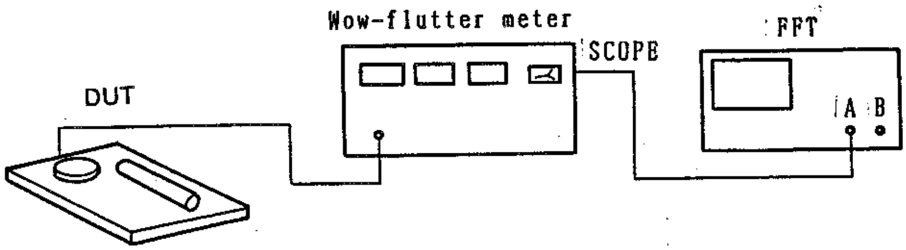


Figure 5-50 Connections for Wow-Flutter Measurement

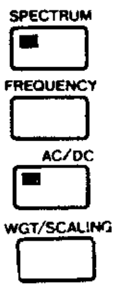
When the motor rotates, FG (frequency generator) pulses are generated by the magnetic field. To measure the wow-flutter of the motor, this pulse signal is input to the FFT analyzer through the wow-flutter meter and thus the frequency components of flutter are analyzed.

This analysis can determine the cause of flutter that cannot be determined by reading the wow-flutter meter only.

1. Connect the SCOPE terminal on the wow-flutter meter rear panel to the INPUT A terminal of the TR9407. (See Figure 5-50).
   The signal that generates 240 pulses per revolution is electrically extracted from the motor rotating at a speed of 400 rpm, and is then input to the input terminal of the wow-flutter meter.
2. Set the wow-flutter meter as follows:

   W & F : ON
   INPUT : L.P.F.
   FUNCTION : UNWEIGHTED (No frequency compensation)
   INDICATION : RMS
   C. FREQ: AUTO ON
   MEMORY : OFF
   REPEAT : ON
   F. FREQ: 1/4.3
   RANGE : f.s. 0.1%

3. Setup of the TR9407.



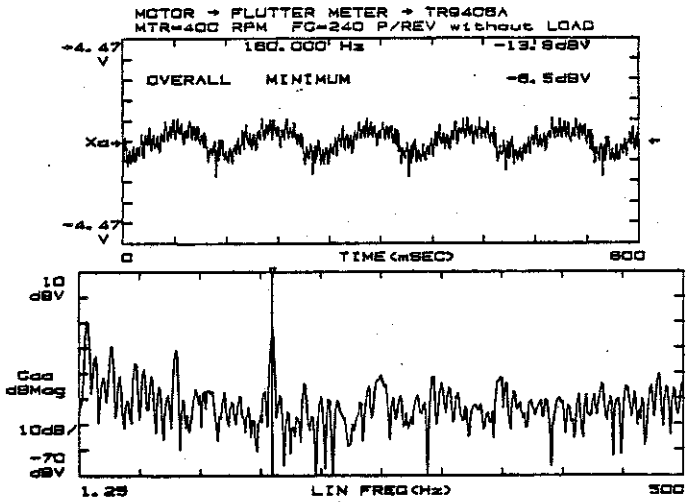
Set the frequency range to 500 Hz.

AC coupling.

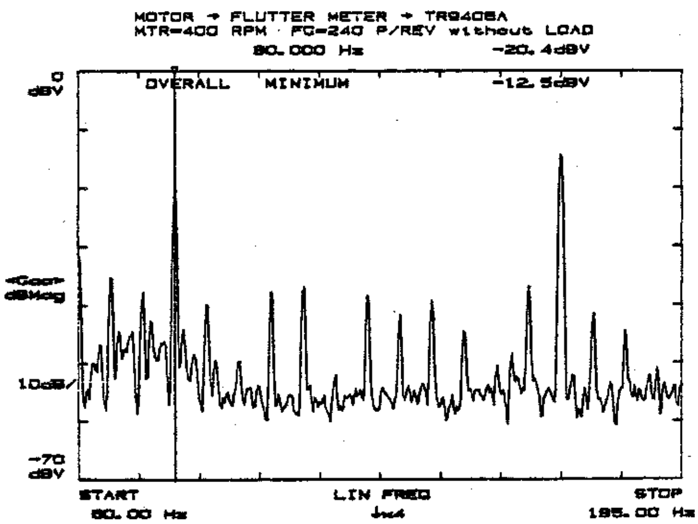
Weighting function: HANNING

Set the FREE RUN state.
Set the averaging conditions.
Raise the TR9407 input sensitivity up to the maximum value just before the overload.
When an OVERALL is to be set, the weighting function is arbitrary because it is internally compensated.

4 Figure 5-51 shows the measurement result. In (a), the low-frequency band (50 Hz or lower) is reflected in the wow-flutter meter.

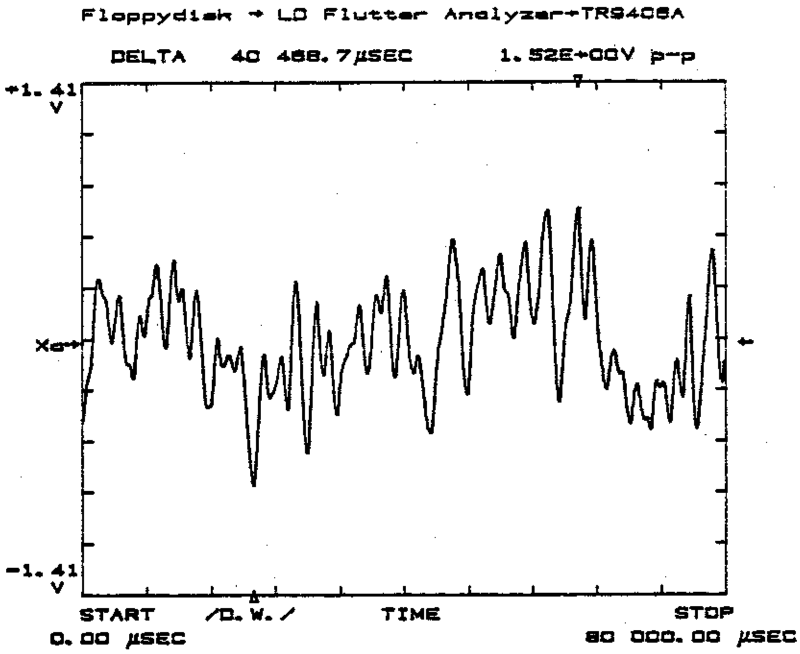


(a) Wow-Flutter at 160 Hz
The upper trace indicates the overall value (-6.5 dBV) when the MINIMUM weighting function is used.

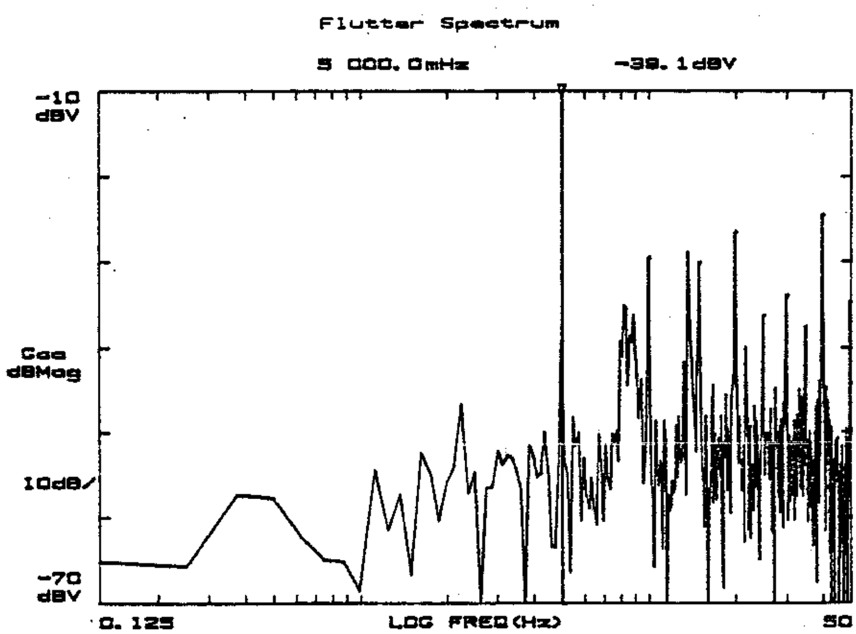


(b) Wow-Flutter at 80 Hz (x 4 zooming)

Figure 5-51 Wow-Flutter Spectra



(a) Waveforms through Data Window



(b) Wow-Flutter Spectra

Figure 5-52 Wow-Flutter Waveforms and Spectra
(through laser doppler and wow-flutter meter)

5.8 MEASUREMENT OF NOISE LEVEL ACCORDING TO PSD (POWER SPECTRUM DENSITY)

The noise level of the same semiconductor device varies with a different frequency range even through they are measured in the same manner.
The reason for this variation is that the frequency resolution depends on the analysis range and weighting function used. (When the resolution is 400 lines, the resolution in the 100-kHz range is 250 Hz and the resolution in the 1-kHz range is 2.5 Hz.)

When the PSD method is used, the noise level is indicated after conversion to the power per Hz, that is, the same value is indicated if a different analysis range is set. The equivalent noise bandwidth depending on the weighting function is automatically compensated. A unit, $V/\sqrt{Hz}$, V^2/Hz, $dBV/\sqrt{Hz}$, is selected corresponding to Mag, Mag^2, or dBMag selected in the DISP CTRL menu.

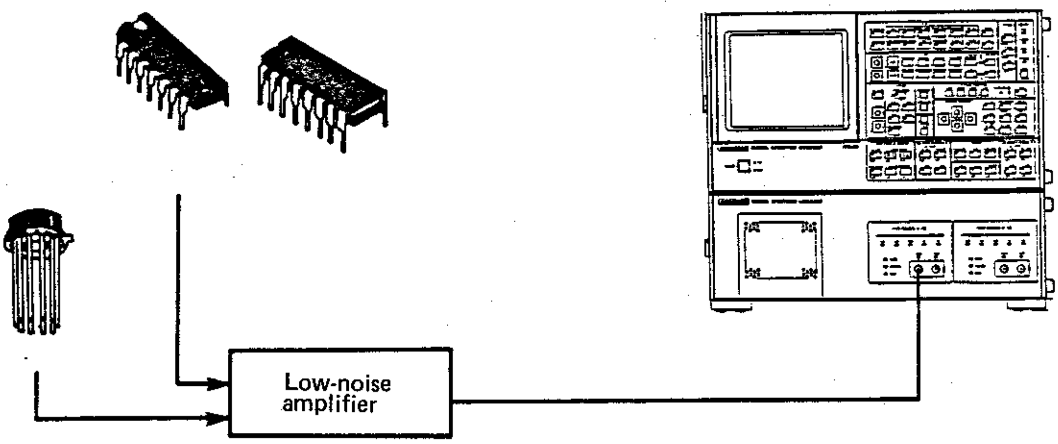


Figure 5-53 Measuring Noise Spectrum

1. (SPECTRUM) Display the spectrum.
2. (FREQUENCY) Set the frequency range to 100 kHz.
3. (SENS. A) Set the input sensitivity (Ch.A) to +10 dBV.
4. (AVG MODE) AVG WHAT: POWER SPECT
   AVG NUMBER: 256 or more
5. (AVG/INST.)
6. (START) Start averaging.
7. (STORE) (MEMORY) Store the averaging result in the memory.
8. (FREQUENCY) Change the frequency range to 1 kHz.

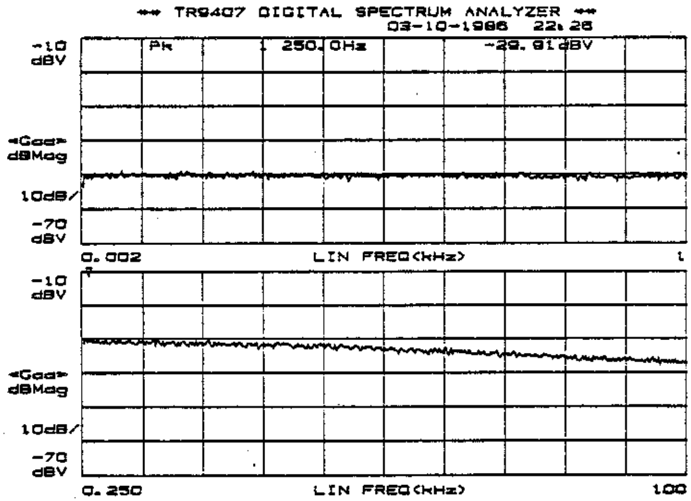
⑨ START — Start averaging under the same condition as the previous averaging.

⑩ RECALL (MEMORY) — Recall the result of measurement at 100-kHz range from the memory.

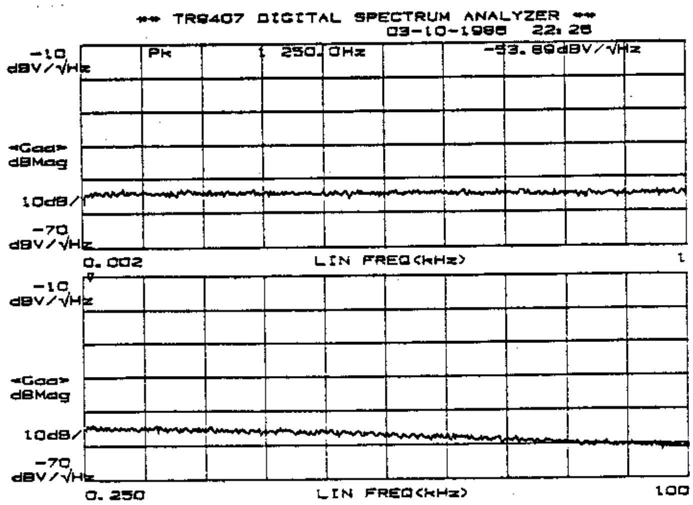
⑪ BOTH — Select the dual display mode and compare the noise (lower) measured at the 100-kHz range with the noise (upper) measured at the 1-kHz range. Note that the noise level difference is about 20 dB in case of the frequency range of 100 kHz and 1 kHz.

⑫ WGT/SCALING — FREQ UNIT: Hz
VERT UNIT: PER Hz (PSD).
As shown in Figure 5-54, noise levels expressed in PSD are almost the same.

WEIGHTING
RECT
HANNING #
MINIMUM
FLAT-PASS
FORCE/RESP
F. 10 (ST)
15 (SP)
R. 10 (ST)
521 (SP)
+0. 250 *FS
READ OUT
FREQ UNIT
Hz #
CPM
VERT UNIT
NORMAL
⇒ PER Hz #
SCALING
KEY #
CURSOR
OFF
FREQ/CH-A
0 dBEU=
+000. 0 dBV
"EU" =EU



PSD OFF
(In spite of the same input noise level, different levels are indicated in different frequency ranges.)



PSD ON
(If frequency ranges are different, the values compared according to the PSD per Hz are the same.)

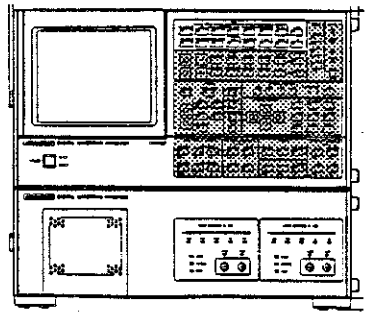
Figure 5-54 Comparing Noise Levels in PSD

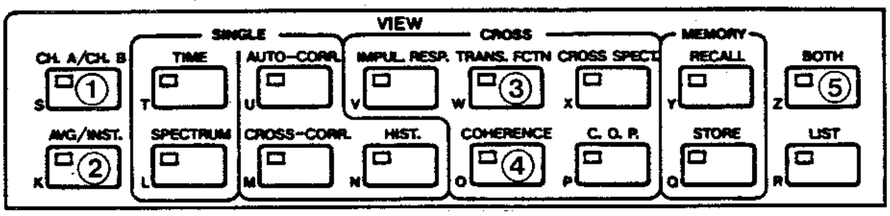
TABLE OF CONTENTS

6. PANEL KEYS EXPLAINED

6.1 EXPLANATION OF FRONT PANEL

(1) Selection of domain and functions in observing the data





① TIME

Data in the time domain is displayed.

② SPECTRUM

The data (auto power spectrum or complex spectrum) in the frequency domain is displayed.

③ TRANS.FCTN

Transfer function, Bode diagram, Nyquist diagram (Cole-Cole plot), and Nichols chart are displayed.

④ COHERENCE

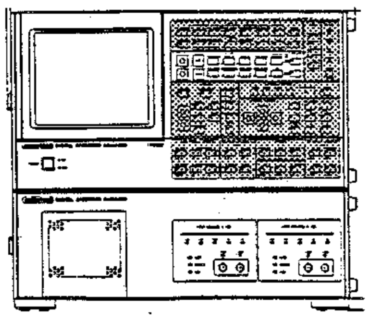
After a transfer function is measured, the reliability of the data is checked. Data becomes more reliable as it approaches 1.

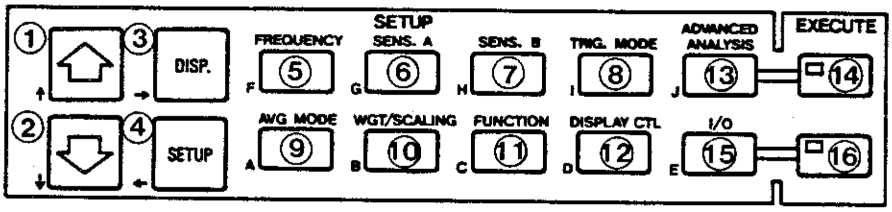
⑤ BOTH

Time data in single-channel operating mode or 4-decade logarithmic frequency analysis data cannot be displayed on two screens because of memory capacity.

For dual screen display, UPPER/LOWER in the DISPLAY section determines which trace in either the upper or lower screen is to be modified. UPPER/LOWER in the GENERAL CURSOR section places the cursor in either the upper or lower areas of the dual screen display.

(2) Displaying various menus to set measurement conditions





① ② 

Move the pointer (⇨) on the menu to the desired position.

③ DISP

This key is used to set conditions where the pointer (⇨) blinks. Each time this key is pressed, the value is incremented, in contrast with the SETUP key.

④ SETUP

Move the pointer (⇨) to the desired position with ① and ②, then set data by this key.

When the pointer (⇨) blinks, this key sets conditions. Each time this key is pressed, the value is decremented, in contrast with the DISP key.

⑤ FREQUENCY

A frequency analysis range can be selected and set only by moving the pointer (⇨). (The mark # automatically moves to the position where the range is set.)

⑥ ⑦ SENS A, SENS B

Input sensitivity is switched in 10 dBV steps. With setting to auto range, the 4-decade logarithmic frequency analysis or swept sine sweep measurement would provide a high-resolution and wide dynamic range transfer function measurement.

Auto range is settable on the SERVO menu, too.

If measurement is needed in short time, sSQ mode may be used instead of the auto range to uniquely set the sensitivity range according to the sequence regions.

⑧ TRIG MODE

Sets trigger conditions, divides and writes to data memory, and sets interchannel delay.

⑨ AVG MODE

AVG PROCESS and AVG NUMBER can be set on the SERVO menu as well. If the three types of menus of average number settings are effective, the one set in the signal sequence menu has the highest priority.

As well as setting the menu by this key, if the sweep mode is set on any one of the menus of SERVO, SINE or SWEPT SINE, then sweep averaging is performed.

⑩ WGT/SCALING

A window function and scaling (the values on the vertical axis are represented in an engineering unit) are set.

If WEIGHTING CTRL is set to AUTO on the SERVO menu, an optimum window function is automatically set according to the signal output from the signal generator.

⑪ FUNCTION

The following functions are included: determination of transfer function both in open loop and closed loop, differential and integral calculus function, equalize, coherence blanking, trend removal, and smoothing functions.

(12) DISPLAY CTL

Nichols chart can be displayed from the dual screen display (Bode diagram with its vertical axes representing phase and dBMag) used as a gain stability criterion.

The amplitude axis of the power spectrum can be calibrated in Mag (V), Mag^2 (V^2), or dBMag (dBV); and for the dB display, 10 dB, 5 dB, or 2 dB per division can be set.

When a transfer function is displayed as Nyquist diagram, the following displays are available from the above setting:

Mag	— Real vs Imag	Nyquist display
Mag^2	— Real vs -Imag	Cole-Cole display
dBMag	— dBMag vs Phase	Nyquist display

Using this menu, averaged frequency domain data such as transfer function will be observed in the time domain after inverse Fourier transform. Frequency domain data can also be displayed by Fourier transform of time domain data.

(13) ADVANCED ANALYSIS

In addition to frequency response analysis, measurements such as three-dimensional display, third- and full-octave analysis, group delay, cepstrum, pre-envelope, and SNR can be performed through a particular menu.

ADVANCED ANALYSIS menu is changed at each press of [ADVANCED ANALYSIS].

Pressing [ADVANCED ANALYSIS] [PANEL RECALL □] will bring about the display of

SCT → T	CPT → U	ENV → V				
LST → L	3DP → M	OCT → N	SVO → O	GDY → P	SNR → Q	ML → R

to show the softkeys needed for each advanced analysis menu display. Pressing the series of keys will immediately display the menu of interest.

As for the servo (frequency response) menu, see the APPENDIX 3 at the end of the manual.

⑭ EXECUTE

Executes the advanced analysis functions. For frequency response analysis, START in the average control section must be pressed after this key.

⑮ I/O

This menu is set when an XY recorder, plotter, floppy disk, and signal generator are connected.

Each time this key is pressed with the pointer (⇨) set in the position of an I/O device on a display menu, the menu changes.

As is the case with ⑬, pressing I/O RECALL would display the following softkey list.

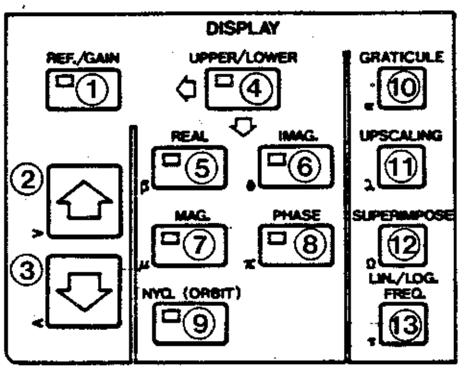
IMP → T	SWP → U	RND → V	MEM → W	SEQ → X		
RCD → L	PLT → M	FLP → N		SIN → P	MSN → Q	WMS → R

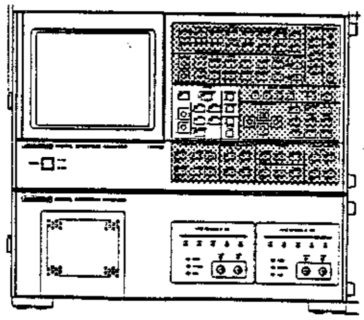
⑯ EXECUTE

The lamp of this key lights when the external devices described above are operating.

Plotting screen data can be started by pressing this key, and it can be canceled by pressing again. (The light goes off.)

(3) How to modify the display





① ② ③ REF/GAIN

This key, when its lamp is on, can move screen data up and down in combination with ⇧ and ⇩ in ② and ③. (In REF mode)

In the GAIN mode when the lamp of the key is off, the display dynamic range can be changed by pressing the keys ② and ③. When the phase display mode is effected by the key ⑧ in the GAIN mode, measurement results can be displayed from $+25600^{\circ}$ to -25600° without wraparound.

④ UPPER/LOWER

When the screen is split into two by BOTH, the display format and analysis data on the upper and lower screens can be selected. The DISP MODE and DISP GAIN on the menu of DISPLAY CTL can be set for the upper and lower screens independently.

⑤ REAL (real part)

⑥ IMAG (imaginary part)

⑦ MAG (magnitude display)

⑧ PHASE (phase display)

This key is used to display spectrum, transfer function, and cross spectrum. When the lamp of [MAG.] lights in the power spectrum display, MAG, Mag^2, and dBMag display can be selected by the menu displayed by [DISPLAY CTL].

⑨ NYQ (ORBIT)

The Nyquist display of the transfer function is made nby setting DISP MODE of [DISPLAY CTL] as follows:

DISP MODE	Mag	Mag^2	dBMag
Transfer function <Hab>	Real, Imag Nyquist (Linear) display	Real, -Imag Cole-Cole	dBMag, Phase Nyquist (dB) display

⑩ GRATICULE

By depressing this key on or off, the graticule lines on the screen can be erased or generated.

⑪ UPSCALING

When this key is pressed, the menu at the right is erased, so that the screen is expanded by 40 percent. The TIME and SPECTRUM data in the single channel mode which cannot be displayed on the two screens, can be made to display in split form by UPSCALING.

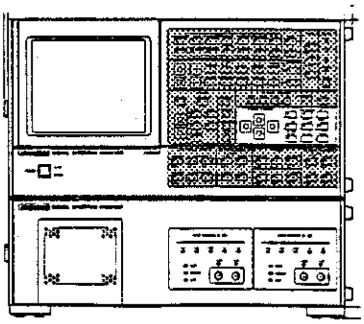
⑫ SUPERIMPOSE

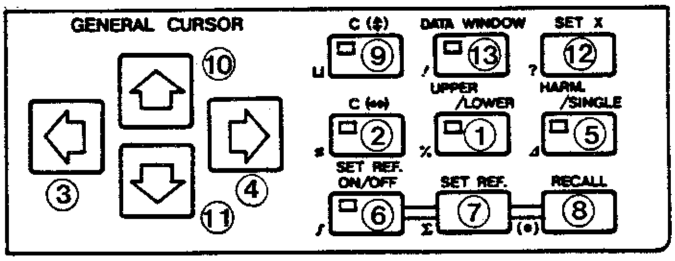
When this key is pressed in the dual screen display mode of the same domain and same analysis range, data is overlapped on a single screen. This function is useful to overlap two data for comparison; the Mag and Phase of spectrum display; and transfer function and coherence function.

⑬ LIN./LOG.FREQ

This key is used to select whether the frequency axis is displayed linearly or logarithmically. The 4-decade logarithmic frequency analysis data is always displayed in logarithmic frequencies. In cepstrum and pre-envelope, the time axis is displayed logarithmically.

(4) Reading data and setting parameters using the cursor





① UPPER/LOWER

In the dual screen display mode, this key is used to select which of the screen data, either upper or lower, is to be read by turning the cursor on.

② Vertical cursor

When this key is turned on, the lamp of the key lights and the vertical cursor is displayed.

When the cursor is off, the auto peak search mode is activated.

③ ④ 

These keys are used to move the vertical cursor or to move the blinking marker horizontally when setting the label mode or AMPLITUDE on the SIGNAL G. menu, respectively. Also used to horizontally move the pointer in the CATALOGUE mode of the FLOPPY menu.

⑤ HARM/SINGLE

When this key is pressed, a maximum of 20 harmonics are indicated with intensified markers with respect to the fundamental of either vertical-cursor specified spectrum or peak spectrum (when cursor is off).

⑥ SET REF.ON/OFF

⑦ SET REF.

⑧ RECALL

Display the vertical cursor by pressing C (↔).

Display the reference cursor by SET REF. ON/OFF. Move the reference cursor (indicated by △ marker and the vertical cursor) to a desirable reference point by the yeller ⇧ ⇩ keys and press SET REF. for the position to be defined as a reference point. In this way a maximum of 20 reference points thus set can be stored in memory.

A list of the reference points thus set up can be viewed by pressing LIST. The lowest reference number in the list represents the most recent data being set. These setup values are cleared by pressing LOCK CLR with the keys SET REF. ON/OFF LIST turned on.

These stored references can be retrieved by pressing SET REF. ON/OFF PANEL STORE RECALL followed by the numerical entry of the setup number in the LIST mode display. Numerical entry is made by the green characters to the lower left of each key.

When the PANEL STORE key is off, a preceding reference setup state is recalled each time RECALL is pressed with the condition of SET REF. ON/OFF. In this case, the capability of the PANEL STORE key is different from the one inherent in this key.

⑨ Horizontal cursor

Activation of this key displays the horizontal cursor

⑩ ⑪ [⇧] [⇩]

1) Moving the horizontal cursor
2) Moving the reference cursor (when the horizontal cursor is not displayed)

   [⇧] : Moves the reference cursor to the right.

   [⇩] : Moves the reference cursor to the left.

3) Scrolling up and down the filing area one line at a time in the floppy CATALOGUE mode.

⑫ SET X

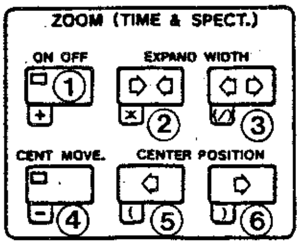
This key is used to set the following values in combination with the vertical or horizontal cursor.

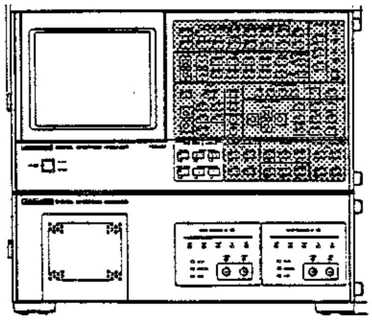
1) TR98201 sweep frequency range in signal sequence method (Fmax and Fmin when sine or swept sine waves are used)
2) Setting the bandwidth (WIDTH) of TR98201 output waveform
3) Coherence blank level
4) Threshold value and liftering value of cepstrum
5) Display reference level
6) Interchannel delay
7) Start/stop points and damping level of force/response window function.
8) Trigger position, trigger level
9) Movement step size of data window
10) Stop and restart of the LEVEL MONITOR

⑬ DATA WINDOW

A specified portion of 512K words (for one channel; 256K words for two channels) of input time data is observed through the window of 2K words (1K word for two channels).

(5) Zoom function (time and frequency domain)





① ZOOM ON/OFF

The data display is expanded at the following Zoom factors, with center at the vertical cursor position or, in the auto peak search mode when the vertical cursor is off, at the maximum amplitude position of waveform.

	Frequency domain	Time domain
Hold zoom	2, 4, 8, 16, 32	2, 4, 8, 16
Running zoom	2, 4, 8. 16, 32 64, 128, 256	

Note

The 4-decade logarithmic frequency analysis data, if zoomed, is lost from memory.

② ③ EXPAND WIDTH

Zoom factor is switched over as in the above table. The set factor is displayed at the bottom center of the screen.

④ CENT.MOVE

By turning this key on, the central position of zoomed data can be moved continuously using the keys ⑤ and ⑥. When this key is turned off, each time the keys ⑤ and ⑥ are pressed, it moves one step at a time.

6.2 EXPLANATION OF REAR PANEL

6.2.1 Connectors on the Rear Panel

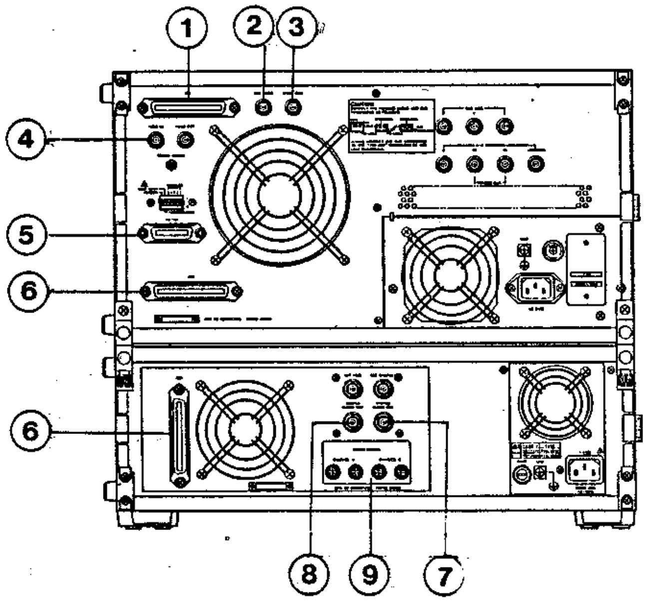


Figure 6-1 Rear Panel of TR9407

① PIO (Peripheral Input Output)

Connected with the TR98201/TR98202 Signal Generator, TR98102 Floppy Disk Digital Data Recorder or the dedicated maintenance gear.

② EXT.GATE

The incoming signal is read and sampled while the TTL high external signal is applied to this connector.

③ SYNC.OUT

TTL active low pulse (pulse width: approx. 100μs) is output. Connect this output to the TR7200 scanner to configure the multi-channel system in which channel switching is carried out on measurement. Define the SCAN mode in the floppy disk CATALOGUE menu to perform the panel sequence measurement.

④ HOLD IN; HOLD OUT

The CRT display is held when TTL low level signal is applied to the HOLD IN connector. When the CRT display is kept still, the TTL level signal is output from the HOLD OUT connector.

⑤ GPIB

24-pin GPIB connector and address switch.

⑥ AIO connector

TR9407's display section (top) and input section (bottom) are interconnected with the supplied cable (DCB-RR2057 x 01).

⑦ SYSTEM CLOCK OUT

20.48 MHz ECL differential output (tricoaxial connector output). Output is in synchronism with the internal (or external) sampling. Used for the simultaneous sampling in the multi-channel system configuration.

⑧ SAMPLE CLOCK OUT

In the system of ⑦, this output is fed to the EXT SAMPLE connector of the neighboring device.

⑨ PROBE POWER

Power supply for the probe with the internal floating ground.

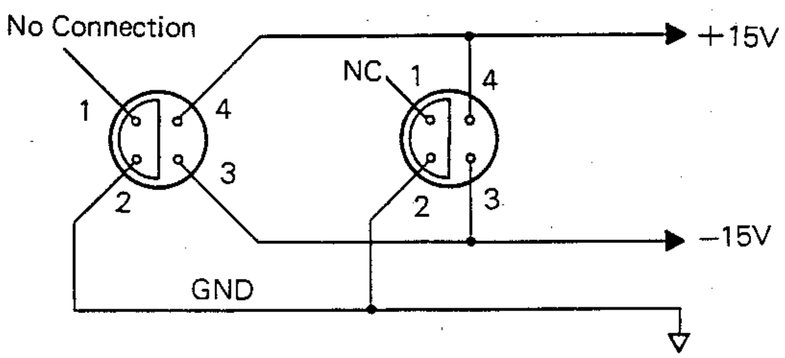


Figure 6-2 Probe Power Internal Circuit

6.2.2 EXT. TRIGGER Connector

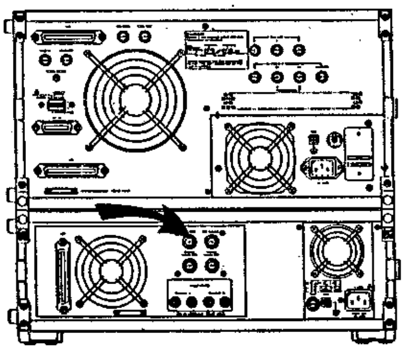


Figure 6-3 EXT. TRIGGER Connector

This connector accepts an external trigger signal which determines the trigger timings for the AUTO ARM or ARM mode. It is effective when item "SOURCE" of the TRIG MODE menu (selected with the SETUP section) is set up for "EXT".

The external trigger signal level may range between +10 V and -10 V, from which the appropriate trigger level can be specified with "LEVEL" in the TRIG MODE menu. If it is set up for "EXT", the trigger level is always a fullscale of ±10 V.

Trigger slope can be switched between positive (+) and negative (-). If the available external trigger signal is TTL compatible, set up "LEVEL" of the TRIG MODE menu for "0.148 * FS" (approximately +1.5 V).

6.2.3 EXT. SAMPLE Connector

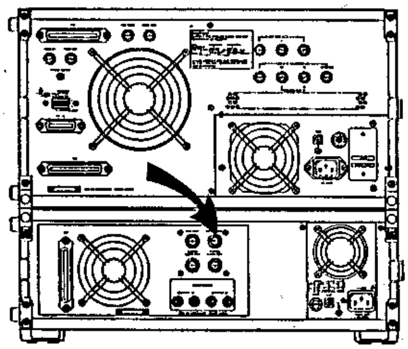


Figure 6-4 EXT. SAMPLE Connector

This connector accepts an external clock which determines the data sampling timing. It is effective when "SAMP CLK" of the FREQUENCY menu is set up for "EXT". The external sampling signal must be TTL compatible (with HIGH level at 2 V or more, and LOW level at 0.8 V or below), with its frequency up to 2.56 MHz and pulse width more than 150 ns. The internal sampling signal is generated in synchronism with the leading edge of the external sample signal.

6.2.4 TOUCH SOUND Control

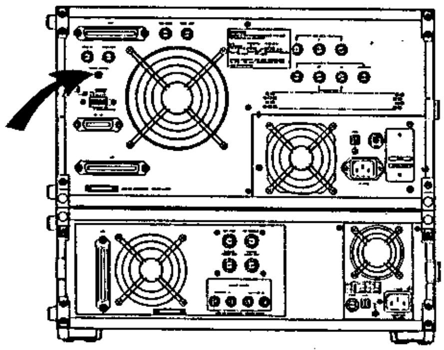


Figure 6-5 TOUCH SOUND Control

This screwdriver adjustment controls the volume level for key touch tone, input overload alarm, and other alarm buzzer sounds. Clockwise rotation of this control increases the volume level. To make the buzzer sound inaudible, turn this adjustment fully counterclockwise.

6.2.5 EXT. CRT Connectors

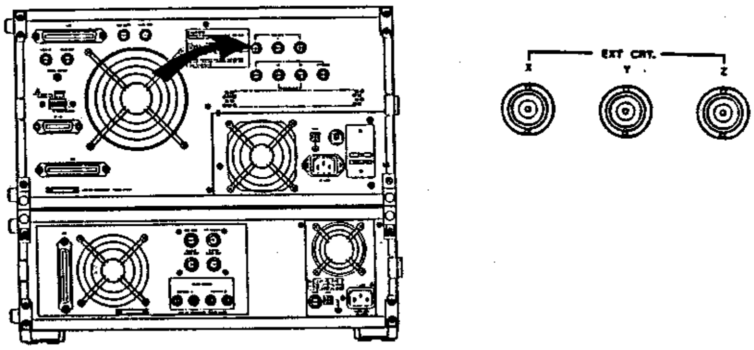


Figure 6-6 EXT. CRT Connectors

These three connectors provide the signal outputs identical to those supplied to the internal CRT display. They may be used to check out the internal display function by attaching an external oscilloscope or monitor scope to them. The output levels are ±1.0 V for X and Y outputs, and TTL active low for Z output.

EXT. CRT connectors are intended for the troubleshooting purposes. No particular measures are taken to meet the requirements of the frequency response of the noise or the signals for the external monitor. Analogical control of intensity, as it is done in the internal CRT, cannot be achieved especially at the digital output of z-axis (active low) for the external monitor.

For the external monitoring through the EXT. CRT terminal, the noise on the signal should be eliminated.

When the connection cable is to be extended, provide the external amplifiers of large CMR as drivers and receivers. If the delay in the transmission path causes the timing lag with the blanking signal (z-axis), provide the appropriate delay circuit for adjustment.

6.3 MENUS EXPLAINED

FREQUENCY

Frequency range setting

```
FREQ  RANGE
SAMP  CLK
   INT          #
   EXT

⇨  1       MHz  #
   500     kHz
   200
   100
   50
   20
   10
   5
   2
   1
   500      Hz
   200
   100
   50
   20
   10
   5
   2
   1

FRAME  TIME
   400  µSEC
```

INT: Select this to sample data using an internal clock (this is the normal mode of operation).

EXT: Select this to apply an external sampling clock via the EXT.SAMPLE connector on the rear panel. (Used for order analysis or sampling data in synchronism with rotation of external object)

Setting marks, ⇨ and #, move together.

FRAME TIME: The frame time varies with the frequency setting. For example, if the frequency is set to 50 kHz, the frame time is 8 ms; if the frequency is 20 kHz, the frame time 20 ms.

SENS. A

Input sensitivity setting for channel A (B)

```
SENSITIVITY
MAX  INPUT
  A: ±  44.7   V
  B: ±  44.7   V
```

Maximum amplitude to each channel

```
  *CH-B*
  NORMAL      B#
  INVERT
```

If INVERT is set using the SETUP key, the input signal polarity is inverted. (Ordinarily, NORMAL is selected.)

```
  ACTIVATE
```

If ACTIVATE is turned to DEACTIVATE using the pointer and the SETUP key, only one channel is placed in operation; as a result, the line resolution becomes 801 from 401.
In correlation function measurement, the DEACTIVATE mode is inhibited; both channels are always used. Moving the pointer to AUTO or a value of 30 dBV to 60 dBV resets the DEACTIVATE mode.

```
  AUTO
   (dBV)
⇨ +30         B#
  +20
  +10
    0
  -10
  -20
  -30
  -40
  -50
  -60
```

# indicates the setting for channel B.

TRIG. MODE

This menu is not used for the FREE RUN mode; used to capture the input signal at the specified point on the CRT display.

```
AUTO CAL
  ON
EXT GATE
  OFF
TRIGGER
SOURCE
  CH-A
SLOPE
  <+>
LEVEL
  +0.078 *FS
POSITION
  +200.00 %
BEEP ON TRIGGER
  OFF
MARKER
  OFF
ARM MODE
  NORMAL
ARM LENGTH
=> 256K
BLOCK NO.
  0
INTERCHAN DELAY
  0/1024
```

- **AUTO CAL**: The first zero calibration is carried out 10 min after AUTO CAL ON; the second in 30 min and thereafter in every 1 hour. Set it to OFF if the data is written into the floppy disk or the GPIB is implemented.
- **EXT GATE**: Data are sampled only at the application of the TTL high external signal by receiving the incoming signal.
- **TRIGGER SOURCE**: Trigger signal selection (Channel A or B, or the external trigger signal applied to the EXT. TRIGGER connector on the rear panel.)
- **SLOPE**: Trigger on the positive-going or negative-going edge.
- **LEVEL**: The trigger level can also be defined using the horizontal cursor and the SET X key.
- **POSITION**: Setting of the trigger position (point on the time axis [x-axis]); also settable with the vertical cursor and the SET X key.
- **BEEP ON TRIGGER**: Setting this to ON gives an audible alarm when triggering takes place.
- **MARKER**: Setting MARKER to ON causes the trigger point, if included in the displayed waveform, to be intensified.
- **ARM MODE**: To be used in combination with the ARM or AUTO ARM key.
  In the NORMAL mode, only block 0 is used.
- **ARM LENGTH**: Determine the unit memory size with which to divide the 256K word data memory for each channel. For single-channel mode, up to a maximum ARM LENGTH of 512K words may be set. (If the ARM LENGTH is set to 512K words, the data memory consists of block 0 only.)

ARM MODE	TRIGGER	Blocks used
NORMAL	ARM	Block 0 only
	AUTO ARM	Block 0 is used repeatedly
ADVANCE	ARM	Block specified by BLOCK No.
	AUTO ARM	Sequential used from 0 to 1, 2 ... until it is held at the maximum block.

- **INTERCHAN DELAY**: Compensates for the interchannel delay to obtain the accurate transfer function. Also settable with the SET X key in the auto peak search mode (with the VIEW mode of AUTO CORR, IMPUL RESP or CROSS CORR).

AVG MODE

Averaging for signal enhancement for readout.

```
AVG MODE
⇨ SUM (N)  #
  SUM (L)
  DIFF
  EXP
  PEAK
  SUM (T)
AVG WHAT ?
  CROSS+POWER
AVG NUMBER
  2
AVG CHANNEL
  CH-A
  CH-B
  DUAL
  CROSS     #
AVG PROCESS
  NORMAL    #
  +1 AVG
  SWEEP
OVERLAP
  0 %       #
  50%
DISPLAY
  ALL       #
  1/2
  END
```

Most commonly used mode. With normalized averaging, the results displayed are always correctly scaled for readout.

Linear summation. An accurate average value cannot be obtained until the preset number of averagings is reached.

Difference averaging is used to remove the effects of given spectra (esp. background noise) from the measurements obtained in SUM mode.

Exponential averaging. This average assigns more significance to the recent data while the older data dies out in importance at a decaying exponential rate.

Peak detection.

Normalized summation of time-domaim data; used only for correlations.

What is to be averaged is selected from 7 categories by DISP or SETUP keys.

DISP. key increase the number; SETUP key decreases the number.

Select the channel in which averaging is to be made.

Averaging is incremented one at a time by CONT. key, confirming a captured transient on CRT. When ARM key is used, set to "+1 AVG" instead of "NORMAL."

Sweep averaging allows high-quality measurement of transfer function (at resonances).

On a low-frequency range 50% overlap minimizes averaging time and reduces measurement errors.

Table 6-1 Combinations of AVG WHAT? and AVG MODE

AVG WHAT? / AVG MODE	TIME	CORRE-LATION	HIST	POWER SPECT	COMPLEX SPECT	CROSS+ POWER
SUM (N)	o	X	o	o	o	o
SUM (L)	X	X	X	o	X	o
DIFF	X	X	X	o	X	X
EXP	o	o	o	o	o	o
PEAK	X	X	X	o	X	X
SUM (T)	X	o	X	X	X	X

o: Allowed X: Not allowed

WGT/SCALING

Weighting function selection and scaling

```
WEIGHTING
⇨ RECT              #
  HANNING
  MINIMUM
  FLAT-PASS
  FORCE/RESP
  F:  10    (ST)
      15    (SP)
  R:  10    (ST)
      521   (SP)
   +0.250  *FS
READ OUT
FREQ UNIT
   Hz               #
   CPM
VERT UNIT
   NORMAL           #
   PER Hz

SCALING
   KEY              #
   CURSOR
   OFF
 TIME/CH-B
   1 "EU"=
 +1.00E+00  V
   "EU"  =EU
```

WEIGHTING: Change the weighting function depending on the purpose of measurement; how data is to be weighted, what is to be precisely analyzed, or whether the input signal is transient or continuous.

FORCE/RESP: FORCE/RESPONSE is used for the transfer function measurement by the impulse method. FORCE eliminates noise, RESPONSE eliminates leakage by damping the impulse response within the frame time. Start point, stop point and damping level are settable either by a menu or a cursor.

FREQ UNIT: Select either Hz or CPM (cycle per minute) as the frequency axis unit.

VERT UNIT: Select either NORMAL for power spectrum or PER Hz for PSD (power spectrum density; power per Hz) as the amplitude unit.

SCALING: Calibration of x- and y-axis for the most appropriate unit; the unit indication and scaling on the CRT change in compliance with this setting.

	KEY MODE	CURSOR mode
Time domain	1EU=... [V]	CURSOR=...[EU]
Frequency domain	1EU=... [Vrms] or 0dBEU=... [dBV]	CURSOR=...[EU] or CURSOR=... [dBEU]

0 dBEU or 1 EU depends on whether the DISP MODE is "dBMag" or "Mag, Mag^2" in the DISP CTRL menu.

Table 6-2 Weighting Functions

	Advantages	Disadvantages	Use
RECTANGULAR	o Energy of waveform in frame time remains constant. o Frequency resolution is highest.	o Amplitude accuracy is low (-3.92 dB worst case). o Discontinuities occur on the aperiodic continuous waveform at each end of the frame time.	o Most suitable for analyzing transient signals and impulse signals
HANNING	o No discontinuity occurs on continuous waveform at each end of the frame time.	o Slightly inferior in frequency resolution to RECTANGULAR. o Amplitude accuracy is relatively low (-1.42 dB, worst case).	o Most commonly used for continuous wave-form measurement.
FLATPASS	o Amplitude accuracy is highest.	o Frequency resolution is low (-0.10 dB, worst case).	o Effective for har-monic analysis.
MINIMUM	o Very good sideband behavior. o Superior in frequency resolution to FLAT-PASS. o Superior in amplitude accuracy to HANNING (-0.85 dB, worst case).	o Inferior in frequency resolution to HANNING. o Inferior in amplitude accuracy to FLAT-PASS.	o Effective to resolve two nearby very dissimilar strength spectra (for example, deep notch).

FUNCTION

FUNCTION
⇨ OFF

<U+L>
OPEN/CLOSED
OFF

Ho/ (1+Ho)
∫Xxdt
OFF/CH-A
OFF/CH-B
dXx/dt
OFF/CH-A
OFF/CH-B
* (VIEW) $(jw)^n$ *
OFF
EQUALIZE
OFF
COH BLANK
OFF
OVERALL
OFF
TREND REMOVAL
OFF/CH-A
OFF/CH-B
SMOOTHING
OFF

Postprocessing of analyzed data

Math operation to be performed in a dual display mode (on data in the same domain and same range); for subtraction, (upper data - lower data) is calculated; for division, (upper data ÷ lower data) is calculated. U represents the upper data; L the lower data.

Transfer function is obtained either from open loop to closed loop or vice versa. Storage of transfer function as the feedback element Hm is required in the feedback control system.

Integration in the time domain for channel A or B.

Differentiation in the time domain for channel A or B. (Results of integration or differentiation can be displayed in the either domain, time or frequency)

Multiplication of the frequency domain data by $j(\omega)$ (approximation to the integration or differentiation).
If averaging and differentiation/integration are both to be made, multiplying the result of averaging by $(j\omega)$ reduces the required time with increased precision. (See Table 6-5)

Removes the effects of the frequency characteristic of the sensor itself. Transfer function of the measurement system is required to be stored in buffer memory.

Blanks irrelevant data in the measurement of cross data such as a transfer function so as to clearly demonstrate the causality between the input and output signals.

Displays the readout of the total power of all spectra being displayed or of part of the spectra being displayed (with the aid of the SET REF. key). Any weighting function can be used for the measurement of OVERALL.

Removal of the dc components or linear trend can be made in the Ch.A or Ch.B independently.

Moving average smooths out the effects of high-frequency components (noise) of the incoming signal.

Table 6-3 Math Operations between Same Type of Data

DATA \ FUNCTION	+	-	*	/
TIME	o	o	o	X
HIST.	o	o	X	X
AUTO-CORR.	o	o	X	X
CROSS-CORR.	o	o	X	X
IMPUL. RESP.	o	o	X	X
POWER SPECT.	o	o	X	o
OCTAVE	o	o	X	o
COMPLEX SPECT.	o	o	o	o
TRANS. FCTN	o	o	o	o

o Applicable
x Inapplicable

Table 6-4 Math Operations between Different types of Data (1)
(Delay Domain)

Lower trace \ Upper trace	AUTO-CORR.	CROSS-CORR.	IMPUL.RESP.
AUTO-CORR.		+, -	+, -
CROSS-CORR.	+, -		+, -
IMPUL. RESP.	+, -	+, -	

Table 6-4 (Continued)

Math Operations between Different Types of Data (2)

Lower trace \ Upper trace	COMPLEX SPECT.	TRANS. FCTN
TRANS. FCTN	* , /	
COMPLEX SPECT		Incomputable

Math Operations between Different Types of Data (3)

Lower trace \ Upper trace	POWER SPECT	TRANS. FCTN
TRANS. FCTN	* , /	
POWER SPECT		Incomputable

Table 6-5 Correspondence between (j) Operations and Differentiation/Integration Functions

	$1/(j\omega)$	$1/(j\omega)^2$	$(j\omega)^2$	$(j\omega)$
Gaa (Gbb) (Power spectrum)	CH-A (CH-B) integration	CH-A (CH-B) double integ.	CH-A (CH-B) double diff.	CH-A (CH-B) differentiation
C.O.P.	CH-B integration	CH-B double integ.	CH-B double diff.	CH-B differentiation
Hab (Transfer function)	CH-B integ. or CH-A diff.	CH-B double integ. or CH-A double diff.	CH-B double diff. or CH-A double integ.	CH-B diff. or CH-A integ.
Gab (Cross spectrum)	CH-B integ. or CH-A integ.	CH-B double integ. or CH-A double integ.	CH-B double diff. or CH-A double diff.	CH-B diff. or CH-A diff.

Table 6-6 OVERALL/PARTIAL and Its Message

	VIEW	OVERALL/PARTIAL	Message
TIME	TIME	o	1
	AUTO-CORR	X	2
	CROSS-CORR	X	2
	IMPUL.RESP.	X	2
FREQUENCY	REAL/IMAG.	X	3, 4
	PHASE	X	3, 4
	MAG.	o	1
	COHERENCE	o	1
AMPLITUDE	HIST.	o	1

o: ENABLE X: DISABLE

Displayed messages

1 PARTIAL SET REF.
Reference is not set. Set the REFERENCE.

2 OVERALL (TIME, HIST., MAG.)
OVERALL is only possible when the VIEW section is set to TIME or HIST or the vertical axis for the SPECTRUM display is in the MAG.

3 PARTIAL: POWER SPECT.
PARTIAL is only possible in the MAG. display.

4 OVERALL: POWER SPECT.
OVERALL is only possible in the MAG. display.

DISPLAY CTL

Display control (scale, unit and others)

```
DISP CTRL
 *LOWER*
AUTO SCALE
   ON
DISP MODE
   TIME

   Mag
   Mag²
   dBMag     L#
   NICHOLS
DISP GAIN
<dB/DIV>
   2
   5
   10        L#

DATA WINDOW
   AUTO
STEP <D. WINDOW>
    15/1024

RE-SAMPLING
   UNIFORM
LEVEL MONITOR
=> ON
   CURSOR
```

- o To make settings for a dual mode display, specify UPPER for the upper half of the screen or LOWER for the lower half of the screen.
- o Analysis data of frequency domain is displayed at the appropriate gain.
- o Time domain (Fourier transformed) or frequency domain (Inverse Fourier transformed) data either recalled from memory or averaged is observed in the time domain.
- o Specify Mag (linear), Mag^2 (V^2), or dBMag (log) as the unit for the power spectrum magnitude axis. For a Nyquist display, Mag is used; Mag^2 is for a real-imag display; dBMag is for a magnitude-phase display.
- o Time domain (Fourier transformed) or frequency domain (Inverse Fourier transformed) data either recalled from memory or averaged is observed in the frequency domain.
- o In this example, L indicates a setting for the lower display and # for the upper display.
- o Transfer function in dual mode (Phase and dBMag display for each vertical axis) is represented as Nichols chart.
- o Set 10 dB, 5 dB, or 2 dB as the value of each division on a dB display.
- o Determines how to shift the time waveforms stored in the input buffer.

  If the ⇦ or ⇨ key is pressed in the AUTO mode, the data window is continuously shifted. In the MANUAL mode, the data window is shifted one step size each time either key is pressed.
- o Setup of step size of data window (up to 2048 points for 1 ch; 1024 points for 2 ch). Also settable with the vertical cursor and SET X key.
- o Decimated time data is displayed according to the zoom factor.

  UNIFORM: Uniformly decimated with the factors of 2 to 256.

  REAK : Resampled at every peak within the points set up as the zoom (decimation) factor.
- o Overall or peak values of time-varying data in the frequency display are monitored.

Three-dimensional display

```
ADVANCED SELECT
⇒ 3D DISPLAY
  <DISABLE>

3D DISP TRIG.
  AUTOMATIC      #
  DATA WINDOW
  AVERAGING
  AUTO ARM
  GP-IB
START LINE NO.
  1/32
ANGLE FACTOR
  0 (90°)
3D DISP SOURCE
  SYSTEM         #
  FLOPPY
3D DISP OUTPUT
  CRT            #
  HARD COPY
STACK LINE NO.
  16
```

Determines the timing of 3D display. (3D display is produced on each performance of averaging (AVERAGING), or each time the data is held after AUTO ARM or ARM execution (AUTO ARM), or at each reception of a DT command (GPIB), etc.)

The number of traces that can be 3D displayed on the CRT is fixed to 14. START LINE NO. specifies the first 14 successive traces out of the 32 lines stored in the TR9407 for the 3D display. Settable from 1 to 19 with DISP. or SETUP key.

One of eight display angles ranging from 90° to 51° can be selected.

Set this to SYSTEM except when displaying the data transferred from a floppy disk in the 3D mode.

If 3D DISP OUTPUT is set to HARD COPY, set the number of traces to be stacked to 16, 64, or 128.

1/3- or 1/1-octave analysis

```
ADVANCED SELECT
⇒ OCTAVE
  <DISABLE>

OCT MODE
  STATIONARY     #
  TRANSIENT
  VIEW POWER

ANALYSIS CHAN
  CH-A           #
  CH-B
  DUAL

BANDWIDTH
  1/3 OCT        #
  1/1 OCT

A-WEIGHTING
  OFF
```

This setting alternates between DISABLE and ENABLE every time the SETUP or DISP. key is pressed.

Select STATIONARY to make 1/3- or 1/1-octave analysis in the free-run mode.
Select TRANSIENT to make the analysis of the transient data. (AUTO ARM may also be utilized.)
Select VIEW POWER to make the power spectrum analysis.

Select the channel in which 1/3- or 1/1-octave analysis is to be made.

Select either 1/3- or 1/1-octave.

Determines whether to compensate the filter output with the A-WEIGHTING value.

Cepstrum analysis

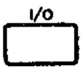
```
ADVANCED SELECT
⇨ CEPSTRUM
  <DISABLE>

ANALYSIS CHAN
  CH-A            #
  CH-B
  DUAL
  VIEW
DOMAIN
  QUEFRENCY       #
  FREQUENCY
THRESHOLD
  OFF

  -774  dBFS
LIFTERING
  SHORTPASS       #
  LONGPASS
  MEMORY (A/B)

   0/511
```

CH-A: Cepstrum for the power spectrum in channel A
CH-B: Cepstrum for the power spectrum in channel B
DUAL: Cepstrum for both channels of A and B
VIEW: Cepstrum for the displayed power spectrum (or Mag of transfer function Hab or C.O.P.)

QUEFRENCY: displays cepstrum (Ca or Caa)
FREQUENCY: displays liftered spectrum

Eliminates noise. If power spectrum (Gaa) is below the threshold value set up, Log(Gaa)=0.

Selection of lifters to apply to the cepstrum to obtain the liftered spectrum.



Setup of timer

```
I/O SELECT
  TIMER

TIMER EDIT
⇨ OFF             #
  ON
```

Set OFF to ON to set the time of day. In setting the year, setup of 2080 or 2090 would become 1080 or 1090 on TIMER EDIT OFF. Improbable numerals, if entered, would become the one last set on TIMER EDIT OFF.

External device selection (Selection of XY recorder)

```
I/O SELECT
⇨ XY-RCDR

CALIBRATION
  0-0
RECORD MODE
  CURSOR        #
  ALL
  SIGNAL
  FRAME
PEN MODE
  ONE           #
  TWO
PLOT SPEED
  SLOW          #
  2
  3
  4
  5
  FAST
```

CALIBRATION: For calibration of the output amplitude scale. Select either 0-0 or FS-FS (full scale) using the SETUP key.

RECORD MODE:

CURSOR: Outputs the x- and y-axis information indicated by the cursor or peak marker. The time-varying point on the waveform is observed with the chart recorder, oscilloscope or digital voltmeter.
ALL : Plots both the waveform being displayed and the scale.
SIGNAL: Plots the waveform only.
FRAME : Plots the scale only.

PEN MODE: If "TWO" is selected with the RECORD MODE: CURSOR, the lower trace data in the dual display mode is output from the Y1 connector in the TR9407 rear panel and the upper trace data is output from the Y2 connector (data should be in the same domain and the same frequency range).
When the FFT analyzer is not in the dual display mode or the frequency ranges are different, cursor- or peak marker-specified trace is output.
Select TWO for the dual display mode to plot on the two-pen type XY recorder.

PLOT SPEED: Select the desired plotting speed; there is a tradeoff between speed and accuracy.

Selection of plotter

```
I/O SELECT
⇨ PLOTTER

PLOT MODE
   ALL            #
   SIGNAL
   FRAME+MENU
PEN SELECTION
   AUTO
PAPER ADVANCE
   SCALE
SCALING
   OFF
PLOT SIZE(mm)
   Xmin:020
   Ymin:005
   Xmax:200
   Ymax:240
PLOTTER TYPE
   HP-GL
PLOT ANGLE
   NORMAL
```

PLOT MODE:

ALL: Plots all information displayed
SIGNAL: Plots only the waveform (to superimpose data, make plotting first in the ALL or FRAME+MENU mode, then in the SIGNAL mode)
FRAME+MENU: Plots only the scale, label, and menu information

PEN SELECTION:

If AUTO is selected, two-color plotting is made using PEN1 and PEN2.

PAPER ADVANCE:

Automatic paper feed function. Set this to A4 to feed paper leftward by about 21 cm; set this to SCALE to feed paper leftward by the distance specified by Xmax (mm).
OFF: Plotting is made in A4 size.
ON : Plotting is made in the size specified by PLOT SIZE.

PLOT SIZE (mm):

Set four points to define the plotting area as desired.
Scaling plot is facilitated providing 1 to 6 plots on A4-sized paper by entering VOO or HOO at Xmin. (See Appendix 8)

PLOT ANGLE:

NORMAL: Plotting in the X- and Y-axis direction on the HP-GL plotter.
90°: Plotting in the position rotated 90° counterclockwise with respect to the X- and Y-axis of the HP-GL plotter.
Opposite is true for the TR9835/9835R/9832.

Selection of floppy disk digital data recorder (TR98102 in WRITE Mode)

I/O SELECT
  FLOPPY

FLOPPY MODE
  READ
⇨ WRITE #
  EDIT
  CATALOGUE

WRITE MODE
  ORIGIN #
  FIXED
  MASS TIME
  GRAPHICS
  PANEL

WRITE TRIG.
  DATA
  FREE RUN
    CH-A

M.TIME FCTN
  OFF
  K→+1.00

ORIGIN : Display at the time of recording will be reproduced on the CRT from the time data (which is the origin of the instantaneous data) or the averaged data.

FIXED : Least unit(s) of data per screen are required in recording, so more information per disk than any other mode can be recorded at high speed. No processing is possible on reproduced data.

MASS TIME: The data image in the 512K word buffer is recorded as it is; the ADVANCE ARM, DATA WINDOW, INTERCHANNEL DELAY, HOLD ZOOM, and FUNCTION (U+L, U-L, U*L) are possible on reproduced data.

GRAPHICS : The displayed information is recorded as it is. Unlike the ORIGIN or MASS TIME modes, this mode is incapable of data processing (such as comparison or math operation on the CRT), but any type of displayed data can be recorded in this mode.

PANEL : All setup conditions of the TR9407 can be stored in a file to incorporate the series of measurements into panel sequence programming.

Defines the timing to create the file in the AUTO mode.

DATA : Data meeting the trigger setting conditions for the TR9407 is recorded. Settable items include FREE RUN, AUTO ARM, ARM, HOLD/DATA WINDOW.

AVGED : Data recording is triggered by an Average-Process-End signal of the TR9407.

SYSTEM: Data recording is triggered by GPIB command WT (Write Trigger).

Used for the WRITE MODE: MASS TIME
Xa is calculated by selecting from OFF,
Xa=Xa+K*Xb, Xa=Xa-K*Xb,
Xa=Xa*K*Xb (-1.00 K 1.00)

Reproduction of file recorded in TR98102

```
I/O SELECT .
   FLOPPY

FLOPPY MODE
   READ              #
⇨  WRITE
   EDIT
   CATALOGUE

DISPLAY SOURCE
   FLOPPY            #
   PANEL

DATA OUT
   CRT

OVERLAY NUMBER
   0
```

Setup conditions on reproduction.

FLOPPY: Reproduction of the data under the same conditions as set at file creation time.

PANEL : Reproduction of the data under the panel key settings made at the time of reproduction

Output device selection. CRT, plotter and XY-recorder are available. In the 3D display mode, the 3D DISP OUTPUT setting made on the 3D display menu overrides this DATA OUT setting.

Number of superimposed traces output on the plotter

Editing of file

```
I/O SELECT
  FLOPPY

FLOPPY MODE
  READ
  WRITE
  EDIT            #
  CATALOGUE

EDIT MODE
⇨ COPY (D1→D0)    #
  READ&WRITE
  EDIT (M.TIME)

M.TIME E.MODE
 FROM
  DRIVO (FRONT)
  CH-A

 TO
  DRIVO (FRONT)
  CH-A
```

COPY: Copies the contents of disk in drive 1 to the disk in drive 0.

READ & WRITE: Editing and file type conversion can be carried out using the copy function in a file unit by specifying the sequential number. Both READ and WRITE conditions in the FLOPPY MODE should also be specified.

EDIT (M. TIME): Editing of mass time file.

Specification of drive and channel in editing the mass time file. The mass time file should have been created in 2 channels.

Floppy Catalogue mode: List of file contents and its reproduction and panel sequence setup.

(File number)

(File type)
O : Origin
M : Mass time
F : Fixed
G : Graphics
P : Panel

Label display

160-169 reserved for WRITE

Sequential number for the file

```
No.  TYPE                        LABEL                          SEQ.
 1 XaXb  :M       /XYZ/    16Kword Time Record           :   0
 2                        WRITE AVAILABLE                 : 160
 3 PANEL :P       /XYZ/    16Kword Time Record           : 170
 (S:ALL            OFF                       0000:00.0       )
 4 PANEL :P       /XYZ/    16Kword Time Record           : 171
 (S:ALL            OFF                       0000:00.0       )
 5 PANEL :P       /XYZ/    16Kword Time Record           : 172
 (S:ALL            OFF                       0000:00.0       )
 6 PANEL :P       /XYZ/    16Kword Time Record           : 173
 (S:ALL            OFF                       0000:00.0       )
 7 PANEL :P       /XYZ/    16Kword Time Record           : 174
 (S:ALL            OFF                       0000:00.0       )

CATALOGUE MODE:           EXIT
DRIVE SELECT:             DRIV0(FRONT)

WRITE PROTECT:            OFF

PANEL SEQ. TIMER START:   OFF
 START TIME:              00:00
PANEL SEQUENCE:           OFF
 LOOP:     1
 FROM:     1
 TO:       1

SETUP LINE:     1
SETUP  ZOOM  AVG   TRIGR   ADVNC   PLOT  FLPY  INTERVAL   SCAN
 ALL    OFF  OFF    OFF     OFF     OFF   OFF  0000:00.0  OFF
```

Setup for the panel sequence function.
(Use yellow arrow keys to move the pointer leftward or rightward.)
Software-like setup of WRITE PROTECT
Setup of drive number and disk side (front or back) for catalogue display
Used to exit the catalogue mode
Place the marker to the desired file and press SETUP key to reproduce the file on the CRT.
This list can be scrolled one line at a time with the yellow up or down arrow keys. Ten lines can be scrolled at a time if the arrow keys in the DISPLAY section are used.

Sine Menu (when connected with the TR98201)

```
I/O SELECT
⇨ SIGNAL G.

FUNCTION
  SINE
FREQ (LINE)
  MANUAL
  200
AMPLITUDE
  02.0E-3 Vpp
OFFSET
  +00.0E-0 V
OUTPUT MODE
  CONT
SYNC OUT
  PER 1    CYCLE
INTERVAL TIME
  .0 SEC
OUTPUT CYCLE
  1
PHASE (deg)
  START: 0
  STOP : 0
  RANGE: NORMAL
SEQUENCE
  A. B. C. D. E. F
```

FREQ (LINE): Setup of the center frequency.

MANUAL: Setup of line number using the DISP. or SETUP key.

CURSOR: Line number at the cursor is displayed.

AMPLITUDE: Output amplitude: 2mVp-p to 30V.
When the signal's amplitude is small, energy is larger in the noise component than in the signal component (S/N ratio is small). Increase the AMPLITUDE to improve the S/N ratio.

OFFSET: Change the DUT's starting point from the non-linear to linear system by providing the dc offset.

OUTPUT MODE:

CONT : Continuous signal output

INT TRIG: Sines of the selected OUTPUT CYCLES are output at every INTERVAL TIME.

EXT TRIG: Sines of the selected OUTPUT CYCLES are output in synchronism with the signal from the EXT. TRIG connector on the rear panel.

EXT GATE: Sines are output in synchronism with the signal gate at the TR98201 EXT TRIG connector.

MANUAL : Sines of the selected OUTPUT CYCLES are output at each press of the PAUSE key of the TR98201.

PHASE (deg): This is displayed when the OUTPUT MODE is other than SWEEP.

START: Start phase of sines at each trigger.

STOP : Stop phase by the MANUAL trigger.

RANGE: NORMAL in the normal mode of operation. START, MIDDLE and STOP ranges are used in the 4-decade logarithmic frequency analysis.

Sine menu (OUTPUT MODE = SWEEP)

```
I/O SELECT
⇨ SIGNAL G.

FUNCTION
  SINE
FREQ (LINE)
  MANUAL
  200
AMPLITUDE
  01.0E-0 Vpp
OFFSET
  +00.0E-0 V
OUTPUT MODE
  LIN SWEEP
SYNC OUT
  PER 1    FRAME
INTERVAL TIME
  .0 SEC
OUTPUT CYCLE
  1
LINE CTRL
  Fmin :  4
  Fmax :  400
  WIDTH:  40
  DIREC:  U⇨L
  RANGE:  NORMAL
SEQUENCE
  D, E, F
```

OUTPUT MODE: Select SWEEP for the sine-wave sweep averaging for the measurement of the transfer function. In this mode LINE CTRL below is shown.

SYNC OUT: TTL active low pulse (approx. 10µs width) is output from the TR98201 rear panel TRIG OUT connector.

INTERVAL TIME:

1. Interval time during the operation of INT TRIG.
2. Delay time provided in the presence of noise

OUTPUT CYCLE: Sine-wave output cycle (1 to 1023) in triggering

LINE CTRL: This is displayed when the SWEEP is selected from the OUTPUT MODE.

Fmin, Fmax: Sweep range setting in the signal sequence measurement

STEP : Step lines in sweep

DIREC: Direction of sweep (from low-frequencey to high-frequency or vice versa)

RANGE: NORMAL is used to sweep the full span. START, MIDDLE and STOP ranges are used for the 4-decade logarithmic frequency analysis.

SEQUENCE: Stores the above conditions into the sequence files (A to F) when using the signal sequence scheme.

RANDOM menu

```
I/O SELECT
  SIGNAL G.

FUNCTION
⇒ RANDOM
AMPLITUDE
  01.0E-3 Vpp
OFFSET
  0.00 V
OUTPUT MODE
  CONT
P.D.F
  GAUSS    #
  POISSON
TYPE
  RANDOM
INTERVAL TIME
  .0 mSEC
OUTPUT FRAME
  1
RANGE CTRL
  NORMAL
SEQUENCE
  C
```

P.D.F:

GAUSS : Amplitude probability density function set to Gaussian distribution

POISSON : Amplitude probability density function set to Poisson distribution

TYPE:

RANDOM Band-unlimited

BAND SEL: Band selected interlocking with each frequency range

PERIODIC: Band-limited periodic random signal

BURST : Band-limited burst random signal

INTERVAL TIME: Interval time provided when the INT TRIG is used. (msec in the 100kHz to 500Hz range; sec in the 200Hz to 1Hz range)

OUTPUT FRAME: Number of output frames on triggering (1 to 1023).
When BURST is selected from TYPE, it denotes burst width setting (1/400 to 400/400).

MEMORY menu

```
I/O SELECT
  SIGNAL G.

FUNCTION
⇒ MEMORY
AMPLITUDE
  01.0E-3 Vpp
OFFSET
  0.00 V
OUTPUT MODE
  CONT
SYNC OUT
  PER 1     FRAM
INTERVAL TIME
  .0 mSEC
OUTPUT FRAME
  1
READ/WRITE
  READ
FILTER
  OFF
RANGE CTRL
  NORMAL
SEQUENCE
  C
```

READ/WRITE:

READ : Reads out the time data to the TR9407 from the TR98201 memory

WRITE: Writes the time data of the TR9407 into the TR98201 memory

The above operation is executed by pressing I/O EXECUTE key with the time data displayed on the CRT.

FILTER: Low-pass filter for the signal output

I/O RECALL x

Sequence menu

```
I/O SELECT
  SIGNAL G.

FUNCTION
⇨ SEQUENCE
SEQUENCER
  OFF
A: SINE
AMP: 14.0E-0 Vpp
MODE: LIN SWEEP
RANGE: STOP
Fmin : 320
Fmax : 400
AVG NO: 2
B: SINE
AMP: 10.0E-0 Vpp
MODE: LIN SWEEP
RANGE: STOP
Fmin : 41
Fmax : 320
AVG NO: 2
C: SINE
AMP: 09.0E-1 Vpp
MODE: LIN SWEEP
RANGE: MIDDLE
Fmin : 41
Fmax : 390
AVG NO: 2
```

Placing the pointer here intensifies the line. Pressing the DISP. or SETUP key scrolls the menu so that any three continuous sequences are monitored.

You can use this sequence menu to change the items included herein. As for the modifications of items not included in this menu, such as WIDTH or OFFSET for example, you should transfer the contents of this menu back to the SIGNAL G. menu of interest before changing the setup conditions. (Display the SIGNAL G. menu of interest and place the pointer at the SEQUENCE in the bottom of menu and press PANEL RECALL key followed by an alphabet key (A to F) corresponding to the region).

```
◆TRANS FCTN
◆CH-B/A (AVG)
◆ZERO START
◆AC/DIFF CH-A
◆AC/DIFF CH-B
◆FREE RUN
◆AVG 0/0

 INTERCHANNEL
 DELAY
   0/1024

 INTEGRAL &
 DIFFERENTIAL
 A: NORMAL
 B: NORMAL

 FUNCTION
   NO-OPERATION

 STEP (D. WINDOW)
   42/1024
 COH BLANK
   0.82
 OVERLAP
 0%:   0/0
 50%:  0/0
```

↔ DISP.

```
◆TRANS FCTN
◆CH-B/A (AVG)
◆ZERO START
◆AC/-GND CH-A
◆AC/-GND CH-B
◆FREE RUN
◆AVG 16/16

 FREQUENCY
  20   kHz
 SENSITIVITY
  A: +10dBV (MAN)
  B: -10dBV (AUTO)

 TRIGGER
 SOURCE: CH-A
 SLOPE : <+>
 LEVEL
  +0.250 *FS
 POSITION
  +603.32 %

 WEIGHTING
  RECT

 AVERAGING
 MODE : SUM (N)
 WHAT :
  CROSS+POWER
 NO   : 16
 CHAN : CROSS
 PRCS : SWEEP
 OVLAP: 0 %
 SIGNAL:
    SWEPT SINE
```

These condition setting menus are alternated at each press of DISP..

For the dual display mode,
indicates a setting for the lower display and
for the upper display.

TABLE OF CONTENTS

7. GPIB INTERFACE

7.1 INTRODUCTION

TR9407 Digital Spectrum Analyzer contains the GPIB interface as standard feature. All analyzer control settings are remotely programmable through the General-Purpose Interface Bus, an instrumentation bus complying with the IEEE Standard 488.
TR9407's GPIB interface has the following attributes:

(1) Settings:

a. Control settings: All analyzer's front panel control settings are remotely programmable.

b. Data send mode setting: Permits various data send mode setting, selection of delimiters, header on/off control, and read command definition.

(2) Reading:

a. Control settings on the front panel can be remotely read from the attached controller.

b. Data read : Readable data includes cursor data, ASCII block, binary block, SET REF. (Set Reference), Overall, Partial, and List.

(3) Service request:
The interface can issue a service request upon generation of input overload, setup error, or measurement end. Specific causes of service request are maskable.
The General-Purpose Interface Bus (GPIB) is outlined in the following:
The GPIB provides simple interface between the components of an instrumentation system via a bus cable. Compared with conventional interface facilities, the GPIB allows for better system expandability and operability, and permits compatibility within the components of the industry in terms of electronics, mechanism and functions. This makes it possible to implement a simple system through a more sophisticated automatic instrumentation system with a single bus cable.
In a GPIB system, device addresses must first be set into each component on the bus. Devices connected to the bus may be talkers, listeners, or controllers. During system operation, only one talker can send data on the bus, while multiple listeners can receive the data.
A controller may address a talker and a listener to cause the talker to transfer data to the listener, or send data (e.g. measurement conditions) from the controller itself to a device addressed to listen. Data and commands are transferred between the components of an instrumentation system on bidirectional 8 signal lines in asynchronous, bit-parallel, byte-serial format. Because of its asynchronous nature, devices of both high and low speeds may concurrently exist in the system.

Data transferred between the components will include measurement information, measurement conditions (program), and various commands, all of which are coded in ASCII 7-bit code.
In addition to the 8 signal lines, the GPIB also has 3 handshake lines for control of asynchronous data transfer between components and 5 control lines for control of data flow on the bus.

- The handshake lines include the following:
  Data Valid (DAV): Indicates data validity.
  Not Ready For Data (NRFD): Indicates data receive ready state.
  Not Data Accepted (NDAC): Indicates end of reception.
- The control lines consist of the following:
  Attention (ATN): Discriminates whether information on the bus is address/command or other information.
  Interface Clear (IFC): Clears the interface.
  End or Identity (EOI): Used upon completion of data transfer.
  Service Request (SRQ): Request for service from a device to the controller.
  Remote Enable (REN): Used for remote control of remote programmable devices.

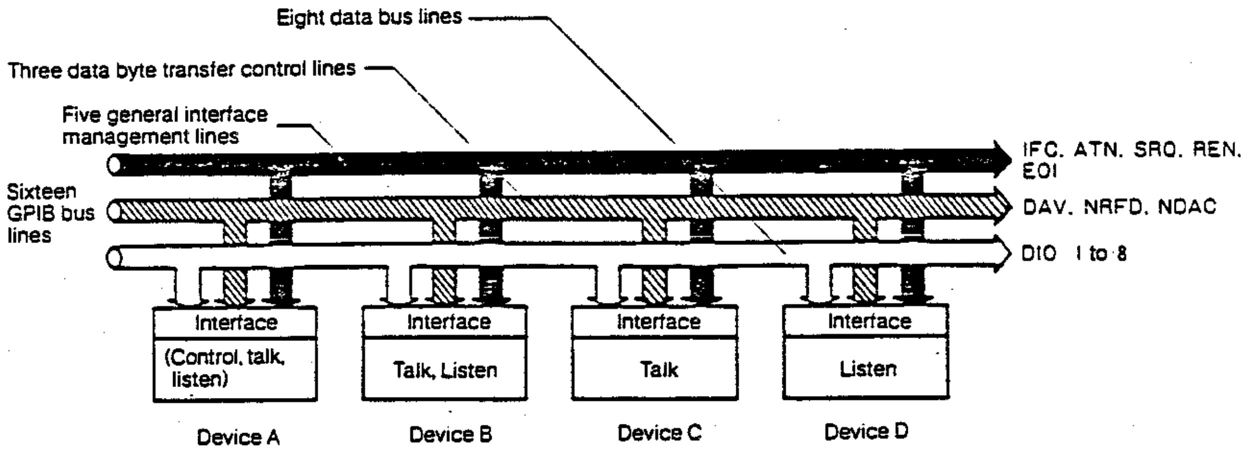


Figure 7-1 Configuration of GPIB

7.2 SPECIFICATIONS

7.2.1 GPIB Specifications

Standard	: IEEE488-1978
Code	: ASCII with the exception of packed format in binary code
Logic levels	: Logic 0 (HIGH): +2.4 V or more Logic 1 (LOW) : +0.4 V or less
Signal line termination	: The 16 bus lines are terminated as shown in Figure 7-2 each.

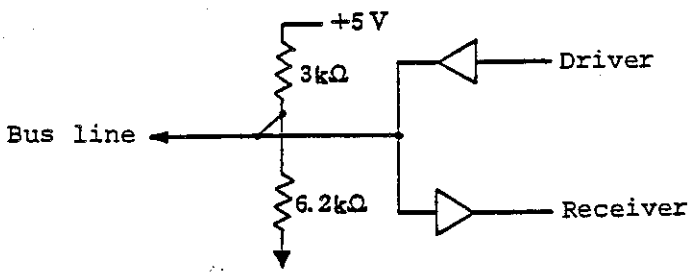
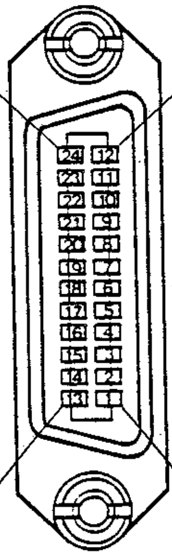


Figure 7-2 Signal line termination

Driver	: Open collector (except for EOI and DAV) LOW state output voltage: 0.4 V or less, 48 mA HIGH state output : +2.4 V or more, -5.2 mA
Receiver	: LOW state at +0.6 V or less HIGH state at +2.0 V or more
Bus cable length	: The maximum length of cable that may be used to connect together a group of devices within one bus system is 2m times the number of devices, or 20m, whichever is less.
Address setting	: Up to 31 talker/listener addresses can be set with a rear ADDRESS switch.
Connector	: 24-pin GPIB connector 57-20240-D35A (Amphenol or equivalent)

Signal Name	Pin No.
GND. LOGIC	24
GND. (ATN)	23
GND. (SRQ)	22
GND. (IFC)	21
GND. (NDAC)	20
GND. (NRFD)	19
GND. (DAV)	18
REN	17
DIO 8	16
DIO 7	15
DIO 6	14
DIO 5	13



Pin No.	Signal Name
12	SHIELD
11	ATN
10	SRQ
9	IFC
8	NDAC
7	NRFD
6	DAV
5	EOI
4	DIO 4
3	DIO 3
2	DIO 2
1	DIO 1

Figure 7-3 GPIB connector pin configuration

7.2.2 Interface Functions

The GPIB interface functions are listed in Table 7-1.

Table 7-1 GPIB interface functions

Code	Function and description
SH1	Source handshake
AH1	Acceptor handshake
T5	Basic talker function, serial poll, talker only function*, addressed to listen when unaddressed to talk
L4	Basic listener function, addressed to talk when unaddressed to listen
SR1	Service request
RL1	Remote function
PP0	No parallel function available.

Table 7-1 GPIB interface functions (Cont'd)

Code	Function and description
DC0	No device clear function available.
DT0	No device trigger function available.
C0	No controller available.
E1	Open collector bus driver. EOI and DAV use E2 (three-state bus driver).

* The talker only function is effective to the plotters (optional).

7.3 GPIB SYSTEM OPERATING PROCEDURE

7.3.1 Connection

A GPIB system consists of multiple system components. Note the following points for system preparation:

(1) Check the conditions and operations of individual components before connection, by referring to their instruction manuals.

(2) Bus cables used for system connection should be necessary minimum in their lengths. The total transmission length of the bus cannot exceed 2 meters times the number of connected devices, or 20 meters (65.6 feet), whichever is less. The following standard bus cables are available from Advantest:

Table 7-2 Standard bus cables (optional)

Length	Type
0.5 m	408JE-1P5
1 m	408JE-101
2 m	408JE-102
4 m	408JE-104

(3) When connecting bus cables, do not stack more than three connectors. Each cable plug should be firmly secured to its receptacle with retention screws.
Bus cable connectors are of piggyback type having both male and female connectors and permit stacked use.

(4) Before powering each system component, verify the power supply, grounding, and, if necessary, setup conditions of each component. All components connected to the bus must be powered on. Should any one of the components be left turned off, the proper system operation will not be guaranteed.

7.3.2 GPIB Interface Section

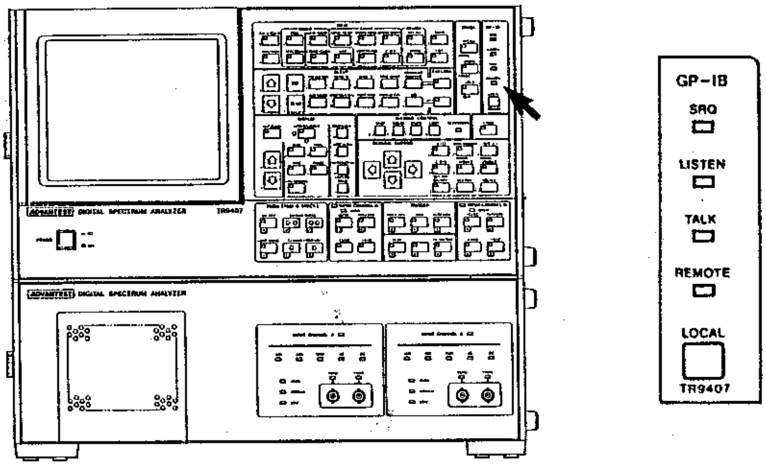


Figure 7-4 GPIB interface panel

Front panel

① LOCAL key
When the instrument is in Remote mode (REMOTE lamp illuminates), operation of this key clears the remote operation and enables the front panel operation, provided the key has not been disabled by the Local Lockout message. The instrument is initially placed in Local mode when powered on.

② REMOTE indicator lamp
This lamp comes on when the TR9407 is controlled over the GPIB. In Remote, the front panel controls are disabled.

③ TALK indicator lamp
This lamp comes on when the TR9407 is addressed to talk.

④ LISTEN indicator lamp
This lamp comes on when the TR9407 is addressed to listen.

⑤ SRQ indicator lamp
This lamp comes on when the TR9407 is in request for service to the controller.

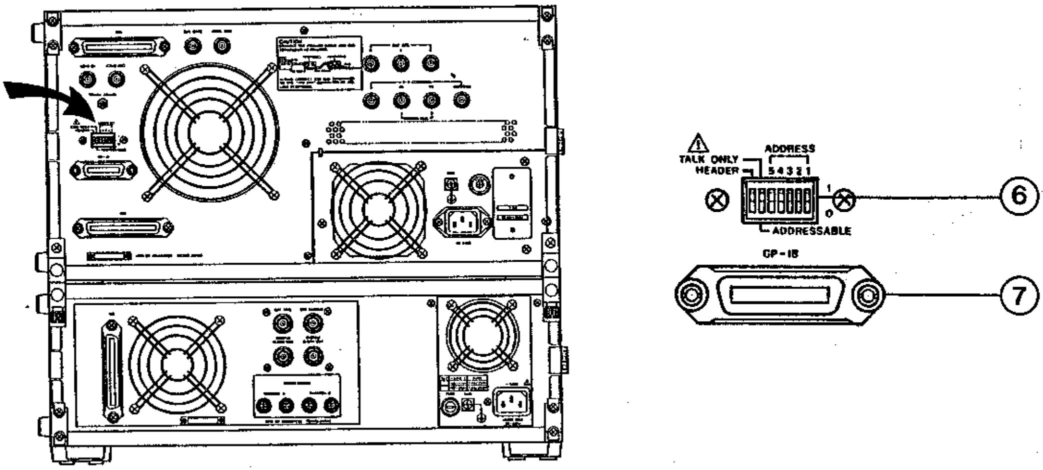


Figure 7-5 GPIB facilities on rear panel

Rear panel

⑥ ADDRESS switch
Bits 1 through 5 of this DIP switch are used to set the address (talker or listener address) of the TR9407.
If bit 6 is set to 1 (TALK ONLY), the instrument is placed in the Talk Only mode to the attached plotter.
Bit 7 of this switch is used to turn on or off the header when the instrument is addressed to talk (1: ON, 0: OFF).

⑦ GPIB connector
A 24-pin connector for bus cable connection. This connector is of piggyback type and permits stacked use of up to three connectors.

CAUTION

Address selection using the ADDRESS switch should be made before powering the TR9407.

7.3.3 Listener Operations

The TR9407 is controllable over the GPIB in the similar manner as the local front panel control. When the analyzer is addressed to talk, it can send its setup conditions and various data on its display to external devices. All these functions are activated by temporarily placing the analyzer in the Listen mode and sending a pertinent command from the controller, with the exception of the SQ mode. Command formats are described in the following:

(1) Set command

Set commands provide various setup functions for the analyzer similar to those obtained with the front panel controls.

```
FR2
│└──────── Setup (signifies 20 kHz)
└───────── Function (signifies frequency range)
```

This command sets the frequency range of the analyzer to 20 kHz.

(2) Read command

Read commands cause the analyzer to send its setup conditions or specific data on the display when the analyzer is subsequently addressed to talk.

```
RFR
│└──────── Parameter type
└───────── Read command
```

For example, if the analyzer is addressed to talk after its frequency range is set to 20 kHz and the above Read command is received, the analyzer sends the following information to the controller:

```
FR2CRLF & EOI
││    └──────── Block delimiter
│└───────────── Body (20 kHz)
└────────────── Header (frequency range)
```

(3) Format

a. Set command format
<Function> <Setup> <Function> <Setup> <Function> <Setup> (block delimiter)

b. Read command (for setup condition reading)
<R> <Function> <R> <Function> <R> <Function> (block delimiter)
Read command (for displayed data reading)
<R> <Data name> (block delimiter)
When sending a command to the TR9407, the following three types of block delimiters are available:

① Send two-byte code of CR and LF. Single line signal of EOI should be sent along with LF.

② Send one-byte code of LF.

③ Send single line signal of EOI sent simultaneously with the last data byte.

Example: Setting frequency range to 100 kHz and input sensitivity to +30 dBV:
FR0AS0BS0CRLF & EOI
Reads overall (in this case, an overall value must be shown on the display.):
ROACRLF & EOI

While a Set command and a Read command can be specified on the same line, the condition set up before the Read command is received will be sent when the analyzer is subsequently addressed to talk.

7.3.4 Talker Operations

The Talker mode of the TR9407 may be caused either by a Read command or by SQ mode. The SQ mode places the analyzer in the Talker mode without using a Read command.

(1) SQ2 Cursor mode
This mode sends the information of vertical and horizontal positions (levels) identified by cursors. When the NYQ./ORBIT key in the DISPLAY section is activated, the X and Y levels on the display are sent out (orbital: X, Y, Nyquist: REAL, IMAG., MAG., PHASE).

a. SQ2 output format

Header	Body	∇	Header	Body	∇	Header	Body	CRLF&EOI
5	10	1	5	10	1	5	10	
Level 1			Level 2			Level 3		Delimiter

where " ∇ " denotes a comma.
While readouts on the display are sent for each level, an arbitrary level out of levels 1 through 3 can be selected and sent by specifying command CO. The CO (Cursor Output) command numbers and the corresponding send levels are listed in Table 7.3.

Table 7-3 CO command and send level

Command No.	Level 1	Level 2	Level 3
0	o	o	o
1	-	o	o
2	o	-	o
3	-	-	o
4	o	o	-
5	-	o	-
6	o	-	-

o: Sent -: Not sent

As a result, data can have the following two lengths depending on the CO command numbers:

① When two levels are sent (CO2, CO4, CO1)

Header	Body	∇	Header	Body	Delimiter

Data length 31

② When only one level is sent (CO3, CO5, CO6)

Header	Body	Delimiter

Data length 15

b. Header section
The header section is controllable with bit 7 of the rear ADDRESS switch or Set command HD. If the header is set to OFF, five space characters "␣ ␣ ␣ ␣ ␣" (ASCII) are sent out (HD0: OFF, HD1: ON).

TIOUS $\boxed{\text{Body}}$

- Header denoting unit (US: µs)
- Header indicating the presence of overload (O: Overload)
- Header indicating data type (FUNCTION)
(TI: TIME data)

c. Header code
See Tables 7-7, 7-8, and 7-9 for code table.

d. Body

(i) The body section consists of 10 characters. Two types of output format are selectable with Set command FX. The formats are shown below:

① When FX0 is specified
The body is sent out in the same format as readouts on the display. Space characters are sent for blanks.
Example: ␣␣2␣117Δ19
␣-5Δ28E-02
␣␣␣␣383.6␣

② When FX1 is specified
The body is sent out in the following format:
+Δ DDDDE ±DD
↑—— Decimal point
The fifth and lower decimal places are omitted.

(ii) If a value unable to operate is internally generated, such as the case where "INVALID" readout is shown, ASCII code "0" is sent out.

① When FX0 is specified

```
00 HZ  44 500.0,00 DG0000000000,00 000000000000
```

② When FX1 is specified

```
00 HZ+.9675E+03,00 DG0000000000,00 000000000000
```

(2) SQ3 block transfer mode (ASCII mode)
This mode sends the data on the display identified by the cursor in ASCII code.

a. SQ3 output format INSERT

Header	Body(1)	∇	Body(2)	∇	≈	Body(N-1)	∇	Body(N)	DELIMITER
5	10	1	10	1		10	1	10	

where " ∇ " denotes a comma.
The body section includes numerals 0 through 9, decimal point Δ , space, E, +/-, and code. The number of data can be read by specifying Read command ROL. The output format for Read command ROL is shown in the paragraph pertaining to SQ4.

b. The header section and header code are identical to those of SQ2.

c. The body section is identical to that of SQ2.

(3) Data Structure of SQ4 (binary block transfer)

a. Transfer function (Mag)

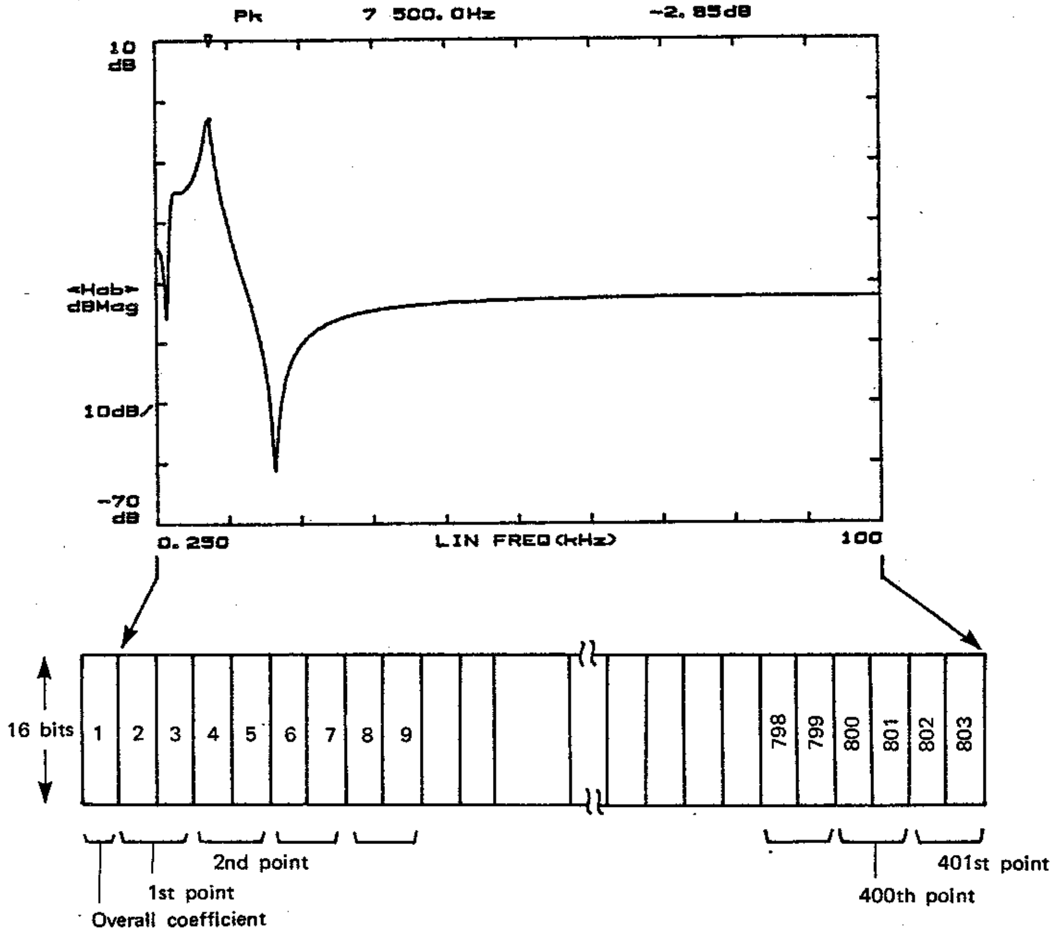
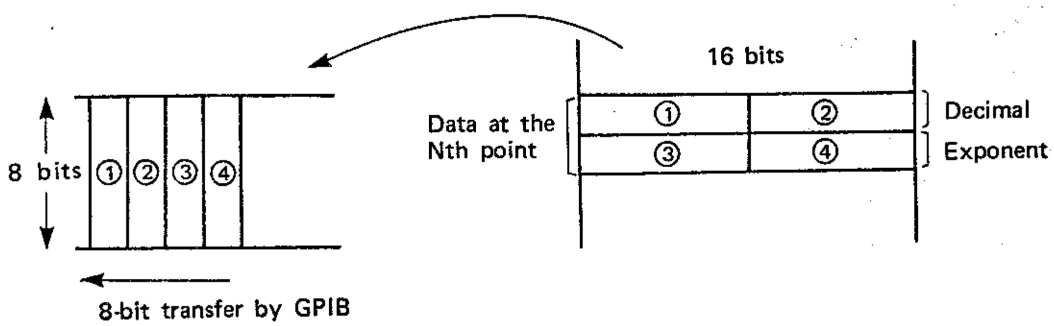


Figure 7-6 Data Structure of Transfer Function (Mag)

Since the transfer function is represented as 32-bit floating point data, data transfer by GPIB is done by using four bytes for one point.



Calculation, therefore, is performed by rearranging data except the first two bytes as illustrated.

For instance, if the values of bytes ①, ②, ③, and ④ are given by

① : 67
② : 222
③ : 255
④ : 254 Overall coefficient = 2,

the decimal is $\frac{① \times 256 + ②}{2^{15}} = 0.530$

and the exponent $-\{2^{16} - (③ \times 256 + ④)\} = -11$.

The value at this point is then calculated as follows:
$0.530 \times 2^{-11} \times 2^{2}$

In this case, if the sensitivity difference (CH.B - CH.A) between channels A and B is -20 dB, a coefficient (Mag) of 10^{-2} is obtained from Table 7-13. The desired value of the transfer function, therefore, is

$10 \log (0.530 \times 2^{-11} \times 2^{2} \times 10^{-2}) = -49.8$ dB

b. Transfer function (Real, Imag)

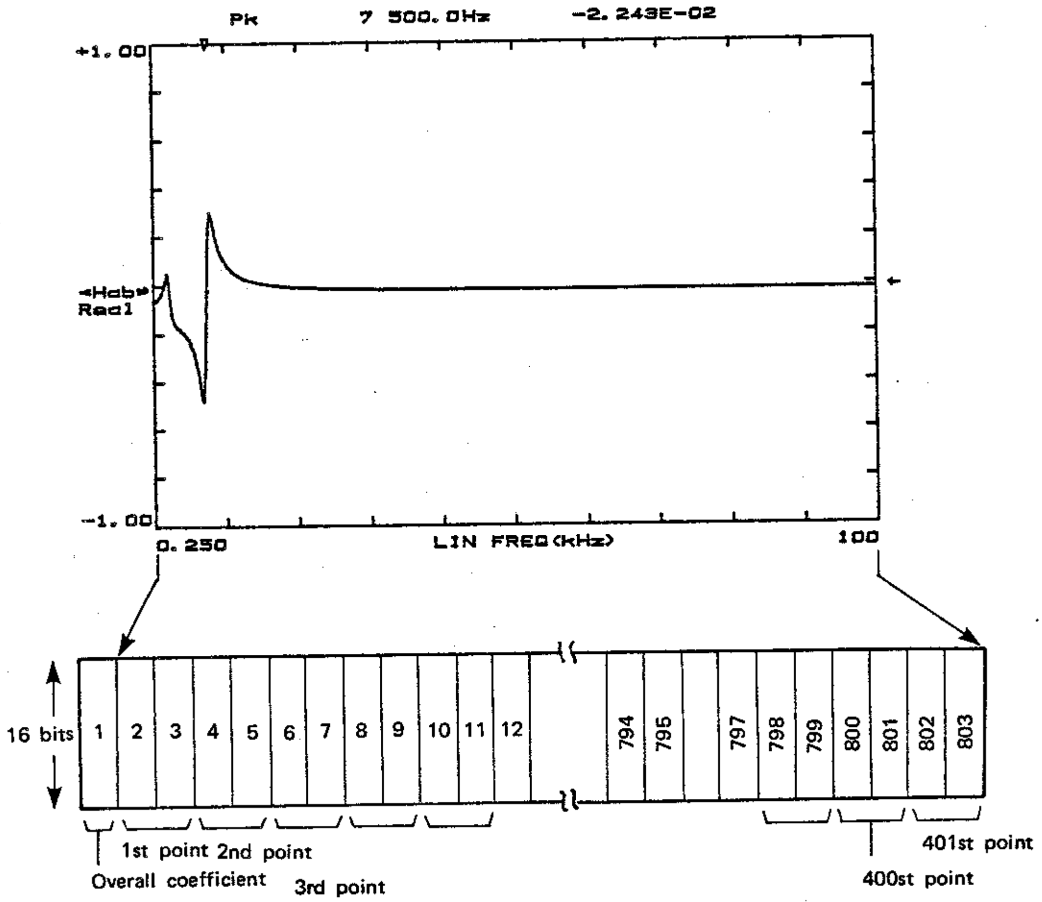


Figure 7-7 Data Structure of Transfer Function (Real, Imag)

As in the case of Mag, with values of bytes ①, ②, ③, and ④ given by

① 191
② 131
③ 0
④ 1   Overall coefficient = 0,

the decimal is $\frac{-\{10^{16} - (① \times 256 + ②)\}}{2^{15}} = -0.504$

and the exponent ③ x 256 + ④ = 1.

If the differential sensitivity between channels A and B is -30 dB, a coefficient (Real, Imaginary) of 31.6E-3 is obtained from Table 7-13. The value of the transfer function, therefore, is $-0.504 \times 2^1 \times 2^0 \times 31.6E-3 = -3.18E-2$

c. Transfer function (PHASE)

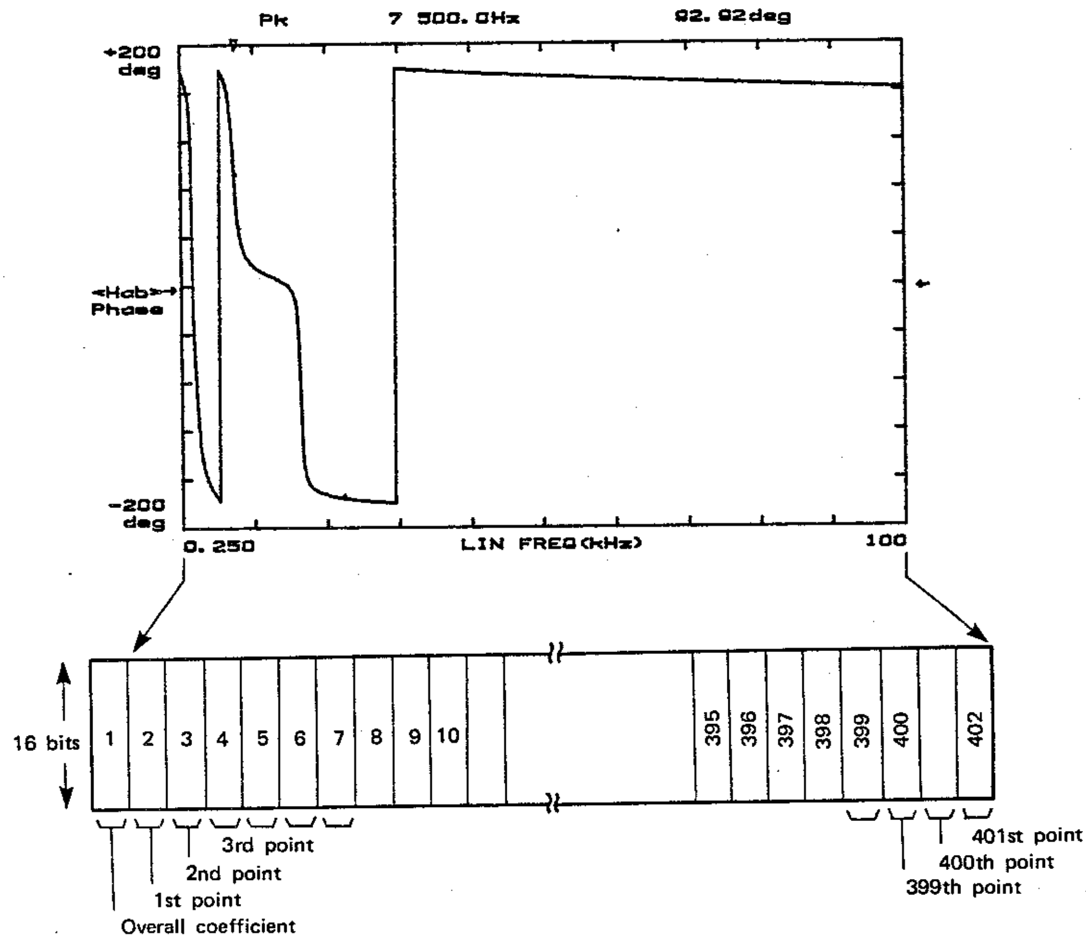
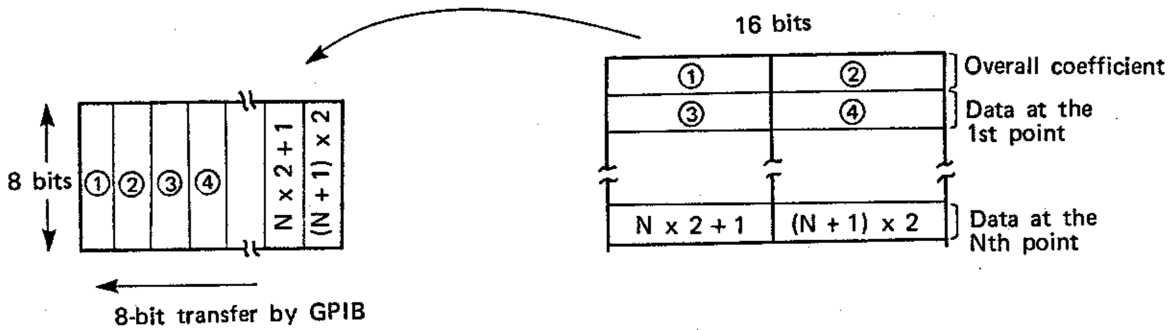


Figure 7-8 Data Structure of Transfer Function (Phase)

The phase of the transfer function is represented as 16-bit fixed point data with 200° being 0.5. Consequently, data transfer by GPIB is done using two bytes for one point like the overall coefficient.



Calculation is performed by rearranging data as illustrated.

For instance, with values of bytes ③ and ④ given by

③: 48
Overall coefficients ① and ② = 0,
④: 166

$$\frac{③ \times 256 + ④}{2^{15}} = 0.380$$

Since 200° is considered to be 0.5, the value of the transfer function is 0.380 x 2 x 200° = 152.02°

d. Transfer function (PHASE UNWRAP)

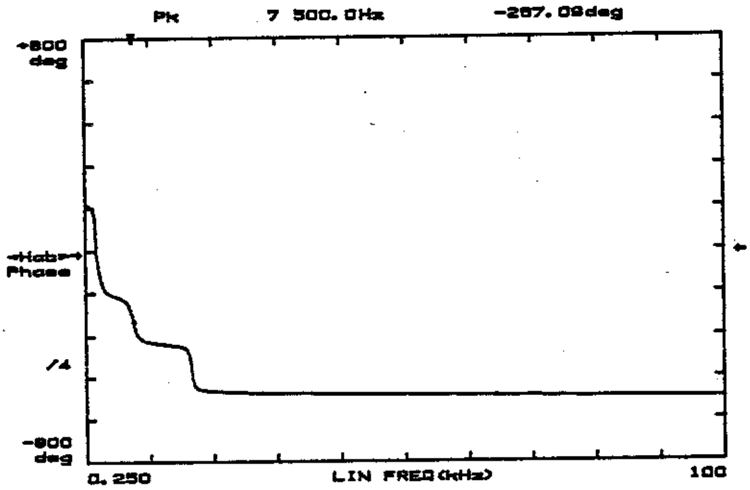


Figure 7-9 Data Structure of Transfer Function (Phase Unwrapped)

The data structure is the same as above.

For instance, with values of bytes ①, ②, ③, and ④ as follows,

① : 0
② : 3 } Overall coefficient = 3 (Zoom factor = 1/4)
③ : 242
④ : 48,

$$\frac{-\{2^{16} - (③ \times 256 + ④)\}}{2^{15}} \times 2^{3} = -0.863$$

The value of the transfer function is calculated, as in c., as follows:

$-0.863 \times 2 \times 200 = -345.20^{\circ}$

e. Group delay

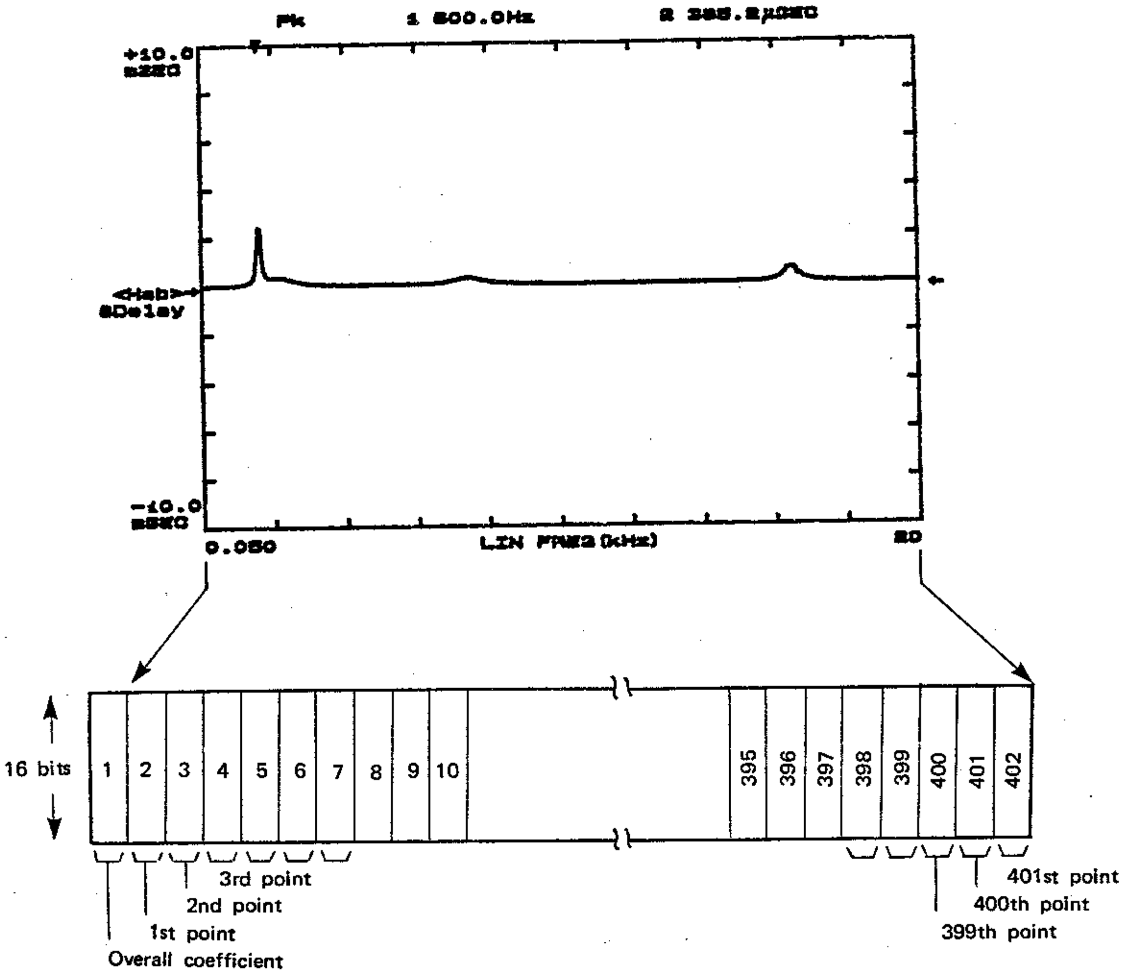


Figure 7-10 Data Structure of Group Delay

A group delay (excluding 4-decade logarithmic frequency measurement) is represented as 16-bit fixed point data with the frame time of the measuring range at full scale. Consequently, data transfer by GPIB is done using two bytes for one point as is the case with the phase.

For instance, with values of bytes ③ and ④ given by

③ : 1
④ : 165,

$$\frac{③ \times 256 + ④}{2^{15}} = 0.0128$$

overall coefficient = 0

If the measuring range is 20 kHz, the frame time will be

$$\frac{1024}{20 \times 10^3 \times 2.56} = 20 \text{ msec}$$

Then, the group delay is obtained as follows:

$$0.0128 \times 20 \times 10^{-3} \times 2^0 = 257 \ \mu\text{sec}$$

f. Group delay (4-decade log frequency measurement)

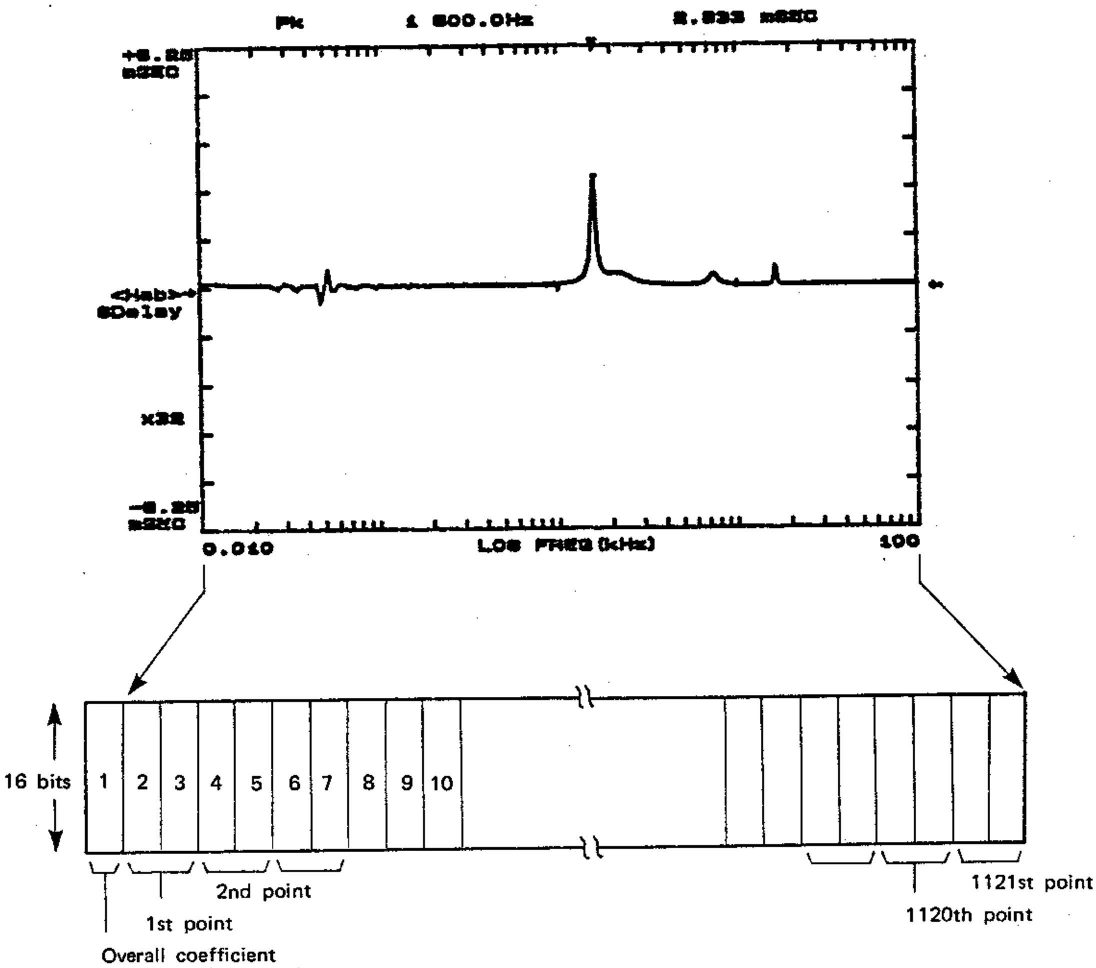
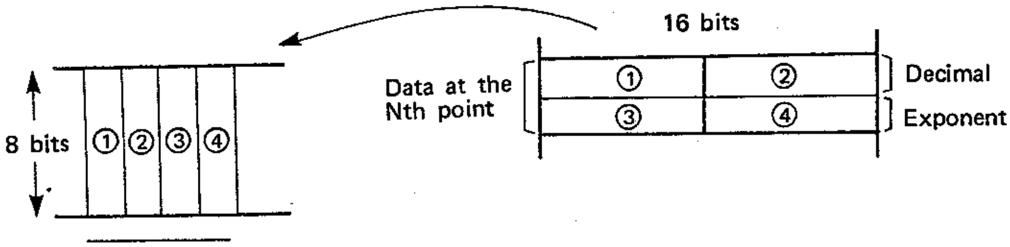


Figure 7-11 Data Structure of Group Delay (4-Decade Log Frequency Measurement)

The group delay of 4-decade logarithmic frequency measurement is represented as 32-bit floating point data with the frame time of the start range at full scale. Consequently, data transfer by GPIB is done using four bytes for one point as is the case with Mag of the transfer function.



8-bit transfer by GPIB

For instance, with values of bytes ①, ②, ③, and ④ given by

① : 106
② : 170
③ : 255
④ : 244,

Overall coefficient = 0

the decimal is $\frac{① \times 256 + ②}{2^{15}} = 0.833$

and the exponent is $-\ 2^{16} - (③ \times 256 + ④) = -12$

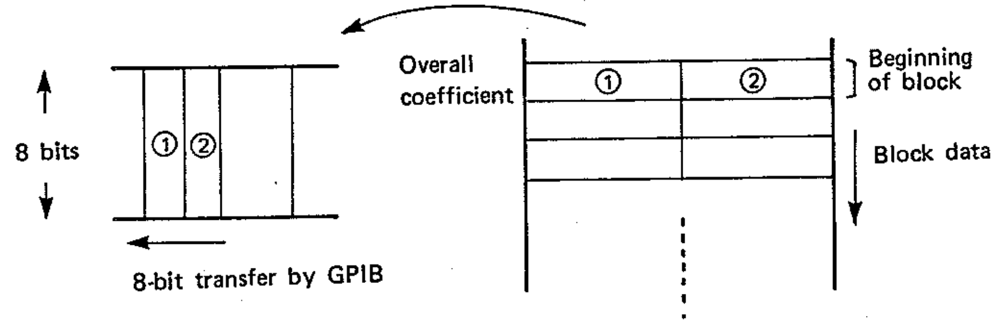
If the stop range is 1 kHz, the frame time is calculated as follows:

$$\frac{1024}{10 \times 10^{3} \times 2.56} = 40 \text{ msec}$$

Then, the group delay is obtained as follows:

$0.833 \times 2^{-12} \times 40 \times 10^{-3} = 0.081$ msec

Notes:
- In a 4-decade log frequency measurement, 1121 points of data are transferred. However, those remaining 1116 points are used as the displayed data with the first four points excluded.
- Since the overall coefficient is represented as two's complement, it is calculated in the same manner as the exponent of floating-point data.



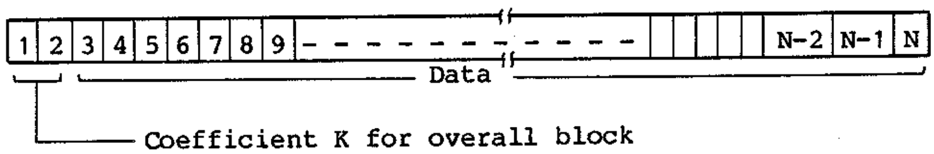
① : 0
② : 2

With values of bytes ① and ② as 0 and 2, the overall coefficient is obtained as follows:

① x 256 + ② = 2

(4) SQ4 block transfer mode (binary mode)
This mode sends displayed data identified by the cursor in binary code.

a. SQ4 output format



Bytes 1 and 2 contain the coefficient for the overall block, which is followed by binary values for each level.
In this mode, the output format differs depending on displayed data types or display methods.
The output formats and the numbers of data in the SQ3 and SQ4 modes can be read by Read command ROL. If the analyzer is addressed to talk after all measurement conditions are set up from the controller and the ROL command is specified, the analyzer sends the output format and data count information (except for coefficient) in the following format:

OL2, 401 CRLF & EOI

Number of data (401 points)

Precision code (double precision fixed point code)

The total number of data sent in the above example is:
4 (byte count needed for one data) x 401 + 2 (coefficient) = 1606
In the SQ4 mode, EOI is sent out simultaneously with the last data byte.

b. Output format in binary mode

The first two bytes contain the coefficient for the overall block.

MSB							LSB	MSB							LSB
D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}

Coefficient K

$$\underbrace{\qquad\qquad\qquad\qquad}_{\text{Byte 1}}\quad\underbrace{\qquad\qquad\qquad\qquad}_{\text{Byte 2}}$$

When $D_0 = 0$,

$$K = \left\{ \sum_{n=1}^{15} Dn \times 2^{15-n} \right\}$$

When $D_0 = 1$,

$$K = \left\{ \sum_{n=0}^{15} Dn \times 2^{15-n} \right\} - 2^{16}$$

Coefficient K can be determined as shown above. Therefore, if the value determined for individual precision types is assumed to be D_A, we obtain the following:

$A = D_A \times 2^k$

c. Output formats classified by precision types

Table 7-4 Precision Type and Byte Length

Code	Precision type and byte length	
1	Single precision, fixed point	2 bytes (16 bytes)
2	Double precision, fixed point	4 bytes (32 bytes)
3	Floating point	4 bytes (32 bytes)

Table 7-5 Output Format for Code "1"

<table>
<tr><th>Code</th><th>Format Δ : Decimal point, FS: Fullscale or coefficient</th></tr>
<tr><td>1</td><td>
2's complement
MSB LSB MSB LSB
<table>
<tr><td>D_0</td><td>D_1</td><td>D_2</td><td>D_3</td><td>D_4</td><td>D_5</td><td>D_6</td><td>D_7</td><td>D_8</td><td>D_9</td><td>D_{10}</td><td>D_{11}</td><td>D_{12}</td><td>D_{13}</td><td>D_{14}</td><td>D_{15}</td></tr>
<tr><td colspan="8">Δ Byte 1</td><td colspan="8">Byte 2</td></tr>
</table>
The MSB or byte 1 is a sign bit.
D_0 = 0 when positive: Note. Dn=1 denotes addition.
$$D = \left\{ \sum_{n=1}^{15} Dn \times 2^{-n} \right\}$$
If the value in question is assumed to be D_A,
D_A = D x FS.
D_0 = 0 when negative
$$D' = -\left\{ 1 - \sum_{n=1}^{15} Dn \times 2^{-n} \right\} = D - 1$$
If the value in question is assumed to be D_A,
D_A = D' x FS
</td></tr>
</table>

Table 7-6 Output Format for Code "2"

<table>
<tr><th>Code</th><th>Format Δ : Decimal point, FS: Fullscale or coefficient</th></tr>
<tr><td>2</td><td>
2's complement
<table>
<tr><td colspan="8">MSB</td><td colspan="8">LSB MSB</td><td colspan="0">LSB</td></tr>
<tr><td>D_0</td><td>D_1</td><td>D_2</td><td>D_3</td><td>D_4</td><td>D_5</td><td>D_6</td><td>D_7</td><td>D_8</td><td>D_9</td><td>D_{10}</td><td>D_{11}</td><td>D_{12}</td><td>D_{13}</td><td>D_{14}</td><td>D_{15}</td></tr>
<tr><td colspan="8">Δ Byte 1</td><td colspan="8">Byte 2</td></tr>
</table>
<table>
<tr><td colspan="8">MSB</td><td colspan="8">LSB MSB</td><td colspan="0">LSB</td></tr>
<tr><td>D_{16}</td><td>D_{17}</td><td>D_{18}</td><td>D_{19}</td><td>D_{20}</td><td>D_{21}</td><td>D_{22}</td><td>D_{23}</td><td>D_{24}</td><td>D_{25}</td><td>D_{26}</td><td>D_{27}</td><td>D_{28}</td><td>D_{29}</td><td>D_{30}</td><td>D_{31}</td></tr>
<tr><td colspan="8">Byte 3</td><td colspan="8">Byte 4</td></tr>
</table>
The MSB or byte 1 is a sign bit.
$D_0 = 0$ when positive:
$$D = \left\{ \sum_{n=1}^{31} Dn \times 2^{-n} \right\}$$
If the value in question is assumed to be D_A,
$D_A = D \times FS$.
$$D' = -\left\{ 1 - \sum_{n=1}^{31} Dn \times 2^{-n} \right\} = D - 1$$
As a result, $D_A = D' \times FS$.
</td></tr>
</table>

Table 7-7 Output Format for Code "3"

Code	Format Δ : Decimal point, FS: Fullscale or coefficient
3	2's complement MSB LSB MSB LSB D_0 D_1 D_2 D_3 D_4 D_5 D_6 D_7 D_8 D_9 D_{10} D_{11} D_{12} D_{13} D_{14} D_{15} Decimal places Δ Byte 1 Byte 2 MSB LSB MSB LSB D_{16} D_{17} D_{18} D_{19} D_{20} D_{21} D_{22} D_{23} D_{24} D_{25} D_{26} D_{27} D_{28} D_{29} D_{30} D_{31} exponent part Δ Byte 3 Byte 4 The MSBs of bytes 1 and 3 are sign bits. The decimal places are identical to those of single precision, fixed point data. D and D' Exponent part D_{16} = 0 when positive $E = \left\{ \sum_{n=17}^{31} Dn \times 2^{-(n-31)} \right\}$ D_{16} = 1 when negative $E = \left\{ \sum_{n=16}^{31} Dn \times 2^{-(n-31)} \right\} - 2^{16}$ As a result, $D_A = D \times 2^E \times FS$.

d. Block delimiter
The delimiter for the talker mode caused by a Read command and for the SQ2 and SQ3 modes are specified by Set command DL. In the SQ4 mode, an EOI is sent out simultaneously with the last data byte.

e. Set commands SP and ON
In the SQ3 and SQ4 modes, the number of data to be sent and the send start point are specifiable. They are specified with Set commands ON and SP respectively. When specifying SP(A) and ON(B), A and B must always satisfy the following relationships:

$A + B < N$

where N is the number of data on the display.
When Set commands SP and ON are specified, the data length can be read with Read command ROL. The number of data on the display is identical to that read by Read command ROL when SP0 and ON0.

(5) Notes on SQ3 and SQ4 modes
In SQ3 or SQ4 mode, sent data contains DC components even if the input is AC coupled.
In SQ4 mode, sent data is normalized to 1.0, except for HIST., PHASE, COHERENCE, and CORRELATION data. In this mode, therefore, it is necessary to correct data by multiplying it by the fullscale.
The following paragraphs show some calculation examples using the data sent in the SQ4 mode:

i) TIME mode (OL1, 1024)
Single precision, fixed point data with data count of 2048. If Bytes 1 and 2 of coefficient K are 00000000 and 00000001, and bytes 1 and 2 of data are 00001001 and 10011111, respectively, we obtain:

$D= 2^{-4}+ 2^{-7}+ 2^{-8}+ 2^{-11}+ 2^{-12}+ 2^{-13}+ 2^{-14}+ 2^{-15}=0.0751647$

$2^K = 2^1$

As a result, the desired value is

$A = D_A \times 2^K = D \times 2^K \times FS$

$= 0.1503295 \times FS$

ii) SPECT., CROSS SPECT., or TRANS. FCTN mode
If the MAG. key in the DISPLAY section is activated, data is sent in the form of X^2. Therefore, conversion must be made for each precision type and the results must be converted into the form compatible with the display.
The conversion method is shown in the following:
V^2 into V: If the result is assumed to be A1,

$A1 = \sqrt{A}$

V^2 into dB or dBV: If the result is assumed to be A2,

$A2 = 10 \log(A)$ [dB, dBV]

$A = D_A \times 2^k = D \times 2^K \times FS$

FS is expressed in V^2 (100 [V^2] in 20 dBV range)
V^4 into dB: If the result is assumed to be A3,

$A3 = 5 \log(A)$ [dB]

- Double precision, fixed point data in SPECT mode
  If bytes 1 and 2 of overall coefficient are assumed to be 11111111 and 11110110, bytes 1, 2, 3, and 4 of data are assumed to be 00000000, 00000001, 11100000, and 10000000, respectively, and the input sensitivity is 30 dBV, then FS = 1000
  $K = -(1 + 2^3 + 2^0) = -10$
  Therefore, we obtain:
  $A = D \times 2^K \times FS$
  $= (2^{-15} + 2^{-16} + 2^{-17} + 2^{-18} + 2^{-24} + 2) \times 2^{-10} \times 10^3$
  $= 5.5937563 \times 10^{-5}$ $[V^2]$
  This value may be converted into V or dBV as follows:
  V^2 into V: 7.4791418×10^{-3}[V]
  V^2 into dBV: -42.52296 [dBV]

- CROSS SPECT. mode
  The coefficient for cross spectrum is determined as the sum of the input sensitivities on channels A and B. For example, if the input sensitivities on channel A is +10 dBV and that on channel B is -10 dBV, then: Coefficient = Input sens. on CH.A + Input sens. on CH.B = 10 dBV + (-10 dBV) = 0 dBV

- TRANS. FCTN mode
  The coefficient for transfer functions is determined as the difference of the input sensitivities on channels A and B. For example, if the input sensitivity on channel A is +30 dBV and that on channel B is -20 dBV, then:
  Coefficient = (input sensitivity on CH.B) - (that on CH.A) = -20 dBV -30 dBV = -50 dBV

iii) HIST. (Histogram) mode
[For single precision data (16 bits)]
If it is assumed that bytes 1 and 2 of data are 00000000 and 11101010, both bytes 1 and 2 of the overall coefficient are 00000000, and the fullscale is 44.7 V, the desired value X is:

$$X = \frac{(2^7 + 2^6 + 2^5 + 2^3 + 2^1)/2048}{2 \times 44.7/256} = 0.327[V^{-1}]$$

where 2048: Number of TIME data (normalized to the number in a single-channel mode)
256: Number of histogram data

[For double precision data (32 bits)]

$$Dk = \left\{ \sum_{n=0}^{31} Dn \times 2^{(31-n)} \right\} / 2^{16}$$

The value to be obtained is

$$A = \frac{Dk/\omega}{2 \times FS/256}$$

[where ω is the sum of 256 points of Histogram data

$$\omega = \sum_{k=1}^{256} Dk \doteqdot 2048$$
]

iv) IMPUL. RESP., COHERENCE, or CORR. mode
For single precision, fixed point data:
If it is assumed that bytes 1 and 2 of data are 11111100 and 10111000, and bytes 1 and 2 of the overall coefficient are 11111111 and 11111111 respectively, coefficient K is given by:

$$K = \{2^0+2^1+2^2+2^3+2^4+2^5+2^6+2^7+2^8+2^9+2^{10}+2^{11}+2^{12}+2^{13}+2^{14} +2^{15}\} - 2^{16} = -1$$

Since this function is sent in 0.5 X -0.5, it must be doubled after operation is completed.

$$D = \{(2^{-1}+2^{-2}+2^{-3}+2^{-4}+2^{-5}+2^{-6}+2^{-7}+2^{-8}+2^{-9}+2^{-10}+2^{-11} +2^{-12}) - 1\} \times 2^{-1} \times 2 = -0.0256348$$

v) PHASE mode
For single precision, fixed point data:
If it is assumed that bytes 1 and 2 of the overall coefficient are both 00000000, and bytes 1 and 2 of data are 00000100 and 01001000 respectively, we obtain:

$$D = (2^{-5}+2^{-9}+2^{-12}) \times 2 \times 200 \text{ (deg.)} = 13.378906 \text{ [deg.]}$$

Data is sent as 0.5 = 200 deg.

vi) REAL or IMAG. mode
[For single precision, fixed point data 10-dBV input sensitivity.
If it is assumed that bytes 1 and 2 of the overall coefficient are both 00000000, and bytes 1 and 2 of data are 01000001 and 10000110 respectively, we obtain:
$D = (2^{-1} + 2^{-7} + 2^{-8} + 2^{-13} + 2^{-14}) = 0.5119$
When the input sensitivity for REAL and IMAG is 10 dBV, the coefficient is 3.16 according to Table 7-13.
Therefore,
$D_A = D \times 3.16(V) \fallingdotseq 1.62(V)$

When the input sensitivity for TIME and HIST is 10 dBV, the coefficient is 4.472 according to Table 7-12.
Therefore,
$D_A = D \times 4.472 \doteqdot 2.29 (V)$

vii) CEPSTRUM or SNR mode
Same as TRANS. FCTN mode

viii) GROUP DELAY mode
Same as PHASE mode

ix) PRE-ENVELOPE mode
Same as SPECTRUM mode

x) SCOT or ML mode
Same as IMPUL. RESP mode

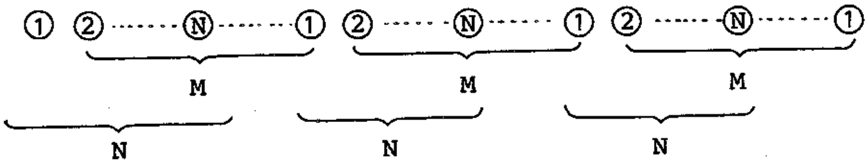
(6) BOTH mode (DO1)
Used in the SQ4 high-speed transfer mode (TX1), where data in the upper and lower display are transferred at once. Commands "SP" and "ON" cannot be set for the upper and lower displays independently; number of data in the upper and lower display is required to be computed in advance with the read command "ROL".
Lower display data are sent out first and the upper display data follow; EOI is output simultaneously with the last byte.
This mode allows two kinds of data to be read all at once.

(7) Notes on data transmission with command OS

Command OS is effective when the command ON is set to other than 0 either in the SQ3 (ASCII) mode or SQ4 (binary) mode in the TX0.

(Example) OSN, M ($1 \leqq N \leqq 2048$, $0 \leqq M \leqq 2047$)

- M → Number of data between blocks
- , → Comma (,)
- N → Number of data in a block ($M+1 \geqq N$)



Number of data sent out can be read by read command "ROL."
Number of the output data and the starting point are set up by the ON and SP commands respectively.
When the last output data exceeds the number of displayed data, the maximum block number derived from the command OS is set up as the set value of ON.
(Example)
In case of the "SP0ON1000OS4,8" set on the spectrum data (data length: 401 points), setup value for command ON is modified to 45 and the total data points are 180.
It is set to "OS1,0" at the power on state.

(8) SQ5 (time data read) mode

MSB							LSB	MSB							LSB
D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
Byte 1								Byte 2							

* The MSB of byte 1 is a sign bit.

On the TR9407, time data is expressed in the form of single precision, fixed point number as shown above. Therefore, time data can be read by the TR9407 by sending the pertinent time data in the same form as in the SQ4 mode (binary mode).
The data to be sent to the TR9407 must contain 2048 data points when in the single channel mode, and 1024 data points per channel when in the dual channel mode.
Since only one byte of data can be transferred at a time through the GPIB, each data (16 bits) is divided into two bytes before being sent. The channel to which data is to be written (channel A or B) is selectable with the set command "IM" (IM0: channel A, IM1: channel B).
Number of transfer bytes in a dual channel mode:
  1024 (data) x 2 + 2 (overall coefficient) = 2050 (bytes)
Number of transfer bytes in a single channel mode:
  2048 (data) x 2 + 2 (overall coefficient) = 4098 (bytes)

- Notes on the SQ5 mode

(a) Be sure to send SQ5 before sending the time data.

(b) The last byte of the time data should always be sent together with the EOI.
The number of transfer data bytes sent with the EOI may be greater or smaller than the specified byte count.

i) When smaller than the specified byte count:
All extra data bytes are read as zero. If the number of input bytes is an odd number, the last data byte is a high order byte. Since, in this case, the low order byte is not read into the instrument, the last data byte is ignored. For example, when the number of input data bytes is 101, 51 words correspond to high order bytes.
However, the 51st word is read as zero since the low order bytes are not input. At this time, a syntax error will result.

ii) When larger than the specified byte count:
Bytes 1 through 2050 are read as valid bytes, and extra bytes are ignored.

(c) When SQ5 is sent, the ZOOM mode is put to OFF.

(d) When time data read is completed, signal input to the analog section will be inhibited. To clear this inhibition, send SQ7 to the TR9407.

(e) When the data read by SQ5 are to be used in differential or integral calculation, send out the data 28 points longer than those sent out with RIL.
e.g., single channel: 2076 points
dual channel: 1052 points

(f) FC command
The FC command is used to send a function other than the time data from a controller. Store the function into memory before transmission. Transmission of the data from the controller in the same format as those stored in memory would write the data into memory. To clear the FC command, send SQ7.

(g) Wait 500 ms before averaging the data read by SQ5.

(h) Differentiation or integration of the data read by SQ5 is executed only once. If execution of another data is needed, clear the old data by sending out SQ7.

(9) Transfer of Mass-time data (SQ8, SQ9)
The TR9407 allows the data transfer through the GPIB to the 512K word data buffer. Position can be specified by ARM LENGTH/BLOCK NUMBER or setup command "IP".

2-channel operation: IP0-262143
1-channel operation: IP0-524287

During the mass-time data transfer, the TR9407 should assume the HOLD state; in the HOLD mode in the ARM operation, the maximum position equals to the ARM LENGTH.

a. SQ8 (MASS TIME DATA IN)
Transfer mode in which data from the controller are written to the data buffer. There is no limitations on input data length; the byte which receives the EO1 will be the last byte.
The data to be transferred, if voluminous, can be divided into some blocks using the "IP". "IP" signifies the position to write the data again after the data transfer.

b. SQ9 (MASS TIME DATA OUT)
Transfer mode in which data in the buffer are transferred to the controller.
Output data length can be set up by "ON" command.

ON 0-65535
(Data length at ON = 0 : 65536 points)

EOI is output with the last byte.

c. Mass-time output format
Overall coefficient for the block is nt transmitted in the mass-time data transfer mode as it is in the other block transfer modes; the coefficient is K = 0 for computation. Position type is single precision with the fixed point.

1	2	3	4	5	6	.....	N-5	N-4	N-3	N-2	N-1	N

(10) 1/3- and 1/1-octave analysis and GPIB

1) Talker format

- In the SQ2 Cursor mode, data is sent in the following format:

Header	Body	∇	Header	Body	∇	Header	Body	CRLF and EOI
5	3	1	5	10	1	5	10	
Filter No.			Center frequency			Level		40 characters

a) Filter number (three characters)

␣ 20

20 — Filter number

␣ — Space

b) Center frequency (10 characters)

k (ASCII) is sent for 1 kHz or higher (for FX0 only).

c) Level (10 characters)
The header field is identical to that in modes other than the octave mode.

- The data format in SQ3 (ASCII mode) or SQ4 (binary mode) is identical to that in modes other than the octave mode. The number of data for 1/3-octave analysis is 30 points; that for 1/1-octave analysis is 10 points.

- Read command (octave list display):
Refer to the command list.

2) Read command output format
- If a read command RLN is sent in the octave list mode, the number of lines displayed at that time will be sent.
  LN10 (four characters) 1/1 octave
  LN30 (four characters) 1/3 octave

- If an RLN read command is followed by a filter number shown in the listing when in the octave list mode, that filter number, center frequency, and its level will be sent.

LNxx	▽	Header	Body	▽	Header	Body
Filter No.		Center frequency			Level	

- The OVERALL in the octave list mode can be read by the RLV. read command

Header	Body

- Center frequency field and level field in the octave list mode:

Header	Body	▽	Body	▽	…	Body	▽	Body

  The data send format is the same as for the SQ3 mode.
  The number of data points can be read with the RLN read command.
  The structures of the header and body fields are identical to those in the SQ2 mode.

- The vertical cursor range is as follows:
  1/3 octave: 0-29
  1/1 octave: 0-9

Figures 7-24 and 7-25 show program examples in which an octave listing is read with the read command and printed out on the controller.

(11) How to read AUTO RANGE measurement data over the GPIB

For AUTO RANGE measurements, the TR9407 sets the optimum range according to the characteristics of DUT and the measuring conditions. It is therefore necessary to correct the sensitivity when reading the transfer function with GPIB. The method of correcting the sensitivity is explained below.

Display a transfer function to be read, and read the sensitivities of CH-A and CH-B using the measuring status read commands (RAS1, RBS1). The read sensitivities become reference sensitivities. Obtain a coefficient from Table 7-13 to correct the measured value.

Example: With CH-A sensitivity being 10 dB and CH-B being -10 dB, a differential sensitivity is obtained as follows:

(CH-B) - (CH-A) = -10 - 10 = -20 dB

The coefficients are:

10^{-2} for Mag display

1.00E-3 for Real or Imaginary display

(12) How to read the measurement status

To read the state of measurement data in the memory or averaged data, set the read command as follows:

Example: When reading the frequency range of averaged data, display the data of interest and select DISPLAY UPPER/LOWER ("DU"). (UPPER: DU1; LOWER: DU0)

RFQ 1<CR><LF>&<EOI>

1 → Argument

RFQ → Read command

The above setting is executed by the commands listed below. Other commands cannot be used.

When the argument is 0 or nonexistent, the current setting is transmitted.

Table 7-8 Read Commands

Command	State of measurement data	Command	State of measurement data
RFR	FREQUENCY RANGE	RID	INTERCHANNEL DELAY
RAS	CH-A INPUT SENSITIVITY	RTL	TRIGGER LEVEL
RAE	CH-A DEACTIVATE	RWC	WEIGHTING CONTROL
RAV	CH-A INVERT	RZO	ZOOMING
RAG	CH-A GND COUPLING	RCM	CENTER MOVE
RAI	CH-A INPUT COUPLING	RTC	TRIGGER SOURCE
RBS	CH-B INPUT SENSITIVITY	RTS	TRIGGER SLOPE
RBE	CH-B DEACTIVATE	RTP	TRIGGER POSITION
RBV	CH-B INVERT	RWG	WEIGHTING
RBG	CH-B GND COUPLING	RAN	AVERAGING NUMBER
RBI	CH-B INPUT COUPLING	RAW	AVERAGE WHAT?
REW	ZOOMING EXPAND WIDTH	RAM	AVERAGE MODE
		RAH	AVERAGE CHANNEL
		RAO	AVERAGE OVERLAP
		RAP	AVERAGE PROCESS
		RAD	AVERAGE DISPLAY

7.3.5 Notes on GPIB Command Execution

When the TR9407 is to be controlled over the GPIB, all setup must be made in the similar manner and procedure as local front panel control settings. Also note the following points:

(1) Of the Set and Read commands, the following commands are not usable concurrently with other commands:
Commands for which mark * is entered in the function column of the command list (Table 7-16), such as LA, RLA, RDT, RLD, etc.

(2) LA command
This command must be specified in the following format:

```
LA03X○○○○ ------------ ○○X
  │ │ X Max 40 characters │
  │ └──────────────────── Terminator
  └────────────────────── Line number (00-34)
```

The character string in between the two terminators is displayed on the specified line as a label. The terminators should be specified with characters or symbols other than those used for the label. The line number should comprise two numeric characters.
The maximum displayable number of characters is 40. Special character codes are listed in Table 7-14.

(3) Read command
Since the modes (SQ0 and SQ1), (SQ2, SQ3, SQ4), and (SQ5, SQ7) are independent of each other, SQ0 will not be affected if SQ3 or SQ5 is specified after SQ0 being specified. If Read command RSQ is specified, SQ command is sent out in the following format.
SQ5 and SQ7 are not readable since they are executed immediately after the command is sent.

```
SQ○ SQ○
  │   └──── Setup condition of SQ2 to 4
  └──────── Setup condition of SQ0 and 1
```

The commands whose formats differ between Set and Read commands are listed in the following:

a. AI and BI commands (Input coupling)

```
AI○AI○
  │   └──── Set 2 or 3
  └──────── Set 0 or 1 (TEST ON/OFF)
```

b. FU command (FUNCTION)

```
FU○ FU○
  │    └──── Set 0 or 1 (ON/OFF)
  └───────── Set 2 to 5
```

b. FU command (FUNCTION)

```
FU○ FU○
  │    └──── Set 0 or 1 (ON/OFF)
  └───────── Set 2 to 5
```

c. VW command (VIEW MODE)

```
VW○VW○ (in the BOTH mode)
 │   └──── LOWER DISPLAY mode
 └──────── UPPER DISPLAY mode
␣␣␣VW2 (in the SINGLE mode)
```

d. SM command (Scaling mode)

```
SM○SM○
 │   └──Set 0 or 1
 └──────Set 2 or 3
```

e. CL command (OPEN/CLOSED LOOP)

```
CL○CL○
 │   └──Set 2 to 5
 └──────Set 0 or 1 (ON/OFF)
```

(4) When reading data by using a Read command, the data must already be on the display. If a Read command is specified to read data which is not on the display, the instrument enters the SQ mode (SQ2, 3, or 4) when it is subsequently addressed to talk and sends each format value.

(5) When reading setup conditions by using a Read command, the maximum number of characters transferable at a time is 200. Once the number of sent characters exceeds 200, the subsequent Read commands are ignored.

(6) No other command than the IE command should be sent while the attached plotter is busy plotting (EXECUTE lamp ON).

7.3.6 Read Command Output Format (Display Data Read)

(1) Reference Delta in the SET REF. mode

Header	Body	▽	Header	Body	▽	Header	Body
Level 1			Level 2			Level 3	

The send method for the header, body, and each level is identical to that in SQ1 mode.

(2) Overall, Partial, Horizontal Level & Delta, Total Harmonics RMS & Distortion in LIST mode

Header	Body

The header and body are sent out at one level. The header and body section structures are identical to those in SQ2 mode.

(3) Frequency block and level block in LIST mode

Header	Body	▽	Body	▽	...	Body	▽	Body

The send format is identical to that in SQ3 mode. The number of data can be read with Read command RLN.

(4) In the LIST mode, the maximum number of display lines on the display is sent out.

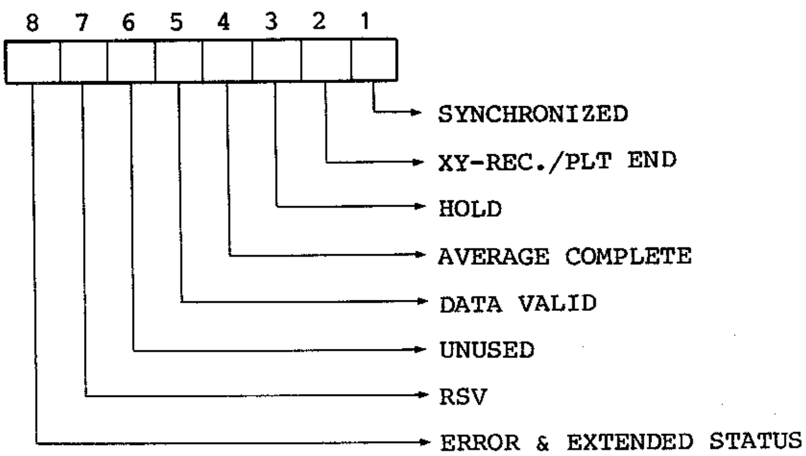
LN XX ——→ Maximum number of lines

(5) If line numbers are specified following Read command RLN in the LIST mode, all the levels of the line are sent out.

LN	XX	▽	Header	Body	▽	Header	Body	▽	Header	Body

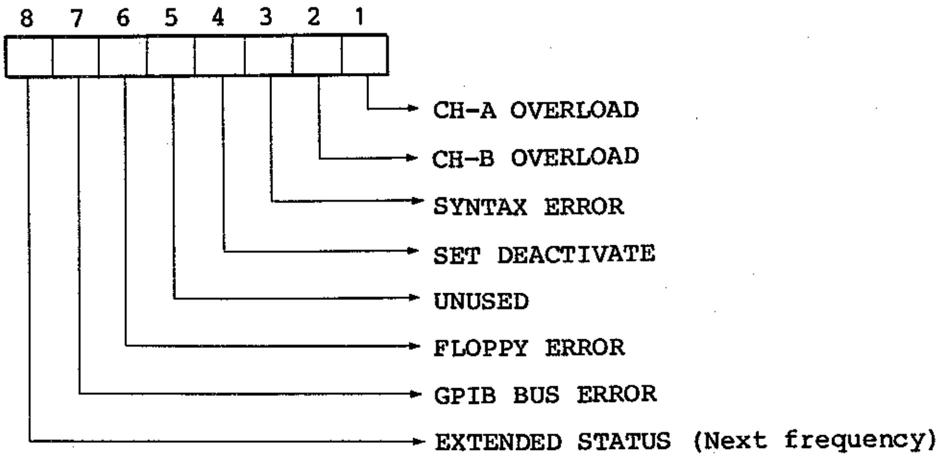
7.3.7 Service Request

(1) A Service Request (SRQ) is issued when any bit of the statusbyte is set to 1.



SQO	: This mode enables SRQ send.
SQ1	: This mode disables SRQ send. This mode is initially selected when powered on.
Bit 1	: Set to 1 if a data which is not identical to the preceding data is read.
Bit 2	: Set to 1 when plotting for XY-REC/PLT is completed, and reset to 0 upon start (I/O execute) of XY-REC/PLT.
Bit 3	: Set to 1 if the HOLD state is entered, and reset to 1 when the FREE RUN mode is restored.
Bit 4	: Set to 1 upon the end of averaging. Remains at 0 during execution of averaging.
Bit 5	: Set to 1 when a newly selected range data is read.
Bit 6	: Not in use.
Bit 7	: Set to 1 if any of bits 1 through 6 and 8 is set to 1, and reset to 0 when all bits of the status byte are reset to 0.
Bit 8	: Set to 1 upon an error generation or EXTENDED STATUS being set. The error contents can be read with Read command RES.

(2) Error status byte



Bit 8 of the status byte is set to 1 if any one of bits 1 through 8 of this error status byte is set to 1.

Bit 1 : Set to 1 if input overload has occurred on channel A.
Bit 2 : Set to 1 if input overload has occurred on channel B.
Bit 3 : Set to 1 if a command has syntax error.
Bit 4 : Set to 1 if illegal setup is executed (e.g. ZOOM ON is specified in HIST mode).
Bit 5 : Not in use.
Bit 6 : Set to 1 if an error is generated in the TR98102 Floppy Disk Digital Data Recorder.
Bit 7 : Set to 1 if an error occurred on the GPIB bus (e.g. incomplete source handshake).
Bit 8 : Set to 1 when averaging of channel-A peak frequency is completed during SWEEP AVERAGE.

(3) Service request mask
Unnecessary service requests can be masked out by the Set Command MK.

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
Error status								Status byte								
0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	1	Mask pattern

Where the above mask pattern is set, service requests will not be output for the following error status:

Synchronize
Data Valid
CH-A, CH-B, OVERLOAD

At this time, the command number is the decimal counterpart of the binary number represented by the above mask pattern. The command number is thus determined as follows:

$$2^0 + 2^4 + 2^8 + 2^9 = 785$$

Where MK128 is specified, all error status can be masked out.

7.3.8 Header Code List

Table 7-9 Header Code List (FUNCTION)

Output code	Send data type
TI	TIME
HI	HISTOGRAM
AC	AUTOCORRELATION
SP	SPECTRUM
CS	CROSS SPECTRUM
TF	TRANSFER FUNCTION
CO	COHERENCE
CP	C.O.P. (Coherent Output Power)
IR	IMPULSE RESPONSE
OT	1/3 OCTAVE
OO	1/1 OCTAVE
CC	CROSS-CORRELATION
CE	CEPSTRUM
EV	PREENVELOPE
ML	ML
SC	SCOT
SN	SNR
00	None

Table 7-10 Header Code List (OVERLOAD)

Output code	Overload
O	Overload
␣	Normal (space)

Table 7-11 Unit Code List

Output code	UNIT
00	No data
␣␣	None
UV	µV
MV	mV
␣V	V
US	µs (µsec)
MS	ms (msec)
␣S	s (sec)
UH	µHz
MH	mHz
HZ	Hz
KH	kHz
DB	dB
DV	dBV
DG	deg
IV	V^{-1}
VV	V^2
QV	V^4
VZ	V/ Hz
VH	$V^2/\sqrt{Hz}$
VQ	V^4/Hz^2
DH	$dBV/\sqrt{Hz}$
PS	%
␣M	M
MM	M^2
CM	CPM
MC	mCPM

Note: denotes a space.
In SCALING mode, no unit
(␣␣) is output.

Table 7-12 Fullscale and Coefficient vs. Input Sensitivity in the "TIME" and "HIST." Modes

Input sensitivity (dBV)	Fullscale (V)	Coefficient
30	44.7	44.72
20	14.1	14.14
10	4.47	4.472
0	1.41	1.414
-10	4.47×10^{-1}	4.472×10^{-1}
-20	1.41×10^{-1}	1.414×10^{-1}
-30	4.47×10^{-2}	4.472×10^{-2}
-40	1.41×10^{-2}	1.414×10^{-2}
-50	4.47×10^{-3}	4.472×10^{-3}
-60	1.41×10^{-4}	1.414×10^{-3}

Table 7-13 Coefficient vs. Input Sensitivity in the "SPECT.", "CROSS SPECT.", and "TRANS. FCTN" Modes

Input sensitivity, sum/difference of sensitivity [dB][dBV]	Coefficient Mag	Coefficient Real,Imag.
90	10^{9}	31.6E+3
80	10^{8}	10.0E+3
70	10^{7}	3.16E+3
60	10^{6}	1.00E+3
50	10^{5}	316
40	10^{4}	100
30	10^{3}	31.6
20	10^{2}	10
10 Sum or	10^{1}	3.16
0 Sensitivity difference	1	1.0
-10 of	10^{-1}	316E-3
-20 sensitivity	10^{-2}	100E-3
-30	10^{-3}	31.6E-3
-40	10^{-4}	10.0E-3
-50	10^{-5}	3.16E-3
-60	10^{-6}	1.00E-3
-70	10^{-7}	316E-6
-80	10^{-8}	100E-6
-90	10^{-9}	31.6E-6
-100	10^{-10}	10.0E-6
-110	10^{-11}	3.16E-6
-120	10^{-12}	1.00E-6

Table 7-14 Special Character Codes for Labels

Character	Equivalent codes		
	(BINARY BITS)	(OCTAL)	(DECIMAL)
α (alpha)	00000001	1	1
β (beta)	00000010	2	2
λ (lambda)	00000011	3	3
μ (micro)	00000100	4	4
π (pi)	00000101	5	5
Ω (ohm)	00000110	6	6
∘ (degree)	00000111	7	7
τ (tau)	00001000	10	8
Δ (delta)	00001001	11	9
θ (theta)	00001011	13	11
Σ (sigma)	00010011	23	19
∫ (integral)	00010111	27	23
→	00011011	33	27
↑ (ASCII ^)	01011110	136	94
← (ASCII _)	01011111	137	95
↓ (ASCII ~)	01111110	176	126

Special characters used for labels are sent in the codes listed in Table 7-14. All other codes are included in ASCII code set listed in Table 7-15.

Table 7-15 ASCII Characters

ASCII character	Equivalent codes Binary	Octal	Decimal	ASCII character	Equivalent codes Binary	Octal	Decimal	ASCII character	Equivalent codes Binary	Octal	Decimal	ASCII character	Equivalent codes Binary	Octal	Decimal
NULL	00000000	000	0	space	00100000	040	32	@	01000000	100	64	`	01100000	140	96
SOH	00000001	001	1	!	00100001	041	33	A	01000001	101	65	a	01100001	141	97
STX	00000010	002	2	"	00100010	042	34	B	01000010	102	66	b	01100010	142	98
ETX	00000011	003	3	#	00100011	043	35	C	01000011	103	67	c	01100011	143	99
EOT	00000100	004	4	$	00100100	044	36	D	01000100	104	68	d	01100100	144	100
ENQ	00000101	005	5	%	00100101	045	37	E	01000101	105	69	e	01100101	145	101
ACK	00000110	006	6	&	00100110	046	38	F	01000110	106	70	f	01100110	146	102
BELL	00000111	007	7	'	00100111	047	39	G	01000111	107	71	g	01100111	147	103
BS	00001000	010	8	(	00101000	050	40	H	01001000	110	72	h	01101000	150	104
H_{TAB}	00001001	011	9	)	00101001	051	41	I	01001001	111	73	i	01101001	151	105
LF	00001010	012	10	*	00101010	052	42	J	01001010	112	74	j	01101010	152	106
V_{TAB}	00001011	013	11	+	00101011	053	43	K	01001011	113	75	k	01101011	153	107
FF	00001100	014	12	,	00101100	054	44	L	01001100	114	76	l	01101100	154	108
CR	00001101	015	13	-	00101101	055	45	M	01001101	115	77	m	01101101	155	109
SO	00001110	016	14	.	00101110	056	46	N	01001110	116	78	n	01101110	156	110
SI	00001111	017	15	/	00101111	057	47	O	01001111	117	79	o	01101111	157	111
DLE	00010000	020	16	0	00110000	060	48	P	01010000	120	80	p	01110000	160	112
DC_1	00010001	021	17	1	00110001	061	49	Q	01010001	121	81	q	01110001	161	113
DC_2	00010010	022	18	2	00110010	062	50	R	01010010	122	82	r	01110010	162	114
DC_3	00010011	023	19	3	00110011	063	51	S	01010011	123	83	s	01110011	163	115
DC_4	00010100	024	20	4	00110100	064	52	T	01010100	124	84	t	01110100	164	116
NAK	00010101	025	21	5	00110101	065	53	U	01010101	125	85	u	01110101	165	117
SYNC	00010110	026	22	6	00110110	066	54	V	01010110	126	86	v	01110110	166	118
ETB	00010111	027	23	7	00110111	067	55	W	01010111	127	87	w	01110111	167	119
CAN	00011000	030	24	8	00111000	070	56	X	01011000	130	88	x	01111000	170	120
EM	00011001	031	25	9	00111001	071	57	Y	01011001	131	89	y	01111001	171	121
SUB	00011010	032	26	:	00111010	072	58	Z	01011010	132	90	z	01111010	172	122
ESC	00011011	033	27	;	00111011	073	59	[	01011011	133	91	{	01111011	173	123
FS	00011100	034	28	<	00111100	074	60	\	01011100	134	92	:	01111100	174	124
GS	00011101	035	29	=	00111101	075	61	]	01011101	135	93	}	01111101	175	125
RS	00011110	036	30	>	00111110	076	62	^	01011110	136	94	~	01111110	176	126
US	00011111	037	31	?	00111111	077	63	_	01011111	137	95	DEL	01111111	177	127

7.3.9 GPIB Command List

Table 7-16 TR9407 Command List

** marked commands are not usable with other commands.

Control item	Command Function	Command Setup	Description	Setup read
Input coupling	AI BI	0 to 3	INPUT COUPLING 0 TEST ON 1 TEST OFF 2 AC 3 DC { AI: CH-A { BI: CH-B	o
	AG BG	0 to 3	GROUND COUPLING 0 SOURCE 1 -GND 2 +GND 3 ±GND { AG: CH-A { BG: CH-B	o
Input impedance	UA UB	0, 1	INPUT IMPEDANCE 0 : 1MΩ 1 : 50Ω { UA: CH-A { UB: CH-B	o
Filter	FE	0, 1	FILTER 0 : OFF 1 : ON	o
Input mode	AV BV	0, 1	INPUT INVERT 0 NORMAL 1 INVERT { AV: CH-A { BV: CH-B	o
	AE BE	0, 1	INPUT DEACTIVATE 0 DEACTIVATE 1 ACTIVATE (AUTO RANGE) { AE: CH-A { BE: CH-B	o

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Input sensitivity	AS BS	0 to :	INPUT SENSITIVITY 0 +30 dBV { AS: CH-A 1 +20 dBV { BS: CH-B 2 +10 dBV 3 0 dBV 4 -10 dBV 5 -20 dBV 6 -30 dBV 7 -40 dBV 8 -50 dBV 9 -60 dBV : AUTO [See 7.3.4 (11), P. 7-39, How to read AUTO RANGE measurement data over the GPIB]	o
Sampling clock	SC	0, 1	SAMPLING CLOCK 0 INTERNAL 1 EXTERNAL	o
Frequency range	FQ	0 to 18	FREQUENCY RANGE 18 1 MHz 17 500 kHz 16 200 kHz 15 100 kHz (FR0 also available) 14 50 kHz (FR1) 13 20 kHz (FR2) 12 10 kHz (FR3) 11 5 kHz (FR4) 10 2 kHz (FR5) 9 1 kHz (FR6) 8 500 kHz (FR7) 7 200 kHz (FR8) 6 100 kHz (FR9) 5 50 kHz (FR:) 4 20 kHz (FR;) 3 10 kHz (FR) 2 5 kHz (FR=) 1 2 kHz (FR) 0 1 kHz (FR?)	o
Auto calibration	AU	0, 1	AUTO CAL 0 : OFF 1 : ON	o

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
External gate	EG	0, 1	EXTERNAL GATE 0 : OFF 1 : ON	o
Trigger	TC	0 to 2	TRIGGER SOURCE 0 CH-A 1 CH-B 2 EXT	o
	TS	0, 1	TRIGGER SLOPE 0 + 1 -	o
	TO	0, 1	BEEP ON TRIGGER 0 OFF 1 ON	o
	TM	0, 1	TRIGGER MARKER 0 OFF 1 ON	o
	TL	-100 to +100	TRIGGER LEVEL -100 to +100 [%] Integer	o
	TP	0 to 25600	TRIGGER POSITION 0 to 25600 [%] Integer	o
	AL	0 to 6	ARM LENGTH 0 1K 1 2K 2 4K 3 8K 4 16K 5 32K 6 64K 7 128K 8 256K 9 512K (single channel only)	o
	AR	0, 1	ARM MODE 0 NORMAL 1 ADVANCE	o

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Trigger	BN	0 to 31	BLOCK NUMBER	o
	ID	-512 to +512	INTERCHANNEL DELAY	o
	BR	-	RECALL BLOCK	x
Averaging	AH	0 to 3	AVERAGE CHANNEL 0 CH-A 1 CH-B 2 DUAL 3 CROSS	o
	AP	0 to 2	AVERAGE PROCESS 0 NORMAL 1 +1 AVG 2 SWEEP	o
	AO	0, 1	AVERAGE OVERLAP 0 0 [%] 1 50 [%]	o
	AD	0 to 2	AVERAGE DISPLAY 0 ALL 1 1/2 2 END When "AVERAGE DISPLAY" in the AVG MODE menu is set to either "1/2" or "END," data transfer over GPIB should be executed upon completion of averaging; during averaging, correct data may not be output.	o
	AW	0 to 6	AVERAGE WHAT? 0 TIME 1 AUTOCORRELATION 2 CROSS-CORRELATION 3 HISTOGRAM 4 POWER SPECTRUM 5 COMPLEX SPECTRUM 6 CROSS + POWER	o

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Averaging	AM	0 to 5	AVERAGE MODE 0 SUM (N) 1 SUM (L) 2 DIFFERENCE 3 EXPONENTIAL 4 PEAK 5 SUM(T)	o
	AN	0 to =	AVERAGE NUMBER 0 1 1 2 2 4 3 8 4 16 5 32 6 64 7 128 8 256 9 512 : 1024 ; 2048 < 4096 = 8192	o
Averaging control	AC	0 to 3	AVERAGE CONTROL 0 ERASE 1 START 2 STOP 3 CONTINUE	x
Weighting	WG	0 to 3	WEIGHTING 0 RECTANGULAR 1 HANNING 2 MINIMUM 3 FLAT-PASS	o
	WF	0 to 1023	FORCE START	o
	WO	0 to 1023	FORCE STOP	o
	WE	0 to 1023	RESPONSE START	o
	WP	0 to 1023	RESPONSE STOP	o

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Weighting	WS	0 to 100	SCALE (%) *FS	o
Readout unit	FN	0, 1	FREQUENCY UNIT 0 Hz 1 CPM	o
	VU	0, 1	VERTICAL UNIT 0 NORMAL 1 PER Hz	o
Scaling	SM	0 to 3	SCALING MODE 0 KEY 1 CURSOR 2 OFF 3 ON SCALING FACTOR ● dBMag display: ±NNN.N 0 to 9 Decimal point 0 to 9 0 to 9 0 to 9 (+), (-), space Set with 6 characters	o
	** SF		● Mag or Mag^2 display: +N.NNE±NN 0 to 9 0 to 9 (+), (-), space E 0 to 9 0 to 9 Decimal point 0 to 9 (+) space Set with 9 characters	o

* Reads the number last set up. With no command, ? is output.

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Scaling	** EU		ENGINEERING UNIT XX (set with 2 characters) Alphabet Greek letters	o
PANEL	PC	0,1	PANEL CONTROL 0 LOCK OFF 1 LOCK ON	o
	PS	0 to 3	PANEL STORE Panel Store 1 to 4	o *
	PR	0 to 3	Panel RECALL Panel Recall 1 to 4	x
Function	FU	0 to 5	FUNCTION 0 OFF 1 ON 2 U+L 3 U-L 4 U*L 5 U/L	o
	FV	0 to 4	FUNCTION VIEW 0 OFF 1 $j\omega$ 2 $(j\omega)^2$ 3 $1/(j\omega)^2$ 4 $1/(j\omega)$	
	CL	0 to 5	OPEN/CLOSED 0 OFF 1 ON 2 Ho/(1+Ho) 3 Hc/(1-Hc) 4 Ho/(1+Ho*Hm) 5 Hc/(1+Ho*Hm)	o
	NA	0 to 2	TREND REMOVAL (CH-A) 0 OFF 1 DC 2 DC+TREND	o

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Function	NB	0 to 2	TREND REMOVAL (CH-B) 0 OFF 1 DC 2 DC+TREND	o
	SO	0 to 4	SMOOTHING 0 OFF 1 3 TERMS 2 7 TERMS 3 11 TERMS 4 13 TERMS	o
Integration and Differentiation	IA IB	0 to 2	INTEGRATION 0 OFF 1 SINGLE 2 DOUBLE IA: CH-A IB: CH-B	o
	DA DB	0 to 2	DIFFERENTIATION 0 OFF 1 SINGLE 2 DOUBLE DA: CH-A DB: CH-B	o
Equalization	EQ	0, 1	EQUALIZE 0 OFF 1 ON	o
Coherence blanking	CB	0, 1	COHERENCE BLANK 0 OFF 1 ON	o
Overall	OV	0 to 2	OVERALL 0 OFF 1 ALL 2 PARTIAL	o
Resampling	EL	0, 1	RESAMPLING 0 : UNIFORM 1 : PEAK	o
Level monitor	LO	0, 1	LEVEL MONITOR 0 : OFF 1 : ON	o

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Level monitor	MV	0, 1	MONITOR LEVEL 0 : CURSOR 1 : OVERALL	o
	MM	0, 1	LEVEL MONITOR 0 : CONTINUE 1 : PAUSE	
Display control	UC	0, 1	AUTO SCALE 0 ON 1 OFF	o
Display control	DM	0, 2 to 5	DISPLAY MODE 0 TIME 2 V 3 V^2 4 dBV 5 NICHOLS	o
	DG	0 to 2	DISPLAY GAIN [dB/DIV.] 0 2 1 5 2 10	o
	DD	0, 1	DISPLAY DATA WINDOW 0 AUTO 1 MANUAL	o
	SD	1 to 2048	STEP DATA WINDOW 1 to 1024 (Dual channel) 1 to 2048 (Single channel)	o
View	VS	0, 1	VIEW CHANNEL SELECT 0 CH-A 1 CH-B	o

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
View	VW	0 to :	VIEW MODE 0 TIME 1 SPECTRUM 2 AUTOCORRELATION 3 CROSS-CORRELATION 4 HISTOGRAM 5 IMPULSE RESPONSE 6 TRANSFER FUNCTION 7 COHERENCE 8 CROSS SPECTRUM 9 C.O.P. (Coherent Output Power) : MEMORY RECALL	o
	VM	0, 1	VIEW MODE 0 INSTANT 1 AVERAGE	o
	MS		MEMORY STORE	x
	BT	0, 1	BOTH 0 SINGLE DISPLAY 1 BOTH DISPLAY	o
	LT	0, 1	LIST 0 DISPLAY 1 LIST MODE	o
Display	DU	0, 1	DISPLAY UPPER/LOWER 0 LOWER 1 UPPER	o
	DV	0 to 4	DISPLAY VIEW 0 REAL 1 IMAGINARY 2 MAGNITUDE 3 PHASE 4 NYQ./ORBIT.	o
	GR	0, 1	GRATICULE 0 ON 1 OFF	o

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Display	US	0, 1	UPSCALING 0 OFF 1 ON	o
	SI	0, 1	SUPERIMPOSE 0 OFF 1 ON	o
	HS	0, 1	HORIZONTAL SCALE 0 LIN. 1 LOG.	o
Display scale	** VG	-5 to 9	VERTICAL GAIN (See Table 7-16(a) Display gain setup on next page)	o
	** VR	-250 to +250 (LOG) -100 to +100 (LIN: Real, Imag, Phase) +50 to +100 (LIN: Mag, Mag^2)	VERTICAL REFERENCE See the following Table 7-16(b) Vertical reference setup	o

Table 7-16(a) Display Gain Setup

VIEW			Command setup														
			-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9
TIME								x1	x2	x4	x8	x16					
AUTOCORR. CROSS-CORR.								x1	x2	x4	x8	x16					
HIST.								x1	x2	x4	x8	x16	x32				
IMPUL. RESP.								x1	x2	x4	x8	x16					
COHERENCE								x1	x2	x4	x8	x16	x32	x64	x128	x256	x512
SPECTRUM TRANS. FCTN CROSS SPECT.	REAL IMAG.		(1/32	1/16	1/8	1/4	Note 1 1/2)	x1	x2	x4	x8	x16	x32	x64	x128	x256	x512
	MAG MAG^2		(1/32	1/16	1/8	1/4	Note 1 1/2)	x1	x2	x4	x8	x16	x32	x64	x128	x256	x512
	dBMAG	2 dB step							14	16	18	20	24	28	32	36	40
		5 dB step						50	35	40	45	50	60	70	90	90	100
		10 dB step					Note 2	60	70	80	90	100	(120	140	160	180	200)
	PHASE							x1	x2	x4	x8						
C.O.P.	MAG MAG^2							x1	x2	x4	x8	x16	x32	x64	x128	x256	x512
	dBMAG	2 dB step							14	16	18	20	24	28	32	36	40
		5 dB step						50	35	40	45	50	60	70	90	90	100
		10 dB step					Note 2	60	70	80	90	100	(120	140	160	180	200)

Note 1. Gain within parentheses is available only at TRANS. FCTN.
Note 2. Gain within parentheses is applicable to the parameters in the CROSS frame on the front panel.

Table 7-16(b) Vertical Reference Setup

VIEW		Reference	Setup value (X)	Graticule readout (Y) on the reference position (X: setup value)
TIME		Center graticule	+100 to -100	Y = F.S. * (X/100)
AUTO-CORR. CROSS-CORR.		Center graticule	+100 to -100	Y = 1.0 * (X/100)
HIST.		-	-	-
IMPUL. RESP.		Center graticule	+100 to -100	Y = 1.0 * (X/100)
COHERENCE		Top graticule	+100 to +50	Y = 0.5 * (X-50)/50 + 1.0
SPECTRUM TRANS.FCTN CROSS.SPECT	REAL. IMAG.	Center graticule	+100 to -100	Y = F.S. * (X/100)
	PHASE	Center graticule	+100 to -100	Y = 200 * (X/100)
	MAG., MAG^2	Top graticule	+100 to +50	Y = F.S. * 0.5 * (X - 50)/50 + 1.0
	dBMAG	Top graticule	+250 to -250	Y = X (NOTE)
C.O.P.	MAG., MAG^2	Top graticule	+100 to +50	Y = F.S. * 0.5 * (X - 50)/50 + 1.0
	dBMAG	Top graticule	+250 to -250	Y = X (NOTE)

(NOTE) Vertical reference value is integer multiple of display gain set up in the "DISP CTRL" menu. Difference is rounded off.
(Examples) If the "DISP. GAIN" is set to 10 dB/div, VR 13 would become 10 dB.
With the "DISP. GAIN" set to 5 dB/div, VR 26 would become 25 dB.

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Cursor control	VC	0, 1	VERTICAL CURSOR 0 OFF 1 ON	o
	HC	0, 1	HORIZONTAL CURSOR 0 OFF 1 ON	o
	UL	0, 1	UPPER/LOWER 0 LOWER 1 UPPER	o
	DW	0, 1	DATA WINDOW 0 OFF 1 ON	o
	HA	0, 1	HARMONIC/SINGLE 0 HARMONICS 1 SINGLE	o
	SR	0, 1	SET REFERENCE 0 OFF 1 ON	o
	ST	-	SET	x
	CS	-	RECALL SET	x
	SX	-	SET X	x
Cursor setup	HT	0 to 1024	HORIZONTAL CURSOR SET	o
	VT	0 to 2047	VERTICAL CURSOR SET When these commands are executed, the cursor is turned on. If the input is AC coupled for frequency domain data, display VT0=VT1. As a result, the cursor is positioned to the leftmost graticule in both cases. The cursor is also positioned to the leftmost graticule if the setup value is outside the display.	o

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command Function	Command Setup	Description	Setup read
Cursor setup	VT	0 to 2047	When the ·DATA WINDOW· is set to ON, command number of setup command VT determines the direction of data window. Positive command number: Negative command number: When "DATA WINDOW" menu is set to "AUTO" mode, the display is shifted continuously while in the "MANUAL" mode it is shifted by the set step width. Use the same procedure as the manual operation in setting up the step width.	
Label	** LA	-	LABEL 1	o
Hold mode	DH	0 to 3	DATA HOLD MODE 0 FREE RUN 1 ARM 2 HOLD 3 AUTO ARM	x
Zooming	** ZO	0, 1	ZOOMING 0 OFF 1 ON	o
	** CM	0, 1	CENTRAL MOVE 0 OFF 1 ON	o
	CP	-	CENTER POSITION Positive integer:(+)direction 0: Stop Negative integer:(-)direction	x

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Zooming	** EW	-8 to 7	EXPAND WIDTH TIME SPECT -8 1/256 - -7 1/128 - -6 1/64 - -5 1/32 - -4 1/16 - -3 1/8 - -2 1/4 - -1 1/2 - 0 x1 x2 1 x2 x4 2 x4 x8 3 x8 x16 4 x16 x32 5 - x64 6 - x128 7 - x256	o
Miscellaneous	SQ	0 to 9	0 Enables SRQ. *1 Disables SRQ. *2 Cursor mode (See 7.3.4 (1), P.7 - 12) 3 ASCII block transfer mode (See 7.3.4 (2), P.7 - 15) 4 Binary block transfer mode (See 7.3.4 (3), (4), (5), P.7 - 16) 5 Input of time data, binary data. [See 7.3.4 (8) P. 7-35] 6 Input of FUNCTION data (FC1, SQ5) 7 Clears time data in SQ5 8 Mass-time data input 9 Mass-time data output Modes of SQ5 to SQ8, if executed, will be cleared and cannot be read.	o

* This mode is initially selected upon power up. Commands which are set up with a number of two or more digits are set to 0.

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Miscellaneous	HD	0, 1	HEADER ON/OFF 0 OFF 1 ON	o
	DL	0 to 2	DELIMITER *0 CRLF & EOI 1 LF 2 EOI	o
	IM	0, 1	0 Reads data into channel A 1 Reads data into channel B	o
	FX	0, 1	0 Same as readout 1 ± ∇ NNNNE±NN	o
	CO	0 to 6	CURSOR OUTPUT CONTROL *0 LEVEL 1, LEVEL 2, LEVEL 3 1 LEVEL 2, LEVEL 3 2 LEVEL 1, LEVEL 3 3 LEVEL 3 4 LEVEL 1, LEVEL 2 5 LEVEL 2 6 LEVEL 1	o
	**IN		INITIALIZE (Internal parameters are all initialized to the power-on state)	x
	OS	0 to 2048	Sends out the data in blocks by specifying the number of data in a block and the block interval (See 7.3.4 (7), P.7 - 34)	o
	SP	0 to 2047	START POINT * 0 to 2047 0: Denotes that this command is inoperative.	o

* This mode is initially selected upon power up. Commands which are set up with a number of two or more digits are set to 0.

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Miscellaneous	ON	0 to 2047	OUTPUT NUMBER * 0 to 2047 0: Denotes that this command is inoperative.	o
	FC	0, 1	Used to send a function other than the time data from a controller. (See 7.3.4 (8) Note (f), P.7 - 36] 0 TIME data 1 Non-time data	o
	MX	0, 1	Mass time transfer mode 0 OFF 1 ON	o
	DS	0, 1	DATA SELECT *0 { (ORBIT), REAL/MAG. (NYQUIST, NICHOLS) 1 { (ORBIT), IMAG./PHASE (NYQUIST, NICHOLS)	o
	TX	0, 1	High-Speed Transfer Mode 0 SQ4 1 SQ4 high-speed mode When a handshake is in trouble at TX1 mode, send out a uniline message of IFC.	o
	DO	0, 1	Dual Display Output 0: Normal 1 BOTH Only available in SQ4 high-speed mode [See 7.3.4 (6), P.7 - 33]	o

* This mode is initially selected upon power up. Commands which are set up with a number of two or more digits are set to 0.

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command: Function	Command: Setup	Description	Setup read
Miscellaneous	IP	0 to 524287	INPUT BUFFER POINTER Start point of mass-time data transfer (SQ8, 9) is specified. 1ch : 0 to 524287 2ch : 0 to 262143	o
Status	MK	0 to 65535	MASK STATUS * 0 - 65535 Masks the status bit of the binary pattern for a set number. [See 7.3.7 (3), P.7 - 45]	o
Data output format	**ROL		Read Output Length: Reads the number of data and output format effected in SQ3 or SE4 mode. e.g.: OL1, 401 401 — Number of data 1 — Single precision, fixed point	
Error	RES		Read Error Status: Reads the error status upon error generation. e.g.: ES3 Overload on CH-A, CH-B 8 7 6 5 4 3 2 1 0 0 0 0 0 0 1 1 = 3 bit 1 → CH-A overload bit 2 → CH-B overload	
Readout	**RHL		Sends DELTA data in horizontal cursor ON mode.	
	**RHV		Sends level data in horizontal cursor ON mode.	
	**RDT		Sends DELTA data when SET REF. is activated. The output format is identical to SQ2.	
	**RSE		Sends reference value when SET REF. is activated. The output format is identical to SQ2.	

Table 7-16 TR9407 Command List (Cont'd)

Control item	Command	Description
Readout	**ROA	Sends an overall value. For the output format, see paragraph 7.3.6.
	**RPR	Sends partial data. For the output format, see paragraph 7.3.6.
Interchannel Delay	RID	Reads Interchannel Delay e.g.: ID 8 8 — 8/1024
List	**RLN0 to **RLN20	● When 0 or no number, the maximum list number is sent out. ● When 1 to 20, line numbers of each list are sent out.
	**RLF	Sends frequency block.
	**RLL	Sends level 1 block.
	**RLR	Sends level 2 block.
	**RLD	Sends distortion block.
	**RLH	Sends harmonic distortion data.
	**RLM	Sends rms harmonic distortion data.
OVERLAP	ROR	Reads OVERLAP e.g.: OR 32, 0, 32 32 — Averaging times 0 — 50% 32 — 0%
DATA WINDOW	**RDP	Sends shift steps and the leftmost position of the present DATA WINDOW with the switch activated. e.g.: DP 512, 2560 2560 — Leftmost position of data window is at point 2560 512 — Data window shift in 512-point steps

Table 7-17 Advanced Analysis Command List

Command marked with ** does not allow simultaneous use of other command.

Control item	Command: Function	Command: Setup	Description	Setup read
Advanced Analysis	AYL	0 to 9	Advanced Select 0 LIST 1 3-D DISPLAY 2 OCTAVE 3 SERVO 4 G-DELAY 5 SNR 6 ML 7 SCOT 8 CEPSTRUM 9 P-ENVELOPE	o
	AX	0, 1	Advanced Analysis Execute 0 STOP 1 START	o
	AYT AA	0, 1	3-D Display 0 DISABLE 1 ENABLE	o
	AYO (AA)	0, 1	Octave 0 DISABLE (AA2) 1 ENABLE (AA3)	o
	AYV	0, 1	Servo 0 DISABLE 1 ENABLE	o
	AYG	0, 1	Group Delay 0 DISABLE 1 ENABLE	o
	AYS	0, 1	SNR 0 DISABLE 1 ENABLE	o
	AYM	0, 1	ML 0 DISABLE 1 ENABLE	o
	AYC	0, 1	SCOT 0 DISABLE 1 ENABLE	o
	AYQ	0, 1	Cepstrum 0 DISABLE 1 ENABLE	o

Table 7-17 Advanced Analysis Command List (Cont'd)

Control item	Command Function	Command Setup	Description	Setup read
Advanced Analysis	AYE	0, 1	Pre-envelope 0 DISABLE 1 ENABLE	o
Octave Analysis	OM	0 to 2	Octave Mode 0 STATIONARY 1 TRANSIENT 2 VIEW POWER	o
	OC	0 to 2	Octave Analysis Channel 0 CH-A 1 CH-B 2 Dual	o
	OK	0, 1	Octave Bandwidth 0 1/3-Octave 1 1/1-Octave	o
	OW	0, 1	A-Weighting 0 OFF 1 ON	o
Read command octave list	**RLNxx		xx represents numerals ● In case of 0 or no numbers, number of filters displayed is sent out. 1/3 Octave: 30 1/1 Octave: 10 ● When filter numbers are set up, list of the filters is sent out. [See 7.3.4 (10), P.7 - 37]	
	**RLF		Block of center frequencies of filters is sent out.	
	**RLL		Block of level values is sent out.	
	**RLV		OVERALL is sent out.	

Table 7-17 Advanced Analysis Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
3-D Display	TT	0 to 4	3-D Display Trig 0 AUTOMATIC 1 DATA WINDOW 2 AVERAGE 3 AUTO ARM 4 GPIB	
	TN	0 to 18	Start Line No. 1 to 19	o
	**DT		3-D Display Trigger	
	TF	0 to 7	Angle Factor 0 90° 1 84° 2 77° 3 71° 4 66° 5 60° 6 56° 7 51°	o
	TR	0, 1	3-D Display Source 0 SYSTEM 1 FLOPPY	o
	TU	0, 1	3-D Display Output 0 CRT 1 HARD COPY	o
	TK	0 to 3	Stack Line No. 0 16 1 32 (note) Setup of "TU1" 2 64 is prerequisite. 3 128	o
	**SS	0, 1	Scrolling Start/Stop 0 START 1 STOP	x
	**SL	0 to 3	Start Line 0 AUTO INC START 1 AUTO INC PAUSE 2 AUTO DEC START 3 AUTO DEC PAUSE	x

Table 7-17 Advanced Analysis Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Servo	YL	0, 1	Analysis Line 0 NORMAL 1 4-DECADE	o
	SA	0, 1	Sense Control (CH-A) 0 MANUAL 1 AUTO	o
	SB	0, 1	Sense Control (CH-B) 0 MANUAL 1 AUTO	o
	WC	0, 1	Weighting Control 0 AUTO 1 MANUAL	o
	GP	0, 1	SG OPERATION 0 ON-KEY 1 ON-AVG	o
	NS	0, 1	NON-STOP AVERAGING 0 STOP 1 NON-STOP	
	MC	0 - 6	AMPLITUDE CONTROL 0 OFF 1 CH-A MONITOR 2 CH-B MONITOR 3 CH-A CONSTANT 4 CH-B CONSTANT 5 CH-A MEMORY 6 CH-B MEMORY	o
	**ML	XX.X	LEVEL CONTROL	o
	**MD	±X.X	LEVEL CONTROL DELTA	o
	**VA **VB	XX.XE-X	OVER LEVEL VA: CH-A VB: CH-B	o
	VO	0 - 3	OVER & SERVICE 0 CONT 1 SKIP 2 BEEP ON 3 SWEEP STOP	o

Table 7-17 Advanced Analysis Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Cepstrum	QC	0 to 3	Analysis Channel 0 CH-A 1 CH-B 2 DUAL 3 VIEW	o
	QD	0, 1	Analysis Domain 0 QUEFRENCY 1 FREQUENCY	
	QT	0, 1	Threshold 0 OFF 1 ON	o
	QS	-256 to +256	Threshold Level dBFS	o
	QF	0 to 2	Liftering 0 SHORT PASS 1 LONG PASS 2 MEMORY	o
	QL	0 to 511	Liftering Position	o
Pre-envelope	EC	0 to 3	Analysis Channel 0 CH-A 1 CH-B 2 DUAL 3 VIEW	x
	ED	0, 1	Analysis Domain 0 TIME 1 FREQUENCY	x

Table 7-18 XY Recorder and Plotter Command List

Command marked with ** does not allow simultaneous use of other command.

Control item	Command		Description	Setup read
	Function	Setup		
Menu	IO	0 to 3, 5	I/O SELECT 0 X-Y RECORDER 1 PLOTTER 2 FLOPPY DISK 3 SIGNAL GENERATOR (option) 5 TIMER	o
I/O control	** IE	0, 1	I/O EXECUTE 0 STOP 1 START No other command than the IE command should be sent while the connected plotter is busy plotting (EXECUTE lamp ON).	x
Timer	TD		Timer Edit (Use 16 characters) MM-DD-YYYY HH:TT MM : month (2 digits) DD : day (2 digits) YYYY : year (4 digits) HH : hour (2 digits) TT : minute (2 digits)	
X-Y recorder control	XM	0 to 3	X-Y RECORDER MODE 0 CURSOR 1 ALL 2 SIGNAL 3 FRAME	o
	XC	0, 1	X-Y RECORDER CALIBRATION 0 0-0 1 FS-FS	o
	XP	0, 1	X-Y RECORDER PEN MODE 0 ONE PEN 1 TWO PEN	o

Table 7-18 XY Recorder and Plotter Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
X-Y recorder control	XS	0 to 5	X-Y RECORDER PEN SPEED 0 SLOW 1 2 2 3 3 4 4 5 5 FAST	o
Plotter control	PM	0 to 2	PLOT MODE 0 ALL 1 SIGNAL 2 FRAME + MENU	o
	PP	0 to 2	PLOTTER PEN SELECTION 0 AUTO 1 PEN 1 2 PEN 2	o
	PA	0, 1	PAPER ADVANCE 0 OFF 1 A4 2 SCALE	o
	PL	0, 1	SCALING 0 OFF 1 ON	o
	PZ		PLOT SIZE NNN, NNN, NNN, NNN (Xmin) (Ymin) (Xmax) (Ymax) (Separated with "," in the above order)	o
	PY	0, 1	PLOTTER TYPE 0 ADVANTEST (TR9835R, TR9832) 1 HP-GL (HP7470A,7475A, 7550A, 9872B/C)	o
	PG	0, 1	PLOT ANGLE 0 NORMAL 1 90°	o

Table 7-19 Floppy Disk Command List

Command marked with ** does not allow simultaneous use of other command.

Control item	Command		Description	Setup read
	Function	Setup		
Menu	IO	0 to 3, 5	I/O SELECT 0 X-Y RECORDER 1 PLOTTER 2 FLOPPY DISK 3 SIGNAL GENERATOR (option) 5 TIMER [Table 7-18]	o
I/O control	** IE	0, 1	I/O EXECUTE 0 STOP 1 START No other command than the IE command should be sent while the connected plotter is busy plotting (EXECUTE lamp ON).	x
Floppy disk	**FS	0 - 3	MODE SELECT 0 READ 1 WRITE 2 EDIT 3 CATALOG	o
	**FL	0 to 2	DATA OUTPUT 0 CRT 1 PLOTTER 2 XY-RCDR	o
	**FW	0 to 2	WRITE TRIGGER 0 DATA 1 AVGED 2 SYSTEM	o
	**FO	0 to 7	OVERLAY NO. 0 1 1 2 2 4 3 8 4 16 5 32 6 64 7 128	o

Table 7-19 Floppy Disk Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Floppy disk	**FD	0 to 1	DISPLAY 0 FLOPPY 1 FRONT PANEL	o
	**FM	0 to 4	WRITE MODE 0 ORIGIN 1 FIXED 2 MASS TIME 3 GRAPHICS 4 PANEL	o
	TG	0 to 999	TAG NUMBER 0 to 999	o
	SN	0 to 999	SEQUENTIAL NUMBER 0 to 999	o
	WR	0,1	WRITE/READ 0 READ 1 WRITE	o
	MA	0,1	MANUAL/AUTO 0 MANUAL 1 AUTO	o
	DI	0,1	INCREMENT/DECREMENT 0 INCREMENT 1 DECREMENT	o
	FT		FLOPPY START (Note)	
	WT		WRITE TRIGGER	

Note: When FT command is set, the MANUAL/AUTO mode is automatically set to MA0 (MANUAL). Therefore, if continuous read/write is required, set FT each time read/write is performed.

Table 7-19 Floppy Disk Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Floppy disk	**MT	0 - 3	MASS TIME FUNCTION 0 OFF 1 <U+L> 2 <U-L> 3 <U*L>	
	**MF	-1 + 1	MASS TIME FACTOR	o
	**EM	0 - 2	EDIT MODE 0 COPY(D1 ← D0) 1 Read & Write 2 EDIT	o
	**EF	0 - 3	EDIT SOURCE DRIVE 0 DRIVE0 (FRONT) 1 DRIVE0 (BACK) 2 DRIVE1 (FRONT) 3 DRIVE1 (BACK)	o
	**HF	0 - 2	EDIT SOURCE CHANNEL 0 CH-A 1 CH-B 2 DUAL	
	**ET	0 - 3	EDIT DESTINATION DRIVE 0 DRIVE0 (FRONT) 1 DRIVE0 (BACK) 2 DRIVE1 (FRONT) 3 DRIVE1 (BACK)	o
	**HO	0 - 2	EDIT DESTINATION CHANNEL 0 CH-A 1 CH-B 2 DUAL	o
	**CF		CATALOG MODE OFF	.

Table 7-19 Floppy Disk Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Floppy disk	**DR	0 - 3	DRIVE SELECT 0 DRIVE0 (FRONT) 1 DRIVE0 (BACK) 2 DRIVE1 (FRONT) 3 DRIVE1 (BACK)	o
	**PO	0, 1	WRITE PROTECT 0 OFF 1 ON	o
	**LE	0, 1	PANEL SEQUENCE MODE 0 OFF 1 ON	o
	**QM	0, 1	PANEL SEQUENCE TIMER START 0 OFF 1 ON	o
	**ER	NNNN	START TIME NN:NN (4 digits)	o
	**LP	0 - 8	LOOP NO 0:1 4:16 8:INFINITE 1:2 5:32 2:4 6:64 3:8 7:128	o
	**OF	1 - 200	SOURCE FILE NO. 1 - 200	o
	**OO	1 - 200	DESTINATION FILE NO. 1 - 200	o
	**EN	1 - 200	SETUP LINE NO. 1 - 200	o
	**EP	0, 1	SETUP 0: ALL 1: DISP	o
	**FZ	0, 1	ZOOM 0: OFF 1: ON	o

Table 7-19 Floppy Disk Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Floppy disk	**FG	0, 1	AVERAGE 0: OFF 1: ON	o
	**GG	0 -2	TRIGGER 0 OFF 1 ARM 2 AUTO ARM	o
	**FI	0, 1	ADVANCED ANALYSIS 0: OFF 1: ON	o
	**HY	0, 1	HARD COPY 0: OFF 1: ON	o
	**FF	0 - 2	FLOPPY 0: OFF 1: READ 2: WRITE	o
	**IV	NNNNNN.N	INTERVAL NNNN:NN.N	o
	**SU	0 -2	SCAN OUT 0 OFF 1 AVG END 2 TRIG END	o
Read command	**RCE	0-Max	Catalog File Label Max: The number of files read CEXX@ABC @<CR><LF>&(EOI) Note: When the argument is 0, the number of files read is output. When the catalog mode is not effective, 0 is output.	

Table 7-19 Floppy Disk Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Read command	**RCY	0-Max	Catalog Type CY XX<CR><LF>&(EOI) →TYPE CODE 0: Origin File 1: Fixed File 2: Mass Time 3: Graphics File 4: Panel Note: When the argument is 0, the number of files read is output. When the catalog mode is not effective, 0 is output.	
	**RCA	0-Max	Catalog File name CA XX<CR><LF>&(EOI) →File Name Code Note: When the argument is 0, number of files read is output. When the catalog mode is not effective, 0 is output. See Table 7-19 "File name codes".	
	**RCQ	1-Max	Catalog Sequence CQ XX<CR><LF>&(EOI) →Sequential No.0-199 0-199 Floppy Front panel	

Table 7-20 File Name Codes

Code	File
0	Xa: Channel-A time series
1	<Xa>: Average of Xa
2	Xb: Channel-B time series data
3	<Xb>: Average of Xb
4	Raa: Auto-correlation function of Xa
5	<Raa>: Average of Raa
6	Rbb: Auto-correlation function of Xb
7	<Rbb>: Average of Rbb
8	Rab: Cross-correlation function
9	<Rab>: Average of Rab
10	Pa: Amplitude probability density function of Xa
11	<Pa>: Average of Pa
12	Pb: Amplitude probability density function of Xb
13	<Pb>: Average of Pb
14	<IMPLS>: Impulse response
15	Xa, Xb: Time series data of dual channels
16	<Xa, Xb>: Average data of dual channels
20	Sa: Fourier spectrum of Xa
21	<Sa>: Sa obtained by averaging the average channel with channel A
22	Sb: Fourier spectrum of Xb
23	<Sb>: Sb obtained by averaging the average channel with channel B
24	Gaa: Auto power spectrum of Xa
25	<Gaa>: Average of Gaa
26	Gbb: Auto power spectrum of Xb
27	<Gbb>: Average of Gbb
28	Gab: Cross spectrum
29	<Gab>: Average of Gab
30	<Hab>: Transfer function
31	<C.O.P.>: Coherent output power
32	<COH>: Coherence function
33	OCTa: Octave analysis of channel A

Table 7-20 File Name Codes (Cont'd)

Code	File
34	<OCTa>: Average of OCTa
35	OCTb: Octave analysis of channel B
36	<OCTb>: Average of OCTb
37	<Hab>4Decade: 4-decade transfer function
38	Sa, Sb: Fourier spectrum of Xa and Xb
39	<Sa, Sb>: Sa and Sb obtained by averaging the average channel with dual display
40	GaaL: Channel A level monitor
41	GbbL: Channel B level monitor
50	Graphics: G-file
51	Panel: Panel

Table 7-21 Signal Generator Command list

Command marked with ** does not allow simultaneous use of other command.

Command		Description	Setup read
Function	Setup		
IO	0 to 3, 5	I/O SELECT 0 X-Y RECORDER 1 PLOTTER 2 FLOPPY DISK 3 SIGNAL GENERATOR (option) 5 TIMER [Table 7-18]	o
** IE	0, 1	I/O EXECUTE 0 STOP 1 START No other command than the IE command should be sent while the connected plotter is busy plotting (EXECUTE lamp ON).	x
SGF	0 to 7	SG FUNCTION 0 SINE 1 MULTI SINE 2 WG MULTI SINE 3 IMPULSE 4 SWEPT SINE 5 RANDOM 6 MEMORY 7 SEQUENCE	o
SGM	0 to 1	SG CURSOR MODE 0 MANUAL 1 CURSOR	o
SGL	1 to 800	SG LINE 1 to 800	x

Table 7-21 Signal Generator Command List (Cont'd)

Command		Description	Setup read
Function	Setup		
SGO	0 to 12	SG SYNC OUT 0 1 1 2 2 4 3 8 4 16 5 32 6 64 7 128 8 256 9 512 10 1024 11 2048 12 4096	o
SGI	0 to 9999	SG INTERNAL TRIGGER NNN. N(sec) (1 to 200 Hz range) NNN. N(msec) (500 Hz to 100 kHz range) Note: Four digits are used for setup.	o
SGT	0 to 5	SG OUTPUT MODE 0 COMT 1 INT TRIG 2 EXT TRIG 3 EXT GATE 4 MANUAL 5 SWEEP Note: SWEEP is available only when FUNCTION is SINE or SWEPT SINE.	o
SGC	1 to 1023	SG CYCLE/FRAME 1 to 1023	o
SGR	0 to 360	PHASE START 0° to 360° Note: Applicable when FUNCTION is SINE and OUTPUT MODE is not SWEEP.	o
SGP	0 to 360	PHASE STOP 0° to 360° Note: Applicable when FUNCTION is SINE and OUTPUT MODE is not SWEEP.	o

Table 7-21 Signal Generator Command List (Cont'd)

Command		Description	Setup read
Function	Setup		
SGN	1 to 800	Fmin (SWEEP LINE) 1 to 800 lines	o
SGX	1 to 800	Fmax (SWEEP LINE) 1 to 800 lines	o
SGE	1 to 800	Fmax (SWEEP LINE) 1 to 800 lines Note: STEP when FUNCTION is SINE; WIDTH when FUNCTION is SWEPT SINE.	o
SGD	0 to 1	SWEEP DIRECTION 0 : L→U 1 : U→L	o
SGZ	0 to 1	P.D.F. (RANDOM only) 0 GAUSS 1 POISSON	o
SGY	0 to 3	RANDOM TYPE 0 RANDOM 1 BANDSEL 2 PERIODIC 3 BURST	o
SGA		AMPLITUDE SGANN. NE-N N 0 to 9	o
SGS		OFFSET SGSNN. NE-N N 0 to 9	o
SGB	0 to 3	MEMORY BLOCK 1 BINARY (1) 2 ASCII (1) 3 BINARY (2) 4 ASCII (2)	
SGG	0 to 3	RANGE CONTROL 0 NORMAL 1 START 2 MIDDLE 3 STOP	o

Table 7-21 Signal Generator Command List (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
	SGJ	0 to 2	SETUP SEQUENCE 0 <A> 1 <B> 2 <C>	
	SGK	0 to 3	SEQUENCER 0 OFF 1 <A> 2 <A-B> 3 <A-B-C>	o
	SGV	0 to 3	MEMORY 0 WRITE 1 READ 2 FILTER ON 3 FILTER OFF	o
Front panel KEY	**SGU	0, 1	PAUSE KEY 0 CONT (lamp off) 1 PAUSE (lamp on)	-
	**SGQ	0, 1	OPERATE KEY 0 STANDBY 1 OPERATE	-
	**SGH	0 to 2	Output impedance 0 50 Ω 1 75 Ω 2 600 Ω	-
	**SGW	0, 1	LO-GND 0 LO-GND OFF 1 LO-GND ON	-

Table 7-22 GPIB Commands in Alphabetical Order

* marked commands are not usable with other commands

Command	Category	Contents
AA0	3-D DISPLAY DISABLE	
AA1	3-D DISPLAY ENABLE	
AA2	OCTAVE ANALYSIS DISABLE	
AA3	OCTAVE ANALYSIS ENABLE	
AC	AVERAGE CONTROL	
AD	AVERAGE DISPLAY	
AE		INPUT DEACTIVATE/ACTIVATE (CH-A)
AG	GROUND COUPLING (CH-A)	
AH	AVERAGE CHANNEL	
AI	INPUT COUPLING (CH-A)	
AL	ARM LENGTH	
AM	AVERAGE MODE	
AN	AVERAGE NUMBER	
AO	AVERAGE OVERLAP	
AP	AVERAGE CHANNEL	
AR	ARM MODE	
AS	INPUT SENSITIVITY (CH-A)	
AU	AUTO CALIBRATION	
AV	INPUT INVERT (CH-A)	
AW	AVERAGE WHAT?	
AX		ADVANCED ANALYSIS EXECUTE
AYC	SCOT	
AYE	PRE-ENVELOPE	
AYG	GROUP DELAY	
AYL		ADVANCED ANALYSIS SELECTION
AYM	ML	
AYO	OCTAVE ANALYSIS	
AYQ	CEPSTRUM	
AYS	SNR	
AYT	3-D DISPLAY	3-D DISPLAY DISABLE/ENABLE

Table 7-22 GPIB Commands in Alphabetical Order (Cont'd)

* marked commands are not usable with other commands

Command	Category	Contents
AYV	SERVO ANALYSIS	
BE		INPUT DEACTIVATE/ACTIVATE (CH-B)
BG		GROUND COUPLING (CH-B)
BI		INPUT COUPLING (CH-B)
BN	TRIG MODE	BLOCK NUMBER
BR	TRIG MODE	RECALL BLOCK
BS	INPUT SENSITIVITY (CH-B)	
BT	VIEW	BOTH
BV		INPUT INVERT (CH-B)
CB	FUNCTION	COHERENCE BLANK
CF*	FLOPPY	CATALOG MODE OFF
CL	FUNCTION	OPEN/CLOSED LOOP
CM*	ZOOMING	CENTER MOVE
CO	CURSOR OUTPUT CONTROL	LEVEL 1, LEVEL 2, LEVEL 3
CP	ZOOMING	CENTER POSITION
CS	GENERAL CURSOR	RECALL SET
DA	FUNCTION	DIFFERENTIATION (CH-A)
DB	FUNCTION	DIFFERENTIATION (CH-B)
DD	DISPLAY CTL	DATA WINDOW
DG	DISPLAY CTL	DISPLAY GAIN
DH	HOLD MODE	FREE FUN, ARM, HOLD, AUTO ARM
DI	FLOPPY	INCREMENT/DECREMENT
DL		DELIMITER
DM	DISPLAY CTL	DISPLAY MODE
DO		DUAL DISPLAY OUTPUT (SQ4, TX1)
DR*	FLOPPY	DRIVE SELECT
DS		DATA SELECT
DT*		3-D DISPLAY TRIGGER
DU	DISPLAY	DISPLAY UPPER/LOWER
DV	DISPLAY	REAL, IMAG, MAG, PHASE, NYQ/ORBIT

Table 7-22 GPIB Commands in Alphabetical Order (Cont'd)

* marked commands are not usable with other commands

Command	Category	Contents
DW	GENERAL CURSOR	DATA WINDOW
EC	PREENVELOPE	ANALYSIS CHANNEL
ED	PREENVELOPE	ANALYSIS DOMAIN
EF*	FLOPPY	EDIT SOURCE DRIVE
EG	TRIG MODE	EXTERNAL GATE
EL	DISP CTL	RESAMPLING (DECIMATION)
EM*	FLOPPY	EDIT MODE
EN*	FLOPPY	SETUP LINE NO.
EP*	FLOPPY	SETUP
ER	FLOPPY (CATALOGUE)	START TIME
EQ	FUNCTION	EQUALIZE
ET*	FLOPPY	EDIT DESTINATION DRIVE
EU*	WEIGHTING	ENGINEERING UNIT
EW*	ZOOMING	EXPAND WIDTH
FC		Data other than the time data are output to the TR9407 via controller
FD*	FLOPPY	DISPLAY SOURCE
FE		FILTER ON/OFF
FF*	FLOPPY	OFF, READ, WRITE
FG*	FLOPPY	AVERAGE
FI*	FLOPPY	ADVANCED ANALYSIS
FL*	FLOPPY	DATA OUTPUT (CRT, PLOTTER, XY RECORDER)
FM*	FLOPPY	WRITE MODE
FN	READOUT UNIT	FREQUENCY UNIT
FO*	FLOPPY	OVERLAY NO.
FQ		FREQUENCY RANGE
FR		FREQUENCY RANGE
FS	FLOPPY	MODE SELECT (READ, WRITE, EDIT, CATALOG)
FT		FLOPPY START
FU	FUNCTION	U+L, U-L, U*L, U/L

Table 7-22 GPIB Commands in Alphabetical Order (Cont'd)

* marked commands are not usable with other commands

Command	Category	Contents
FV	FUNCTION	$j\omega$, $(j\omega)^2$, $1/(j\omega)^2$, $1/(j\omega)$
FW*	FLOPPY	WRITE TRIGGER
FX		± ∇NNNNE ±NN
FZ*	FLOPPY	ZOOM
GG	FLOPPY (CATALOGUE)	TRIGGER (ARM/AUTO ARM)
GP	SERVO	SG OPERATION
GR	DISPLAY	GRATICULE
HA	GENERAL CURSOR	HARNOMIC/SINGLE
HC	GENERAL CURSOR	HORIZONTAL CURSOR
HD		HEADER ON/OFF
HF*	FLOPPY	EDIT SOURCE CHANNEL
HO*	FLOPPY	EDIT DESTINATION CHANNEL
HS	DISPLAY	LIN/LOG. FREQ
HT		HORIZONTAL CURSOR SET (0-1024)
HY*	FLOPPY	HARD COPY
IA	FUNCTION	INTEGRATION (CH-A)
IB	FUNCTION	INTEGRATION (CH-B)
ID	TRIG MODE	INTERCHANNEL DELAY
IE*		I/O EXECUTE
IM		Read data into CH-A (CH-B)
IN*		INITIALIZE
IO	I/O SELECT	XY RECORDER, PLOTTER, FLOPPY, S.G.
IP		INPUT BUFFER POINTER (Mass-time data transfer)
IV*	FLOPPY	INTERVAL
LA*		LABEL 1
LB*		LABEL 2
LE*	FLOPPY	RECALL MODE
LO	DISPLAY CTL	LEVEL MONITOR ON/OFF
LP*	FLOPPY	LOOP NO.

Table 7-22 GPIB Commands in Alphabetical Order (Cont'd)

* marked commands are not usable with other commands

Command	Category	Contents
LT	VIEW	LIST
MA	FLOPPY	MANUAL/AUTO
MC	SERVO	AMPLITUDE CONTROL
MD*	SERVO	LEVEL CONTROL DELTA
MF*	FLOPPY	MASS TIME FACTOR
MK		MASK STATUS (0-65535)
ML*	SERVO	LEVEL CONTROL
MM	DISPLAY CTL	LEVEL MONITOR CONTINUE/PAUSE
MS	VIEW	MEMORY STORE
MT*	FLOPPY	MASS TIME FUNCTION
MV	DISPLAY CTL	LEVEL MONITOR CURSOR/OVERALL
MX		MASS TIME TRANSFER MODE
NA	FUNCTION	TREND REMOVAL (CH-A)
NB	FUNCTION	TREND REMOVAL (CH-B)
NS	SERVO	NON-STOP AVERAGING
OC		OCTAVE ANALYSIS CHANNEL
OF*	FLOPPY	SOURCE FILE NO.
OK		OCTAVE BANDWIDTH
OM		OCTAVE MODE
ON		OUTPUT NUMBER (0-2047)
OO*	FLOPPY	DESTINATION FILE NO.
OS		Data output in a unit of blocks (number of data and interval of blocks are set)
OV	FUNCTION	OVERALL
OW	OCTAVE ANALYSIS	A-WEIGHTING
PA	PLOTTER	PAPER ADVANCE
PC		PANEL CONTROL
PG	PLOTTER	PLOT ANGLE
PL	PLOTTER	SCALING
PM	PLOTTER	PLOT MODE

Table 7-22 GPIB Commands in Alphabetical Order (Cont'd)

* marked commands are not usable with other commands

Command	Category	Contents
PO*	FLOPPY	WRITE PROTECT
PP	PLOTTER	PEN SELECTION
PR		PANEL RECALL
PS		PANEL STORE
PY	PLOTTER	PLOTTER TYPE
PZ	PLOTTER	PLOT SIZE
QC	CEPSTRUM	ANALYSIS CHANNEL
QD	CEPSTRUM	ANALYSIS DOMAIN
QF	CEPSTRUM	LIFTERING
QL	CEPSTRUM	LIFTERING POSITION
QM	FLOPPY (CATALOGUE)	PANEL SEQUENCE START TIMER ON/OFF
QS	CEPSTRUM	THRESHOLD LEVEL
QT	CEPSTRUM	THRESHOLD
RCA*	FLOPPY	CATALOG FILE NAME
RCE*	FLOPPY	CATALOG FILE LABEL
RCQ*	FLOPPY	CATALOG SEQUENCE
RCY*	FLOPPY	CATALOG TYPE
RDP*	DATA WINDOW	Output of data window step size
RDT*	READOUT	
RES		READ ERROR STATUS
RHL*	READOUT	Output of data at horizontal cursor ON
RHV	READOUT	Output of level at horizontal cursor ON
RID	INTERCHANNEL DELAY	READ INTERCHANNEL DELAY
RLD*	LIST	Output of distortion blocks
RLF*	LIST	Output of frequency blocks
RLF*	OCTAVE LIST	
RLH*	LIST	Output of harmonic distortion
RLL*	LIST	
RLL*	OCTAVE LIST	
RLM*	LIST	Output of harmonic rms

Table 7-22 GPIB Commands in Alphabetical Order (Cont'd)

* marked commands are not usable with other commands

Command	Category	Contents
RLN*	LIST	Output of maximum LIST No. (or LIST No. lines
RLR*	LIST	Output of blocks of LEVEL 2
RLV*	OCTAVE LIST	
ROA*	READOUT	Output of overall value
ROL*	OUTPUT FORMAT	READ OUTPUT LENGTH
ROR	OVERLAP	READ OVERLAP
RPR*	READOUT	Output of partial data
RSE*	READOUT	Reference value on setting up SET REF.
SA	SERVO	SENSITIVITY CONTROL (CH-A)
SB	SERVO	SENSITIVITY CONTROL (CH-B)
SC		SAMPLING CLOCK (EXTERNAL/INTERNAL)
SD	DISPLAY CTL	STEP (DATA WINDOW)
SF*	WEIGHTING	SCALING FACTOR
SGA	SG	AMPLITUDE
SGB	SG	MEMORY BLOCK
SGC	SG	SG CYCLE/FRAME
SGD	SG	SWEEP DIRECTION
SGE	SG	STEP (SINE), WIDTH (SWEPT SINE)
SGF	SG	FUNCTION (Selection of output signals)
SGG	SG	RANGE CONTROL
SGH*	SG	OUTPUT IMPEDANCE
SGI	SG	SG INTERNAL TRIGGER
SGJ	SG	SETUP SEQUENCE
SGK	SG	SEQUENCER (A, A-B, A-B-C)
SGL	SG	SG LINE
SGM	SG	CURSOR MODE
SGN	SG	Fmin
SGO	SG	SG SYNC OUT
SGP	SG	PHASE STOP

Table 7-22 GPIB Commands in Alphabetical Order (Cont'd)

* marked commands are not usable with other commands

Command	Category	Contents
SGQ*	SG	OPERATE KEY
SGR	SG	PHASE START
SGS	SG	OFFSET
SGT	SG	SG OUTPUT MODE
SGU*	SG	PAUSE KEY
SGV	SG	MEMORY
SGW*	SG	LO-GND.
SGX	SG	Fmax
SGY	SG	RANDOM TYPE
SGZ	SG	P.D.F.
SI	DISPLAY	SUPERIMPOSE
SL*	3-D DISPLAY	START LINE
SM	WEIGHTING	SCALING MODE
SN	FLOPPY	SEQUENTIAL NUMBER
SO	FUNCTION	SMOOTHING
SP		START POINT (0-2047)
SQ		SRQ ENABLE, SRQ DISABLE, ...
SR	GENERAL CURSOR	SET REFERENCE
SS*	3-D DISPLAY	SCROLLING START/STOP
ST	GENERAL CURSOR	SET
SU	FLOPPY (CATALOGUE)	SCAN (OFF, AVG END, TRIG END)
SX	GENERAL CURSOR	TRIGGER SOURCE
TC		TRIGGER SOURCE
TD	I/O SELECT	TIMER EDIT
TF	3-D DISPLAY	ANGLE FACTOR
TG	FLOPPY	TAG NUMBER
TK	3-D DISPLAY	STACK LINE NO.
TL		TRIGGER LEVEL
TM		TRIGGER MARKER

Table 7-22 GPIB Commands in Alphabetical Order (Cont'd)

* marked commands are not usable with other commands

Command	Category	Contents
TN	3-D DISPLAY	START LINE NO.
TO		TRIGGER OUTPUT (BEEP)
TP		TRIGGER POSITION
TR	3-D DISPLAY	3-D DISPLAY SOURCE
TS		TRIGGER SLOPE
TT	3-D DISPLAY	3-D DISPLAY TRIGGER
TU		3-D DISPLAY OUTPUT
TX		FAST TRANSFER MODE (SQ4 MODE)
UA		INPUT IMPEDANCE (CH-A)
UB		INPUT IMPEDANCE (CH-B)
UC	DISPLAY CTL	AUTO SCALE
UL	GENERAL CURSOR	UPPER/LOWER
US	DISPLAY	UPSCALING
VA*	SERVO	OVER LEVEL (CH-A)
VB*	SERVO	OVER LEVEL (CH-B)
VC	GENERAL CURSOR	VERTICAL CURSOR
VG*	DISPLAY	VERTICAL GAIN
VO	SERVO	OVERLOAD & SERVICE
VR*	DISPLAY	VERTICAL REFERENCE
VS	VIEW	CH. A/CH. B SELECTION
VT		VERTICAL CURSOR SET (0-2047)
VU	READOUT UNIT	VERTICAL UNIT
VW		VIEW MODE (Corresponds to the VIEW group keys)
WC	SERVO	WEIGHTING CONTROL
WE	WEIGHTING	RESPONSE START
WF	WEIGHTING	FORCE START
WG		Selection of WEIGHTING functions
WO	WEIGHTING	FORCE STOP
WP	WEIGHTING	RESPONSE STOP

Table 7-22 GPIB Commands in Alphabetical Order (Cont'd)

* marked commands are not usable with other commands

Command	Category	Contents
WR	FLOPPY	WRITE/READ
WS	WEIGHTING	SCALE (%)*FS
WT	FLOPPY	WRITE TRIGGER
XC	XY RECORDER	CALIBRATION
XM	XY RECORDER	RECORD MODE
XP	XY RECORDER	PEN MODE
XS	XY RECORDER	PEN SPEED
YL	SERVO	ANALYSIS LINE
ZO*		ZOOMING

7.4 PROGRAMMING EXAMPLES

All the following examples are the programs created on the Hewlett Packard desk top computer 200 series.

Example 1. Setting up measurement conditions for the TR9407 with a set command.
Example 2. Reading the current condition setup from the TR9407 with a READ command.
Example 3. Reading the data identified by the cursor with SQ2 (Cursor mode).
Example 4. Reading distortion block during the LIST Mode.
Example 5. Reading the precision type and number of data on display with SQ4 (Binary Block Transfer mode) and performing high-speed block transfer of the entire data.
Example 6. Making block transfer with SQ3 (ASCII Block Transfer mode).
Example 7. Reading the status byte upon service request interrupt to the controller.
Example 8. Feeding time data SIN(X)/(X) into the TR9407 by using SQ5 (Time Data Read mode).
Example 9. Transfer function measurement based on sinusoidal sweep with a GPIB compatible function generator.
Example 10. Reading the octave list with the read command to print out through the controller.
Example 11. Setting up VIEW mode from TIME through C.O.P. over the GPIB and write each display into floppy disk and read them out later by designating SEQUENTIAL number.
Example 12. Binary block transfer in SQ4 (Transfer function)
Example 13. Service request on completion of averaging
Example 14. Writing computed arbitrary waveforms into Signal generator (TR98201) memory.
Example 15. SQ8 (Mass Time Data) Program
Example 16. SQ9 (Mass Time Data) Program

Example 1. Frequency range of 50 kHz, input sensitivity of +10 dBV on both channels A and B with AC and -GND coupling, averaging number of 64, Free Run mode, and transfer function display for the VIEW mode:

```
FR1  AN6  AS2  BS2  AI2  BI2  AG1  BG1  DH0  VW6
```

- VW6 — Transfer function
- DH0 — Free Run mode
- BG1 — CH.B GND coupling (-GND)
- AG1 — CH.A GND coupling (-GND)
- BI2 — CH.B input coupling (AC)
- AI2 — CH.A input coupling (AC)
- BS2 — CH.B input sensitivity (+10 dBV)
- AS2 — CH.A input sensitivity (+10 dBV)
- AN6 — Averaging number (64)
- FR1 — Frequency range (50 kHz)

```
10      ! PROGRAM EXAMPLE NO. 1
20      ! LISTENER FORMAT (SET COMMAND)
30      OUTPUT 701; "FR1AN6AS2BS2AI2BI2AG1BG1DH0VW6"
40      END
```

Figure 7-12 Programming Example 1

Example 2. This example reads the current cursor position and label with a Read command and prints them on the controller.

```
10      ! PROGRAM EXAMPLE NO.2
20      ! LISTENER FORMAT (READ COMMAND)
30      DIM A$[50]
40      OUTPUT 701; "RVT"
50      ENTER 701;A$
60      PRINT A$
70      OUTPUT 701; "RLA"
80      ENTER 701;A$
90      PRINT A$
100     OUTPUT 701;"RLB"
110     ENTER 701;A$
120     PRINT A$
130     END




VT90
LA00@* TR9407 DIGITAL SPECTRUM ANALYZER **@
LB01@ ****      MFD BY ADVANTEST          ****@
```

Figure 7-7 Programming Example 2

Example 3. This example positions the cursor to the 100th data point to read its value and prints it on the controller (FX0 and FX1).

```
10      ! PROGRAM EXAMPLE NO.3
20      ! SET COMMAND & SQ2
30      DIM A$[50]
40      OUTPUT 701; "VT100FX0"
50      ENTER 701;A$
60      PRINT A$
70      OUTPUT 701; "FX1"
80      ENTER 701;A$
90      PRINT A$
100     END




TF HZ  12 500.0,TF DB    383.45,TF 000000000000
TF HZ+.1250E+05,TF DB+.3834E+03,TF 000000000000
```

Figure 7-8 Programming Example 3

Example 4. This example reads a distortion block in the Harmonic Distortion List mode, and prints it on the controller.

```
10     ! PROGRAM EXAMPLE NO. 4
20     ! READ COMMAND (LIST READ OUT)
30     DIM A$ [300]
40     OUTPUT 701;"FX0"              ! FX0 MODE
50     OUTPUT 701;"RLD"              ! READ DISTORTION BLOCK
60     ENTER 701;A$
70     PRINTER A$
80     OUTPUT 701;"FX1"              ! FX1 MODE
90     OUTPUT 701;"RLD"
100    ENTER 701;A$
110    PRINT A$
120    END
```

```
SP PS   19.502 ,   91.797 ,   90.051 ,   36.914 ,   131.961 , 79.395 , 110.500
 ,   99.555 , 135.016 ,   32.301 ,   70.559 ,   66.516 ,    72.715 ,   31.870,
  92.551 ,   89.738 ,   88.613 ,   80.426 ,   79.594
SP PS+.1950E+02,+.9179E+02,+.9005E+02,+.3691E+02,+.1319E+03,+.7989E+02,+.1105E+0
3,+.9955E+02,+.1350E+03,+.8230E+02,+.7055E+02,+.6651E+02,+.7271E+02,+.3187E+02,-
.9255E+02,+.3973E+02,+.3361E+02,+.8042E+02,+.7959E+02
```

Figure 7-15 Programming Example 4

Example 5. This example reads the number of data on the display and the precision type in binary mode with a Read command and transfers the entire data in the high-speed block transfer mode. The data type is of single precision, fixed point, and data length is 401 points.

```
10      ! PROGRAM EXAMPLE NO.5
20      ! BINARY BLOCK TRANSMISSION MODE
30      OPTION BASE 1
40      !
50      OUTPUT 701;"SQ4"              ! SET BINARY MODE
60      OUTPUT 701;"HD0"              ! HEADER OFF
70      OUTPUT 701;"ROL"              ! READ COMMAND "ROL"
80      ENTER 701; Prec,Length        ! GET PRECISION TYPE & BLOCK LENGTH
90      PRINT "Prec=";prec;"Length=";Length
100     Byte=4
110     IF Prec=1 THEN Byte=2         ! SINGLE PRECISION IS 2 BYTE DATA
120     L=Length*Byte+2               ! CALCULATE ALL LENGTH
130     REDIM Data(L)
140     ENTER 701 USING"%", B;Data(*)
150     MAT PRINT Data
160     END
```

```
Prec= 1 Length= 401
 255        255        0          0
 255        253        0          1
 255        255        0          2
 255        255        0          0
 255        252        0          7
 255        249        0          4
 255        252        0          2
 0          0          255        252
 0          3          255        254
 0          1          255        253
 0          2          255        252
 0          4          255        252
 0          1          0          0
 255        255        255        255
 0          0          255        255
 0          0          0          0
 255        255        255        254
```

Figure 7-16 Programming Example 5

Example 6. Data read example in ASCII Block mode:
Line 60: Specifies the ASCII Block Transfer mode.
Line 70: "T" is an example of free field character.

```
10    ! EXAMPLE PROGRAM OF ASCII-BLOCK TRANSMISSION MODE
20    !
30    !
40 Start: REM
50    DIM A$[10000]
60    OUTPUT 701;"SQ3"                ! SQ3=ASCII-BLOCK TRANSMISSION MODE
70    ENTER 701;A$
80    PRINT A$
90    END
```

Figure 7-17 Programming Example 6

Example 7. This example reads the status byte when the controller is interrupted by a service request.
Lines 50-70: Jump to line Int if interrupted from interface #7 (GPIB).
Line 170: Read the status byte.

```
10    ! EXAMPLE PROGRAM OF INTERRUPT SERVICE ROUTINE
20    !
30    !
40 Start:    REM
50    ON INTR #7 GOSUB Int        ! WHEN INTERRUPT FROM (#7) , JUMP LINE Int
60    !
70    ENABLE 7;2
80 Next:   REM
90    FOR I=1 TO 10
100   DISP I
110   NEXT I
120   GOTO Next
130   !
140   !
150 Int:                          ! INTERRUPT SERVICE ROUTINE START HERE
160   PRINT "INRERRUPT"
170   Status=SPOLL(701)           ! READ STATUS BYTE FROM DEVICE CODE OF (1)
180   PRINT Status                ! PRINT STATUS BYTE
190   ENABLE INTR 7               ! ENABLE NEXT INTERRUPT
200   RETURN
```

Figure 7-18 Programming Example 7

Example 8. Programming using SQ5

In this program, time data of 1024 words (2048 bytes) were created by using the function SIN(X)/(X) and is transferred to the TR9407 through the GPIB. Figure 7-20 shows the time data created by this program and the result of the fast Fourier transform performed on the time data.

* Program description (see Figure 7-20.)
  Line 160: Generates the Data variable (time data)(-1<Data<1) .
  Line 200: Jump to line 790.
  Line 790-820: Convert the variable (Data) into 16-bit pattern (0-65535) and return. This is illustrated as follows:

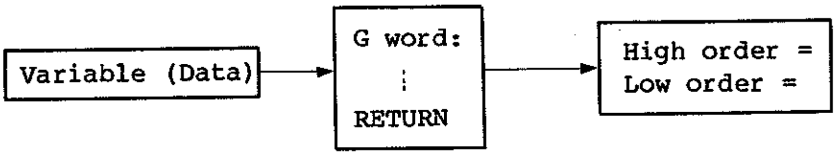


Figure 7-19 SQ5 Mode Flow Chart

Line 320: Sends SQ5 to set the TR9407 into the time data read mode (be sure to send SQ5 every time before sending the time data to the TR9407).
Line 340: Sends words 1 through 2049 ("END" will send out EOI tegether with the last byte).
Line 370-580: Save words 1 through 2050 to the floppy disk.

```
10   !****************************************
20   !* CALCULATE TIME-DATA WITH SIN (X) / X *
30   !****************************************
40   !
50   !
60   OPTION BASE 1
70   !
80   INTEGER Word (1026)
90   !
100  RAD
110  REM
120  Word (1)=0              ! BLOCK EXPONENT=0 (WORD)
130  I=2
140  !
150  FOR X=-40*PI TO 40*PI STEP PI*80/1024
160   Data=7/5*SIN  (X) / X-.5
170   DISP "Data  (";Numb+1;") =";Data
180   Numb=Numb+1
190   !
200   GOSUB Gword
210   Word (I)=Binary
220   I=I+1
230 NEXT X
240  !
250  !
260  !*******************************************************
270  !* SEND (1024) - POINTS TIME-DATA & EXPONENT WITH GPIB *
280  !*******************************************************
290 Sending: !
300  DISP CHR$ (130) & "SENDING TIME-DATA TO (TR9407) NOW !!!"
310  !
320  OUTPUT 701;"SQ5"
330  !
340  OUTPUT 701 USING "W";Word(*),END ! SEND 1025 WORDS WITHOUT (CR/LF)
350                                   ! SEND LAST BYTE WITH "EOI"
360  !
370  OUTPUT 701; "LA00@  Y(t)=7/5*SIN (X)/X-0.5@"
380  !
390  DISP "FINISHED SENDING DATA !!!"
400  !
410  !
420  !
430  ! ******************************************************
440  ! * SAVE (1024) - POINTS TIME DATA & EXPONENT INTO DISK *
450  ! ******************************************************
460  INPUT "***** SAVE DATA (0) , NOT SAVE DATA (1) *****", Num
470  IF Num=0 THEN GOTO Save_data
480  GOTO Finish
```

Figure 7-20 Programming Example 8

```
490  !
500 Save_data:!
510  INPUT "TYPE IN DATA-FILE NAME !!!",B$
520  DISP CHAR $ (130) & "SENDING DATA INTO FILE OF "&B$&"NOW !!!"
530  CREATE BDAT B$ 1,2051                    ! 2051 = 1026*2-1
540  ASSIGN @File TO B$                       ! B$ IS THE DATA-FILE NAME
550  OUTPUT @File;Word(*)
560 Finish:!
570  DISP CHAR$ (130) &"ALL WORK FINISHED !!!"
580  STOP
590  !
600  !
610  !
620  !
630  ! ********************************************
640  ! * CONVERT <Data> INTO BINARY               *
650  ! *                                          *
660  ! * <NOTE>                                   *
670  ! *   -1  = Data  = 1 -----------            *
680  ! *            0  = Binary  =65535           *
690  ! *                                          *
700  ! * <INPUT>                                  *
710  ! * Data : DECIMAL FRACTION WITH SIGN        *
720  ! *                                          *
730  ! * <OUTPUT>                                 *
740  ! * Binary : 0  = X  = 65535                 *
750  ! *                                          *
760  ! ********************************************
770  !
780  !
790 Gword:!
800  Binary=INT(ABS(Data)*(2  15))
810  IF Data<0 THEN Binary=-Binary
820  RETURN
830  END
```

Figure 7-20 Programming Example 8 (Cont'd)

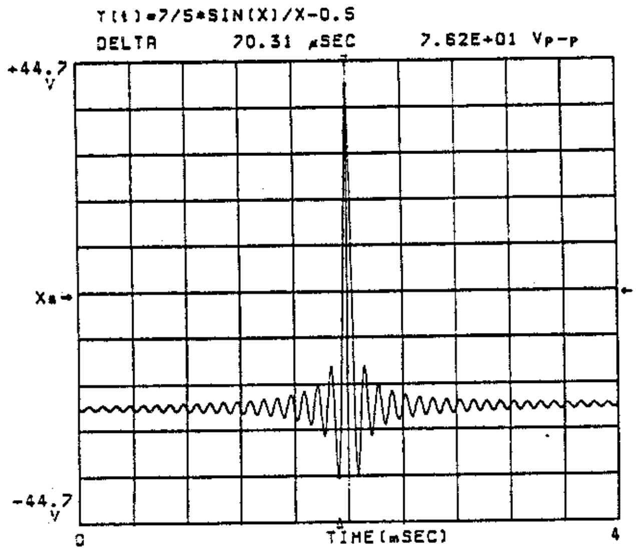


Figure 7-21(a) Time-domain data example using function SIN(X)/(X)

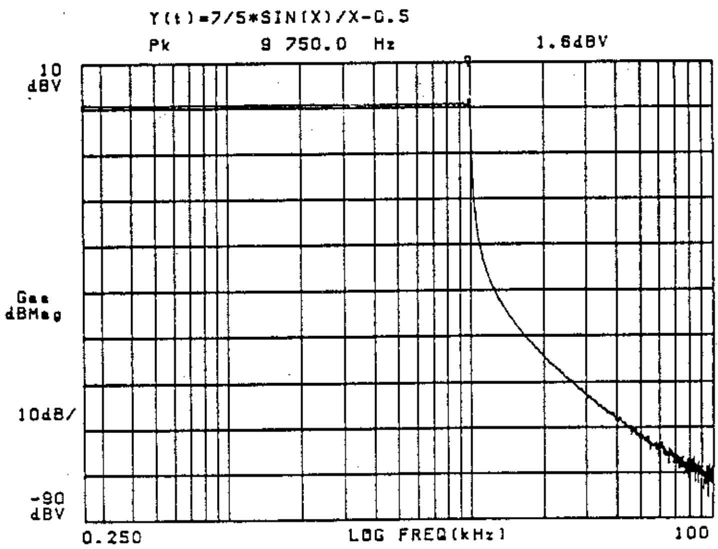


Figure 7-21(b) Logarithmic display of frequency domain data converted from the above time domain data

Example 9. Transfer function measurement based on sinusoidal sweep with a GPIB compatible function generator

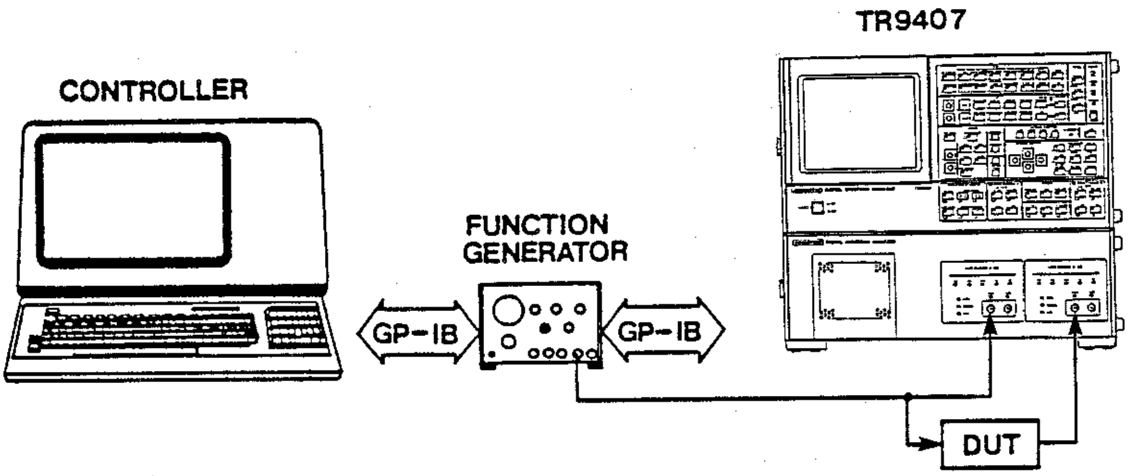


Figure 7-22 Transfer function measurement with sinusoidal sweep scheme

Set up an interconnection between TR9407, the controller and a function generator as shown in Figure 7-22. Make necessary setups including "AVERAGE MODE" being set to "SWEEP".

* Program description (see Figure 7-23)

Line 110: Input start-, stop- and step-frequencies in Hz (HP 3325A is used as a function generator. Set up frequency resolution for step frequency e.g. 250 Hz for 100 kHz; 125 Hz for 50 kHz)
Line 140: Set up averaging number (1 to 8192)
Line 180 to 240: Set up measurement conditions
Line 300: Clear previous status
Line 340: Set up start frequency
Line 360 to 370: Mask status except NEXT FREQUENCY
Line 580 to 590: Read status and error status

```
10    ! *****************************************
20    ! *                                       *
30    ! *    Example Program of Sweep Average   *
40    ! *                                       *
50    ! *****************************************
60    !
70    ! *** GPIB ADDRESS ***
80    !   TR9407= > 1  , FUNCTION GENERATOR = > 2
90    !
100   !
110 Start: !
120   INPUT "Start , Stop , Step Frequency ?",Frs,Fre,Frd
130   !
140   INPUT "  Average Number ? ",N
150   Nn=   (LGT(N)/LGT(2))
160   OUTPUT 701;"AN";CHR$(Nn+48)     ! Set Average Number
170   !
180   OUTPUT 701;"AC2HA1"             ! Average Stop & Harm. Off
190   OUTPUT 701;"FU0IA0IB0DA0DB0"    ! Function OFF
200   OUTPUT 701;"ZO0"                ! Zooming OFF
210   OUTPUT 701;"AI1"                ! Test Signal OFF
220   OUTPUT 701;"BT1DU0VW6DU1VW7"    ! Display
230   OUTPUT 701;"DU0DV2DM4"
240   OUTPUT 701;"AM0AP2AO0AD0"       ! Average Mode
250   !
260   ON INTR#7 GOSUB Int
270   !
280   ENABLE INTR 7;2
290   !
300   =SPOLL (701)                    ! Clear Old Status
310   OUTPUT 701;"RES"
320   !
330   Fr=Frs                          ! Set Start Frequency (GENERATOR)
340   OUTPUT 702;"FR";VAL$(Fr);"HZ"
350   !
360   OUTPUT 701;"MK32639             ! Mask Status
370   OUTPUT 701;"SQ0"                ! & Extended Status
380   !                               ! SQ0
390   !
400   OUTPUT 701;"AC0"                ! Erase
410   OUTPUT 701;"AC1"                ! Average Start
420   !
430 Loop: !
440   IF Ed=1 THEN GOTO Comp
450   !
460   DISP " Sweep Averaging Now // "
470   !
480   GOTO Loop
490   !
```

Figure 7-23 Programming Example 9

```
500 Comp: !   Average Complete
510    OUTPUT 701;"AC2"                ! Average Stop
520    BEEP
530    DISP " Average Complete // "
540    WAIT 2
550    GOTO Start
560    !
570 Int: !  Interrupt Service Routine
580    A=SPOLL (701)                   ! Status
590    OUTPUT 701;"RES"                ! Error Status
600    !
610    IF Fr=Fre THEN Endf             ! Stop Frequency ?
620    Fr=Fr+Frd                       ! Next Frequency
630    !
640    OUTPUT 702;"FR";VAL$(Fr);"HZ"   ! Set Next Frequency
650    !
660    GOTO Rtn
670    !
680 Endf:!   Stop Frequency
690    Ed=1
700    Rtn: !
710    ENABLE INTR 7                   ! Interrupt Enable for Next SRQ
720    RETURN
```

Figure 7-23 Programming Example 9 (Cont'd)

Example 10. Reading the octave list with the read command to print out through the controller

```
10    ! ***************************************
20    ! *                                     *
30    ! *   EXAMPLE PROGRAM OF OCTAVE LIST    *
40    ! *                                     *
50    ! ***************************************
60    !
70    DIM Data$[50]
80    !
90    DISP "  TR9407 Ready ? ,PUSH CONT. KEY //"
100   PAUSE
110   OUTPUT 701;"DH2HD0FX0"      ! Data Hold & Header OFF, FX0
120   !
130   OUTPUT 701;"RLN             ! Read Line number
140   ENTER 701;Ln                ! Line NO. 1/1 OCTAVE :10 ,1/3 OCTAVE :30
150   !
160   Oct$="1/3 OCTAVE LIST"
170   IF Ln=10 THEN Oct$="1/1 OCTAVE LIST"
180   !
190   OUTPUT 701;"ROW"            ! Read A-Weight ON/OFF
200   ENTER 701;Ow
210   Ow$="OFF"
220   IF Ow=1 THEN Ow$="ON"
230   !
240   OUTPUT 701;"RWG"            ! Read Window
250   ENTER 701;Wg
260   ON Wg+1 GOTO Rect,Hann,Minm,Flat
270 Rect:!
280   Wg$="RECT"
290   GOTO Print
300 Hann:!
310   Wg$="HANNING"
320   GOTO Print
330 Minm:!
340   Wg$="MINIMUM"
350   GOTO Print
360 Flat:!
370   Wg$="FLAT-PASS"
380 Print:!
390   PRINT Oct$;" : ";" A-WEIGHT ";Ow$
400   !
410   PRINT TAB(20);"WINDOW ";Wg$
420   !
430   OUTPUT 701;"RLV"            ! Read OVERALL
440   ENTER 701;Data$
```

Figure 7-24 Programming Example 10

```
450   PRINT TAB(20);"OVERALL";Data$;" dBV"
460   !
470   PRINT ""
480   !
490   PRINT "FILTER,"CENTER","     LEVEL"
500   !
510   PRINT "  NO. "," FREQ. HZ","     dBV"
520   !
530   Line=0
540   I=2
550 Loop:!
560   OUTPUT 701;"RLN";VAL$(I)    ! Read Line NO. I
570   ENTER 701;Data$             ! Get One Line
580   IF LEN(Data$)<=4 THEN GOTO Next   ! Exists Line I ?
590   Fil$=Data$[3,5]             ! Filter No.
600   Freq$=Data$[12,21]          ! Center Freq
610   Lev$=Data$[28,37]           ! Level
620   PRINT "#";Fil$,Freq$,Lev$
630   IF Line=Ln THEN GOTO End
640 Next: !
650   IF I=49 THEN GOTO End
660   I=I+1
670   GOTO Loop
680 End: !
790   DISP " END "
700   END
```

Figure 7-24 Programming Example 10 (Cont'd)

```
1/1 OCTAVE LIST :  A-WEIGHT ON
                   WINDOW  RECT
                   OVERALL          -1.4 dBV

FILTER              CENTER            LEVEL
  NO.                FREQ. Hz          dBV
# 21                      125         -61.0
# 24                      250         -41.3
# 27                      500          -6.3
# 30                     1.0k         -13.1
# 33                     2.0k         -35.0
# 36                     4.0k         -12.1
# 39                     8.0k          -4.2
# 42                    16.0k         -39.2
# 45                    31.5k         -37.2
# 48                    63.0k         -28.5
```

Figure 7-25 Example of 1/1-octave Analysis List Printout

Example 11. Setting up VIEW mode from TIME through C.O.P. over the GPIB and write each display into floppy disk and read them out later by designating SEQUENTIAL number.

Note the following points on operating the floppy disk through the GPIB implementation:

1. Follow the same procedure as the manual operation to set up commands.
2. Do not set up other commands than the floppy disk command while the data file retrieved from the floppy disk is being displayed on the CRT.

* Program description (see Figure 7-26)

Line 70: Set I/O to FLOPPY
Line 80: Set up master unit item
Line 90: Select floppy READ mode
Line 100: Set up G. FILE
Line 110: Select floppy WRITE mode
Line 120: Set up data
Line 160: Select VIEW mode
Line 170: Set up SEQUENTIAL number
Line 190: Start
Line 260: Select floppy READ mode
Line 330: Specify SEQUENTIAL number
Line 350: Start

```
10    ! ******************************************
20    ! *                                        *
30    ! *      Example Program for Floppy        *
40    ! *                                        *
50    ! ******************************************
60    !
70    OUTPUT 701;"IO2"                    ! I/O Floppy
80    OUTPUT 701;"DI0MA0SN0               ! Increment , Manual ,Sequential No.0
90    OUTPUT 701;"WR0"                    ! Floppy Read Mode
100   OUTPUT 701;"FL0"                    ! G. File
110   OUTPUT 701;"WR1"                    ! Floppy Write Mode
120   OUTPUT 701;"FW0"                    ! Data
130   !
140 Loop: !
150   FOR I=0 TO 9
160    OUTPUT 701;"VW";VAL$(I)            ! View Select
170     OUTPUT 701;"SN";VAL$(I*5)         ! Set Sequential NO.
180       WAIT 2
190     OUTPUT 701;"FT"                   ! Floppy Start
200    WAIT 1
210   NEXT I
220   !
230   DISP " Write End // "
240   BEEP
250   !
260   OUTPUT 701;"WR0"                    ! Floppy Read Mode
270   !
280   WAIT 3                              ! Key Mode Set Wait Time
290   !
300 Read: !
310   INPUT " Read View No.  0 - 9  ?. ",View   ! Read View NO.
320   !
330   OUTPUT 701;"SN";VAL$(View*5)        ! Set Sequential NO.
340   !
350   OUTPUT 701;"FT"                     ! Read
360   !
370   WAIT 2
380   !
390   GOTO Read
```

Figure 7-26 Programming Example 11

Example 12. Transmission of transfer function by SQ4

A program to transmit the transfer function to the controller by SQ4 (binary block transfer) and convert it to a value corresponding to the VIEW setting

[Explanation of program]

- Lines 10 to 270 make up the main program.

Setup:
  Reads sensitivity, frequency range, and display status of CH-A and CH-B when measuring a transfer function.

Precision:
  Reads the precision type and length of displayed data to calculate the internal memory area.

Data:
  Reads data into the controller. (16-bit data array)

Store:
  Converts binary data to a displayed format.

  Gdata: Calculates one point data of each precision type from the binary data array.

  Scale: Converts binary data to values in a displayed format.

  Disp: Displays read data.

```
10    !**************************
20    !*                        *
30    !*   Example program      *
40    !*         for            *
50    !*   Binary block mode    *
60    !*  % Transfer function % *
70    !*     -- SQ4 --          *
80    !*                        *
90    !**************************
100   !
110   ! GPIB Interface card No.= 7
120   OPTION BASE 1
130   DIM A$[20]
140   DISP " Example program for SQ4 Binary block mode. push cont key !! "
150   PAUSE
160   !    --- Main program ---
170   GOSUB Setup                   ! Set SQ4
180   !
190   GOSUB Precision               ! Read "Precision" & "Length"
200   !
210   GOSUB Data                    ! Data
220   !
230   GOSUB Store                   ! Data conversion
240   !
250   GOSUB Disp                    ! Display
260   !
270   STOP
280   !
290   !   --- Subroutine ---
300 Setup:!
310   INPUT " GPIB Address ?",Adrs
320   Gadrs=700+Adrs
330   OUTPUT Gadrs:"SQ4"            ! Set binary mode
340   OUTPUT Gadrs:"RFR1RAS1RBS1"   ! Read "Frequency" & "Sense" range
350   ENTER Gadrs:A$
360   Fr=NUM(A$[3,3])-48            ! Frequency range
370   As=-NUM(A$[6,6])+51           ! Ch-A Sense
380   Bs=-NUM(A4[12,12])+51         ! Ch-b Sense
390   Diff=Bs-As
400   OUTPUT Gadrs:"RDV"
410   ENTER Gadrs:Rdv               ! Read view
420   OUTPUT Gadrs:"RDM"            ! Read display mode
430   ENTER Gadrs:Rdm
440   RETURN
450   !
460 Precision:!
470   OUTPUT Gadrs:"HD0"            ! Header off
480   OUTPUT Gadrs:"ROL"            ! Read command "ROL"
```

Figure 7-27 Programming Example - 12

```
490   ENTER Gadrs:Prec.Length          ! Get precision type & Data length
500   ON Prec GOSUB Prec1,Prec2,Prec3
510   Word=2
520   IF Prec=1 THEN Word=1            ! Single precision data is 1Word data
530   L=Length*Word+1                  ! Calculate data length
540   ALLOCATE Data(L)
550   ALLOCATE Dataa(Length)
560   RETURN
570   !
580 Data:!
590   ENTER Gadrs USING "%,W":Data(*) ! Data
600   RETURN
610   !
620 Prec1:!  Single precision: 16bit
630   Prec$="Single precision"
640   RETURN
650 Prec2:!  Double precision: 32bit
660   Prec$="Double precision"
670   RETURN
680 Prec3:!  Floating point   : 32bit
690   Prec$="Floating point"
700   RETURN
710   !
720 Store:!  Data conversion ( Binary conversion )
730   ! Data convertion
740   !
750   Bxp=Data(1)                      ! Block exponent
760   FOR T=1 TO Length
770    GOSUB Gdata                     ! Get Data
780    GOSUB Scale                     ! Scaling
790   NEXT T
800  RETURN
810  !
820 Gdata:!
830   ON Prec GOSUB Single.Double.Float
840   RETURN
850   !
860 Single:!  Single precision data
870    Bdata=Data(T+1)
880    Bdata=Bdata/32768               ! Bdata/2^15
890    RETURN
900 Double:!  Double precision data
910    Udata=Data(T*2)
920    Ldata=Data(T*2+1)
930    IF Ldata<0 THEN Ldata=Ldata+65536
940    Bdata=Udata*65536+Ldata         ! Udata*2^16+Ldata
950    Bdata=Bdata/2147483647          ! Bdata/2^31
```

Figure 7-27 Programming Example - 12 (Cont'd)

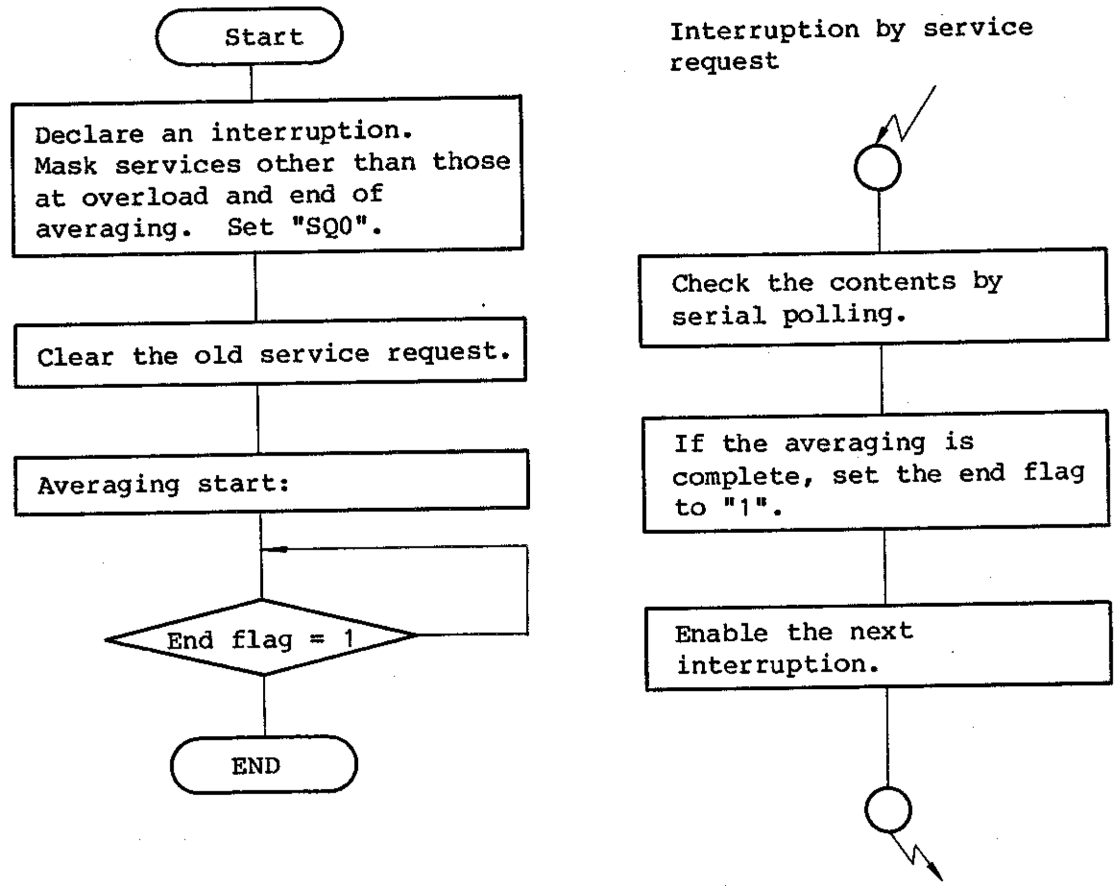
```
960     RETURN
970 Float: !  Floating point data
980     Udata=Data(T*2)
990     Ldata=Data(T*2+1)
1000    Bdata=(Udata/32768)*(2^Ldata)   !(Udata/2^15)*(2^Ldata)
1010    RETURN
1020    !
1030 Scale:!  Scaling
1040  ON Rdv+1 GOSUB Read,Imag,Mag,Phase
1050  RETURN
1060   !
1070 Real:!  Real data
1080 Imag:!  Imaginary data
1090  Di=Diff-2*(INT(Diff/2))
1100  ON Di+1 GOSUB Case1,Case2
1110   Dataa(T)=Bdata*2^Bxp*K
1120  RETURN
1130  !
1140 Case1:!
1150   K=10^(Diff/2)
1160  RETURN
1170  !
1180 Case2:!
1190   K=44.72/14.14*10^((Diff-1)/2)
1200  RETURN
1210  !
1220 Phase: !
1230   K=400
1240   Dataa(T)+Bdata*2^Bxp*K
1250   RETURN
1260  !
1270 Mag:!
1280   ON Rdm-1 GOSUB Mag1,Mag2,Dbmag
1290   RETURN
1300   !
1310 Mag1:!
1320  K=10^Diff
1330  Dataa(T)=SQR(Bdata*2^Bxp*K)
1340  RETURN
1350  !
1360 Mag2:!
1370  K=10^Diff
1380  Dataa(T)=Bdata*2^Bxp*K
1390  RETURN
1400  !
1410 Dbmag:!
1420  K=10^Diff
1430  Bdata=Bdata*2^Bxp*K
```

Figure 7-27 Programming Example - 12 (Cont'd)

```
1440  IF Bdata>0 THEN Bdata=10*LGT(Bdata)
1450  Dataa(T)=Bdata
1460  RETURN
1470  !
1480 Disp:!  Display
1490  PRINT Prec$:" data "
1500  PRINT " Data length=";VAL$(Length)
1510  PRINT " Block exponent=":VAL$(2^Bxp)
1520  PRINT " Scaling factor=":VAL$(K)
1530  Fq=15-Fr
1540  Fx=(Fq-INT(Fq/3)*3)^2+1
1550  Ex=INT(INT(Fq-9*INT(Fq/9))/3)
1560  Hz$="Hz"
1570  IF INT(Fq/9)=1 THEN Hz$="kHz"
1580  PRINT " Frequency range is ":VAL$(Fx*10^Ex):Hz$
1590  PRINT " Ch-A :":VAL$((As)*10);"dBV"
1600  PRINT " Ch-B :";VAL$((Bs)*10);"dBV"
1610  PRINT Dataa(*)
1620  RETURN
1630 END
```

Figure 7-27 Programming Example - 12 (Cont'd)

Example 13. Service request at end of averaging
An example program to perform averaging in each frequency range and detect the end of averaging by a service request.



```
10     ! ***********************************
20     ! *                                 *
30     ! *          EXAMPLE PROGRAM        *
40     ! * -------- SERVICE REQUEST -------- *
50     ! *                                 *
60     ! ***********************************
70     !
80     Time=1
90     Adres=701
100    ON INTR 7 GOSUB Interrupt          ! Assign interrupt service routine
110     OUTPUT Adres;"MK6435"             ! Enable Service
120                                       ! Over.Average Complete
130     OUTPUT Adres:"SQ0"                ! Enable SRQ
140     ! ------ Clear old status ------
150     S=SPOLL(Adres)
160     OUTPUT Adres:"RES"
170     OUTPUT Adres:"AN6"                ! Average number=64
180     End=0
190     Fr=0
200     ! -----------------------------
210     !
220     !    **** Average Start ****
230 Start:!
240     OUTPUT Adres;"FR":CHR$(Fr+48);"US1"
250     OUTPUT Adres;"AC0"                ! Erase
260     OUTPUT Adres;"AC1"                ! Start
270     SET TIME 0                        ! Reset Timer
280     Endavg=0
290     DISP
300     ENABLE INTR 7;2
310     !
320 Wait:  !
330       DISP TIME$(TIMEDATE)
340       IF END=1 THEN GOTO End
350       IF Endavg=0 THEN GOTO Wait      ! Wait
360       Fq=15-Fr
370       Fx=(Fq-INT(Fq/3)*3)^2+1
380       Ex-INT(INT(Fq-9*INT(Fq/9))/3)
390       Hz$="Hz"
400       IF INT(Fq/9)=1 THEN Hz$="kHz"
410       Fr$=VAL$(Fx*10^Ex)&Hz$
420       PRINT "(";Time;")Times end of average. Frequency range is ";Fr$;" Total
Time :";TIME$(Endtime)
430       Time=Time+1
440       Fr=Fr+1
450       GOTO Start
460 End:!
```

Figure 7-28 Programming Example - 13

```
470     DISP "End //"
480     STOP
490     !
500     !
510  !  ******  Interrupt service routine ******
520 Interrupt:!
530     S=SPOLL(Adres)
540     IF BINAND(S,64)=0 THEN GOTO Inta    ! Rsv=1 ?
550     IF BINAND($,128)=0 THEN GOTO Intb   ! Error & Extended Status
560       OUTPUT Adres:"HDORES"             ! Read Error Status
570       ENTER Adres;Res
580       S1=BINAND(Res,3)
590        ON S1+1 GOTO Novr.Cha.Chb,Both
600 Novr:!
610        DISP " Error Extend & Error Status !! "
620        GOTO Intb
630 Cha:!
640        DISP " Channel [A] Overload "
650        GOTO Intb
660 Chb:!
670        DISP " Channel [B] Overload "
680        GOTO Intb
690 Both:!
700        DISP " Channel [A] & [B] Overload "
710 Intb:!
720        IF BINAND(S,8)=0 THEN GOTO Inte
730        DISP "  Average Complete "
740        Endtime=TIMEDATE
750        Endavg=1
760        IF Fr=15 THEN End=1
770 Inte:!
780     ENABLE INTR 7
790     RETURN
800 Inta:!
810        DISP " Undefined Interrupt "
820        GOTO Intb
830   END
```

Figure 7-28 Programming Example - 13 (Cont'd)

Example 14. Running the following program on the desk-top computer will write the computed arbitrary waveforms into the internal memory of the signal generator TR98201.

```
10    ! ***********************************
20    ! *                                 *
30    ! *       EXAMPLE PROGRAM FOR       *
40    ! *             TR98201             *
50    ! *        - WAVE MEMORY -          *
60    ! *                                 *
70    ! ***********************************
80    !
90    DIM Data$[10000]
100   Pc=1
110   !***** Triangle Wave *****
120   FOR I = 1 TO 50
130     Data = INT (10.23 * (I-1) +511)
140     GOSUB Set
150   NEXT I
160   !
170   FOR I = 51 to 150
180     Data = INT (-10.23 * (I-151) +1023)
190     GOSUB Set
200   NEXT I
210   !
220   FOR I = 151 TO 200
230     Data = INT(10.23 * (I-151))
240     GOSUB Set
250   NEXT I
260   !
270   ! ****** Step Function ******
280   Data = 512
290   FOR I = 201 TO 300
300     FOR (I - INT (1/20) * 20) = 0 THEN Data = INT (Data = INT (1024/10)
310     GOSUB Set
320   NEXT I
330   !
340   Data = 0
350   FOR I = 301 to 500
360     IF ( I - INT (I/20) * 20) = 0 THEN Data = INT (Data +1024/10)
370     GOSUB Set
380   NEXT I
390   !
400   !******Sine Wave******
410   FOR I = 501 to 700
420     Data = INT (511 *COS (4*PI* (I-500)/200+511)
430     GOSUB Set
```

Figure 7-29 Programming Example - 14

```
440   NEXT I
450   !
460   !******Rectangular Wave******
470   FOR I = 701 to 900
480     IF (I - INT(I/40)*40)=0 THEN Data = Data +1023
490     IF Data>=1024 THEN Data = 0
500     GOSUB Set
510   NEXT I
520   !
530   !*****Damping function*****
540   FOR I = 901 to 1023
550     Data = (( -1/122)*(I-901)+1)*(COS(4*PI*I/172)*511+511
560     Data = INT(Data)
570     GOSUB Set
580   NEXT I
590   !
600    WAIT
610    OUTPUT 701:"103"     ! Set I/O TR98201
620    OUTPUT 701:"SGF6"    ! Output function is "Memory"
630    OUTPUT 701:"SGB1"    ! Block output mode "SGBI"
640    OUTPUT 701:"Data$"   ! Output data
650   STOP
660  Set:!      Binary to ASCII
670    Data = ABS(Data)
680     Data$ [Pc,Pc +LEN(VAL$(Data)) +2 ] = VAL$(Data)&" "
690     Pc = Pc +LEN(VAL$(Data)) +1
700     RETURN
710     END
```

Figure 7-29 Programming Example - 14 (Cont'd)

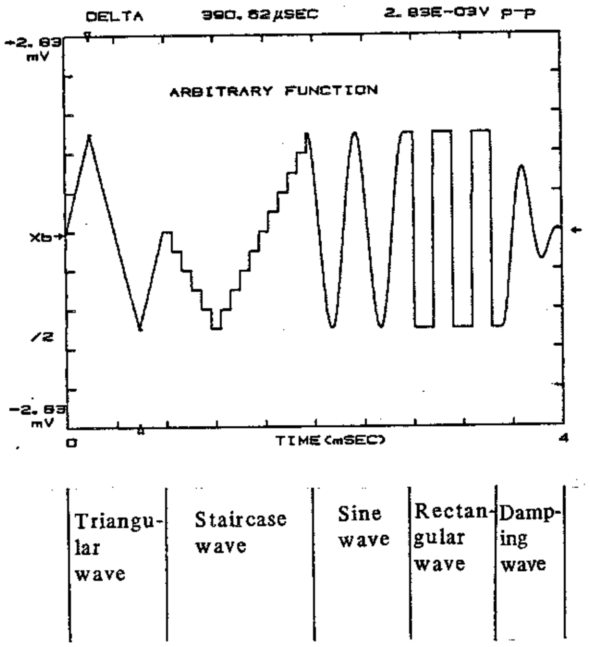


Figure 7-30 Typical Arbitrary Waveforms

Example 15. SQ8 (Mass Time Data) Program

Two adjacent sine waves are computed, transferred to the input buffer with the SQ8, and then zooming is performed to separate the two signals.

Since the input buffer point is set to 0 (IP = 0), the transferred data enters from the first point (0.00 [µs, ms, sec] on the leftmost time axis) when the data window is activated.

```
10   ! ****************************************
20   ! *                                      *
30   ! *      Example program for TR 9407     *
40   ! *                                      *
50   ! *      --------- SQ8 -----------       *
60   ! *                                      *
70   ! ****************************************
80   !
90   OPTION BASE 1
100  INTEGER Word(2048)
110  Adres=702
120  RAD
130  FOR I=1 TO 2048
140    Data=.2*SIN(2*PI*I*64/2048)+.5*SIN(2*PI*1*62/2048)
150    DISP "Data  (";I;" )=*;Data
160    Binary=INT(ABS(Data)*2  15))
170    IF Data 0 THEN Binary=-Binary
180    Word(I)=Binary
190  NEXT I
200  !
210  OUTPUT Adres;"DH2"                       ! Data HOLD
220  OUTPUT Adres;"IP0"                       ! Set Input buffer pointer
230  !
240 Sending :  !
250  !
260  OUTPUT Adres ;"SQ8"
270  !
280  OUTPUT Adres USING "#.W" ;Word(*) END
290  !
300  OUTPUT Adres ; "HDORIP"                 ! Read next pointer
310  ENTER Adres ;Ip
320  PRINT " Next Input buffer pointer =" ;Ip
330  PRINT " END !! "
340  STOP
350  !
360  END!
```

Figure 7-31 Programming Example - 15

Example 16. SQ9 (Mass Time Data) Program Example

The 4096-point A/D converted time data stored in the input buffer is transferred to the controller with the SQ9. Then, this data is transferred back to the same area of the input buffer with the SQ8. After transferring the 4096-point data, the input buffer pointer (IP) indicates the next destination of transfer. When continuous data is to be transferred, therefore, set only the first IP; it will be incremented automatically.

```
10    ! ****************************************
20    ! *                                      *
30    ! *      Example program for TR 9407     *
40    ! *                                      *
50    ! *      --------- SQ9 -----------       *
60    ! *                                      *
70    ! ****************************************
80    !
90    OPTION BASE 1
100   Adres=702
110   OUTPUT Adres;"DH2"                    ! Data HOLD
120   OUTPUT Adres;"ON4096SQ9"
130   OUTPUT Adres;"IP0"                    ! Set Input buffer pointer
140   OUTPUT Adres ; "HDOROL"
150   ENTER Adres ;Prec, Length
160   ALLOCATE Mtime(Length)               !
170   ENTER Adres USING "%,W" ;Mtime(*)    ! Get Mass time data
180   OUTPUT Adres ;"RIP"                  ! Read input buffer pointer
190   ENTER Adres ;Ip
200   PRINT " Next input buffer pointer =" ;Ip
210   !
220   !          Re-store time data
230   DISP " Push cont. key ! "
240   PAUSE
250   OUTPUT Adres ;"DH2"                   ! Data HOLD
260   OUTPUT Adres ;"IP0"                   ! Set input buffer pointer
270   OUTPUT Adres ;"SQ8"
280   OUTPUT Adres USING "#.W" ;Word(*) END
290   DISP" END !!"
300   STOP
310   END
```

Figure 7-32 Programming Example - 16

MEMO

TABLE OF CONTENTS

8. PERIPHERAL DEVICES AND USAGE

8.1 INTRODUCTION

To enlarge the range of application, various peripheral devices are available for the TR9407 Digital Spectrum Analyzer. You can make the best use of functions of this analyzer and use the analyzer for additional applications by using these peripheral devices.

All the peripheral devices except the close-up camera can be controlled by the I/O and EXECUTE keys in the SETUP section. The following peripheral devices are available:

- Close-up camera
- Analog-type X-Y recorder (1-pen or 2-pen)
  (+1 V full-scale range, pen up/down control)
- Digital plotter
  ADVANTEST TR9835/9835R/9832
  Hewlett Packard 7225A/7470A/7475A/7550A/9872B/9872C HP-GL plotter
- Floppy disk digital data recorder
  ADVANTEST TR98102
- Signal generator
  ADVANTEST TR98201/TR98202
- Universal scanner
  ADVANTEST TR7200 Series

8.2 HANDLING THE CLOSE-UP CAMERA

Assemble the close-up camera according to Figure 8-2.

Photographing conditions:

Aperture		Shutter speed
F11	....	1
F8	....	1/2

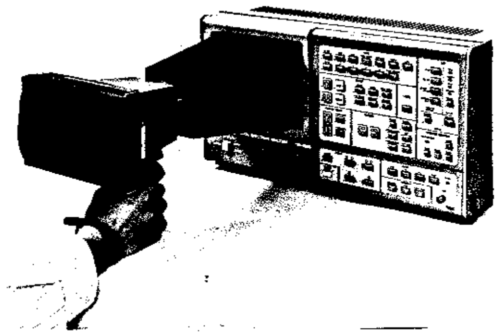


Figure 8-1 Handling a Close-up Camera

CAUTION

If the CRT screen surface or a filter is contaminated, poor picture quality will result. Clean the CRT screen surface and filter by following the instructions given in Section 9.
If the roller section inside the back lid of the camera is contaminated, the film may fail to come out. Clean the roller section periodically.

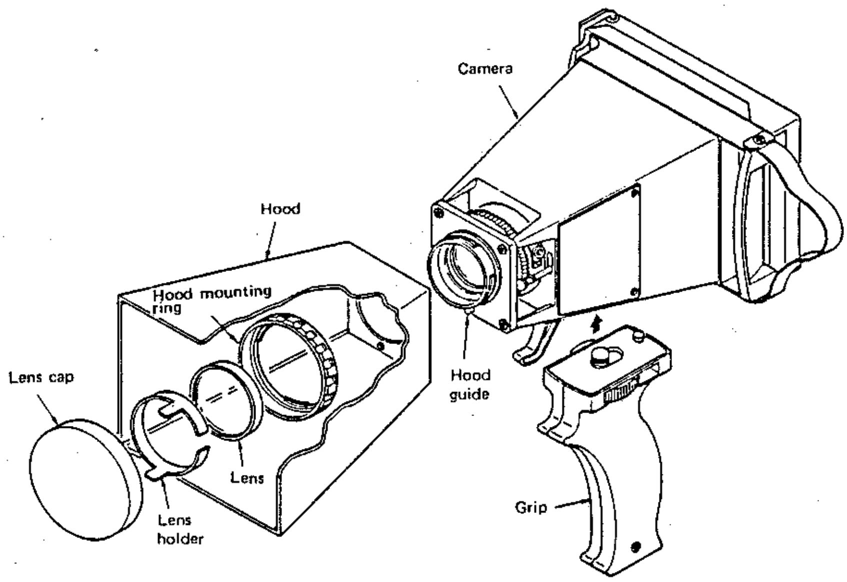
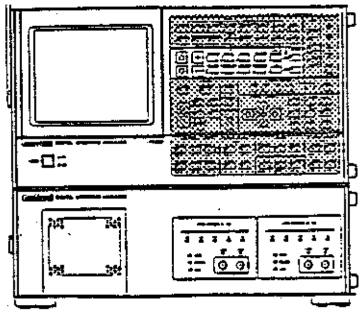


Figure 8-2 Assembly Illustration of M-085DII Polaroid Camera

8.3 PERIPHERAL DEVICE SELECTION AND HANDLING



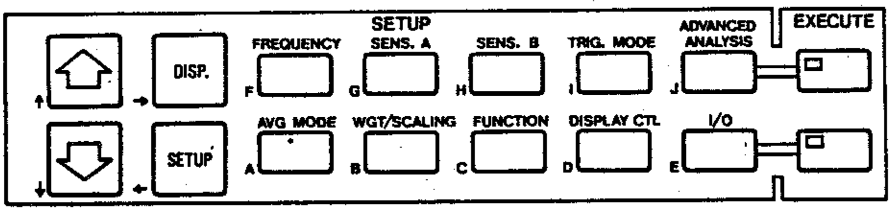


Figure 8-3 Peripheral Device Control Panel

(1) Set up the peripheral devices

(2) Setting menus
If the I/O key in the SETUP section is pressed, an I/O select menu (shown in Figure 8-4) is shown in the right area of the CRT.

XX-RCDR : Selects an X-Y recorder.
PLOTTER : Selects a digital plotter.
FLOPPY : Selects the Floppy Disk Digital Data Recorder.
SIGNAL G.: Selects the Signal Generator.

There are two methods for displaying the above menus.

a. Move the pointer to the I/O unit position. Each time I/O SETUP or DISP. is pressed, the current menu is switched to the next menu.

b. I/O is pressed, "KEY(PANEL RECALL) + KEY(?)" is displayed. Press RECALL. Then, the following will be displayed at the bottom of the screen.

IMP → T	SWP → U	RND → V	MEM → V	SEQ → X		
RCD → L	PLT → M	FLP → N		SIN → P	MSN → Q	WMS → R

Press SPECTRUM (L) for X-Y recorder

Press CROSS-CORR. (M) for plotter

Press HIST. (N) for floppy

Press the rest of the alphabetic keys for the SG signal menu.

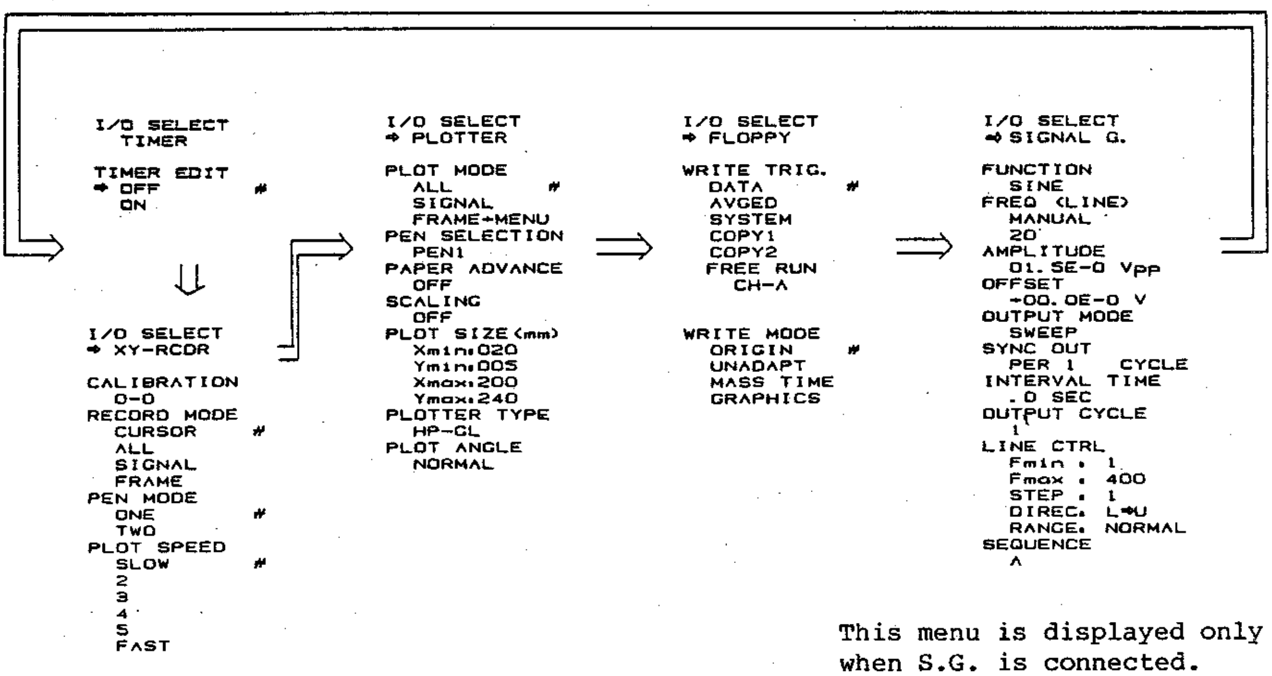


Figure 8-4 Menus for Selecting Peripheral Devices

(3) Execution with the EXECUTE key
To start control over the selected peripheral devices, press the EXECUTE key (2). When the LED in the EXECUTE key is on, the selected devices are being operated.
If the key is pressed again while this LED is on, operations of the selected peripheral devices can be terminated.

8.4 OPERATING PROCEDURES OF DIGITAL PLOTTER

8.4.1 Connection and Preparation

(1) Connection

Digital plotters that can be connected to this analyzer are the TR9835/9835R, TR9832 of Advantest Corporation, and Hewlett Packard HP-GL plotter.

The Advantest digital plotter uses a TR13207 interface as a GPIB option. The Hewlett Packard HP-GL plotter should be provided with a HP-IB interface.

TR9407 is connected to each plotter with an Advantest GPIB standard bus cable (to be purchased separately). Connect the 24-pin GPIB connector on the rear panel of the analyzer and the 24-pin GPIB connector on the rear side of the plotter.

Use a thick ground cable to assure reliable operations. Connect the GND terminals of the TR9407 and the plotter

CAUTION

Read the Operation Manual of the plotter before connecting it or switching the power on. Use the shielded GPIB standard bus cable to prevent improper operation and introduction of noise.

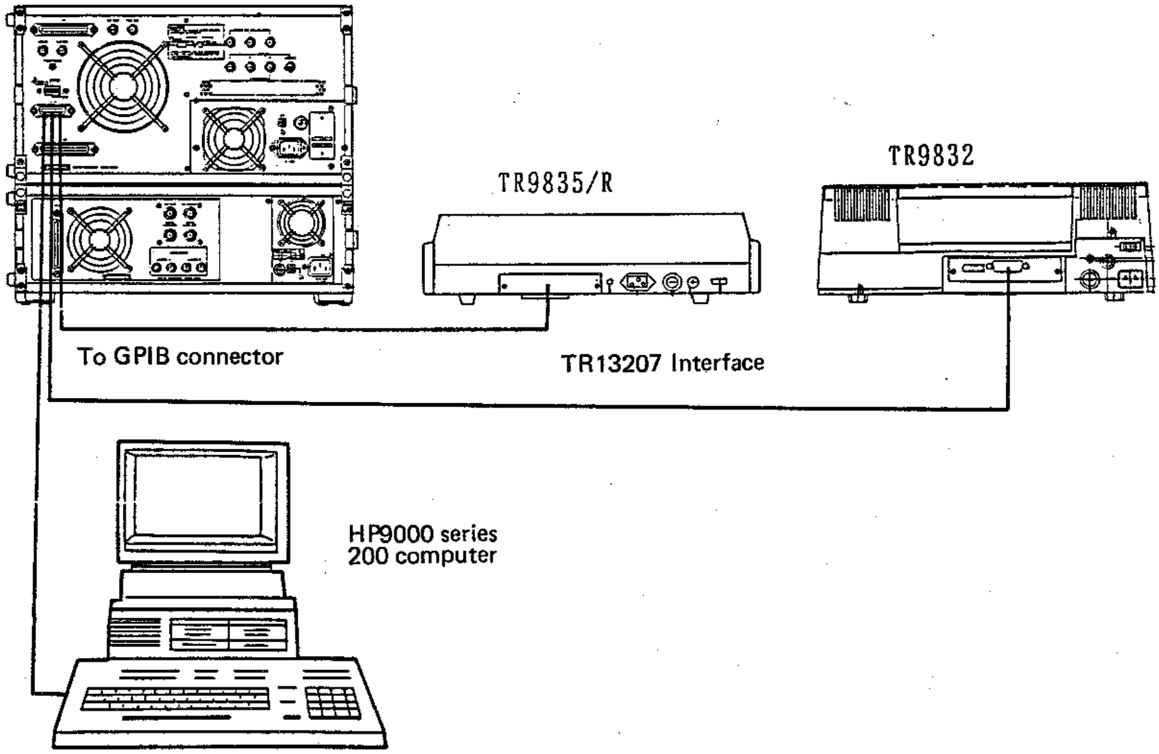


Figure 8-5 Connecting TR9407 and TR9835/9835R/9832

8.4.2 Description of the TR9835/R Panels

(1) Operation panel
Figure 8-6 shows the TR9835/R operation panel.
Functions and operations of the keys used when the TR9835/R is connected are described below.

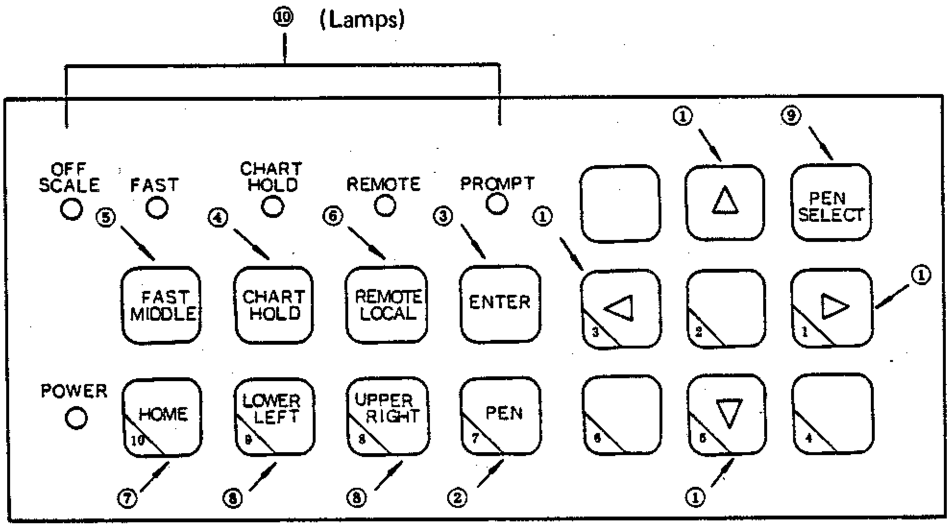


Figure 8-6 Operation Panel

① POSITION (non-lock push button switch)

Four switches are used for four directions (+X, -X, +Y, and -Y).
When one or two of these switches is (are) pressed, the pen moves in the 45° direction.
When the FAST/MIDDLE switch is set to FAST (FAST lamp is on), holding the POSITION switch pressed will increase the pen speed to about 10 cm/sec.
If a POSITION switch is pressed while another POSITION switch is pressed, the pen speed is once decelerated then accelerated.
When the FAST/MIDDLE switch is set to the MIDDLE, the pen moves step by step by pressing a POSITION switch and releasing it immediately (within 0.15 second). If the switch is kept depressed, the pen moves at a speed of about 2 mm/sec.
These POSITION switches are effective in the REMOTE mode in which the PROMPT lamp is blinking during execution of CALL GIN instruction as well as the LOCAL mode.

(2) PEN: Non-lock push button switch

Pressing this switch will move the pen downward. Pressing the switch again will move the pen upward. This switch is effective in the LOCAL mode when the power LED blinks during execution of a CALL instruction in the REMOTE mode.

(3) ENTER: Non-lock push button switch

This switch has three functions.

a) If this switch is pressed in the LOCAL mode, the PROMPT lamp blinks, and while it blinks, set the plotting range with the LOWER LEFT and UPPER RIGHT switches and the current position of selected pen. When the setting is completed, LED lights.
b) When a CALL GIN instruction is received in the REMOTE mode, the PROMPT LED blinks. If this switch is pressed at this time, the current pen coordinates and status are transferred to the external controller. When the transfer is completed, the lamp goes off.

c) Press this switch together with [△] or [▽ 6] (release [△] or [▽ 6] first). The operation at power on (initialization) takes place.

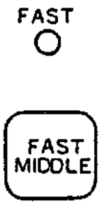
(4) CHART HOLD switch

This is a non-lock push button switch.
The TR9835R can use roll or leaf paper. The switch function and operation depend on the paper type.

a) Leaf paper
When the CHART HOLD switch is pressed in to ON, recording paper is fixed to the panel (electrostatic plate). When this switch is set to OFF, electrostatic adhesion stops.

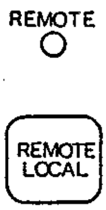
b) A roll of paper
When a roll of paper is used, do not press the CHART HOLD switch. When the CHART HOLD switch is set to ON, paper will not be fed if the MANUAL FEED switch of the TR9835R is pressed, or perforation of the roll paper becomes stuck and breaks at the time of feeding.

(5) FAST/MIDDLE switch



This is a non-lock push button switch.
This switch is used to determine the maximum plotting speed. When this switch is set to FAST, the maximum plotting speed is 45 cm/sec. When it is set to MIDDLE, the maximum plotting speed is 22.5 cm.
Usually, set this switch to FAST.

(6) REMOTE/LOCAL

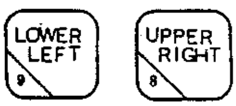


This switch is used to select a REMOTE or LOCAL mode.
When the power is switched on, the REMOTE mode is selected automatically. These two modes are switched at each press of the switch. Observe the red REMOTE lamp (10) to check the selected mode (REMOTE or LOCAL).

(7) HOME: Non-lock push button switch

When this switch is pressed, the pen is lifted and moved back to the home position.
This switch is effective when the PROMPT lamp blinks during execution of a CALL GIN instruction in the LOCAL or REMOTE mode.

(8) LOWER LEFT : Non-lock push button switch
UPPER RIGHT: Non-lock push button switch



These switches are used to set the plotting range according to the size of the recording paper. These switches are effective in the LOCAL mode.

a) The plotting range can be set. If these switches are pressed immediately after pressing the ENTER switch (the PROMPT LED is blinking), the current pen position is set as the lower left or upper right position.
If an instruction requiring plotting outside the plotting range is given after specifying the plotting range, the plotter plots a chart only within the plotting range, lights the OFF SCALE LED, and sets the OFF SCALE status in that direction to 1.

b) If these switches are pressed when the ENTER switch is not pressed, the pen moves to the preset LOWER LEFT or UPPER RIGHT point. This function is convenient for checking the plotting range.

(9) PEN SELECT: Non-lock push button switch

This switch is used to select the PEN SELECT mode.
This switch is effective only in the ONLY mode.
If this switch is pressed in the LOCAL mode, the REMOTE LED blinks and the PEN SELECT mode is selected.
If a SELECT switch having a number (1 - 10) at the lower left corner is pressed, the corresponding pen is selected. Upon selection of a pen, the PEN SELECT mode is cancelled immediately. To select the next pen, repeat the above procedure.

CAUTION

Never set pens in pen holders after the power is switched on.

(10) Status indication lamps

(2) Paper feeder panel

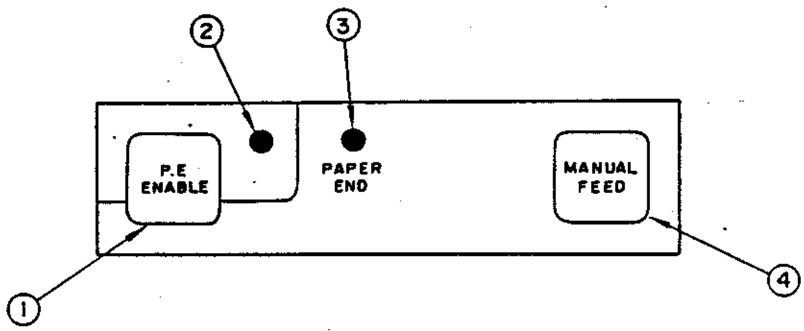


Figure 8-7 Paper Feeder Panel

① PAPER END (P.E.) switch (① to ④ are provided only for the TR9835R)
This is a non-lock push button switch used for a leaf of paper. When a leaf of paper is used, the PAPER END lamp ③ is on. Press this switch to cancel the paper end state.

② PAPER END ENABLE lamp
This lamp goes on when the power is switched on.
When a roll of paper is used: Lamp on
When a leaf of paper is used: Lamp off

③ PAPER END lamp
With the PAPER END ENABLE switch set to ON (lamp on), this lamp goes on when the roll paper end is detected, then plotting stops.

④ MANUAL FEED switch
This is a non-lock push button switch.
Paper is fed while the REMOTE/LOCK switch ⑥ is set to LOCAL.

(3) TR9835/R rear panel
Figure 8-8 shows the TR9835/R rear panel.

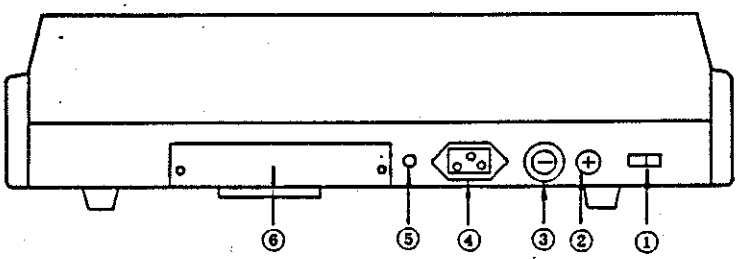


Figure 8-8 TR9835/R Rear Panel

① POWER switch
When this switch is set to the . marked position, power is supplied and the POWER LED goes on.

CAUTION

When setting this switch to ON/OFF, make sure that the TR9407 is powered. When a GPIB controller is connected, confirm that both the controller and TR9407 are powered.

(2) Glass tube fuse holder

Line voltage	Slow-blow fuse rating
AC100, 110, 117V	2A
AC200, 220, 240V	1A

(3) Selecting a line voltage

Setting position	Supply voltage	
	100V	200V
	110V	220V
	117V	240V

(4) AC connector
Supply AC power by connecting the provided power cable.

(5) GND: Ground terminal (screw dia.: M6)
Connect to the frame and middle point of filter.

(4) Setting TR9835/R recording paper
When the TR9835 is connected to the TR9407 for plotting, the plotting range on one screen is limited to JIS A4 size.

a) Plot to a roll of paper (TR9835R)
Refer to Section 3.2 "Setting Recording Paper" of TR9835R (TR5301-A) Plotter Operation Manual for the roll paper setting method.
An A4-sized cut mark is provided and roll paper is fed 21 cm for one screen.

b) Leaf paper (TR9835 or 9835R)
Figure 8-9 shows the leaf paper setting method. Set the A4 recording paper laterally on the left side of the top panel. Set the CHART HOLD switch on the TR9835/9835R panel ON and let the recording paper be stuck to the top panel by static electricity.

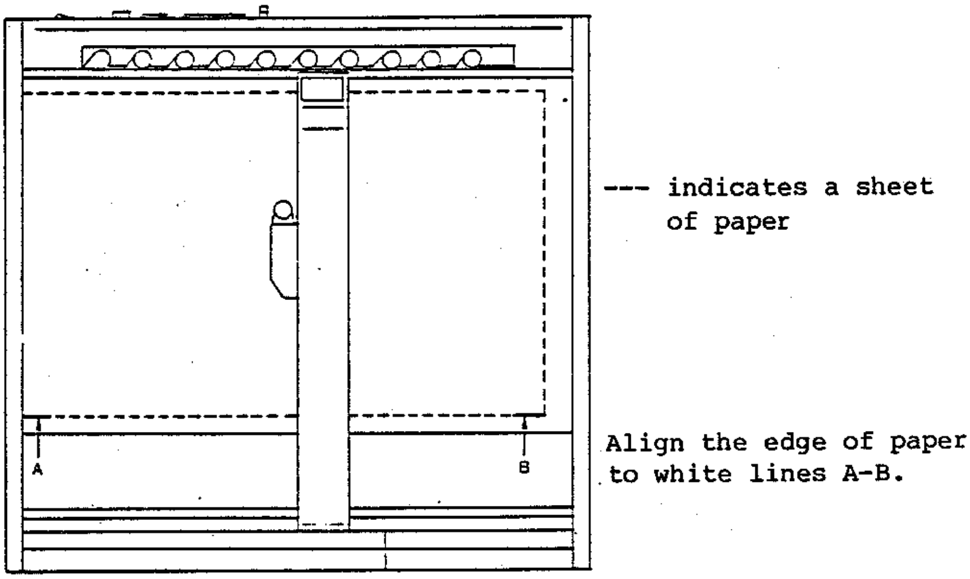


Figure 8-9 Setting Leaf Paper

8.4.3 Panel Description of the TR9832

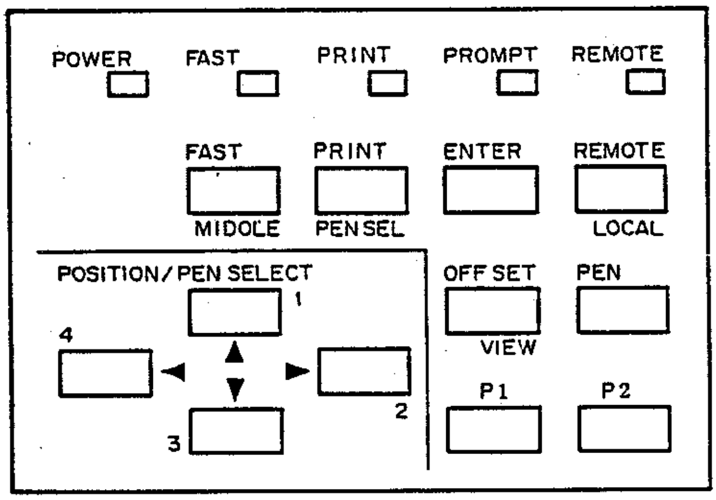


Figure 8-10 TR9832 Panel

(1) POSITION/PEN SELECT
There are four POSITION/PEN SELECT keys.

a) Specifying a pen movement direction
When one or two of these switches are pressed, the pen moves in the axial or 45° direction. When the FAST lamp is on (FAST mode), the pen moves at a speed of approximately 8 cm/sec. When the FAST lamp is off (MIDDLE mode), the pen is moved step by step (0.1 mm) by releasing this switch immediately after pressing it (within about 0.15 sec.). If this switch is pressed and held continuously, the pen moves at a speed of 2 cm/sec.

b) Selecting a pen
When the PEN SEL switch and one of four switches 1 - 4 are pressed simultaneously, the corresponding pen is selected.
Note: This switch is effective in the local mode (REMOTE LED off) or when a CALL GIN instruction is executed (PROMPT lamp blinks).

(2) PEN
This switch is used to move the pen up and down. When this switch is pressed, the pen moves downward. When it is pressed again, the pen moves upward.
Note: This switch is effective in the local mode (REMOTE LED off) or when a CALL GIN instruction is executed (PROMPT lamp blinks).

(3) ENTER
This switch has five functions.

a) Transferring the current pen coordinates and states
When a CALL GIN instruction is accepted in the REMOTE mode, the PROMPT lamp blinks. If the ENTER switch is pressed at this time, the current pen coordinates and state are transferred to the external controller. When the transfer is completed, the PROMPT lamp goes off.

b) Setting the plotting scale
Press the ENTER switch, then press the P1 or P2 switch to reduce the plotting scale.

c) Resetting the plotter
Press the ENTER switch and a position switch ▼3 (+X) or ▲1 (-X) simultaneously and the plotter assumes the initialization state (same as the power is switched on).
Note: Release the ▼3 (+X) or ▲1 (-X) switch earlier than the ENTER switch.

d) Setting the print mode
This switch is used to switch the graphic mode to the print mode or vice versa.
When this switch is pressed in the LOCAL mode, the PROMPT lamp blinks. If the PRINT switch is pressed, the PRINT lamp goes on to indicate that the PRINT mode has been set.
When this switch is pressed in the PRINT mode, the PROMPT lamp blinks. If the PRINT switch is pressed, the PRINT lamp goes off to indicate that the GRAPHIC mode has been set.

e) Moving the plotting origin
When this switch is pressed together with the OFFSET switch, the plotting origin moves. If the ENTER switch is pressed in the LOCAL mode, the PROMPT lamp blinks. Move the pen with POSITION switches ▲1, ▲2, ▲3, and ▲4, then press the OFFSET switch to define the pen position as the plotting origin.

(4) VIEW
This switch performs the same function in both REMOTE and LOCAL modes. When this switch is pressed once, the pen carriage moves to the VIEW position, the PROMPT lamp goes on, and the next pressing of this switch is waited for.
If this key is pressed again, the VIEW operation is performed (one round operation in grid direction) and the PROMPT lamp goes off.

(5) FAST
This switch is used to set the maximum plotting speed. When the power is switched on, this switch is automatically set to FAST (the FAST LED goes on). When this switch is pressed once, the MIDDLE mode is selected and the FAST LED goes off. When this switch is pressed again, the FAST mode is selected.
When this switch is set to FAST, the maximum plotting speed is 40 cm/sec. When it is set to MIDDLE, the maximum plotting speed is 20 cm/sec.
If this switch is pressed during plotting, the speed changes after the current vector is plotted.

(6) REMOTE
This switch is used to switch plotter operation modes. When the REMOTE LED is off, the LOCAL mode is selected. When the LED is on, the REMOTE mode is selected.
In the REMOTE mode (a computer is connected for plotting), the plotter plots data from the external controller.
In the local mode, the plotter transfers data from the external controller into the buffer (until the buffer becomes full). In this case, plotting is not performed and data is held in the buffer.
When the power is switched on, the REMOTE mode is selected automatically.
When modes are switched from REMOTE to LOCAL, plotting is interrupted after the current command is completed.

7 P1 and P2 (in LOCAL mode only)
These keys are used to reduce the plotting scale.
The size of the data input into the plotter is reduced according to this setting.

a) If the ENTER switch has been pressed just in advance (the PROMPT lamp blinks), pressing these switches will set the current pen position as P1 or P2. Thus, the plotting scale can be set.
b) If the ENTER switch has not been pressed, pressing one of these switches will move the pen to the previously set position P1 or P2.

8 PEN SELECT (in LOCAL mode only)
This switch is used to select the PEN SELECT mode.
When a POSITION switch, 1 - 4, is pressed with the PEN SELECT switch pressed, the corresponding pen is selected.
Switching between the high speed plotting mode (coarse resolution) and fine mode is made by turning the rotary digital switch inside the bottom cover of the TR9832.

8.4.4 Interface Setup

(1) Connection between the TR9407 and the plotter alone
Set the TALK ONLY/ADDRESSABLE bit of the ADDRESS switch on the rear of the TR9407 to TALK ONLY. Then set the LISTEN ONLY/ ADDRESSABLE switch on the rear of the plotter to LISTEN ONLY.
(As for the HP-GL plotters, designate LISTEN ONLY referring to the instruction manual of respective plotter.)
After these switch settings are completed, switch on both instruments. The TALK lamp in the GPIB section of the TR9407 and the REMOTE and PEN 1 lamps on the operation panel of the TR9835R or POWER lamp on the TR9832 will come on.

(2) Setup including a GPIB controller
Set the TALK ONLY/ADDRESSABLE bit of the ADDRESS switch on the TR9407 to ADDRESSABLE. Then set the LISTEN ONLY/ADDRESSABLE switch on the plotter to ADDRESSABLE. After completion of these setup, switch on the controller, TR9407, and plotter.

NOTE

The power to the plotter should be turned on or off while the TR9407 analyzer is powered. If a GPIB controller is included in the system, the power to the plotter should be turned on or off only while both the TR9407 and GPIB controller are powered.

Noise derived from switching of POWER ON/OFF of a plotter may cause improper operation to the connected equipment through the interface signal line. Minimize manipulation of the POWER switch during operation of equipment connected to the plotter.

8.4.5 Automatically Divided Plotting on A4-sized paper

Plots of 1 to 6 divisions can be drawn on A4-sized paper using the following procedure:

① Set the ADDRESS switch on the rear panel of the TR9407 to TALK ONLY.
② Set the plotter to LISTEN ONLY.
③ Switch ON power to the TR9407.
④ Switch ON power to the plotter.
⑤ Connect the GPIB cable to the TR9407 and the plotter.
⑥ Take a measurement.
⑦ Put A4-sized paper in the plotter.
⑧ [I/O], [PANEL RECALL ■], M[CROSS-CORR. □] : Display the "PLOTTER" menu.
: PLOT MODE : ALL
PEN SELECTION: AUTO
PAPER ADVANCE: OFF
⑨ [⇧] [⇩], [SETUP] [DISP.] : Select the "PLOTTER TYPE".
⑩ [⇧] [⇩] : Place the pointer (⇨) to "Xmin:" of "PLOT SIZE".
⑪ Keys with green characters:
Key in a character string corresponding to the desired division type. (V ○○ or H ○○ , see next page)
⑫ Display analysis data to be plotted with or without menu.
⑬ I/O [EXECUTE ■] : Start plotting.
'Position number' increments automatically from V21 to V22 after plotting.
⑭ Display the next trace to plot on completion of the current plot.
Press [EXECUTE □].

(1) Commands for automatic plotting and their meanings

① Commands for automatic vertical plotting
[Command format]

```
V x y
↑ ↑ ↑
│ │ └── Plotting order (plot position)
│ └──── Number of plots
└────── Vertical plotting
```

This means plotting in the position of the yth plot of x plots drawn vertically on A4-sized paper

Number of plots	Command name
1	V11
2	V21, V22
3	V31, V32, V33
4	V41, V42, V43, V44
5	V51, V52, V53, V54, V55
6	V61, V62, V63, V64, V65, V66

② Commands for automatic horizontal plotting
[Command format]

H x y

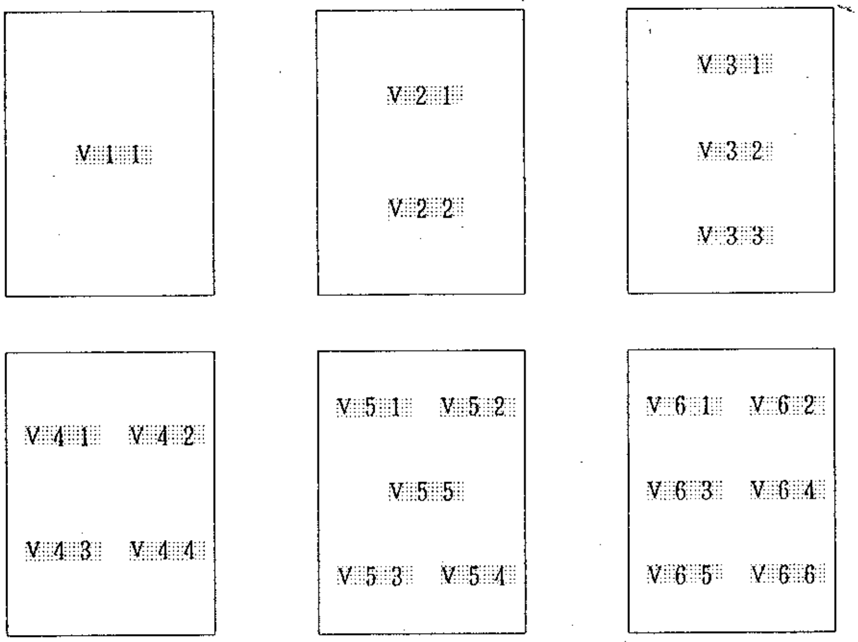
Plotting order (plot position)
Number of plots
Horizontal plotting

This means Plotting in the position of the yth plot of x horizontal plots on A4-sized paper

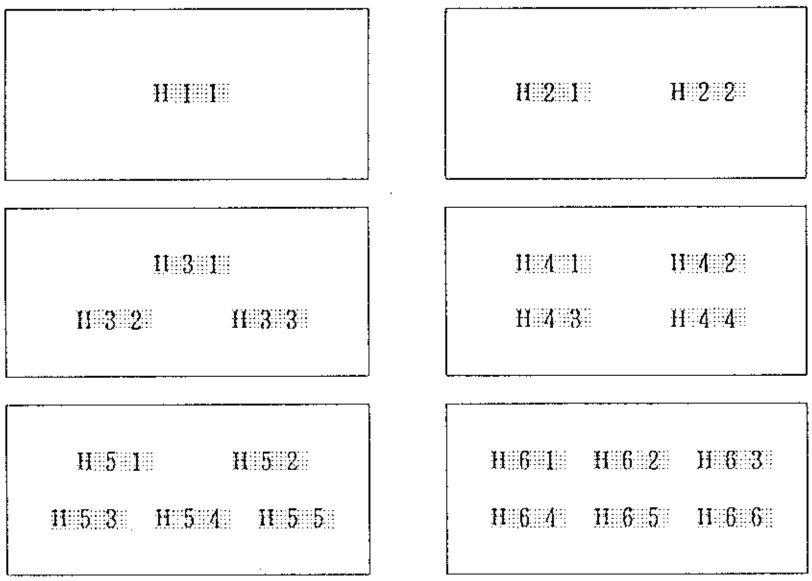
Number of plots	Command name
1	H11
2	H21, H22
3	H31, H32, H33
4	H41, H42, H43, H44
5	H51, H52, H53, H54, H55
6	H61, H62, H63, H64, H65, H66

(2) Types of automatic plotting on A4-sized paper

① Types of vertical plotting



② Types of horizontal plotting



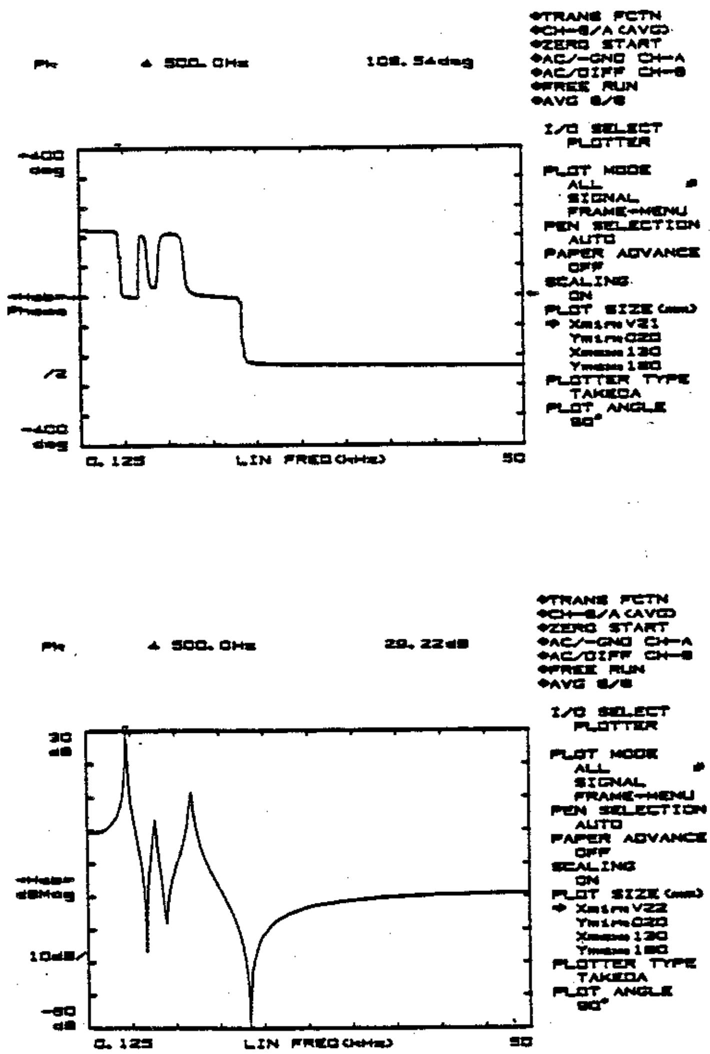


Figure 8-11 Examples of Plotting by V21 and V22

8.4.6 Description of Plotter Menu

Press [I/O] [PANEL RECALL] , [CROSS-CORR. M] to display plotter menu.

```
I/O SELECT
⇨ PLOTTER

PLOT MODE
  ALL          #
  SIGNAL
  FRAME+MENU
PEN SELECTION
  AUTO
PAPER ADVANCE
  SCALE
SCALING
  OFF
PLOT SIZE (mm)
  Xmin:020
  Ymin:005
  Xmax:200
  Ymax:240
PLOTTER TYPE
  HP-GL
PLOT ANGLE
  NORMAL
```

ALL : Plots all information displayed.

SIGNAL : Plots only the waveform (to superimpose data, make plotting first in the ALL or FRAME+MENU mode, then in the SIGNAL mode)

FRAME+MENU: Plots only the scale, label, and menu information.

If AUTO is selected, two-color plotting is made using PEN1 and PEN2.

Automatic paper feed function. Set this to A4 to feed paper leftward by about 21 cm; set this to SCALE, to feed paper leftward by the distance specified by Xmax (min). Applicable to the TR9835R plotter.

OFF: Plotting is made in A4 size.
ON : Plotting is made in the size specified by PLOT SIZE.

Set four points to define the plotting area as desired.
For plots automatically divided on A-4 size paper, enter V◯◯ or H◯◯ at Xmin: to define the size and the number of plots.

NORMAL: Plotting is performed along the x-axis and y-axis of a HP-GL plotter.

90° : Plotting is positioned 90 degrees counterclockwise with respect to the x-axis and y-axis of a HP-GL plotter.

The opposite is true when the PLOTTER TYPE is set to ADVANTEST.

Figure 8-12 "PLOTTER" Menu

(1) Menu selection and plotting operation

Press the I/O key in the SETUP section on the TR9407 front panel to display the I/O SELECT menu on the CRT. Position the pointer to item "PLOTTER" in the menu. This will show a plotter setup menu as shown in Figure 8-12.

Then operate [⇧], [⇩], and [DISP.], [SETUP] keys in the SETUP section and [⇦], [⇨] keys in the GENERAL CURSOR section to select the appropriate modes from the PLOT MODE, PEN SELECTION, PAPER ADVANCE, SCALING, PLOT SIZE, PLOTTER TYPE and PLOT ANGLE menu.

Plotting can be started by pressing the EXECUTE key just beside the I/O key while the I/O SELECT menu is set up for the PLOTTER (the menu need not be shown on the display). During plotting, the lamp within the EXECUTE key lights and the measurement functions of the TR9407 are disabled. During plotting, the message

"PLOTTER IS PLOTTING!"

is shown in the bottom left area on the CRT. When all the plotting data has been transferred to the plotter, the lamp on the EXECUTE key goes off even if plotting is not completed, and an electronic "pip" tone sounds several times repeatedly. The measurement functions of the TR9407 are now enabled and the next plotting data transfer becomes ready.

If the lamp within the TR9407 EXECUTE key goes off, the plotter will continue plotting so far as plotting data still remains in its buffer memory. When plotting is completed, the TR9835R automatically performs a paper feed operation of A4 size span (approximately 21 cm). If the EXECUTE key is pressed when its lamp is on, the current plotting will be suspended. In this case as well, the EXECUTE key lamp will go off, "pip" tone will sound several times, and the TR9835R will perform a paper feed operation. If the plotter does not start plotting when the EXECUTE key is pressed, any of the following causes may be suspected:

a) Plotter is left switched off.
b) Plotter is in the LOCAL mode.
c) The ADDRESS switch on the rear of TR9407 is not set in the TALK ONLY position.
d) The ADDRESS switch on the rear of the plotter is not set in the LISTEN ONLY position.
e) Improper connection or defective cable.

Most of the illustrated traces appearing in this manual have been plotted by the plotters attached to the TR9407 analyzer. So they may be used as good examples of the plotter performance.

(2) "PLOT MODE" setup

"ALL" : This mode plots all the information currently shown on the TR9407's display (except for the message shown in the bottom information area of the display, such as "OVERLOAD: CH-A"). Figure 6-15 shows a plotting example by TR9835R.

If the PLOT MODE menu is replaced with another menu after the ALL mode is selected on the PLOT MODE menu, the new menu will be plotted. If A4 is selected out of the PAPER ADVANCE menu when plotting is completed, the plotter will plot a cut mark at the end of the plotting area.

If the CHART HOLD switch (TR9835R) is set to OFF at the end of plotting, the paper is automatically fed approximately 21 cm to the left.

"SIGNAL" : In this mode the plotter plots only the graphic information (signal traces) currently shown on the display. If plotting is executed first in the FRAME+MENU mode and then in the SIGNAL mode, the plotter plots the signal traces along with the cursor and the data identified by the cursor in the former mode. In the latter mode, the plotter plots only the signal traces. This combined mode allows for superposition of plotted traces.

If the PAPER ADVANCE menu is set to A4, the plotter will plot a cut mark upon the end of plotting. If the CHART HOLD switch (TR9835R) is set at OFF, a paper feed operation will automatically take place to feed paper by approximately 21 cm to the left.

"FRAME+MENU": In this mode the plotter plots only the scale,label, and menu information currently shown on the display. If the PAPER ADVANCE menu is set to A4, the plotter plots a cut mark (for A4 size) upon the end of plotting. If the CHART HOLD switch (TR9835R) is set to OFF, the plotter automatically performs a paper feed operation of approximately 21 cm to the left.

(3) "PEN SELECTION" setup

"AUTO" : In this mode the plotter automatically selects between pen 1 and pen 2 while plotting. Dual-color plotting is possible by using different colors for pens 1 and 2 each. When signal traces are displayed in the SUPERIMPOSE mode, the trace which would have been shown in the lower display area if the SUPERIMPOSE mode was set to OFF, is plotted by pen 1 along with the vertical scale, and the trace which would have been shown in the upper display area if the SUPERIMPOSE mode was set to OFF, is plotted by pen 2 along with the vertical scale. The cursor and readouts are plotted by pen 1 when the UPPER/LOWER key in the GENERAL CURSOR section is set in the LOWER position (key lamp goes off), and is plotted by pen 2 when the same key is set in the UPPER position (key lamp comes on). In other words, the cursor and readouts are plotted by the pen with which the trace with the cursor is plotted.

When a signal trace is displayed in a mode other than the SUPERIMPOSE mode, the trace, cursor and readouts are plotted by pen 2, while labels, scales, cursor point and measurement conditions are plotted by pen 1.

"PEN 1" : In this mode the plotter uses only pen 1 to plot the information shown on the display.

"PEN 2" : In this mode the plotter uses only pen 2 to plot the information shown on the display.

"OFF" : Since this mode does not make a pen selection, specify a pen manually or by using the controller before plotting.

(4) "PAPER ADVANCE" setup

This menu is effective for the TR9835R and used for setting a paper feed mode after plotting. For the HP-GL plotter, a paper feed is not performed.

"OFF" : In this mode, an automatic paper feed is not performed after plotting. When paper is to be fed with the TR9835R/9832, press the ENTER key on the plotter operation panel to set the LOCAL mode and press MANUAL FEED SWITCH. The recording paper is fed while this key is pressed.

"A4: : In this mode, the A4 cut mark is automatically plotted after a completion of plotting. If the CHART HOLD switch (TR9835R) is set to OFF, the paper is automatically fed "21 cm" to the left.

"SCALE" : Cut mark is automatically plotted upon completion of plotting at a place of "Xmax." If the CHART HOLD switch (TR9835R) is OFF, this mode allows automatic paper feed "Xmax" (mm) to the left.

If the HP-GL plotter is set to "A4", plus signs (+) are plotted at corners (four corners of square enclosed by Xmin, Ymin, Xmax, and Ymax); if it is set to "SCALE," it feeds the paper (only with the plotter having the paper feeding capability) on completing the plot.

(5) "SCALING" setup

"OFF" : Plotting is performed for A4 size. A4 size is equivalent to the "PLOT SIZE" as follows:

a. TR9835R/9832 A4 size
   Xmin: 020
   Ymin: 005
   Xmax: 200
   Xmin: 240 (mm)

b. HP-GL plotter A4 size (This value is not displayed if "PLOTTER TYPE" is set to "HP-GL".)
   Xmin: 010
   Ymin: 010
   Xmax: 270
   Ymax: 185 (mm)

"ON" : Scaling is performed for plotting within the range specified by "PLOT SIZE".

(6) "PLOT SIZE" setup

This setup is effective when the "SCALING" menu is set to "ON". Scaling is performed with the lower left and upper right corners demarcated.

To set values, press the $\boxed{\Leftarrow}$ or $\boxed{\Rightarrow}$ key in the "GENERAL CURSOR" section to blink the values at the setting positions, then press keys with 0-9 inscribed on the lower left side.
When the power is switched on, the values are set to the A4 size for the TR9835R/9832. When the lower left and upper right corners are set, the plotting area is set as shown in Figure 8-13.

Where, ΔX = Xmax - Xmin (mm)
ΔY = Ymax - Ymin (mm)

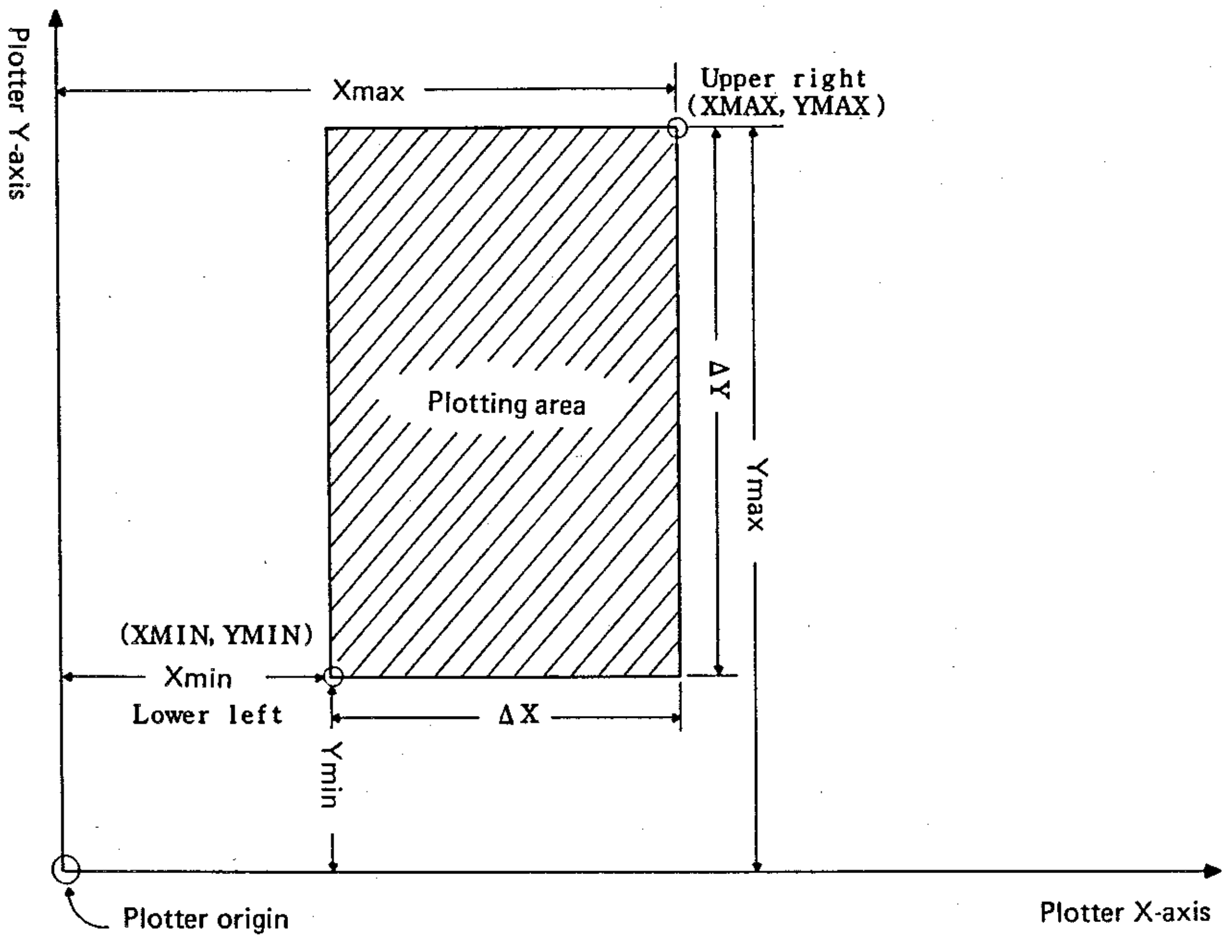


Figure 8-13 Plotting Area Set by "PLOT SIZE" Setup

Scaling is performed within the range enclosed by four points (Xmin, Ymin), (Xmin, Ymax), (Xmax, Ymax), and (Xmax, Ymin) as shown in Figure 8-13. (Unit: mm)
Each value can be set in the range from 0 to 999 (mm); however, the plotting area must be set within the range of the plotter in use.
Values of ΔX and ΔY which gives a graticule frame whose one side length is 10 cm are as follows:

			TR9835R/9832		HP-GL plotter	
	Domain	Display	ΔX	ΔY	ΔX	ΔY
Normal scale	Time	Single	194	203	206	178
		Dual	387	203	206	356
	Frequency	Single	194	174	176	178
		Dual	387	174	176	356
UPSCALING	Time	Single	144	151	153	132
		Dual	288	151	153	264
	Frequency	Single	144	127	130	132
		Dual	288	128	130	264

(In the marker plot function (see 8.4.8), one side of the trace is equivalent to that of the PLOT SIZE.)

When the above values are used, "PLOT ANGLE" must be set to "NORMAL". When 90° is set, values of ΔX must be replaced with values of ΔY.

(7) "PLOTTER TYPE" setup
"ADVANTEST": This is set when the TR9835/9835R/9832 is used.
"HP-GL" : This is set when the HP-GL plotter (Hewlett Packard) is used.

(8) "PLOT ANGLE" setup
"NORMAL" : a. TR9835R/9832 A4 size
Plotting is oriented 90 degrees counterclockwise with respect to the X-axis and Y-axis of the plotter.
b. HP-GL plotter
Plotting is performed along the X-axis and Y-axis of the plotter.
"90°" : a. TR9835R/9832 A4 size
Plotting is performed along the X-axis and Y-axis of the plotter.
b. HP-GL plotter
Plotting is oriented 90 degrees counterclockwise with respect to the X-axis and Y-axis of the plotter.

NOTES ON PLOTTING

(1) If "PLOT SIZE" is not set normally, the low alarm sound is on four times when the EXECUTE key is set to ON and the following message is displayed on the bottom area of the CRT screen:

"PLOTTER IS NOT AVAILABLE!"

When this message is displayed, check whether "PLOT SIZE" is correctly set. "PLOT SIZE" should meet the following conditions:

Xmin < Xmax
Ymin < Ymax
Xmax > 0
Ymax > 0

If the above message is not displayed when the "PLOT SIZE" is correctly set, check the plotter connection according to Section 8.4.1 (1).

(2) The error lamp may be on when the EXECUTE key is pressed to terminate plotting by the HP-GL plotter; however, this does not affect the succeeding plotting.

(3) When the "PLOT ANGLE" is set to "NORMAL" and the value of $\Delta Y/\Delta X$ is equivalent to the ratio of A4 size, that is,

$\Delta Y/\Delta X = 235/180 \fallingdotseq 1.3$ (for TR9835R/9832)
$\Delta Y/\Delta X = 180/260 \fallingdotseq 0.69$ (for HP-GL plotter),

a circle is displayed in the ORBIT or NYQUIST mode.

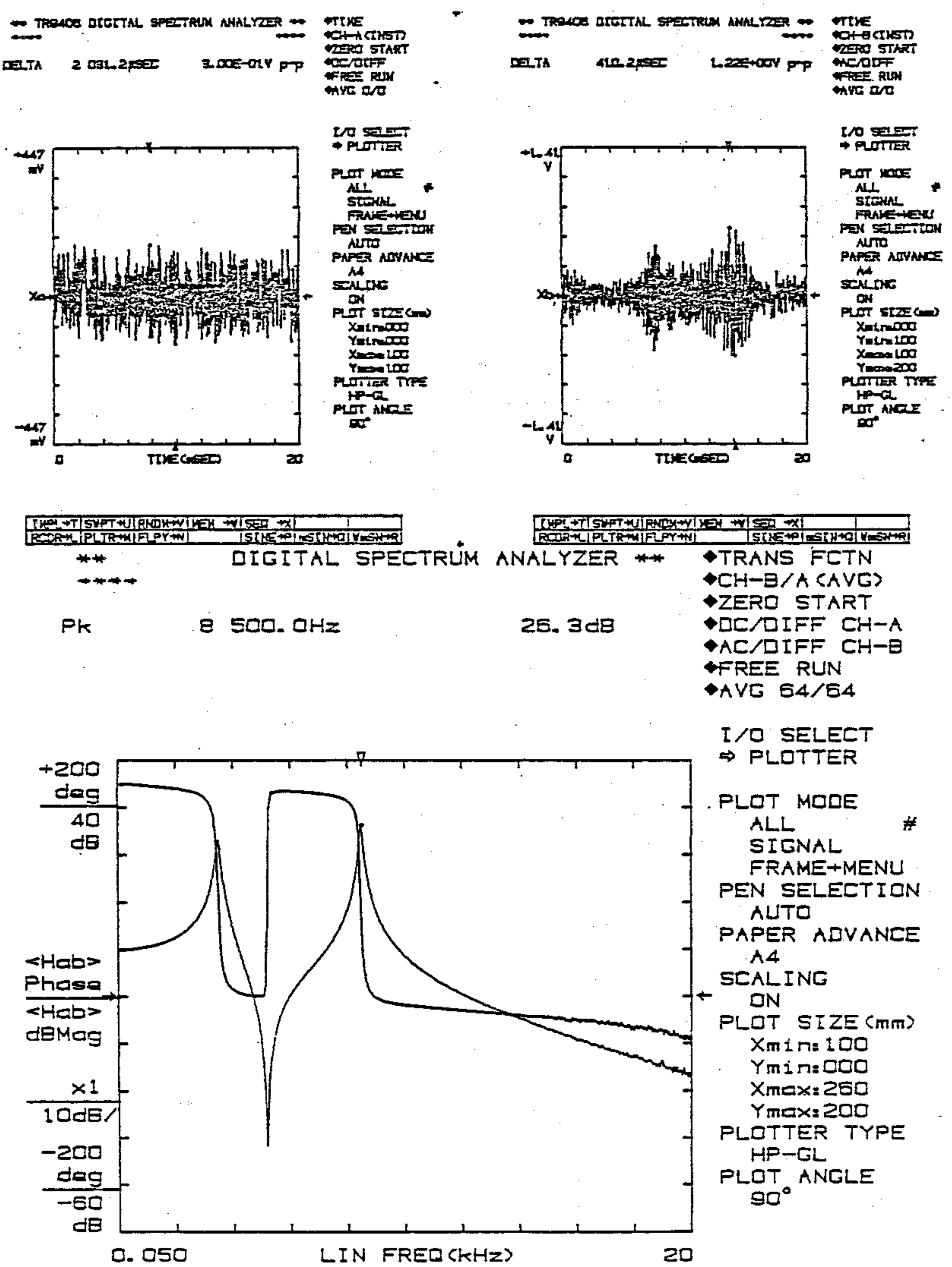


Figure 8-14 Example of Scaling Plot with the HP-GL Plotter

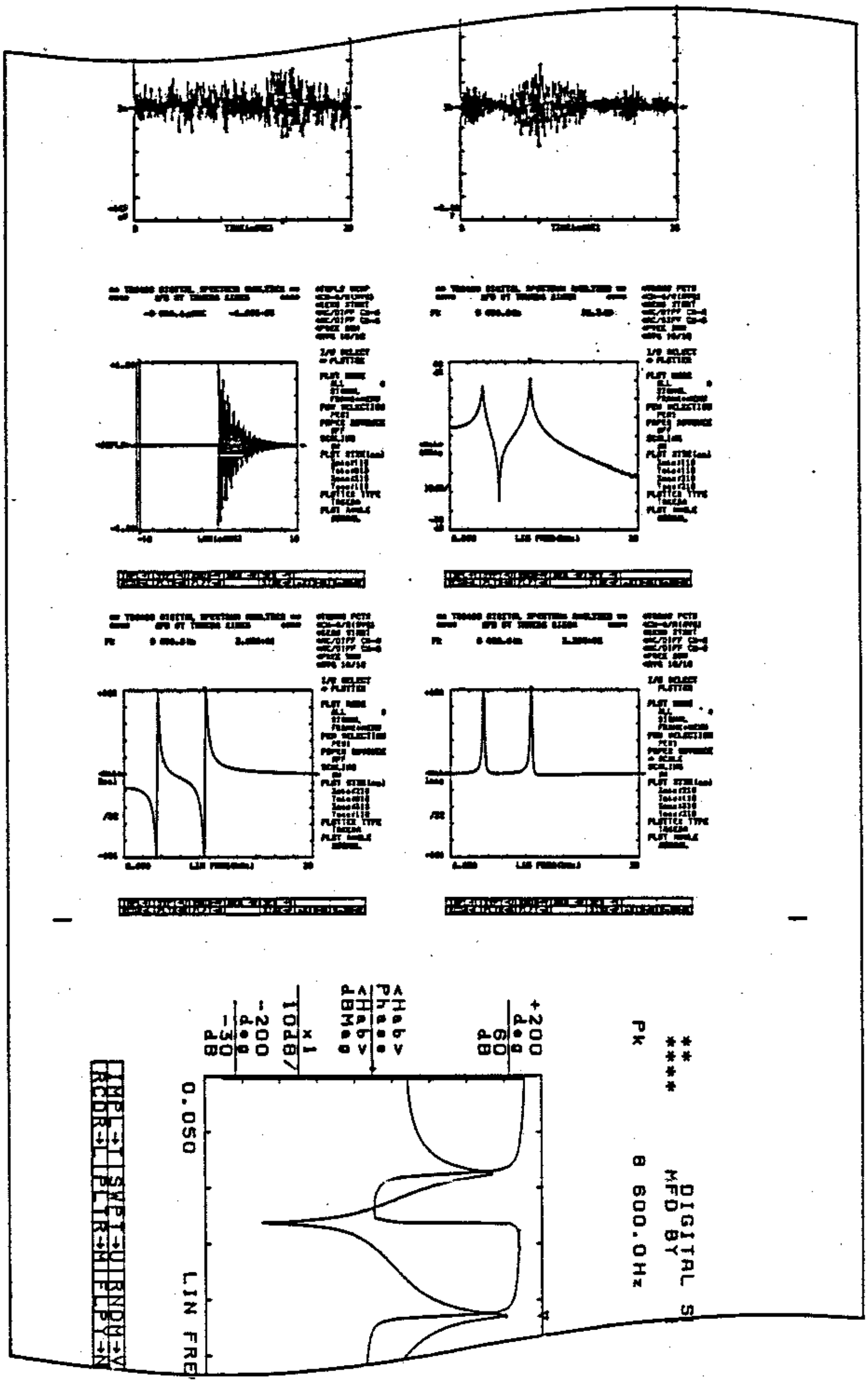
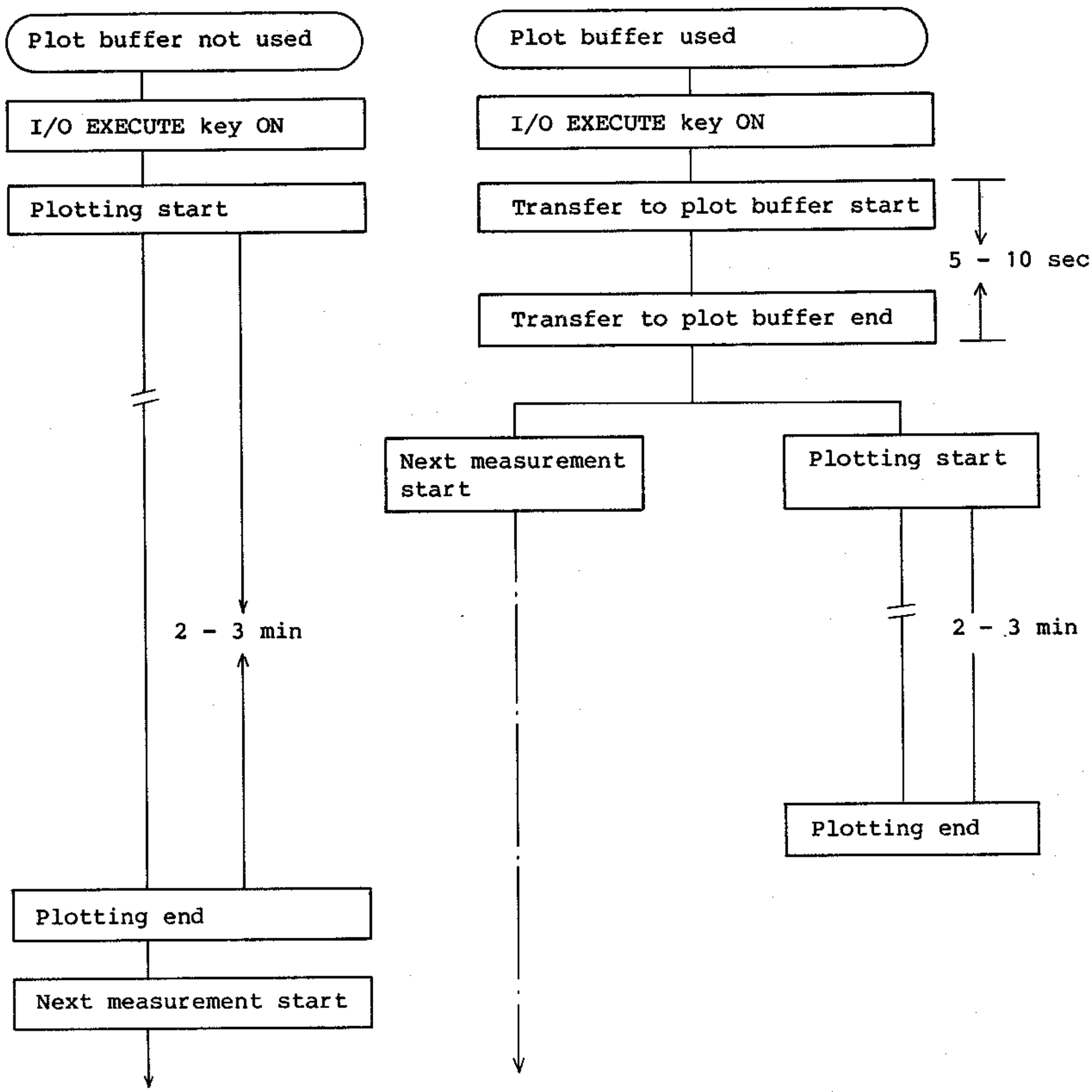


Figure 8-15 Example of Scaling Plot on Roll Paper

8.4.7 Plot Buffer

The plot buffer is used to store plot data before being transferred to the GPIB. Completion of data transfer makes the TR9407 ready to start measurement before the end of plot operation. The difference between plotting using the plot buffer and the plotting without using the plotting buffer is as follows:



When the plot buffer is used, the time from pressing the I/O EXECUTE key to start of next measurement is reduced by the time of plotting.

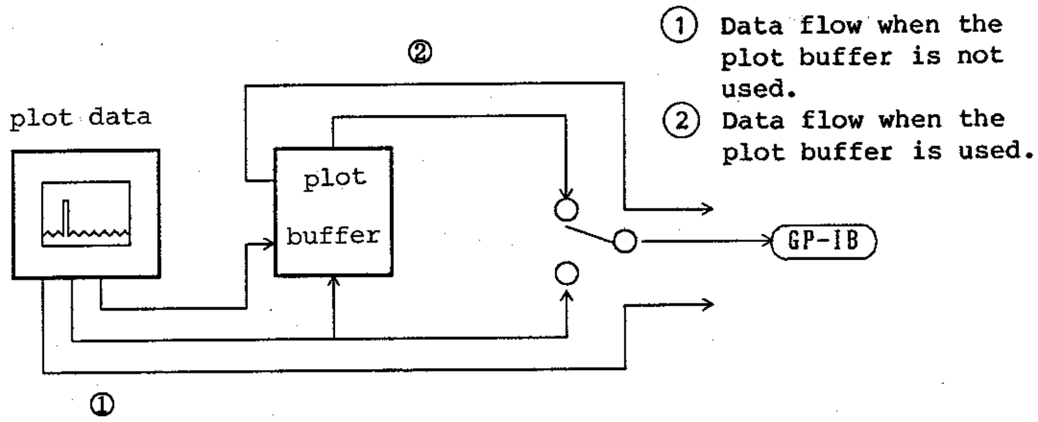


Figure 8-16 Plot Buffer

(1) Operating the plot buffer
The plot buffer does not operate until the following three conditions are satisfied.

(a) Set the TR9407 in the TALK ONLY mode.
(b) Set the HEADER ON.
(c) Set spectrum zoom to OFF.

CAUTION

(1) When spectrum zooming is executed before start of plotting, data is automatically plotted without using the plot buffer. Spectrum zooming is inhibited if plotting is being performed using the plot buffer.

(2) If the I/O key is pressed while the data are being transferred to the plot buffer (5 - 10 seconds), all the data held in the plot buffer are deleted.

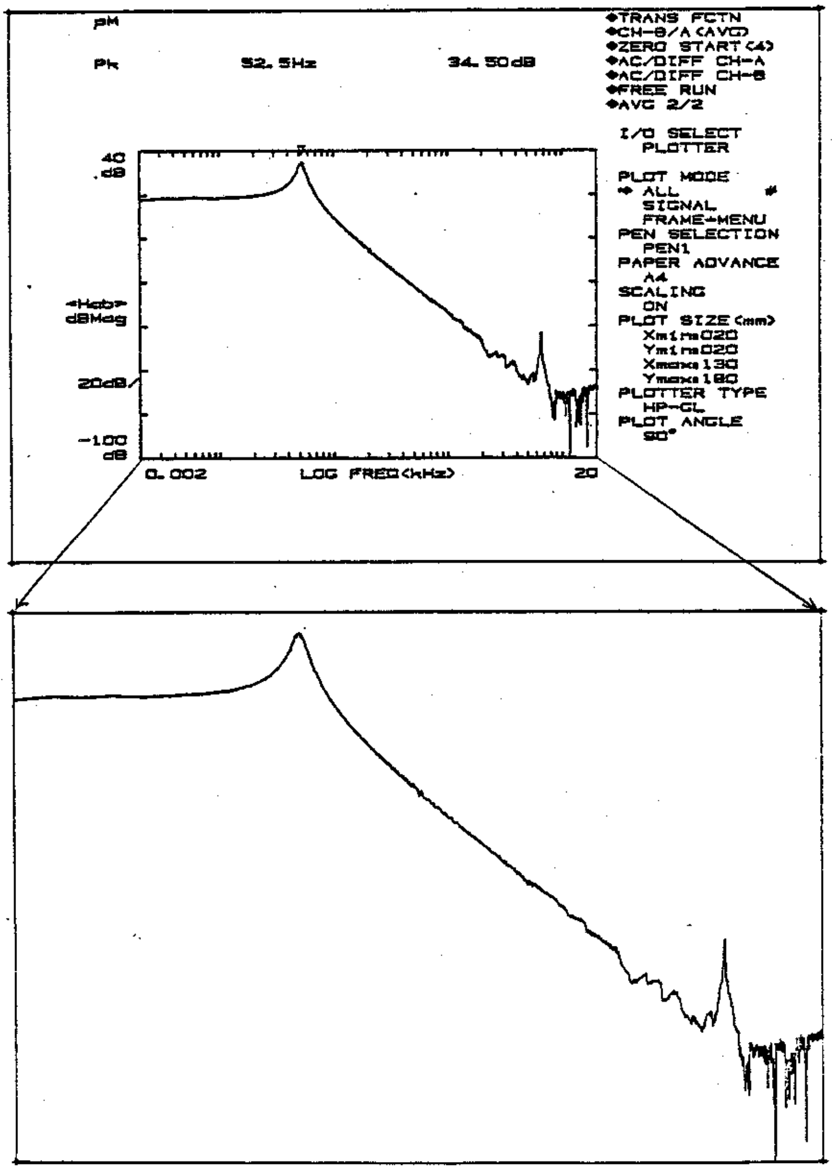
(3) Plotting is interrupted during floppy operation or data transfer to the plot buffer.

8.4.8 Plotting only traces

Only the trace on the screen can be enlarged and plotted by PLOT SIZE in the plotter menu.

When the vertical cursor and reference cursor are set ON, the traces between these two cursors are enlarged by PLOT SIZE.

Since only the trace scale can be set as desired, plotting on the special paper and logarithmic graph on the market is facilitated.



(1) Plotting the whole trace

① UPSCALING Cancel the upscaling function

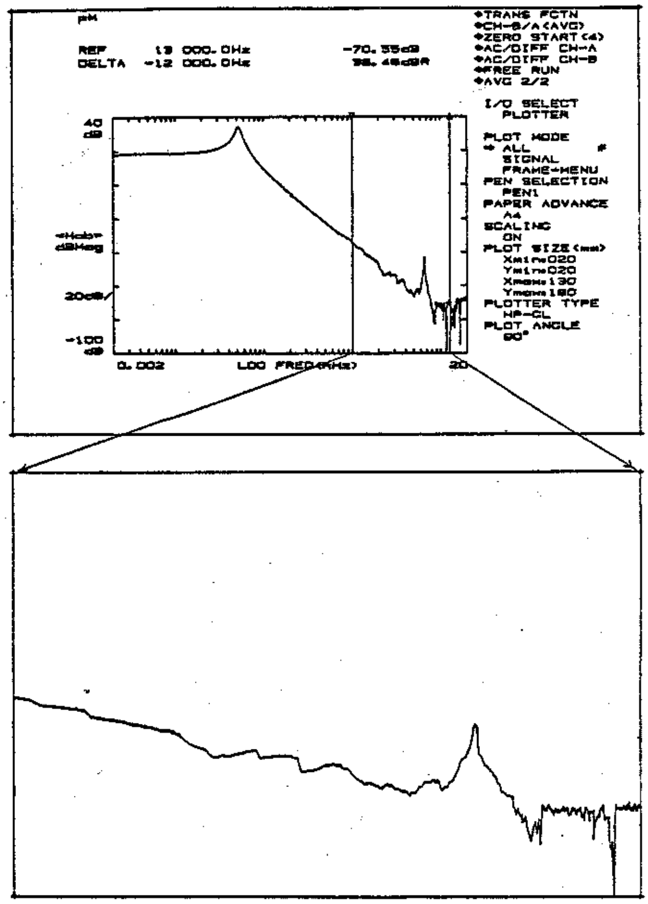
② I/O, PANEL RECALL, CROSS-CORR. Display the plotter menu.
Select SIGNAL from the PLOT MODE item.

③ Set a plot size.

④ LABEL Select the label mode (LABEL lamp goes on) and enter pM at the upper left corner of the screen.

⑤ Press the EXECUTE key in the I/O section.

Figure 8-17 Plotting Trace Alone within the Frame



(2) Plotting the trace between cursors

Press [UPSCALING], then press the follows keys:

[C (↔)] [SET REF. ON/OFF] [SET REF.]

Only the trace between the vertical and reference cursors is plotted on the scale set by PLOT SIZE.

Figure 8-18 Plotting only Trace between Cursors

8.4.9 Superimposed Plotting

Superimposed plotting of more than one signal trace is a very useful means for comparing measurement information taken under different measurement conditions. Superimposed plotting can be executed by using the ALL or FRAME+MENU and SIGNAL modes selected from the PLOT MODE menu. The operating procedure is described:

① Set up the PLOT MODE in the I/O SELECT menu shown on the TR9407 for the ALL or FRAME+MENU mode. If the ALL mode is selected, the signal trace is plotted along with the scale, label, and menu information. If the FRAME+MENU mode is selected, only the scale, label, and menu information will be plotted at first.
② Set up the PEN SELECTION menu.
③ Set the PAPER ADVANCE menu to OFF.
④ Press the EXECUTE key on the TR9407 after making sure that the plotter is placed in the REMOTE mode. This will turn on the lamp within the EXECUTE key and start plotting. When the plotting is completed, the EXECUTE key lamp will go off.
⑤ Set up the PLOT MODE menu to SIGNAL.
⑥ Display the next measurement information on the TR9407's CRT.
⑦ When using the other pen for plotting the new measurement information, set up the PEN SELECTION menu for the other pen mode (PEN 1 or PEN 2) or change pen color.
⑧ Press the EXECUTE key on the TR9407. The plotter will plot only the signal trace shown on the display and then stop without feeding paper.
⑨ To superimpose successive information on the chart, repeat steps ⑤ through ⑧.
⑩ When paper feed is desired (TR9835R only) after the last superimposed information is plotted, set the PAPER ADVANCE menu to the "A4" or "SCALE" before pressing the EXECUTE key. The plotter will automatically feed paper upon the end of plotting.

Figure 8-19 shows plotting example obtained through the above plotting procedure.

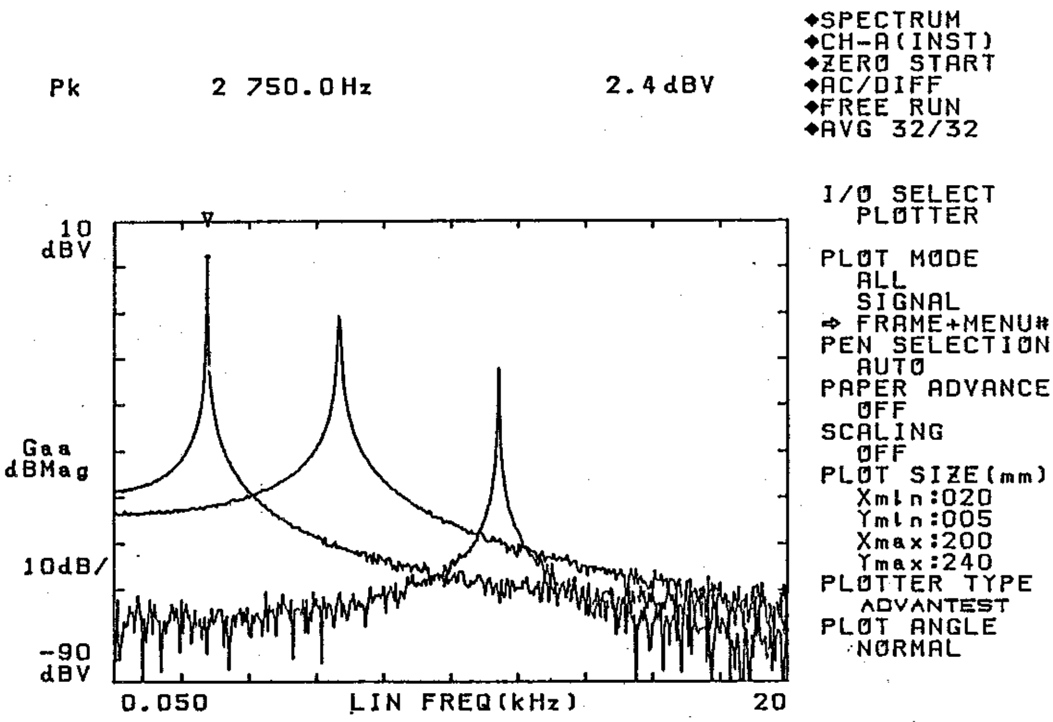


Figure 8-19 Plotting Example (Superimposed Plotting)

8.4.10 Plotter Control over the GPIB

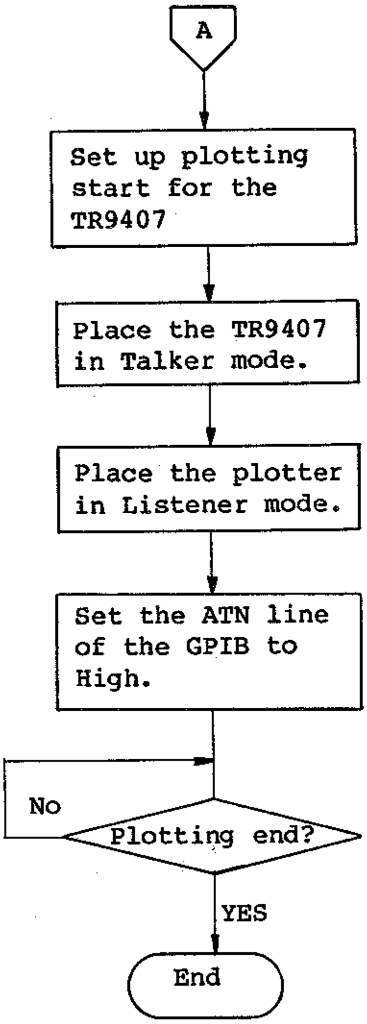
If a GPIB controller and a plotter are attached to the GPIB connector on the TR9407 analyzer, automatic plotting is available on the attached plotter. This makes the analyzer applicable to a larger measurement system because of its added automatic measurement information plotting capability.

(1) Setup
When connecting a GPIB controller to the TR9407, set the TALK ONLY/ADDRESSABLE bit of the ADDRESS switch on the rear of the analyzer to ADDRESSABLE. Similarly, set the TALK ONLY/ ADDRESSABLE switch on the rear of the plotter to ADDRESSABLE. Then supply power to GPIB controller, TR9407, and plotter.

(2) Creating plotting program with a GPIB controller
Plotting program generation flowcharts are shown in the following, along with a GPIB command list concerning plotter control:

Command		Description	Setup read
Function	Setup		
IO	0 to 3	I/O SELECT 0 X-Y RECORDER 1 PLOTTER 2 FLOPPY DISK 3 SIGNAL GENERATOR	o
PM	0 to 2	PLOT MODE 0 ALL 1 SIGNAL 2 FRAME+MENU	o
PP	0 to 2	PEN SELECTION 0 AUTO 1 PEN 1 2 PEN 2	o
PA	0 to 2	PAPER ADVANCE 0 OFF 1 A4 2 SCALE	o
IE	0, 1	I/O EXECUTE 0 STOP 1 START	x
PL	0, 1	SCALING 0 OFF 1 ON	o
PZ		PLOT SIZE NNN, NNN, NNN, NNN (Xmin) (Ymin) (Xmax) (Ymax) (Separate with " ," in the above order)	o
PY	0, 1	PLOT ANGLE 0 ADVANTEST (TR9835/R, TR9832) 1 HP-GL (7470A,7225A HP-GL plotter)	o
PG	0, 1	PLOT ANGLE 0 NORMAL 1 90°	o

START	
Measurement	Set up TR9407's panel conditions over the GPIB and perform pertinent measurement.
Set the I/O SELECT menu to "PLOTTER"	
Select the appropriate "PLOT MODE"	Selects the plotting mode.
Set up the "PEN SELECTION".	Selects the pen to be used.
Set up the "PAPER ADVANCE"	Specifies the paper feed mode upon the end of plotting.
Set up the "SCALING"	Determines ON/OFF of scaling plot
Set up the "PLOT SIZE"	Defines the plot area
Set up the "PLOTTER TYPE"	Selects the plotter type
Set up the "PLOT ANGLE"	Selects the plot direction (X- or Y-axis)
A	



Set up the TR9407 for I/O EXECUTE "IE1".

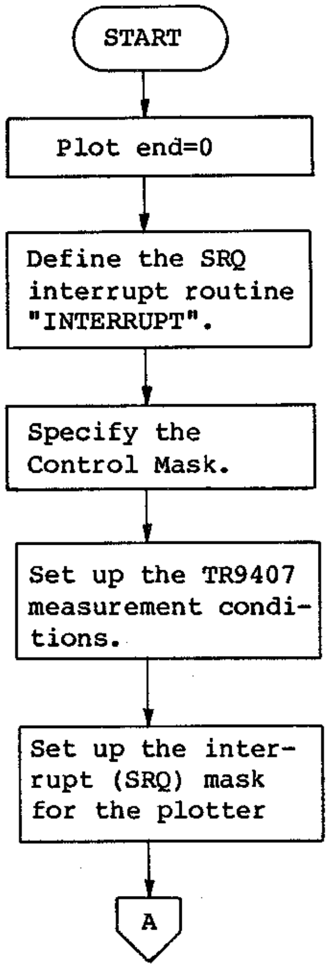
When the ATN line is changed from Low (command mode) to High (data mode), plotting data is transferred from the TR9407 to the plotter.

Upon the end of plotting, the XY-REC/PLT END bit of the status byte is set in the TR9407. If the TR9407 is set up for the "SQ0" mode, it issues a service request (SQR) to the controller.

CAUTION

During plotting, do not deliver any command other than the I/O Execute Stop command "IE0" to the plotter. Otherwise, plotting data transfer to the plotter will be suspended. If this occurs, activate the IFC (Interface Clear) signal to reset the GPIB interface.

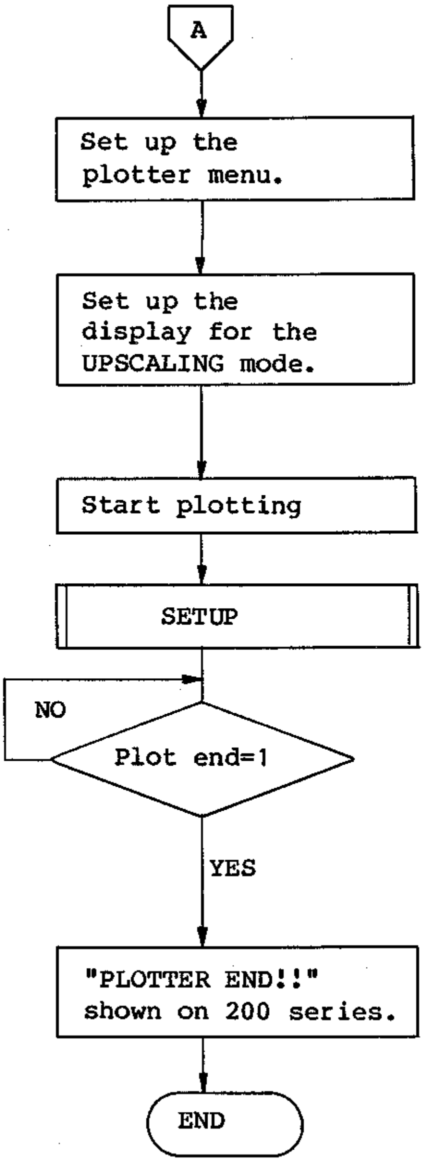
(3) Programming example
The following programming example is obtained on the Hewlett Packard desk-top computer 200 series:



Reset the plotting end flag.

Set up the HP 200 series.

The display shows 50 kHz, +10 dBV range, and SPECTRUM.

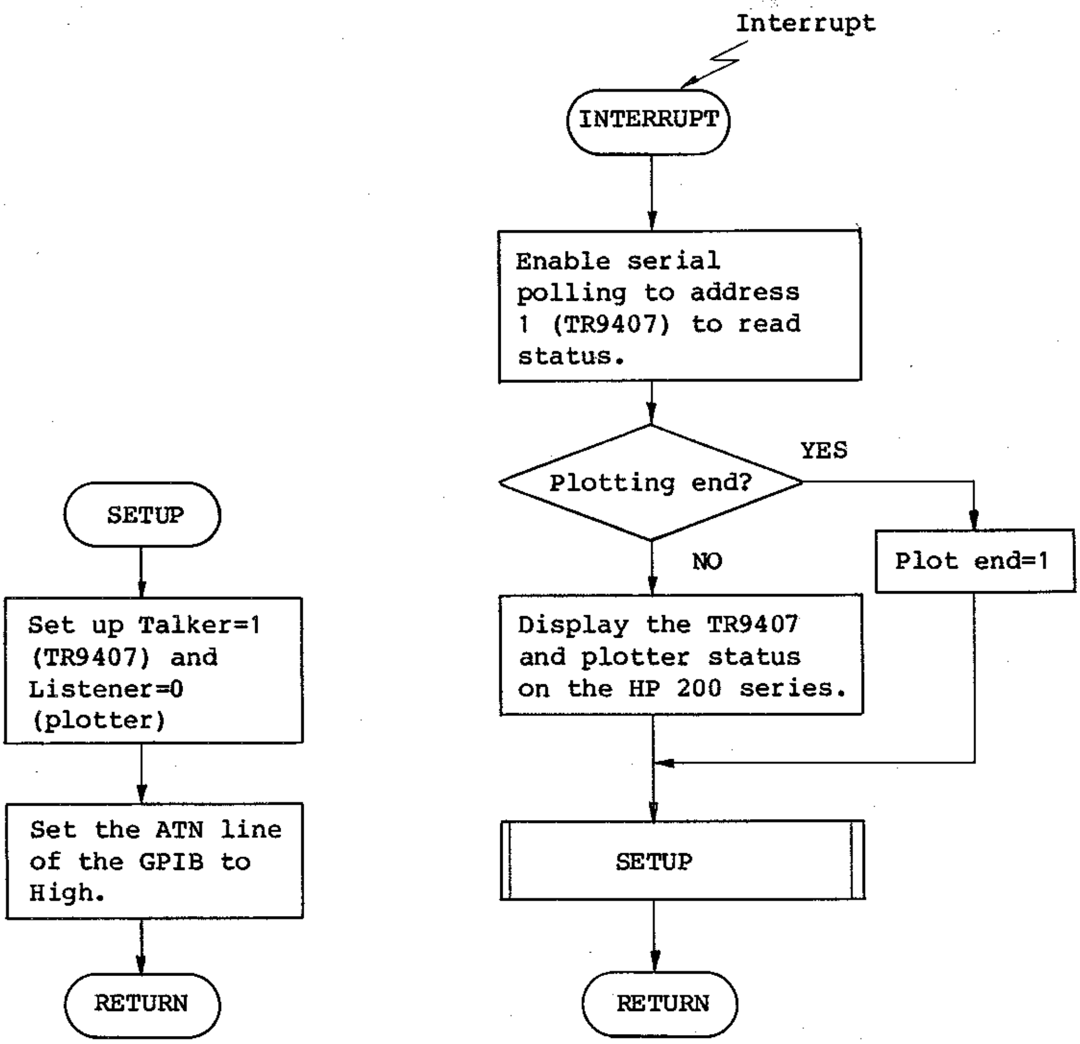


I/O SELECT : PLOTTER
PLOT MODE : ALL
PEN SELECTION : AUTO
PAPER ADVANCE : SCALE
SCALING : ON
PLOT SIZE : 10, 10, 150, 150
PLOTTER TYPE : ADVANTEST
PLOT ANGLE : NORMAL

Send "IE1".

Set up the talker and listener addresses.

Plotting end?


SETUP
Set up Talker=1 (TR9407) and Listener=0 (plotter)
Set the ATN line of the GPIB to High.
RETURN
Interrupt
INTERRUPT
Enable serial polling to address 1 (TR9407) to read status.
Plotting end?
YES
NO
Plot end=1
Display the TR9407 and plotter status on the HP 200 series.
SETUP
RETURN

```
100  !
110  ! *************************************************
120  ! *                                               *
130  ! *    TR9407 Plotting Program With GPIB Control  *
140  ! *    MT File Name: "PLOTEX"                     *
150  ! *                                               *
160  ! *    GPIB ADDRESS--- TR9407=1,TR9835R/32=0      *
170  ! *                                               *
180  ! *************************************************
190  !
200 Start:   REMOTE 7
210          Plotend=0                ! Clear Flag
220          ON INTR 7 GOSUB Interrupt
230          !
240          OUTPUT 701;"FR1VW1AS2"   ! 100kHz,VIEW=SPECTRUM, A-CH SENSE +10dBV
250          WAIT 1
260          OUTPUT 701;"MK189"       ! Set MASK to TR9407
270          OUTPUT 701;"SQ0DL1"      ! Enable SRQ, Delimiter Code=<LF>
280          OUTPUT 701;"IO1"         ! I/O Selection is "PLOTTER"
290          OUTPUT 701;"PM0"         ! Plotting Mode is "ALL"
300          OUTPUT 701;"PP0"         ! Pen Mode is "AUTO"
310          OUTPUT 701;"PA2"         ! Paper Advance is "SCALE"
320          OUTPUT 701;"PL1"         ! Scaling "ON"
330          OUTPUT 701;"PZ010,010,150,150" ! Plot Size (10,10,150,150)mm
340          OUTPUT 701;"PY0"         ! Plotter type is TR9835R/TR9832
350          OUTPUT 701;"PG0"         ! Plot Angle is "NORMAL"
360          OUTPUT 701;"IE1"         ! I/O EXECUTE <Start Plotting>
370          GOSUB Setup              ! Set TALKER(TR9407) & LISTENER(TR9835R/32)
380 Wait:    IF Plotend=1 THEN GOTO Dispend     !Plotting END?
390          DISP "  PLOTTER IS PLOTTING  //  "
400          GOTO Wait                          !No. Wait
410  !
420 Dispend: DISP "PLOTTER END !!"              !Yes
430          STOP
440  !
450  !
460  ! *******************************
470  ! * TALKER,LISTENER SETUP ROUTINE *
480  ! *******************************
490 Setup:   SEND 7;CMD LISTEN 0 TALK 1     ! Set Listener & Talker
500          STATUS 7;DATA                  ! Set ATN to HIGH (DATA MODE)
510          ENABLE INTR 7;2                ! Interrupt Enable
520          RETURN
```

Figure 8-20 Programming Example for Plotter Control Over the GPIB

```
530  !
540  ! **********************************
550  ! * INTERRUPT SERVICE ROUTINE      *
560  ! **********************************
570 Interupt:S=SPOLL(701)                 !Serial Poll
580          S1=BINAND(S,66)
590          IF S1=66 THEN GOTO Int1      ! PLOTTER END?
600          DISP "9407 INTERRUPT=";S
610          S=SPOLL(700)
620          PRINT "9835R/32 STATUS=";S
630          GOTO Int2
640 Int1:    Plotend=1
650 Int2     RETURN
660          END
```

Figure 8-20 Programming Example for Plotter Control Over the GPIB (Cont'd)

8.5 OPERATING INSTRUCTIONS OF X-Y RECORDER

8.5.1 X-Y Recorder Connection

(1) Usable X-Y recorder
The usable X-Y recorder should have a ±1 V full scale and pen up/down control capability. If the PEN MODE (to be described later) is set up for TWO, a dual-pen X-Y recorder is necessary.

CAUTION

If the phase responses on the X and Y axes of an X-Y recorder deviate from each other, a diagonal line drawn on a chart will not be a straight line. The X-Y recorder used should have identical phase responses on the X and Y axes.

(2) X-Y recorder outputs

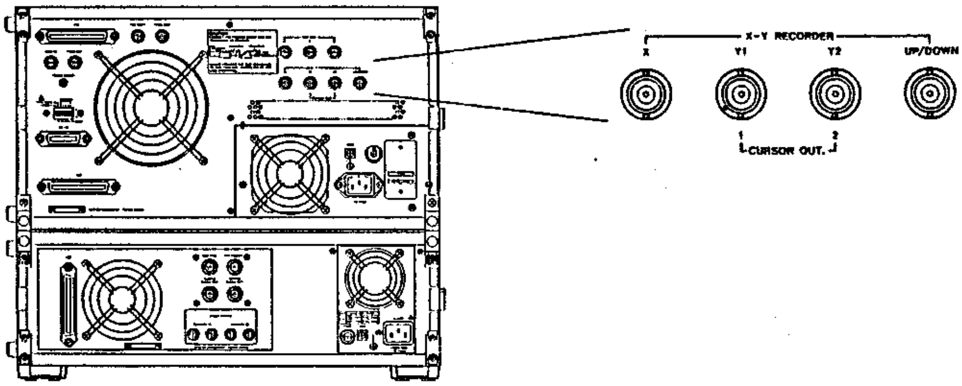


Figure 8-21 X-Y Recorder Outputs

The outputs for the X-Y recorder and CURSOR OUT mode are provided at the BNC connectors on the TR9407 in the form of analog voltage (0 to 1 V)

① X	:	X axis output for an X-Y recorder or cursor position output for the CURSOR OUT mode.
② Y1 ③ Y2	:	Y axis output for the X-Y recorder or the output of data amplitude at the cursor in the CURSOR OUT mode. When using a single pen recorder, connect it to Y1 connector. When using a dual pen recorder, connect it to Y1 and Y2 connectors.

(4) UP/DOWN: Contact output for pen up/down control. A make output causes a pen to go down, while a break output causes a pen to go up. The rating of the internal relay for this output is 250 V, 2 A. On some X-Y recorder, the pen up/down control input may be connected to the AC line (100 or 200 Vac). Check it before connection to be sure of operation safety.

8.5.2 Plotting on the Attached X-Y Recorder

(1) "XY-RCDR" menu setup

Place the pointer to an I/O device with the [⇧] or [⇩] key and the pointer begins to blink. Select the "XY-RCDR" mode from the I/O SELECT menu by depressing the [DISP.] or [SETUP] key.

```
I/O SELECT
⇨ XY-RCDR

CALIBRATION
   0-0
RECORD MODE
   CURSOR      #
   ALL
   SIGNAL
   FRAME
PEN MODE
   ONE         #
   TWO
PLOT SPEED
   SLOW        #
   2
   3
   4
   5
   FAST
```

Place the pointer (⇨) and change the menu contents in turn with I/O, DISP or SETUP keys.

For calibration of the output amplitude scale. Select either 0-0 or FS-FS (full scale) using the DISP or SETUP key.

CURSOR: Outputs the x- and y-axis information indicated by the cursor or peak marker.
ALL : Plots both the waveform being displayed and the scale.
SIGNAL: Plots the waveform only.
FRAME : Plots the scale only.

Select TWO for the dual display mode.

Select the desired plotting speed; there is a tradeoff between speed and accuracy.

Figure 8-22 X-Y Recorder Setup Menu

(2) RECORD MODE menu setup
This menu is used to select between the CURSOR OUT mode and the X-Y recorder plotting mode.

- CURSOR: This item selects the CURSOR OUT mode, in which the data identified by the cursor or peak marker is output to the X-Y RECORDER connectors in the form of analog voltages. The X connector provides the relative voltage of the data point on the X axis identified by the cursor or marker with respect to the fullscale voltage. When the vertical cursor control key (C (↔)) in the GENERAL CURSOR section is set to OFF, the Auto Peak Search mode is selected, in which the maximum peak of the displayed signal is automatically pointed. In this mode, therefore, the output at the CURSOR OUT connector follows up the variation of the frequency of the maximum peak. The time-varying peak data (such as a fundamental spectrum) may be observed by recording the X output on an X-Y recorder while in the Auto Peak Search mode.

  The Y1 and Y2 connectors provide the amplitude information of the displayed data according to the selection of the PEN MODE menu. With this feature, the time-dependent variation of any signal on the display may be observed on a chart recorder, oscilloscope, or digital volmeter attached to the TR9407 analyzer.

  The output amplitude can be calibrated by selecting the "0-0" and "FS-FS" items from the CALIBRATION menu.

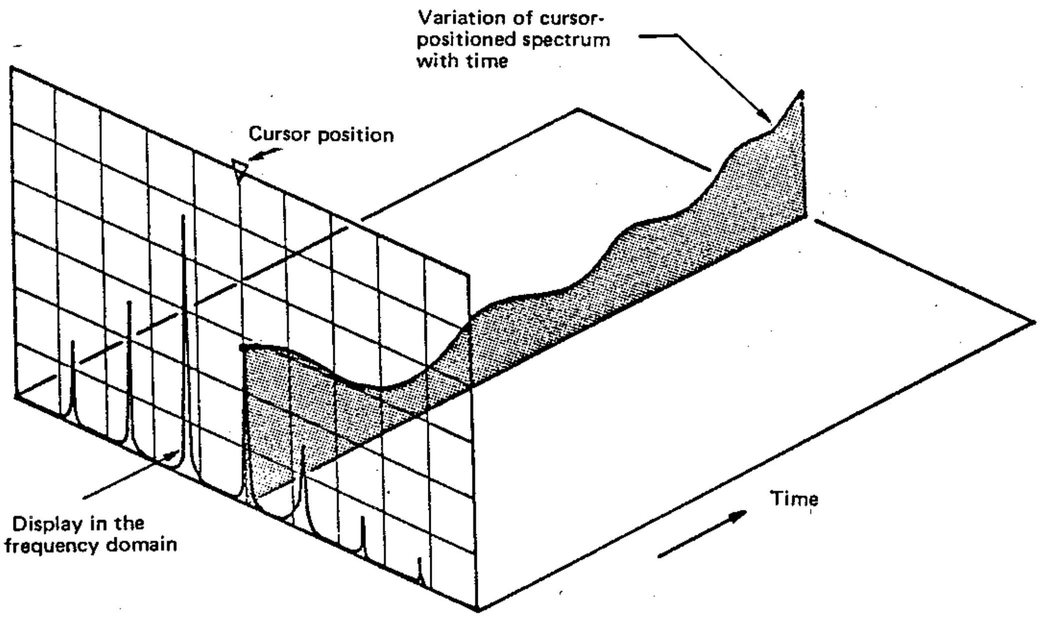


Figure 8-23 Spectrum Variation with Time Observed in the CURSOR OUT Mode

- ALL : In this mode the X-Y recorder plots both signal trace (SIGNAL) and scale (FRAME) information out of the information displayed on the CRT. Figures 8-24 and 8-25 show plotting examples in this mode.
- SIGNAL: In this mode the X-Y recorder plots only the signal trace displayed on the CRT. Figure 8-26 shows a plotting example obtained in this mode.
- FRAME : In this mode the X-Y recorder plots only the scale information displayed on the CRT. Figure 8-27 shows a plotting example obtained in this mode.

Figures 8-24 through 8-27 are plotted on a single chart of paper while shifting the zero and fullscale calibration points. It is also possible to make superimposed plotting by first plotting in the ALL mode and then in the SIGNAL mode, or by first plotting only the graticule lines in the FRAME mode and then plotting only signal traces in the SIGNAL mode.

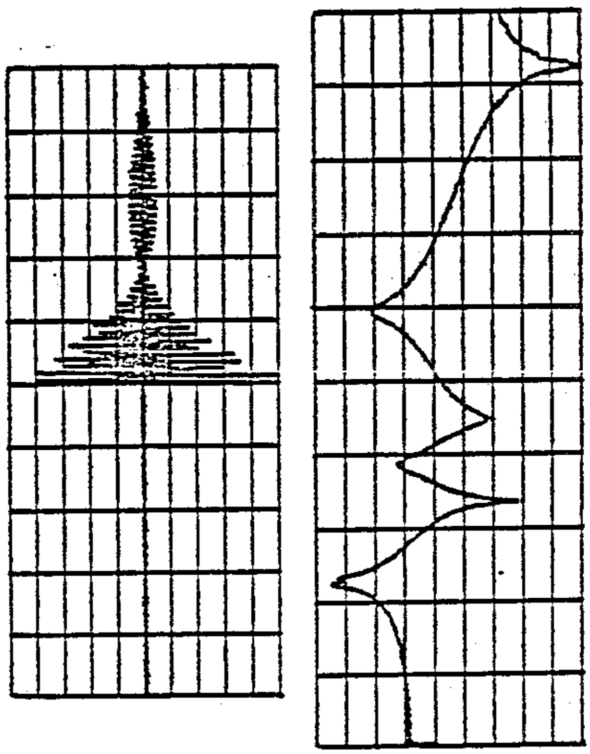


Figure 8-24 Plotting Example in the ALL Mode

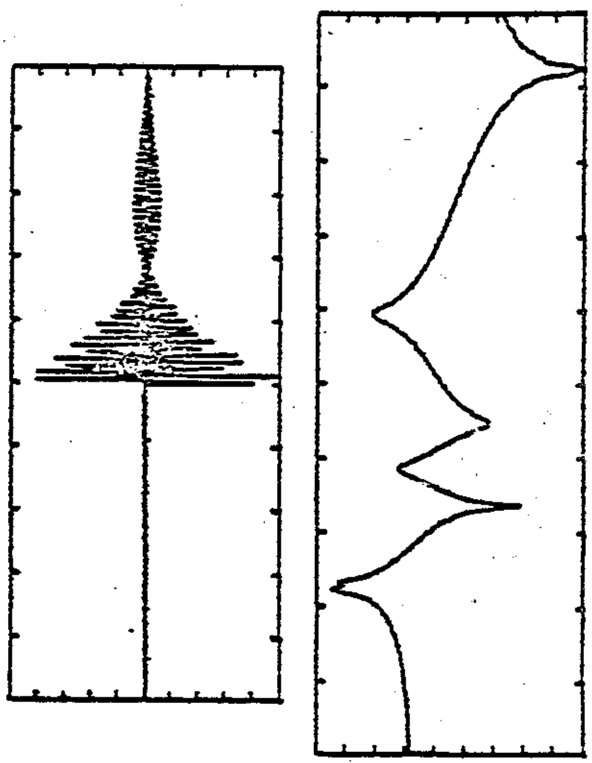


Figure 8-25 Plotting Example in the ALL Mode

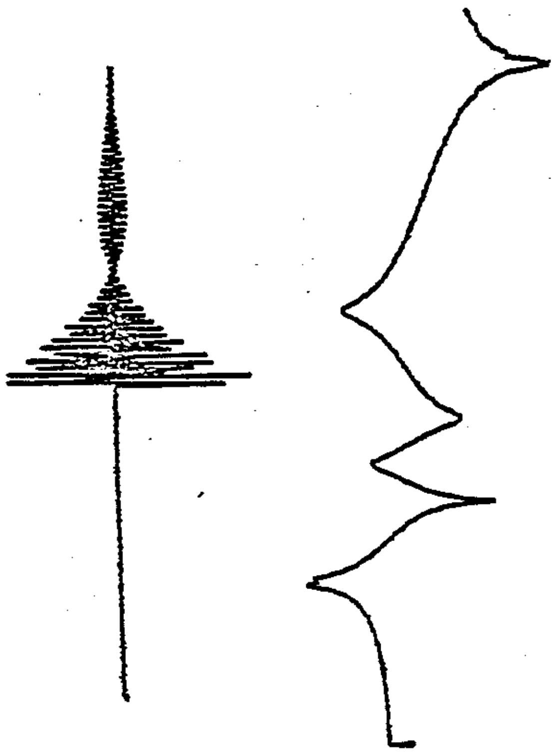


Figure 8-26 Plotting Example in the SINGLE Mode

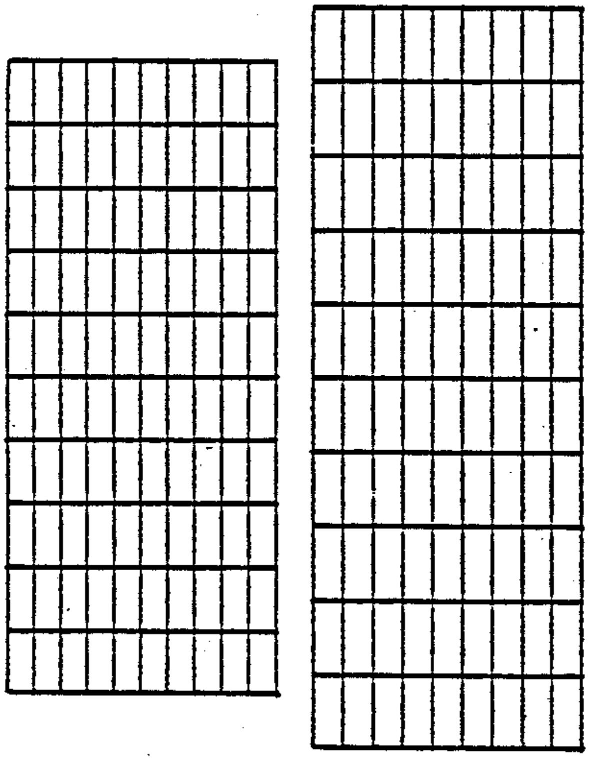


Figure 8-27 Plotting Example in the FRAME Mode

(3) PEN MODE menu setup

① CURSOR OUT mode

- "ONE": In this mode, the data identified by the vertical cursor or peak marker is output to the Y1 connector.
- "TWO": In this mode, the cursor-point data of the signal traces shown in the upper and lower display areas are output to the Y2 and Y1 connectors respectively, so far as the both traces have the same domain and analysis range in the BOTH mode. To obtain the same calibration points for the Y1 and Y2 outputs, activate the SUPERIMPOSE key in the DISPLAY section.
  If the BOTH mode is not selected or if two signal responses have different domains or analysis ranges in the BOTH mode, the same data identified by the cursor or peak marker will be output to both Y1 and Y2 connectors.

② X-Y recorder mode

- "ONE": This mode should be selected when a single-pen X-Y recorder is to be attached to the TR9407.
- "TWO": This mode should be selected when two signal traces are to be simultaneously plotted on a dual-pen X-Y recorder or the top and bottom displays are plotted with Pen 1 (Y1 output) and Pen 2 (Y2 output) respectively.

  The simultaneous plotting of the two signal traces is effective only if the signal responses shown in the BOTH mode have the same domain and analysis range. Otherwise, the trace in the bottom is first plotted by pen 1 (Y1) and then the trace in the top by pen 2 (Y2). The same is true for plotting graticule lines; two-pen mode includes simultaneous plotting and successive plotting where pen 1 (Y1) plots the graticule in the bottom display and then pen 2 (Y2) plots the graticules in the top.
  The relative positions of the two plotted traces are identical to those on the display with respect to the pen calibration positions.

  In the SUPERIMPOSE mode, the relative position of the two plotted traces can be controlled in any way by adjusting the calibration points for Y1 and Y2 during pen calibration.

(4) "PLOT SPEED" menu setup

"SLOW" : Select this mode for an X-Y recorder of the lowest speed type.
"2"
"3"
"4"
"5"
"FAST" : Select this mode for an X-Y recorder of the highest speed type.

This menu allows selection of various plotting speed according to the response speed of the X-Y recorder. Figure 8-28 shows plotting results for partial signal traces obtained on an X-Y recorder with the maximum pen speed of 500 mm/sec at each of the above speed settings. This figure proves that plotting accuracy is gradually decreased as the plotting speed setting is increased. In the case of this example, the optimum speed is "2".

The response of individual recorders may differ from one manufacturer to another, even though the nominal maximum pen response are same. When making a final recording chart, be sure to carry out some speed tests to determine the optimum plotting speed.

Table 8-1 shows an example of measured time taken from the start to the end for each plotting example at each plotting speed with PEN MODE set to ONE. Actually, the plotting speed may depend greatly on the complexity of the signal response trace to be plotted.

Table 8-1 Required Plotting Time (PEN MODE: "ONE")

Unit: minutes (') seconds (")

PLOT SPEED	Figure 8-24	Figure 8-25	Figure 8-26
SLOW	12'00"	9'55"	7'55"
2	9'15"	7'55"	6'15"
3	7'20"	6'25"	4'55"
4	5'35"	4'50"	3'40"
5	4'00"	3'30"	2'30"
FAST	2'35"	2'00"	1'16"

(5) Plotting execution on an X-Y recorder

To start calibration or plotting on the attached X-Y recorder, press the EXECUTE key just beside the I/O key on the TR9407 while the I/O SELECT menu is set to XY-RCDR (the menu need not be shown on the display). The lamp within the EXECUTE key will come on and the message "XY-RCDR IS PLOTTING " flashes in the bottom left portion of the CRT (not displayed in the "CALIBRATION" or "CURSOR OUT" modes). When the "PEN MODE" is set to "TWO" while the two-pen plotting is impossible, the mode is automatically changed into "ONE" and setup mark (#) is also moved from "TWO" to "ONE" if the X-Y recorder menu is on the CRT display.

If the EXECUTE key is pressed when the pointer on the menu is at item "0-0" (or "FS-FS") below "CALIBRATION", a calibration voltage for 0-0 or FS-FS is output to the X, Y1, and Y2 connectors on the rear of the analyzer. When the pointer is at another item on the menu, execution in the CURSOR OUR mode will be initiated. These executions can be suspended by pressing the EXECUTE key a second time.

When plotting on the X-Y recorder is suspended or completed, a buzzer sounds intermittently and the lamp within the EXECUTE key goes off to indicate completion.

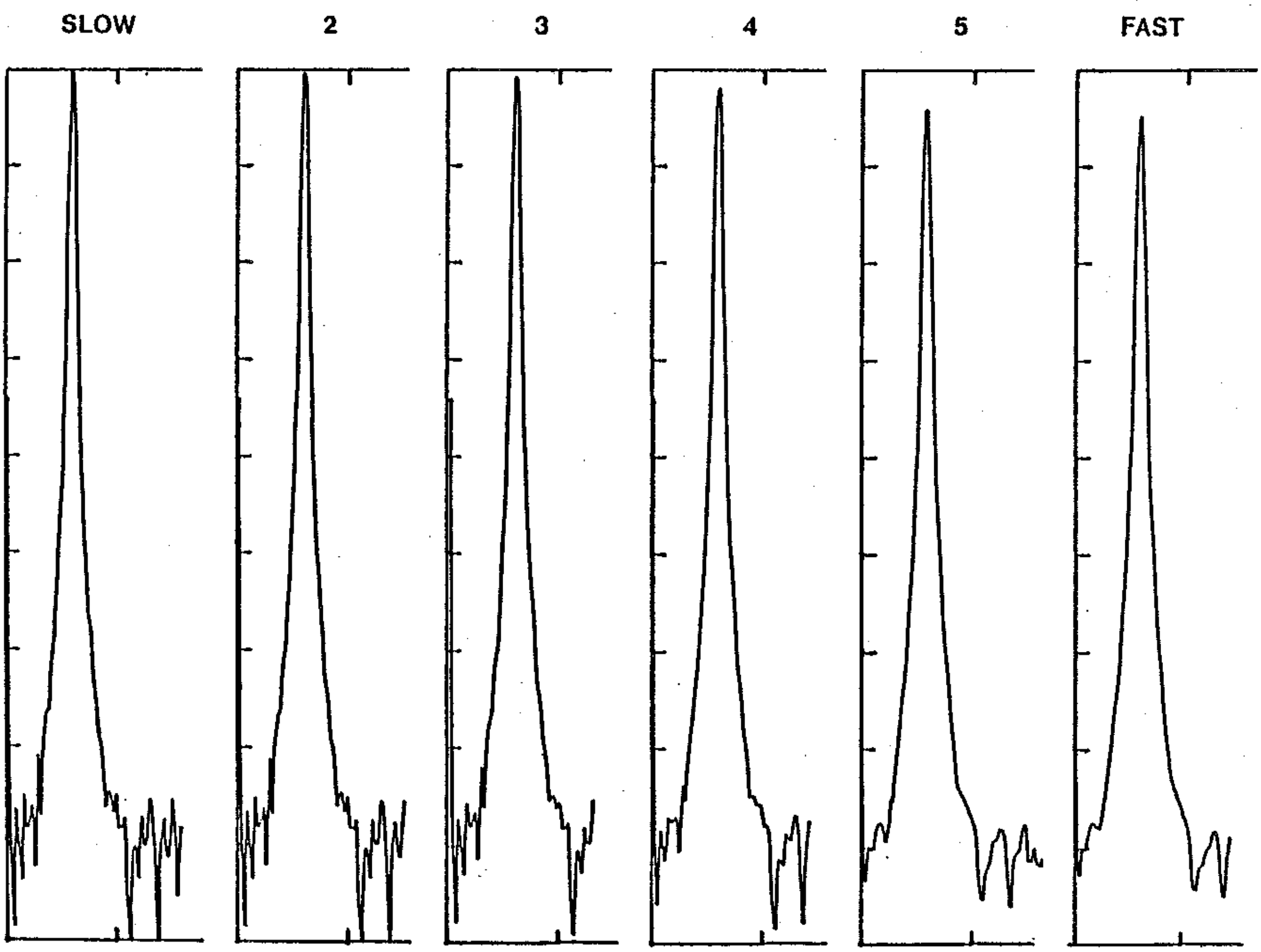


Figure 8-28 Plotting Example Obtained at Each Plotting Speed

(6) CALIBRATION menu setup
The CALIBRATION menu is used to output calibration voltage in the X-Y recorder or CURSOR OUT mode.
If the pointer on the menu is positioned to "CALIBRATION" and then the EXECUTE key just beside I/O [ ] is pressed, the lamp within the EXECUTE key comes on and calibration voltage is output to the X, Y1, and Y2 connectors on the rear of the analyzer.

Calibration points of 0-0 and FS-FS can be selected by operating [SETUP].

At this time, the contact signal for pen up/down control is in the pen-up state (break). The calibration voltages are listed in Table 8-2. The calibration points for several signal traces are shown in Figures 8-29, 8-30 and 8-31.

Table 8-2 Calibration Voltage

0 - 0		FS - FS	
X	Y1, Y2	X	Y1, Y2
0 V	0 V	Approx. +1 V	Approx. +1 V

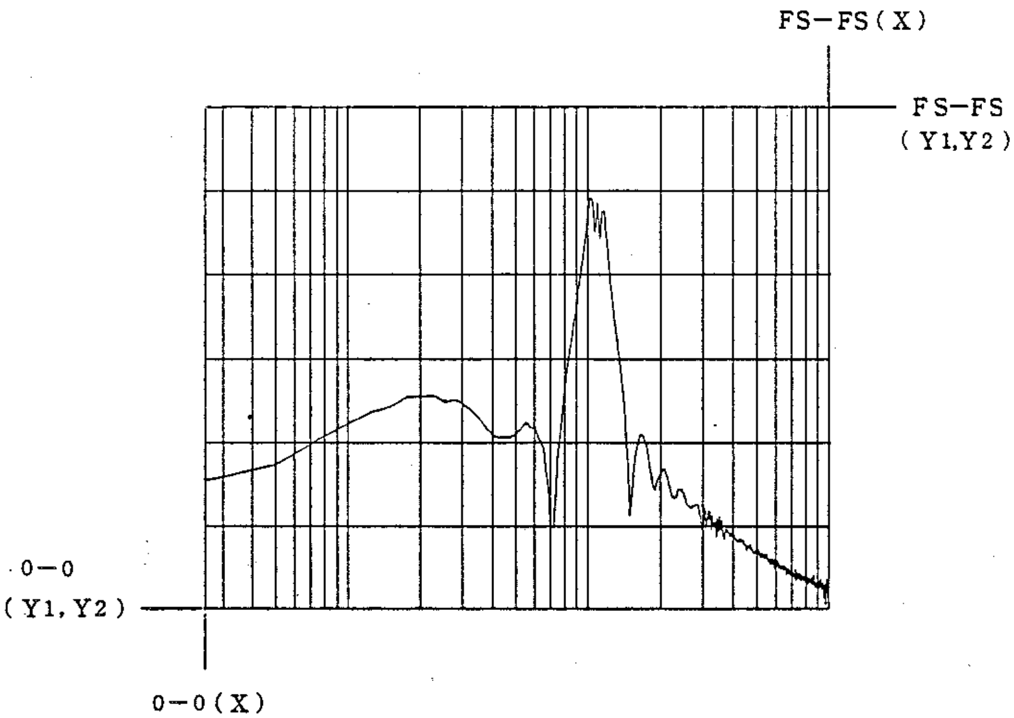


Figure 8-29 Calibration Value (SINGLE Display)

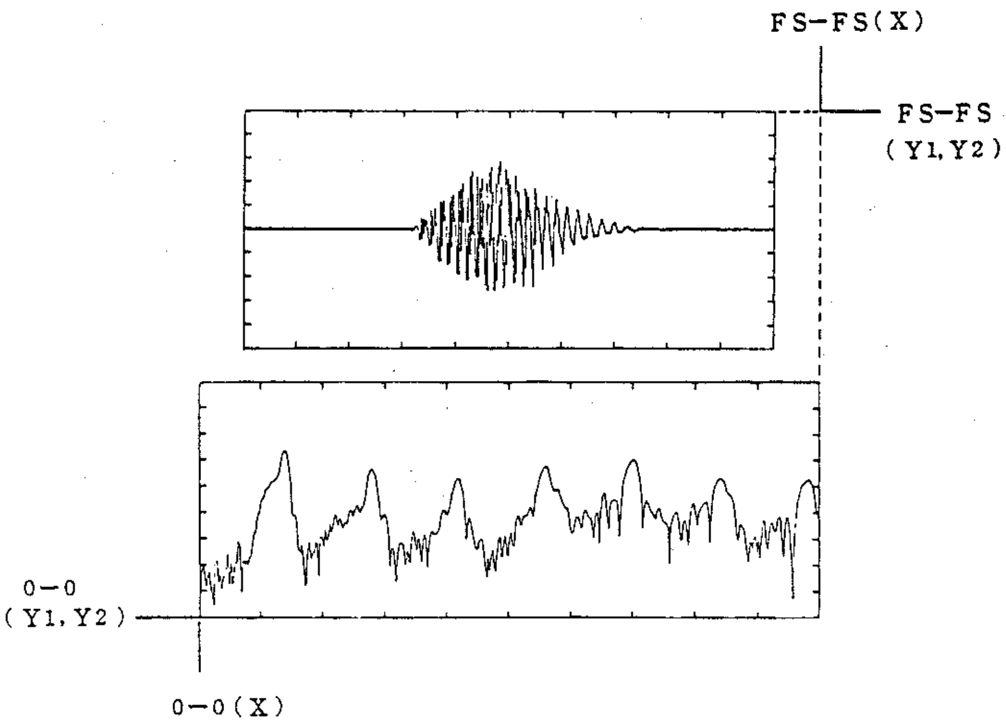


Figure 8-30 Calibration Value (DUAL Display)

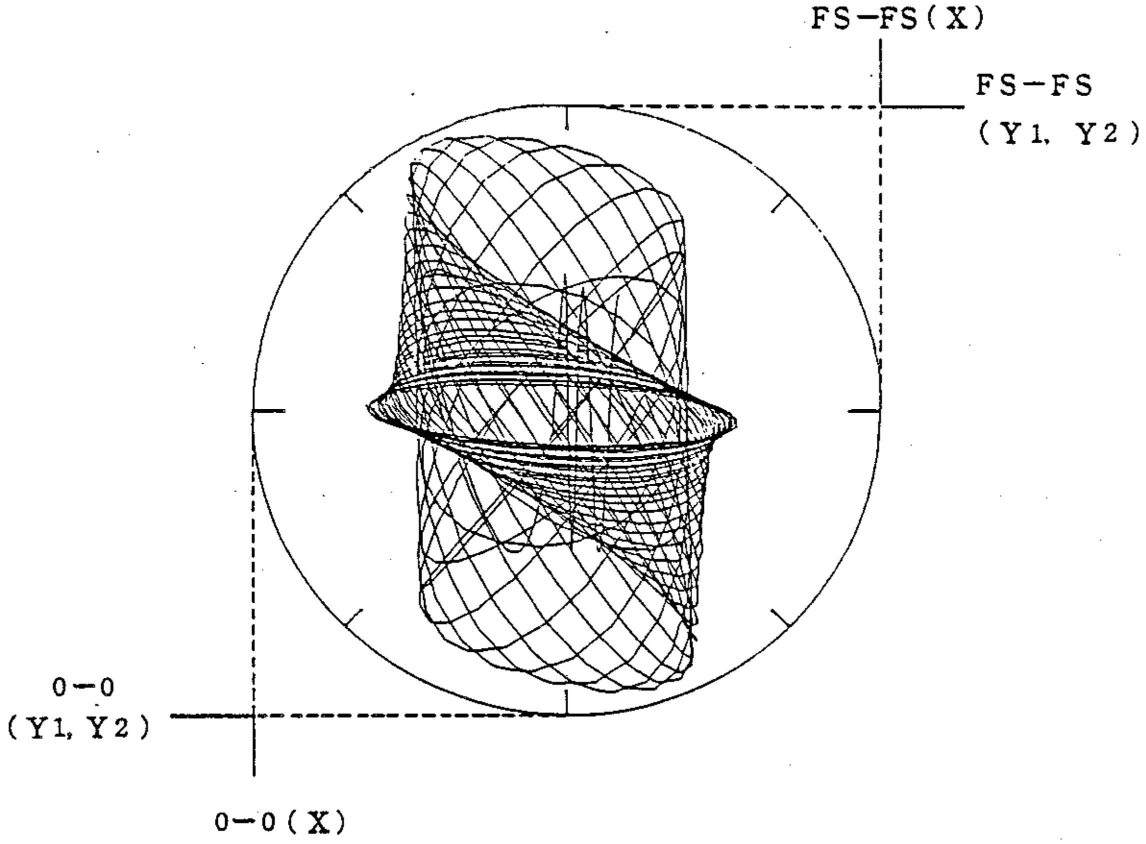
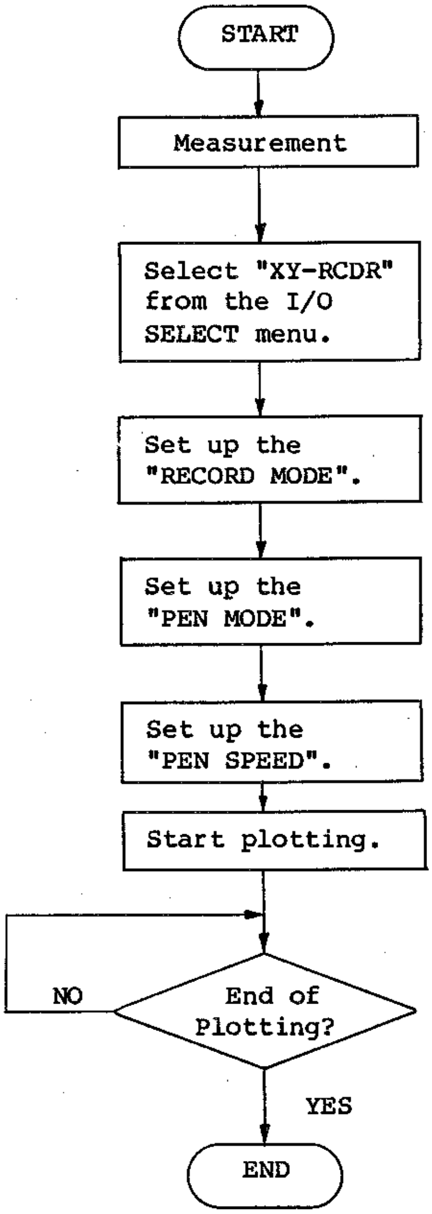


Figure 8-31 Calibration Value

8.5.3 X-Y Recorder Control over the GPIB

The TR9407 Analyzer is equipped with the GPIB interface as a standard feature, and is capable of automatic plotting on an attached X-Y recorder via an external controller.

(1) Programming for X-Y recorder control over the GPIB



Set up the TR9407's panel conditions over the GPIB and perform pertinent measurement.

Selects the appropriate record mode.

Selects 1-PEN or 2-PEN mode.

Selects the pen speed.

NOTE

During plotting, do not execute any command other than the I/O Execute Stop command "IE0".

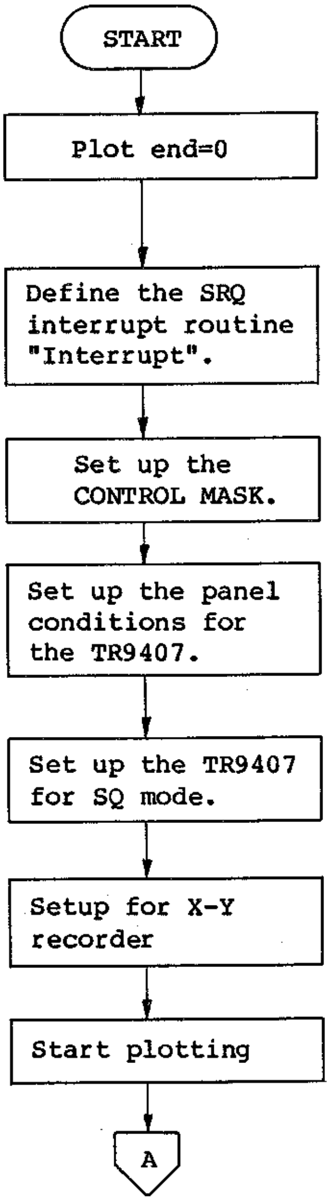
(2) List of GPIB commands concerning X-Y recorder control

Table 8-3 GPIB commands for X-Y recorder control

Command		Description	Setup read
Function	Setup		
IO	0 to 2	I/O SELECT 0 X-Y RECORDER 1 PLOTTER 2 FLOPPY DISK	o
XM	0 to 3	X-Y RECORD MODE 0 CURSOR 1 ALL 2 SIGNAL 3 FRAME	o
XC	0, 1	X-Y RECORDER CALIBRATON 0 0-0 1 FS-FS	o
XP	0, 1	X-Y RECORDER PEN MODE 0 ONE-PEN 1 TWO-PEN	o
XS	0 to 5	X-Y RECORDER PEN SPEED 0 SLOW 1 2 2 3 3 4 4 5 5 FAST	o
IE	0, 1	I/O EXECUTE 0 STOP 1 START	x

(3) Programming example

The following programming example is obtained on the Hewlett Packard desk-top computer 200 series:



Resets the plotting end flag.

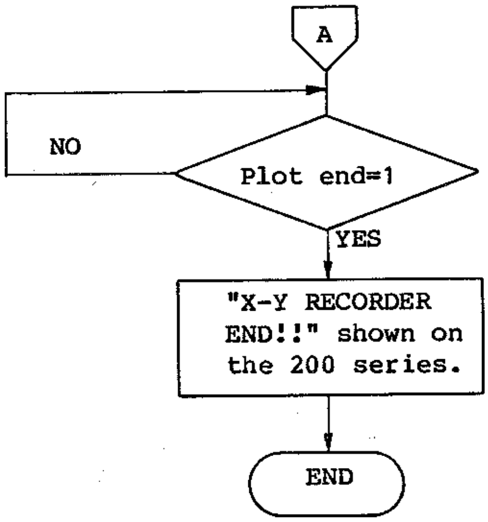
Set up the HP 200 series.

Display shows 50 kHz, +10 dBV range, and SPECTRUM.

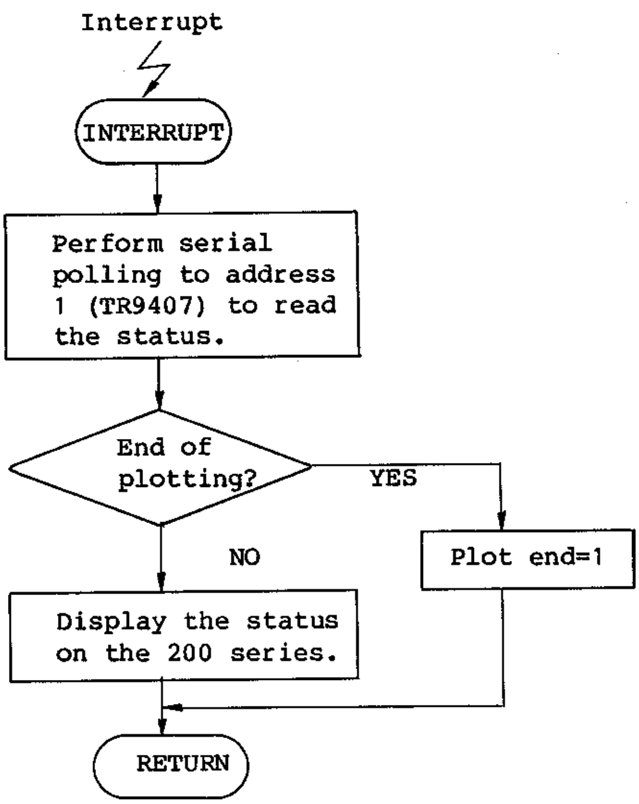
Set up the TR9407 for the SQ0 mode (SRQ output mode).

I/O SELECT : XY-RCDR
RECORD MODE: ALL
REN MODE : ONE PEN
PEN SPEED : 3

Sends "IE1"



End of plotting?



```
100  !
110  ! *******************************************
120  ! *                                         *
130  ! *   TR9407 XY-RECORDR Plotting Program    *
140  ! *          With GPIB Control              *
150  ! *   MT File Name:  "RECEX"                *
160  ! *                                         *
170  ! *   GPIB ADDRESS---TR9407=1               *
180  ! *******************************************
190  !
200 Start:    !
210           Plotend=0                 !Clear Flag
220           ON INTR#7 GOSUB Interupt
230           !
240           OUTPUT 701;"FR1VW1AS2     !100kHz,VIEW=SPECTRUM, A-CH SENSE +10dBV
250           WAIT 1
260           OUTPUT 701;"SQ0"          !Enable SRQ
270           OUTPUT 701;"IO0"          !I/O Selection is XY-RECORDER
280           OUTPUT 701;"XM1"          !Plotting Mode is ALL
290           OUTPUT 701;"XP0"          !Pen Mode is ONE
300           OUTPUT 701;"XS2"          !Plot Speed is 3
310           OUTPUT 701;"IE1"          !I/O EXECUTE (Start Plotting)
320           ENABLE INTR 7;2           !Enable Interrupt
330 Wait:     IF Plotend=1 THEN GOTO Dispend   !Plotting END?
340           GOTO Wait                        !No, Wait
350 Dispend:  DISP "XY-RECORDER END !!"          !Yes.
360           STOP
370  !
380  !
390  ! ******************************
400  !   INTERRUPT SERVICE ROUTINE
410  ! ******************************
420  !
430 Interupt:S=SPOLL  (701)             !Serial Poll
440           S1=BINAND(S,66)
450           IF S1=66 THEN GOTO Int1
460           DISP "9407 INTERRUPT=";S
470           ENABLE INTR 7
480           RETURN
490 Int1:     Plotend=1
500           RETURN
510           END
```

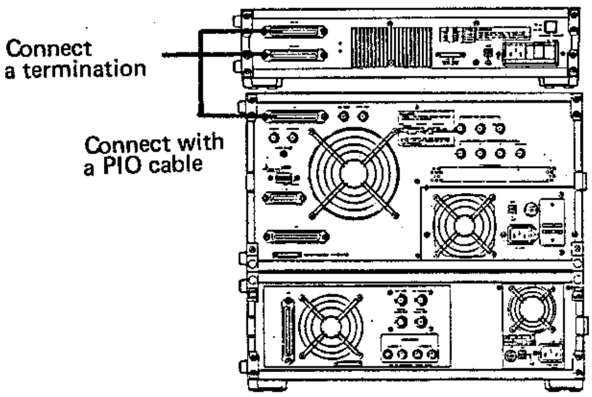
Figure 8-32 Programming Example for X-Y Recorder Control Over the GPIB

8.6 OPERATING PROCEDURES OF FLOPPY DISK DIGITAL DATA RECORDER

8.6.1 Connecting the TR98102

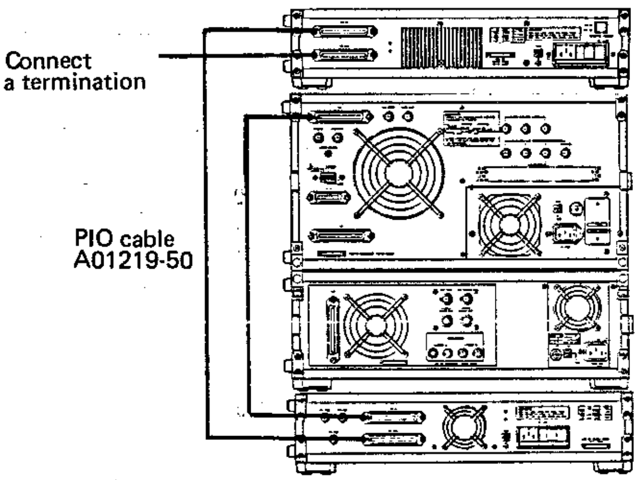
The TR98102 and the TR9407 are connected with a PIO bus cable.

- TR9407 + TR98102



Connect the TR9407's PIO connector (1) and TR98102's PIO IN connector (2) with a PIO cable. Connect bus termination A09035 to the TR98102's PIO OUT connector (3).

- TR9407 + TR98201 + TR98102

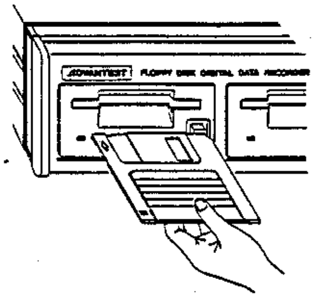


Connect the TR9407's PIO connector (1) and TR98102's PIO IN connector (2) with a PIO cable. Connect the TR98201's PIO OUT connector (3) and the TR98102's PIO IN connector (4) with a PIO cable. Connect bus termination A09035 to the TR98102's PIO OUT connector (5). (You may connect (1) and (4) with a cable, connect (5) and (2) with a cable, and connect a termination to (3).

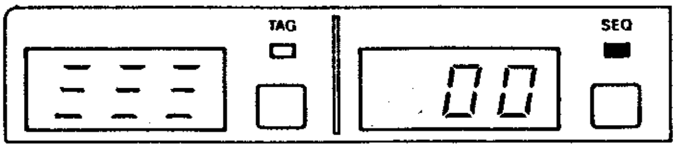
Figure 8-33 Connecting the TR98102

8.6.2 Initializing the Floppy Disk

Two 3.5 in. micro floppy disks are provided with the TR98102. Data cannot be written straightforward on these disks. Before using the floppy disk, it must be initialized. Data is written on the disk according to the previously written ID field. The procedure for writing the ID field and other necessary information is called initialization. For the TR98102, initialization is performed in the IBM format. Perform a read/write test to check whether the disk is damaged.

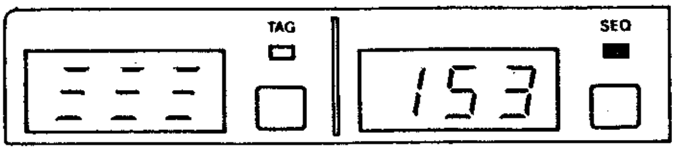


Insert a floppy disk (not write-protected) in drive 0 (left). If a disk is write protected, error code of 66 or 69 will be displayed.

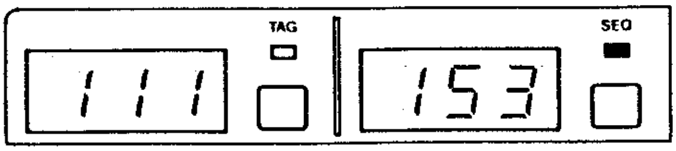


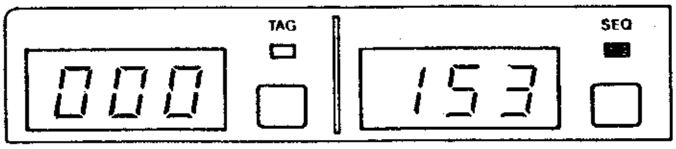
Press 

for about 2 seconds to start writing the ID field.

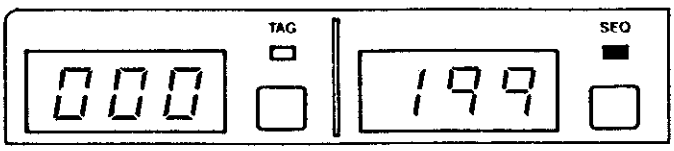


Continue writing until the SEQ indicator indicates 153 (about 2 minutes).



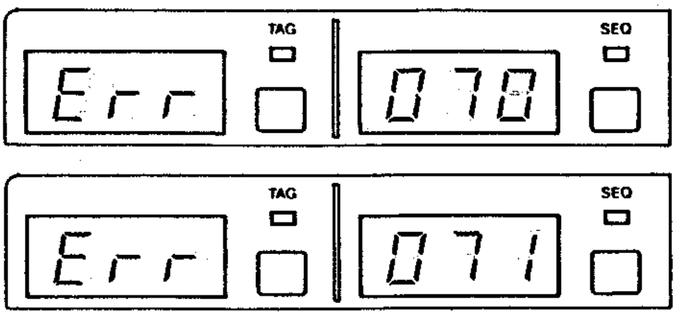


Start a read/write test. The TAG indicator indicates 111 and 000 alternately and the value indicated by the SEQ indicator is reduced from 153 to 0 (about 3 minutes).

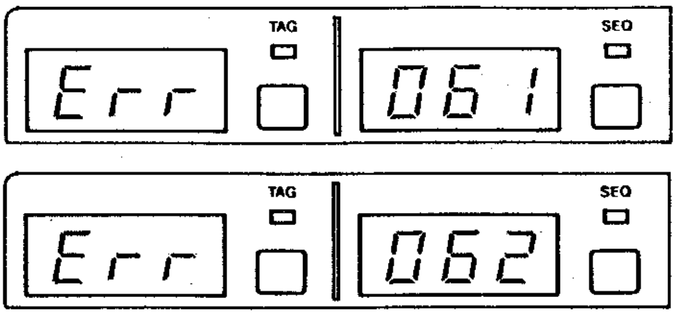


About 5 minutes later, the buzzer sounds to indicate that initialization has been completed.

If the ERROR indicator goes on and initialization is terminated during read/write test, press ERR CHECK



The possible error is in the PIO cable or termination. Connect the cable and termination firmly.



The floppy disk is defective. It cannot be used.

To terminate initialization forcibly,

- remove the floppy disk, or
- press START/STOP to turn off the lamp (in the READ/WRITE test only).

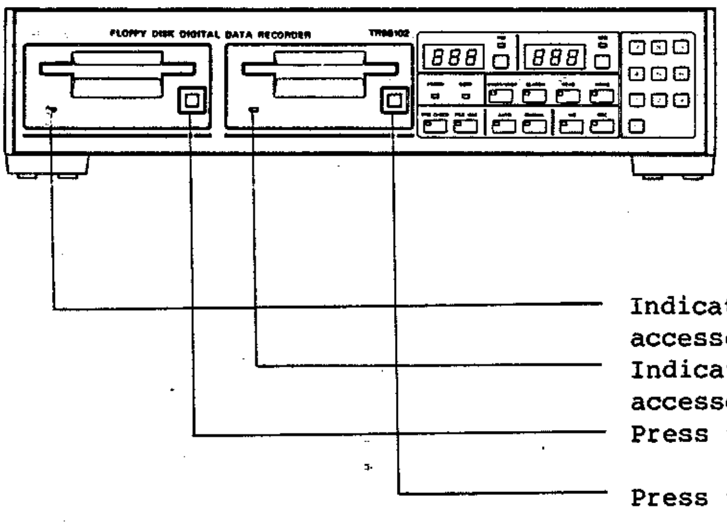
If the ERROR lamp does not go on, this disk can be used.

8.6.3 Description of Panel

The TR98102 is operated with panel keys and a FLOPPY menu of the TR9407.

There are three methods for displaying the FLOPPY menu.

1. Press [I/O] of the TR9407 to display one of I/O menus. Press this key repeatedly until the FLOPPY menu is displayed.
2. When [I/O] is pressed, ⇨ blinks under the I/O SELECT. Press [SETUP] or [DISP.] until the floppy menu is displayed.
3. Press [I/O], then press [PANEL RECALL] and [HIST.].



TAG Pressing this key enters the tag setting mode. Set the tag number with a ten-key pad. Since the tag number is used as the label for writing data, a 3-digit number can be specified for each file unit. The data with a tag number can be searched quickly.

SEQ

When this key is pressed, the sequential number setting mode is selected. Set a sequential number with a ten-key pad. A sequential number corresponds to a physical position for each unit on the disk. If 2-unit or 5-unit data is read/written, the sequential number is incremented (INC mode) or decremented (DEC mode) by 2 or 5.

Sequential numbers	0 - 199:	Drive 0 (front)
	200 - 399:	Drive 0 (rear)
	400 - 599:	Drive 1 (front)
	600 - 799:	Drive 1 (rear)

ERROR

This lamp goes on when an error occurs while accessing a floppy disk.

COPY

Indicates that file editing mode is set.

ERR CHECK

If this key is pressed when the ERROR lamp is on, the error check mode is set. If this key is pressed when the search mode is set, the search mode is cancelled.

FILE INIT

Press this key to initialize the disk.

SEARCH

Press this key to enter the file search mode.
If this key is pressed in the error check mode, the erroneous sequential number is displayed.

START/STOP

Press this key to start read/write of file. When the disk to be cataloged in the CATALOGUE mode is replaced, press this key to take the catalogue of the disk. If this key is pressed when the START/STOP lamp is on, execution can be terminated forcibly.

READ

Press this key to set the READ mode.

WRITE

Press this key to set the WRITE mode.
Resume analog input signal analysis when the graphics file or instant time origin file is read.

AUTO

Press this key to access file continuously.

MANUAL

Press this key access a file.

INC

Press this key to access the disk so that the sequential number is incremented.

DEC

Press this key to access the disk so that the sequential number is decremented.

8.6.4 Feature of Data Files

Write Mode	Characteristics	Units used	Comparison and math operation between data	Domain conversion and averaging
ORIGIN	● Origin time data (Recorded as instantaneous time data. Can be processed like an analog input signal on reproduction.) ● Origin transfer data (Origin <Gaa>, <Gbb>, and <Gab> data is recorded. On reproduction, the transfer function, impulse response, coherence function and coherence output power are obtained from the recorded data.) ● Origin averaged correlation data (recording and reproduction of the averaged autocorrelation function and averaged cross-correlation function data)	5 units	Yes (Comparison and calculations between recorded data or between recorded data and current data being analyzed are possible using the MEMORY key and the dual display mode.)	Yes (Data conversion into convertible domain.)
	● Averaged Complex spectrum data	10 units	Yes (Ditto)	Yes (Ditto)
	● 4-decade transfer data data	20 units	No	Yes (Ditto)
	● Level monitor	10 units	No	No

(Continued)

Write Mode	Characteristics	Units used	Comparison and math operation between data	Domain conversion and averaging
MASS TIME	● Time data in 512K word buffer can be recorded as it is. Four disks are required to record 512K words. ● Time data is recorded regardless of the data being displayed on the screen. ● ADVANCE ARM, DATA WINDOW, Interchannel Delay and FUNCTION (U+L, U-L, U*L) are usable after reproduction. ● Writing is always started with SEQUENTIAL NO. 0. ● Writing in DEC. mode is not possible.	1280 units (5 units x 256)	Yes (Ditto)	Yes (Ditto)
FIXED	● Only the data required for reproduction is recorded, so the number of record units is small. As a result, more screen information per disk can be recorded faster.	1 or 2 units	Yes (Ditto)	No
GRAPHICS	● Any type of display trace can be recorded. ● The recorded trace can be reproduced as they were without being affected by the internal processing of the TR9407.	5 to 10 units	No	No
PANEL	● Every setup condition has been filed and it allows complete reproduction of created data (excluding the time of day of writing). Panel sequence measurement is programmable using the CATALOGUE mode.	1 unit	No	No

Table 8-4 File Enable/Disable Data in Each Mode

Mode / Data type	2 channel Zero Start	1 channel Zero Start	Zooming	4 decade
Xa, Xb	O, F, G	O, G	G	O, F, G <1>
<Xa>, <Xb>	F, G	G	-	-
Gaa, Gbb	O, F, G	O, G	F, G	O, F, G <1>
<Gaa>, <Gbb>	O, F, G	G	O, F, G	O, G
Sa, Sb	O, G	O, G	G	O, F, G <1>
<Sa>, <Sb>	O, G	G	O, G	-
Raa, Rbb	O, F, G	-	-	-
<Raa>, <Rbb>	O, G	-	-	-
Rab	O, F, G	-	-	-
<Rab>	O, G	-	-	-
Pa, Pb	O, F, G	O, F, G	-	O, F, G <1>
<Pa>, <Pb>	G	G	-	-
<Impls>	O, F, G	-	-	-
<Hab>	O, G	-	O, G	O, G
<COH>	O, F, G	-	O, F, G	O, G
<COP>	O, F, G	-	O, F, G	O, G
Gab	O, G	-	G	O, F, G <1>
<Gab>	O, G	-	O G	O, G
OCTa, OCTb	F, G	-	-	-
<OCTa>, <OCTb>	F, G	-	-	-
Za, Zb	O, G	O, G	-	-
Zaa, Zbb	O, G	O, G	-	-

(Continued)

Data type \ Mode	2 channel Zero Start	1 channel Zero Start	Zooming	4 decade
G_{aa}^{z}, G_{bb}^{z}	O, G	O, G	-	-
Ca, Cb	O, G	O, G	-	-
Caa, Cbb	O, G	O, G	-	-
G_{aa}^{c}, G_{bb}^{c}	O, G	O, G	-	-
<SNR>	O, G	-	-	-
<ML>	O, G	-	-	-
<SCOT>	O, G	-	-	-
GaaL, GbbL	O, G	-	O, G	-

Notes: - : Indicates that there is no data in this mode.
<1>: Indicates that the data in the current frequency range is written.
O: Origin
F: Fixed
G: Graphics

8.6.5 ORIGIN file; Creation and Reproduction

Display the FLOPPY menu by one of the methods given in Section 8.6.2, and data is written in the ORIGIN mode. The file created in the origin mode allows data comparison, arithmetic operation, and domain conversion. Therefore, the ORIGIN mode is used most frequently.

The following eight types of data are actually written in the origin file:

(a) 2-channel instant time data	:	Xa, Xb
(b) Single-channel instant time data	:	Xa or Xb
(c) Transfer data	:	<Gaa>, <Gbb>, or <Gab>
(d) 4-decade transfer data	:	<Gaa>4, <Gbb>4, or <Gab>4
(e) Averaged complex spectrum data	:	<Sa> or <Sb>
(f) Averaged autocorrelation function data	:	<Raa> or <Rbb>
(g) Averaged cross-correlation function data	:	<Rab>
(h) Level monitor	:	GaaL or GbbL

Data that cannot be converted from the above data cannot be written in the ORIGIN mode. Table 8-5 lists the data that is actually written when an ORIGIN file is created. Table 8-6 lists the data that can be converted from each ORIGIN file. The ORIGIN file stores the TR9407 setting condition as well as data. When the file is reproduced, the TR9407 can be set to the state in which the file has been created.

(1) Creating an ORIGIN file

① Press [⇧] or [⇩] to move the pointer (⇨) to WRITE, then press [SETUP].

```
I/O SELECT
  FLOPPY

FLOPPY MODE
  READ          #
⇨ WRITE
  EDIT
  CATALOGUE

DISPLAY SOURCE
  FLOPPY        #
  PANEL

DATA OUT
  CRT

OVERLAY NUMBER
  0
```

② The WRITE mode is selected.

Press [⇧] or [⇩] to move the pointer (⇨) to ORIGIN, then press [SETUP] to choose the ORIGIN mode from the WRITE mode.

```
I/O SELECT
  FLOPPY

FLOPPY MODE
  READ
⇨ WRITE         #
  EDIT
  CATALOGUE

WRITE MODE
  ORIGIN        #
  FIXED
  MASS TIME
  GRAPHICS
  PANEL

WRITE TRIG.
  DATA
  FREE RUN
    CH-A

M.TIME FCTN
  OFF
  K = +1.00
```

③ Operate a file with the TR9407 internal test signal.

TEST Input a Test signal

BOTH Select the SINGLE VIEW mode.

MAG. Select the amplitude display mode.

SENS. A Display the SENSITIVITY menu.

Press ⇧ or ⇩ to move the pointer (⇨) to 0 dB (input sensitivity).

```
SENSITIVITY
MAX INPUT
  A:  ±1.41 V
  B:  ±1.41 V

  *CH-A*
  NORMAL     A#
  INVERT

  ACTIVATE

  AUTO
  (dBV)
  +30
  +20
  +10
⇨   0        A#
  -10
  -20
  -30
  -40
  -50
  -60
```

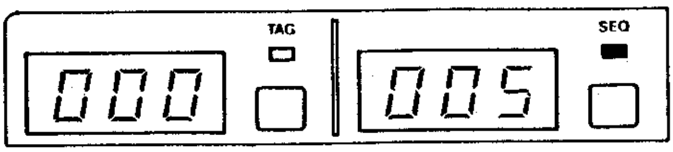
④ Press WRITE and MANUAL to select the MANUAL WRITE mode.

⑤ Press SEQ and press numeric key 0 three times to set the sequential number to 0. Then, press INC.

Write four items of data: time, spectrum, autocorrelation function and histogram.

① Create a time data file.

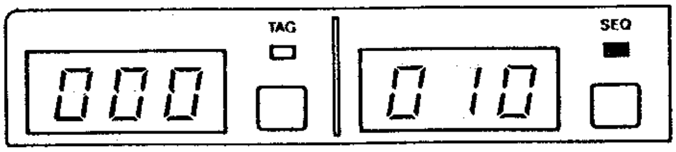
Press TIME to display the time data on the TR9407, then press START/STOP to create the time data file.



The displayed sequential number 5 indicates that 5 units of data has been written into the file.

② Create a spectrum file.

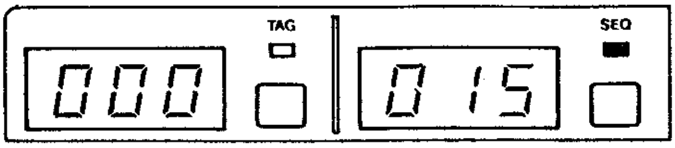
Press SPECTRUM to display a spectrum, then press START/STOP to create a file.



The sequential file changes to 10, indicating that 5 units (5 - 9) of data have been written into the file.

③ Create an autocorrelation file.

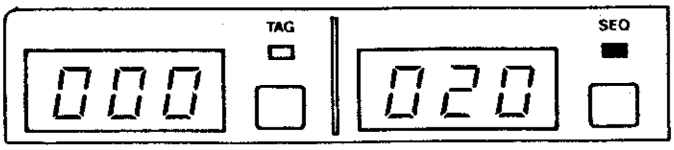
Press AUTO-CORR. to display an autocorrelation, then press START/STOP to create a file.



Five units (10 - 14) of data have been written.

④ Create a histogram file.

Press HIST. to display the histogram, then press START/STOP to create a histogram file.



The sequential number changes to 20 indicating that five units (15 - 19) of data have been written into the file.

(2) Reproducing an ORIGIN file (DISPLAY SOURCE = FLOPPY)
Now a file for four screens of data has been created. To reproduce it, first display the READ menu on the screen.

① When [I/O] is pressed, the previous FLOPPY WRITE menu is displayed.

Move the pointer (⇨) to WRITE, then press [SETUP] to select the READ mode.

```
I/O SELECT                          I/O SELECT
  FLOPPY                              FLOPPY

FLOPPY MODE                         FLOPPY MODE
  READ                              ⇨ READ          #
⇨ WRITE          #                    WRITE
  EDIT                                EDIT
  CATALOGUE                           CATALOGUE
                          ⇨
WRITE MODE                          DISPLAY SOURCE
  ORIGIN                              FLOPPY        #
  FIXED                               PANEL
  MASS TIME
  GRAPHICS                          DATA OUT
  PANEL                               CRT

WRITE TRIG.                         OVERLAY NUMBER
  DATA                                0
  FREE RUN
    CH-A

M.TIME FCTN
  OFF
  K = +1.00
```

② To have the setting (display) made at the time of file creation, select FLOPPY in the DISPLAY SOURCE item.

③ Select the data output unit.

Move the pointer (⇨) to DATA OUT, then press [SETUP]. The display cyclically changes from CRT, XY-RCDR, PLOTTER and CRT back again.

If [DISP.] is pressed, this display changes in the reverse sequence. Select CRT for displaying the file on the screen.

④ [READ] [MANUAL]

To reproduce only one file, set to the MANUAL mode.

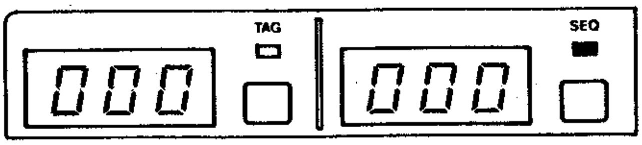
⑤ Press numeric key 0 three times to set the sequential number to 0.

If the INC lamp is off, press this key.

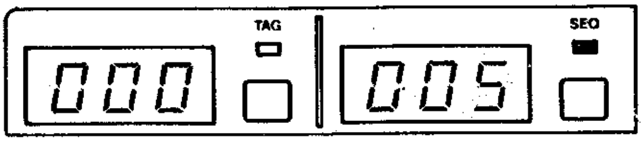
⑥ Reproduce the time data.

Press START/STOP to reproduce the time data (Xa).

The sequential number does not change, that is, the file is reproduced from sequential number 0.

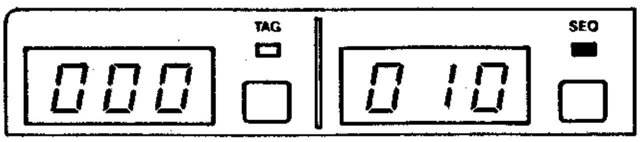


⑦ Press START/STOP to reproduce the spectrum (Gaa).



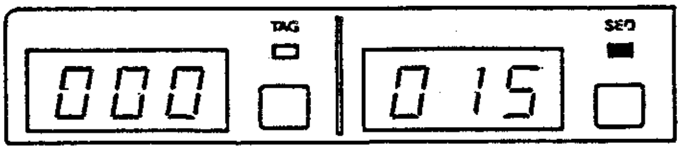
The file is reproduced from sequential number 5.

⑧ Press START/STOP to reproduce the autocorrelation function (Raa)



(The file in the sequential numbers 10 - 14 is reproduced.)

(9) Press START/STOP [□] to reproduce the histogram (Pa).



(3) Reproducing an ORIGIN file (DISPLAY = PANEL)

In (1) and (2) above, FLOPPY was selected in the DISPLAY SOURCE item and the origin file was reproduced under the conditions imposed at the time of file creation.
If PANEL is selected in the DISPLAY SOURCE item, the same data as above can be reproduced under different setting conditions by pressing numeric key 0.

```
I/O SELECT
  FLOPPY

FLOPPY MODE
  READ          #
  WRITE
  EDIT
  CATALOGUE

DISPLAY SOURCE
  FLOPPY
⇨ PANEL         #

DATA OUT
  CRT

OVERLAY NUMBER
  0
```

Table 8-5 ORIGIN Data Written in ORIGIN Mode

Data type \ Mode	2 channel Zero Start	1 channel Zero Start	Zooming	4 decade
Xa, Xb	(a)	(b)	△ 〈1〉	(a) 〈4〉
〈Xa〉, 〈Xb〉	x	x	-	-
Gaa, Gbb	(a)	(b)	△ 〈1〉	(a) 〈4〉
〈Gaa〉, 〈Gbb〉	(c) 〈2〉	x	(c) 〈2〉	(d) 〈2〉
Sa, Sb	(a)	(b)	△ 〈1〉	(a) 〈4〉
〈Sa〉, 〈Sb〉	(e)	x	(e)	-
Raa, Rbb	(a)	-	-	-
〈Raa〉, 〈Rbb〉	(f)	-	-	-
Rab	(a)	-	-	-
〈Rab〉	(g)	-	-	-
Pa, Pb	(a)	(b)	-	(a) 〈4〉
〈Pa〉, 〈Pb〉	x	x	-	-
〈Impls〉	(c)	-	-	-
〈Hab〉	(c)	-	(c)	(d)
〈COH〉	(c)	-	(c)	(d)
〈COP〉	(c)	-	(c)	(d)
Gab	(a)	-	△ 〈1〉	(a) 〈4〉
〈Gab〉	(c)	-	(c)	(d)
OCTa, OCTb	x	-	-	-
〈OCTa〉, 〈OCTb〉	x	-	-	-
Za, Zb	(a) 〈3〉	(b)	-	-
Zaa, Zbb	(a) 〈3〉	(b)	-	-

(Continued)

G_{aa}^{z}, G_{bb}^{z}	(a) ⟨3⟩	(b)	-	-
Ca, Cb	(a) ⟨3⟩	(b)	-	-
Caa, Cbb	(a) ⟨3⟩	(b)	-	-
G_{aa}^{c}, G_{bb}^{c}	(a) ⟨3⟩	(b)	-	-
⟨SNR⟩	(c)	-	-	-
⟨ML⟩	(c)	-	-	-
⟨SCOT⟩	(c)	-	-	-
GaaL, GbbL	(h)	-	-	-

Notes:
- \- : Indicates that there is no data in this mode.
- △ : Indicates that data exists but there is no origin data.
- x : Indicates that this data is not supported.
- ⟨1⟩ : The origin data is complex and cannot be stored in a file.
- ⟨2⟩ : Valid only when "AVERAGE WHAT?" is CROSS + POWER.
- ⟨3⟩ : The VIEW mode is not supported.
- ⟨4⟩ : Indicates that the time data in the current frequency range is written.

Table 8-6 Data Convertible from Each ORIGIN File

(a)	Xa, Xb, Gaa, Gbb, Sa, Sb, Raa, Rbb, Rab, Pa, Pb, Gab Za, Zb, Zaa, Zbb, $\text{G}\overset{z}{\text{a}}\text{a}$, $\text{G}\overset{z}{\text{b}}\text{b}$, Ca, Cb, Caa, Cbb. $\text{G}\overset{c}{\text{a}}\text{a}$, $\text{G}\overset{c}{\text{b}}\text{b}$, GaaL, GbbL
(b)	Xa, Gaa, Sa, Pa or Xb, Gbb, Sb, Pb
(c)	⟨Gaa⟩, ⟨Gbb⟩, ⟨Impls⟩, ⟨Hab⟩, ⟨COH⟩, ⟨COP⟩, ⟨Gab⟩, ⟨SNR⟩ ⟨ML⟩, ⟨SCOT⟩
(d)	⟨Gaa⟩4, ⟨Gbb⟩4, ⟨Gab⟩4, ⟨COH⟩4, ⟨COP⟩4, <Hab>4
(e)	⟨Sa⟩, ⟨Sb⟩
(f)	⟨Raa⟩, ⟨Rbb⟩
(g)	⟨Rab⟩
(h)	GaaL, GbbL

8.6.6 FIXED File

```
I/O SELECT
  FLOPPY

FLOPPY MODE
  READ
  WRITE         #
  EDIT
  CATALOGUE

WRITE MODE
  ORIGIN
⇨ FIXED         #
  MASS TIME
  GRAPHICS
  PANEL

WRITE TRIG.
  DATA
  FREE RUN
    CH-A

M.TIME FCTN
  OFF
  K = +1.00
```

Press [I/O] to display the FLOPPY menu.

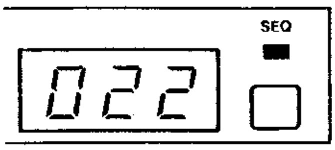
Press [⇧] or [⇩], then press [SETUP] to select WRITE in the FLOPPY MODE item.

(1) Creating a FIXED file

① Press [WRITE] and numeric keys to set the sequential number to 20.

(Sequential numbers 0 - 19 are assigned to the ORIGIN file data.)

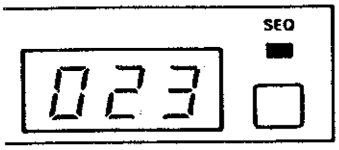
② Time data file



Press [TIME] to display the TR9407 time data, then press [START/STOP] to create a file.

Sequential number 22 is displayed to indicate that two units of file data have been created.

(3) Spectrum file

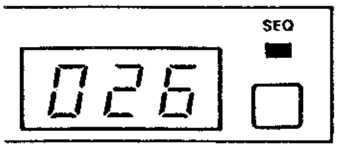


Press SPECTRUM to display a spectrum, then press START/STOP to create a file. Sequential number 23 is displayed to indicate that one unit of file data has been created.

(4) Autocorrelation function file

Press AUTO-CORR. to display an autocorrelation function, then press START/STOP to create a file. Sequential number 25 is displayed to indicate that two units of file data have been created.

(5) Histogram file



Press HIST. to display a histogram, then press START/STOP to create a file. Sequential number 26 is displayed to indicate that one unit of file data has been created.

(2) Reproducing a FIXED file
To reproduce four screens of a FIXED file, select READ in the FLOPPY MODE item and CRT in the DATA OUT item.

```
I/O SELECT
  FLOPPY

FLOPPY MODE
⇨ READ          #
  WRITE
  EDIT
  CATALOGUE

DISPLAY SOURCE
  FLOPPY        #
  PANEL

DATA OUT
  CRT

OVERLAY NUMBER
  0
```

① Press READ, then set sequential number 20 with numeric keys

② Every time START/STOP is pressed, the MEMORY RECALL LED goes on and the time data, spectrum, autocorrelation function and histogram are displayed. In this case, the RECALL LED goes on to indicate that the FIXED data has been reproduced in the memory store buffer.
The amount of increment (INC) of the sequential number at reproduction indicates that the FIXED file is smaller than the ORIGIN file. Since the FIXED data is stored in the memory store buffer, the reproduced data can be handled like the data stored in the memory. Data conversion is disabled but math operations are enabled.

8.6.7 GRAPHICS file

(1) Creating a GRAPHICS file

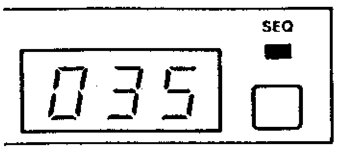
```
I/O SELECT
  FLOPPY

FLOPPY MODE
  READ
  WRITE         #
  EDIT
  CATALOGUE

WRITE MODE
  ORIGIN
  FIXED
  MASS TIME
⇨ GRAPHICS      #
  PANEL

WRITE TRIG.
  DATA
  FREE RUN
    CH-A

M.TIME FCTN
  OFF
  K = +1.00
```

① Press [⇧], then press [⇩] to select WRITE in the FLOPPY MODE item and GRAPHICS in the WRITE MODE item.

② Press WRITE [□] and numeric keys to set the sequential number to 30.

(Sequential numbers 0 - 19 and 20 - 26 are assigned to the ORIGIN and FIXED files respectively.)

③ Time data file

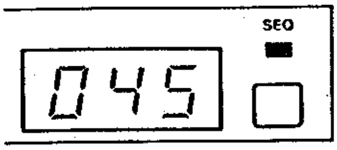


Press TIME [□] to display the time data, then press START/STOP [□] to create a file. Sequential number 35 is displayed to indicate that five units of file data have been created.

④ Spectrum file

Press SPECTRUM to display a spectrum, then press START/STOP to create a file. Sequential number 40 is displayed to indicate that five units of file data have been created.

⑤ Autocorrelation function file



Press AUTO-CORR. to display an autocorrelation function, then press START/STOP to create a file. Sequential number 45 is displayed to indicate that five units of file data have been created.

⑥ Histogram file

Press HIST. to display a histogram, then press START/STOP to create a file. Sequential number 50 is displayed to indicate that one unit of file data has been created.

(2) Reproducing a GRAPHICS file

① Press READ.

② Every time START/STOP is pressed, time data, spectrum, atuocorrelation function, and histogram are displayed.

③ When a GRAPHICS file is reproduced, data is not analyzed but only the reproduced file is displayed. Only the I/O EXECUTE and LOCAL keys are effective on the TR9407 panel.

8.6.8 MASS TIME File

All time data is written from the TR9407's 512K-word time buffer into the MASS file, so its size is very large (1280 units). Since one side of a floppy disk can contain 200 units, four floppy disks are required to store the MASS TIME file entirely. The ORIGIN, FIXED, and GRAPHICS files are created according to the display. Since it is explicitly known that 512K-word time data is to be stored in a MASS TIME file, 512K-word time data is filed irrespective of the display.

MASS-time file is 512K word in the free-run or hold mode while in the ADVANCE ARM mode the memory buffer is divided into some blocks depending on the ARM LENGTH as shown in Table 8-7. Data window, hold zooming, interchannel delay, FUNCTION (U+L, U-L, U*L) can be applied to the reproduced MASS TIME file.

Table 8-7 Arm Length and Block Number

IB length	2K	4K	8K	16K	32K	64K	128K	256K	512K
ARM LENGTH (1 ch)	2K	4K	8K	16K	32K	64K	128K	256K	512K
ARM LENGTH (2 ch)	1K	2K	4K	8K	16K	32K	64K	128K	256K
Max. Block No.	32	32	32	32	16	8	4	2	1
No. of disk	0.5	1	1	4	4	4	4	4	4

(1) Creating a MASS TIME file

```
I/O SELECT
  FLOPPY

FLOPPY MODE
  READ
  WRITE         #
  EDIT
  CATALOGUE

WRITE MODE
  ORIGIN
  FIXED
⇨ MASS TIME     #
  GRAPHICS
  PANEL

WRITE TRIG.
  DATA
  FREE RUN
    CH-A

M.TIME FCTN
  OFF
  K = +1.00
```

Press [⇧] or [⇩], then press [SETUP] to select WRITE in the FLOPPY WRITE item and select MASS TIME in the WRITE MODE item.

Check that the sequential number is 000 (drive 0, front), then press WRITE and START/STOP. The MANUAL LED goes off, the AUTO LED goes on, the CRT screen displays the "WRITING: MASS TIME" message, and the sequential number is incremented by 5. If the next floppy disk is not inserted before the sequential number reaches 360, the "INSERT NEXT DISK, PLEASE!" message is displayed on the CRT screen. Insert a floppy disk in drive 0. When write is completed, the START/STOP LED goes off and the buzzer sounds.

(2) Setting WRITE TRIG.

```
WRITE  TRIG.
⇨ DATA
    FREE  RUN
      CH-A
```

Effective setup when the AUTO is on. Press ⇧ or ⇩ to move the pointer (⇨) to WRITE TRIG. (this pointer blinks). Press SETUP or DISP. to select DATA, AVGED, or SYSTEM.

① WRITE TRIG. DATA

```
DATA
FREE  RUN
  CH-A
```

A trigger is set for CH-A (no execution).
Data is written each time TR9407's analysis is completed.

```
⇨ DATA
  AUTO  ARM
    CH-A
```

AUTO ARM

A trigger is set for CH-A.
Data is written each time the TR9407 is armed.

```
⇨ DATA
  ARM
    CH-A
```

ARM

A trigger is set for CH-A.
Data is written each time the TR9407 is armed and the next arming is waited.

⇨ DATA HOLD DATA WINDOW	HOLD/REL.	Data is written each time the data window moves.

② WRITE TRIG. AVGED

⇨ AVGED AVG NUMBER 2	The data is written each time averaging is completed.

③ WRITE TRIG. SYSTEM

⇨ SYSTEM GP-IB WT-COM.	The data is written each time a WT command is sent from the GPIB.

(3) AUTO / MANUAL setup

AUTO — Continuously create a file according to WRITE TRIG.

MANUAL — When START/STOP is pressed, one file is created. In the MASS TIME file, the AUTO LED goes on when data is written.

(4) INC / DEC setup

INC — A file is created so that the sequential number increases.

DEC — A file is created so that the sequential number is decremented. This function cannot be used for the ORIGIN files (including MASS TIME files) with more than 10 units. If the DEC LED is on at first, the INC LED goes on when the above file is created.

(5) Setting a sequential number — Set the sequential number of the file to be created with numeric keys. For the MASS TIME file, only 0,200,400, and 600 can be assigned.

(6) [WRITE] [START/STOP]

Select the WRITE mode (see Note) to create a file. When a MASS TIME is created, the "WRITING: MASS TIME" message is displayed. When creation is completed, the buzzer sounds. When a small file is to be written in a larger file, the "IN PROCESS: FILLING ZEROS" message is displayed.

Note: WRITE is automatically selected in response to [WRITE] even if READ is selected in the FLOPPY MODE item of the FLOPPY menu.

(7) Setting M. TIME FCTN

```
M. TIME FCTN
⇨ OFF
  K = +1.00
```

This setting can be made when MASS TIME is selected in the WRITE MODE item.

Press [⇧] or [⇩] to move the pointer (⇨) to the line under M. TIME FCTN (the pointer will blink).

Press [SETUP] or [DISP.] to move the pointer to OFF and select one of the following:

Xa = Xa+K*Xb
Xa = Xa-K*Xb
Xa = Xa*K*Xb

```
M. TIME FCTN
   Xa=Xa+K*Xb
⇨ K=+1.00
```

Press [⇩] to move the pointer to K= (the pointer will blink). Press [SETUP] or [DISP.] to set the value of K. The [SETUP] key is for decrement and the [DISP.] key is for increment. The range of K is from -1.00 to +1.00.

When M. TIME FCTN is set, a MASS TIME file can be created according to the operation result Xa.

(8) Reproducing a MASS TIME file
Like other files, the following two procedures are available to reproduce the MASS FILE file.

(1) Select READ in the FLOPPY MODE item.

READ

Set the sequential number of the file to be reproduced with numeric keys.

START/STOP

Start reproduction.

Another procedure is as follows:

(2) Select CATALOGUE in the FLOPPY MODE item.
Move the pointer (⇨) to the objective file in the displayed file list, then press SETUP to display the file.

For the MASS TIME data, the following message is displayed when a floppy disk is read for sequential numbers 0 and 360:

INSERT NEXT DISK, PLEASE!

Insert the next disk. If reproduction of one disk is enough, press START/STOP to extinguish the internal LED.

If a floppy disk of an incompatible data is inserted, the following message will be displayed on the CRT screen:

DIFFERENT DISK : CHECK RECORDED TIME

Check whether the disk is one of the series of four sets of disks storing a MASS TIME file.
If a read of the data from only one disk is completed, the following features can be used without necessarily reading all four disks:

Data window
Zooming
FUNCTION (U+L, U-L, U*L)

8.6.9 Cataloging a File

CATALOGUE mode provides a means of reproducing the file of interest straightforward from the CATALOGUE display in addition to the lookup table to view the file contents.

```
I/O SELECT
  FLOPPY

FLOPPY MODE
  READ        #
  WRITE
  EDIT
⇨ CATALOGUE

DISPLAY SOURCE
  FLOPPY      #
  PANEL

DATA OUT
  CRT

OVERLAY NUMBER
  0
```

Press [⇧] or [⇩] to move the pointer (⇨) to CATALOGUE in the FLOPPY WRITE item.

Press [SETUP] to display the left-hand menu.

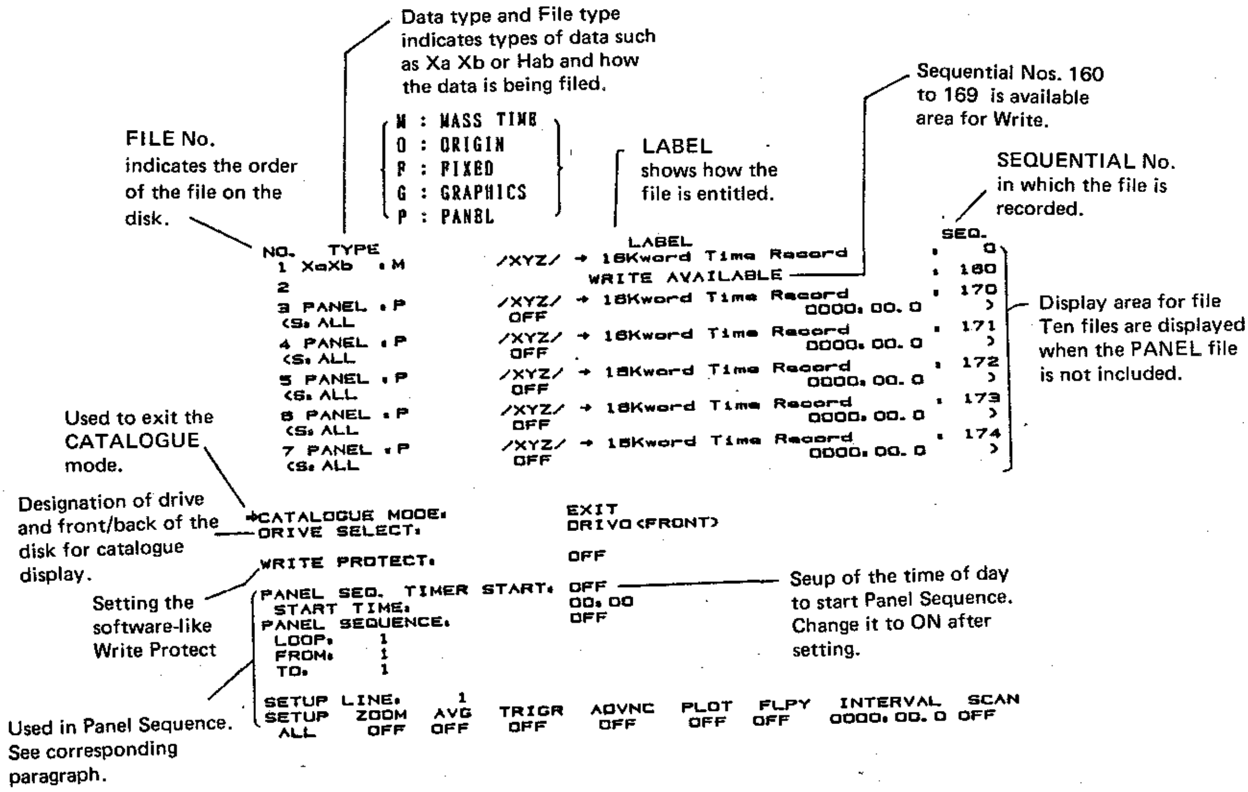
This [LIST] LED of the TR9407 goes on and the CATALOGUE MODE data shown below is displayed. The lamps of [READ], [MANUAL], [INC], and [START/STOP] go on, TR98102 starts to read the disk and the following message blinks on the screen:

IN PROCESS : CATALOGUE MODE

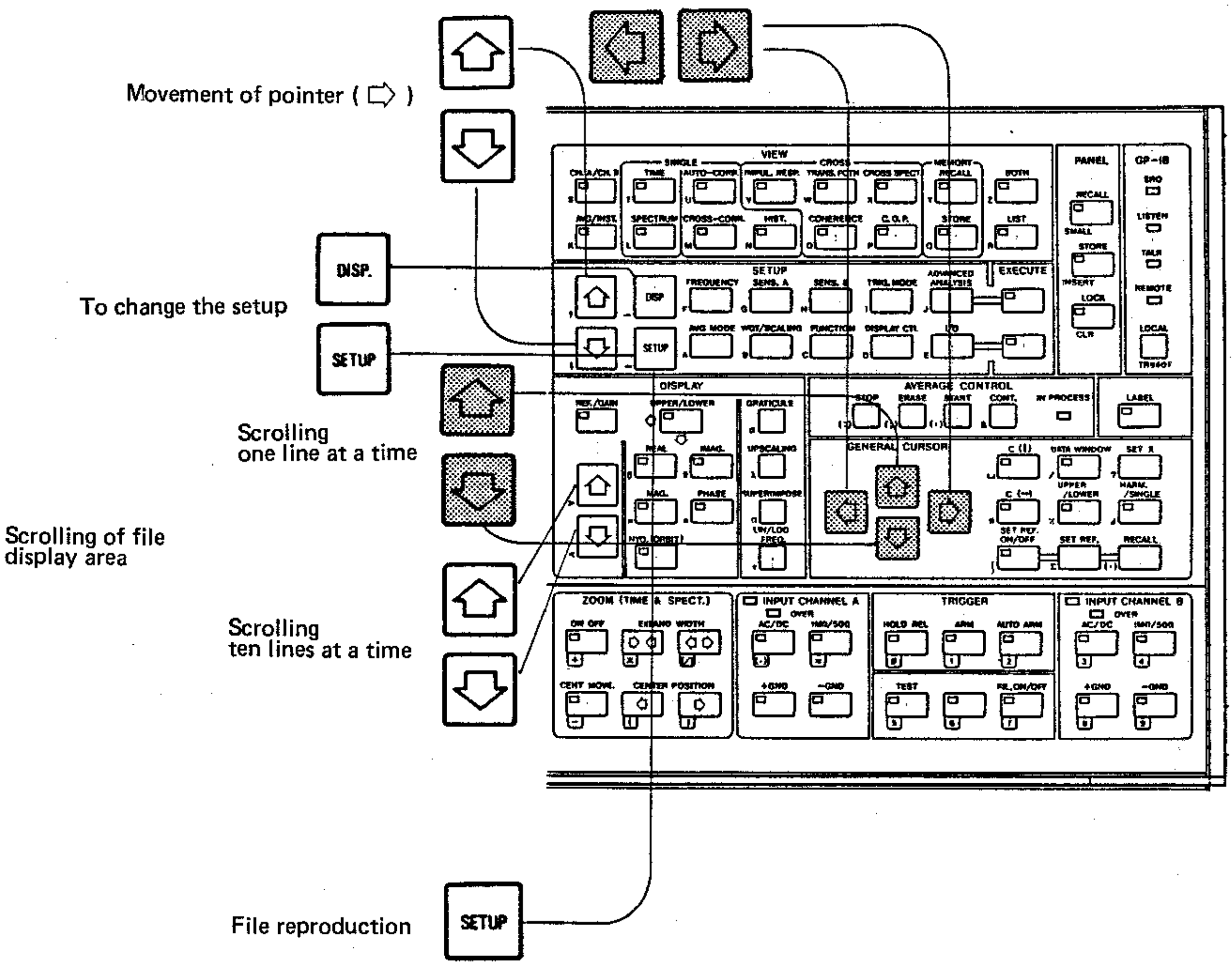
```
   No.   TYPE                    LABEL                    SEQ.




⇨CATALOGUE MODE:          EXIT
 DRIVE SELECT:            DRIV0(FRONT)

 WRITE PROTECT:           OFF

 PANEL SEQ. TIMER START:  OFF
  START TIME:             00:00
 PANEL SEQUENCE:          OFF
  LOOP:    1
  FROM:    1
  TO:      1

 SETUP LINE:      1
 SETUP  ZOOM  AVG  TRIGR  ADVNC  PLOT  FLPY  INTERVAL  SCAN
  ALL    OFF  OFF   OFF    OFF    OFF   OFF  0000:00.0 OFF
```

When read is completed, the buzzer sounds and the data type, file type, label, and sequential number of the file are displayed. Sequential numbers 0 - 199 are assigned to the front side of the disk in drive 0. When the sequential number reaches 199, the files on the disk are listed.

(Sequential numbers 200 - 399 are assigned to the rear side of the disk in drive 0; 400 - 599 to the front side of the disk in drive 1; 600 - 799 to the rear side of the disk in drive 1.)



The file display area is allocated for 10 files. The data in this area is scrolled one line at a time to display the succeeding file name and number at each press of [⇧] in the GENERAL CURSOR section. Press [⇧] or [⇩] to move the pointer (⇨) to the file number of interest, then press [SETUP] to display the file on the screen.



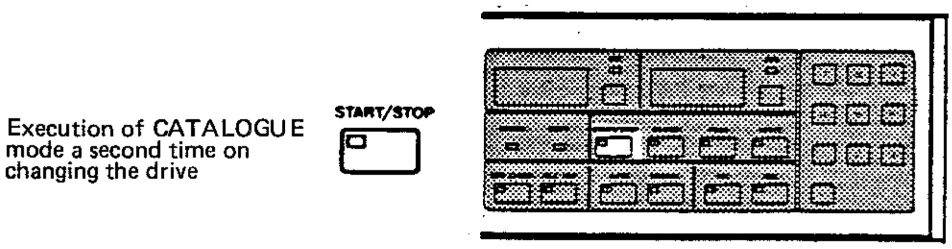


Figure 8-34 Keys for CATALOGUE Menu Setting

To cancel the CATALOGUE mode,

- move the printer (▷) to CATALOGUE MODE: EXIT, then press [SETUP] or [DISP.].
- read or write a file or initialize the disk, or
- specify the drive having no disk and execute cataloging.

After the CATALOGUE mode is cancelled, the following LEDs of the TR98102 go on:

Table 8-8 File Creation/Reproduction by TR98102

File Creation	(1) Select FLOPPY MODE: WRITE SETUP	(2) Set a file type. (WRITE MODE)	(3) Display the file on the screen ACCORDING TO DISPLAY: When displaying an ORIGIN, FIXED, or PANEL file in the dual screen mode, the contents in the lower screen are stored. When a GRAPHICS file is displayed, it is stored in file just as it is. IRRESPECTIVE OF DISPLAY: For the MASS TIME file, 512Kword is stored irrespective of the display.	(4) Set a sequential number with numeric keys. SEQ In the WRITE mode, the INC is always on. For the MASS TIME file (160 units), sequential numbers can be started with only 0, 200, 400 and 600.	(5) WRITE MANUAL For the MASS TIME data file, AUTO automatically goes on when the START switch is pressed.	(6) START/STOP
File reproduction	(1) Set FLOPPY MODE: READ SETUP	(2) Set DISPLAY SOURCE: FLOPPY and DATA OUT : CRT		(3) Set a sequential number with numeric keys. SEQ	(4) READ The TR9407 does not analyze data but display the reproduced data. MANUAL For the MASS TIME file, data is read in the AUTO mode. In the MANUAL mode, a 2K-word origin file is read.	(5) The reproduced file data is displayed at each press of START/STOP. When the ORIGIN file is reproduced, the VIEW lamp corresponding to the reproduced data goes on. When the FIXED file is reproduced, data is read into the memory buffer and the MEMORY RECALL lamp goes on.
	Set FLOPPY MODE: CATALOGUE	Move the pointer to the objective file number in the file list, then press SETUP.				

Note: If level monitor display is in dual mode, the upper and lower traces are written into a file.

Table 8-9 Reproduction of Data Recorded on Floppy Disk

Output format setting by menu	Reproduction on CRT		Reproduction on hard copy (Select XY-RCDR/PLOTTER from I/O SELECT menu)	
	DATA OUT (FLOPPY READ in I/O SELECT)	3D DISP OUTPUT (3D display menu)	DATA OUT (FLOPPY READ in I/O SELECT)	3D DISP OUTPUT (3D display menu)
Non-3D display	Set DATA OUT = CRT.	X	DATA OUT = PLOTTER/XY-RCDR Set an OVERLAY NUMBER.	X
3D display	For the output format, the 3D display menu is given the highest priority.	3D DISP OUTPUT =CRT 3D DISP TRIG =AUTOMATIC (For the ORIGIN or MASS TIME data file, AVERAGING may be set.) 3D DISP SOURCE =FLOPPY (The number of waveforms displayed on the CRT screen is fixed to 14. The stack line number cannot be set.)	For the output format, the 3D display menu contents are given priority over the I/O SELECT FLOPPY READ menu contents.	3D DISP OUTPUT =HARD COPY 3D DISP SOURCE =FLOPPY Set the stack line number.

8.6.10 Editing a File

Specify the file to read with a sequential number and specify the place to write this file for editing.

If the WRITE mode is set at this time, the file type can be changed

Press [⇧] or [⇩] to move the pointer (⇨) to EDIT in the FLOPPY MODE item, then press [SETUP] to display the EDIT mode menu. When the edit mode is set the COPY lamp on the TR98102 panel blinks.

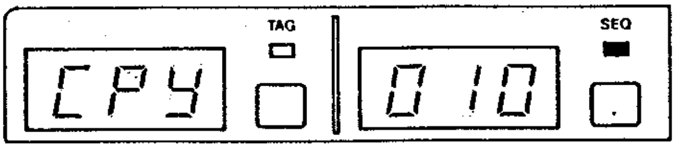
```
I/O SELECT
  FLOPPY

FLOPPY MODE
  READ
  WRITE
⇨ EDIT
  CATALOGUE    #

EDIT MODE
  COPY(D1 D0) #    Copying data from drive 1 to drive 0
  READ&WRITE       Editing in file units (READ and WRITE modes
  EDIT(M.TIME)     should be set at the same time)
                   MASS TIME file editing (set the following
M.TIME E.MODE      items)
 FROM
  DRIV0(FRONT)
  CH-A             Set MASS TIME file editing.
                   Set source and destination drive numbers
 TO                and disk sides (front or rear)
  DRIV0(FRONT)
  CH-A
```

① Copying disk data

```
EDIT MODE
⇨ COPY (D1  D0)  #
  READ&WRITE
  EDIT(M.TIME)
```

Insert floppy disks in drive 1 (source drive) and drive 0 (destination drive).

When START/STOP is pressed, "CPY" is displayed by the TAG indicator and the sequential number of the file being copied is displayed by the SEQ indicator.



② Setting READ and WRITE
Set the READ and WRITE modes in advance.

- Setting READ

```
FLOPPY MODE
⇨ READ          #
  WRITE
  EDIT
  CATALOGUE

DISPLAY SOURCE
  FLOPPY        #
  PANEL

DATA OUT
  CRT
```

Select the READ mode.
To display the data available at file creation, select FLOPPY in the DISPLAY SOURCE item. To convert data, select PANEL.
Select CRT from the DATA OUT item, or the plotter or XY-RCDR will operate every time a file is reproduced.

- Setting WRITE

```
FLOPPY MODE
  READ
⇨ WRITE         #
  EDIT
  CATALOGUE

WRITE MODE
  ORIGIN        #
  FIXED
  MASS TIME
  GRAPHICS
  PANEL
```

Select the WRITE mode.
Writing the data in the READ & WRITE of EDIT mode complies with the file creation by the WRITE mode. It is necessary to set up the WRITE mode. If this setting is improper, unnecessary data conversion may be caused or unrelated data may be stored in the file.

After the above setting, select the EDIT mode again.

```
EDIT MODE
  COPY (D1  D0).
⇨ READ&WRITE      #
  EDIT(M.TIME)
```

③ READ — Set the sequential number of the file to be read with numeric keys.

④ WRITE — Set the sequential number of the file to be written with numeric keys. Pressing here READ and WRITE alternately will show that sequential numbers for read and write files have been set separately.

⑤ Press INC/DEC to increment or decrement the read data sequential number. (DEC cannot be used for the ORIGIN file consisting of 10 or more units.) The write data sequential number is always incremented.

⑥ Press AUTO or MANUAL.

⑦ Generally, data to be written can be monitored prior to writing. To skip the data, press READ and START/STOP until the file to be written is displayed. Then, press WRITE and START/STOP.

⑧ Editing a MASS TIME file

```
EDIT MODE
  COPY(D1  D0)
  READ&WRITE
⇨ EDIT(M.TIME)    #

M.TIME E.MODE
 FROM
  DRIV0(FRONT)
  CH-A

 TO
  DRIV1(FRONT)
  CH-A
```

← Set the drive containing the MASS TIME file to be copied, the side (front or rear) of the disk, and channel.

← Set the destination drive and channel.

Practical combinations of FROM and TO items and the resulting processing are as follows:

FROM	TO	Copy processing
CH-A (CH-B)	CH-A	The CH-A data set in TO is replaced with the CH-A (CH-B) data set in FROM. The CH-B data in TO does not change.
CH-A (CH-B)	CH-B	The CH-B data set in TO is replaced with the CH-A (CH-B) data set in FROM. The CH-A data set in TO does not change.
CH-A (CH-B)	DUAL	The CH-A data and CH-B data set in TO are replaced with the CH-A (CH-B) data set in FROM.
DUAL	CH-A	The CH-A data set in TO is replaced with the CH-A data set in FROM.
DUAL	CH-B	The CH-B data set in TO is replaced with the CH-B data set in FROM.
DUAL	DUAL	The CH-A data and CH-B data set in TO are replaced with the CH-A data and CH-B data set in FROM.

The MASS TIME file created using one channel cannot be treated in the EDIT (M.TIME) mode.

8.6.11 Panel Sequence

The panel file stores all the TR9407 setting conditions, so the file creation state can be completely reproduced. Panel sequence mode allows programming of sequential read of the panel file contents, setting of TR9407 in the panel file setting state, and start of the TR9407 analysis function.

Start of the TR9407 functions is set in the CATALOGUE mode; the last two lines of the CATALOGUE menu represents the functions which can be started by reading the setup in the file.

When the above functions are set at the same time, they are executed in the following order:

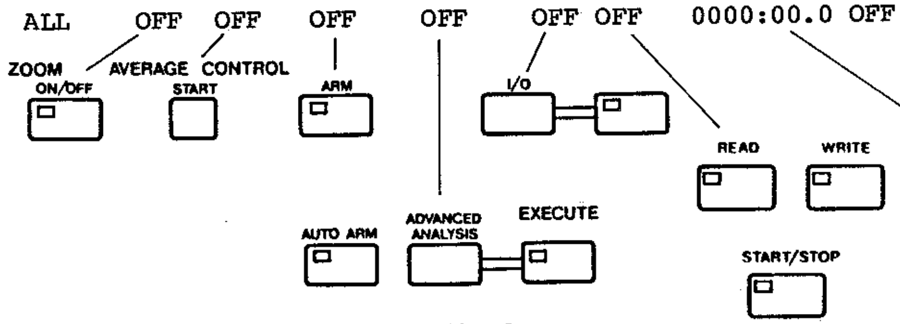
ZOOM → ADVNC → TRIGR → AVG → PLOT → FLPY

```
NO.  TYPE                  LABEL                                  SEQ.
1 PANEL : P          4-Decade Transfer Function                :    0
(SET: ALL        AVG  ADV ANALY  HARDCOPY FLP: WT          INT:SHT )
2 PANEL : P          4-Decade Group Delay                      :    1
(SET: ALL             ADV ANALY  HARDCOPY                  INT:SHT )


CATALOGUE MODE:              EXIT
DRIVE SELECT:                DRIVE0(FRONT)

WRITE PROTECT:               OFF

PANEL SEQ. TIMER START:      OFF
 START TIME:                 00:00
PANEL SEQUENCE:              OFF
 LOOP:    1
 FROM:    1
 TO:      1

SETUP LINE:    1
SETUP  ZOOM  AVG  TRIGR  ADVNC  PLOT  FLPY  INTERVAL   SCAN
 ALL    OFF  OFF   OFF    OFF    OFF   OFF  0000:00.0  OFF
```

Set the time to start the panel sequence.

Use of a SYNC OUT signal permits construction of a multichannel system with a scanner (TR7200).

Select an analysis function



Interval time until the next panel file is read. (0 sec. to 100 hours)

Determine whether only the display information (DISP) or all information (ALL) is to be reproduced.

Panel sequence does not allow all combinations of trigger and averaging. Following combinations are available:

TRIG		AVG
OFF	↔	OFF
OFF	↔	ON
ARM	↔	OFF
AUTO ARM	↔	ON
AUTO ARM	↔	OFF

In this example, two panel files have been created on the disk and the panel sequence is ready to be started.

(1) Panel sequence example

An example of the sequence of obtaining a transfer function and group delay is given as follows:

1. Measure the transfer function through 4-decade logarithmic frequency analysis.
2. Save the transfer function on the floppy disk as an origin file.
3. Dump the transfer function onto the hard copy.
4. Obtain the group delay.
5. Dump the group delay onto the hard copy.

Use the following procedure to make measurements with panel sequence. Insert the disk for sequence in drive 0 and the data disk in drive 1.

① Press [FREQUENCY] to set the frequency range.

② Set the TR98201 signal generator menu.

Press [I/O], [PANEL RECALL] and [AUTO-CORR.] to select the swept sine and set AMPLITURE, LINE CTRL, and so forth.

③ Set the 4-decade logarithmic frequency analysis.

Press [ADVANCED ANALYSIS], [PANEL RECALL], and [COHERENCE] to display the servo menu and select 4-DECADE in the ANALYSIS LINE menu. Set SENSE CTRL, WEIGHTING CTRL, AVG NUMBER, AVG PROCESS, and so forth, then select ENABLE in SERVO item.

④ [AVG MODE]

Set "AVG WHAT?" to "CROSS+POWER."

⑤ Setting the plotter

Press [I/O] and [PANEL RECALL] to display the plotter menu.

⑥ Display the transfer function.

The system is now ready for 4-decade logarithmic frequency analysis. Display the transfer function to save the transfer function into the panel file and dump it onto the hard copy.

Press [BOTH] to select the single screen mode, the press the [TRANS. FCTN] and [MAG.].

⑦ Create a panel file

Press [I/O], [PANEL RECALL], and [HIST. N] to display the FLOPPY menu.

Select PANEL in the WRITE MODE item to create a panel file in the sequential number 0.
It is convenient to write a title (using a LABEL mode) at the top of instant data display for the future cataloging.

⑧ Set the group delay

Press [ADVANCED ANALYSIS], [PANEL RECALL], and [C. O. P. P] to display the group delay menu and set ENABLE .

⑨ Display the transfer function phase.
Since group delay analysis is performed when the transfer function phase is displayed, press [TRANS. FCTN] and [PHASE] to display the transfer function phase.

⑩ Create a PANEL file
Create a PANEL file in the sequential number 1.

⑪ Modify the PANEL file

Press [I/O], [PANEL RECALL], and [HIST. N] to display the FLOPPY menu and select CATALOGUE mode.

Move the pointer (⇨) to SETUP LINE: and select 1 to modify the first file.

SETUP	ALL
ZOOM	OFF
AVG	ON
TRIGR	OFF
ADVNC	ON
PLOT	ON
FLPY	WRITE
INTERVAL	00:05:00

(If this file is read in the sequence mode, the 4-decade transfer function is measured, output to the plotter, and stored in a file.)

Move the pointer (⇨) to SETUP LINE: and select 2 to modify the second file.

SETUP	ALL
ZOOM	OFF
AVG	OFF
TRIGR	OFF
ADVNC	ON
PLOT	ON
FLPY	OFF
INTERVAL	00:05:00

(If this file is read in the sequence mode, the group delay is obtained from the transfer function and output to the plotter.)

Thus the PANEL file setting is completed.

```
LOOP: 1
FROM: 1
TO  : 2
```

Set the menu to the PANEL SEQUENCE:ON to start the panel sequence.

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9. PRECAUTIONS ON SHIPPING & STORAGE

9.1 SHIPPING PRECAUTIONS

Should it become necessary to repack the instrument for shipment, use the original packing material or equivalent. A carrying case (TR16025) dedicated for the TR9407 is optionally available from us for transportation convenience.

9.2 STORAGE PRECAUTIONS

The storage temperature for the instrument is between -20°C and +70°C. If the instrument is to be left unused for a long period of time, wrap it with a vynil cloth or put it in a carton box. The storage site should be free of direct sunlight or excessive moisture.

9.3 CLEANING THE INSTRUMENT

The CRT screen and the reverse side of the CRT filter should be cleaned periodically with a soft cloth moisted with alcohol. Never use any cleaning solvent other than alcohol.

How to remove the CRT filter. (See Figure 9-1)

1 Remove the belt cover with a flat-tipped screwdriver or other adequate tool. The belt cover is mounted without using any screws or bond.

2 Loosen the two screws at the top of the bezel.

3 Remove the bezel by pulling it forward-upward.

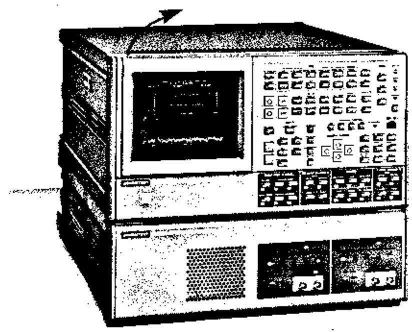

Figure 9-1 Removing the CRT Filter

MEMO

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10. SPECIFICATIONS & ACCESSARIES

10.1 SPECIFICATIONS

Input Specifications

Input channels : 2
Input mode : Differential or single ended
Input impedance: Approx. 1 MΩ or 50 Ω (only 1 MΩ at 30 dBV input sensitivity)
Input coupling : AC, DC, GND
CMRR : 50 dB min. (DC coupling at 50/60 Hz)
Max. common mode signal voltage:
±5 V (-30 dBV to -60 dBV)
±50 V (-20 dBV to -10 dBV)
±100 V (0 dBV to +30 dBV)
Amplitude range: -60 dBV to +30 dBV (1 mVrms to 31.6 Vrms) in 10 dB steps

Input sensitivity range: +30 dBV to -60 dBV in 10 dB steps and AUTO

Max. differential input voltage: ±100 Vp-p

Overload indicator: If a differential voltage exceeding approx. 95% of the selected amplitude range or a common mode signal exceeding the specified value (regardless of amplitude range setting) is applied to the input, the OVERLOAD indicator lamp on the front panel lights for approx. 0.5 sec. and an alarm is sound. Message such as "OVERLOAD: CH-A" blinks of the CRT display for a few seconds.

Test signal : Test signal is to be generated to verify operation.

Analyzing Characteristics

Frequency range : 19 ranges of 1 Hz, 2 Hz, 5 Hz, 10 Hz, 20 Hz, 50 Hz, 100 Hz, 200 Hz, 500 Hz, 1 kHz, 2 kHz, 5 kHz, 10 kHz, 20 kHz, 50 kHz, 100 kHz, 200 kHz, 500 kHz and 1 MHz

Data buffer memory: 512K words/ch for single channel mode
256K words/ch for dual channel mode

Resolution : Time domain data (1 frame)
2048 points for single channel mode
1024 points for dual channel mode

Frequency domain data
800 lines for single channel mode
400 lines for dual channel and zoom modes
1116 lines for 4-decade logarithmic frequency analysis mode
Amplitude domain data
256 points

Analyzing frequency span:
"0" start mode : Analysis starts from 0 Hz and the setup frequency range is set to the full scale
4-decade logarithmic frequency analysis mode
: Frequency range is automatically switched in a ratio of 1 to 0.1 to 0.01 (only available at averaging)

Number of points of displayed waveform
: In time data display, arbitrary 2048 points (1024 points for dual channel mode) of data out of 512K words (single channel mode) or 256K words (dual channel mode) of data can be specified and displayed.

Data sampling : Input signal is sampled by a 12-bit A/D converter at a sampling frequency 2.56 times the setup frequency range.

External sampling : External TTL-level signal fed through BNC connector on the rear panel can be used as the sampling clock. Input filters are menu-selectable.
Time and frequency calibration in this mode is given as a percentage of full scale.

Input filters : With the FIL.ON/OFF key set to ON, each frequency range automatically selects anti-alialing filter except in the 1, 2, 5 and 10 Hz ranges for which 20 Hz filter is used.
Filter is settable to OFF.

Dynamic range : -65 dB of harmonic distortion in "0" start mode (with the incoming signal -5 dB or more short of full scale, +10 dBV range, Filter ON, Hanning, 32 times averaging, at 23°C ±5°C)

Interchannel delay: -1024 to +1024 points of measurement delay of CH.B in responce to CH.A.

Weighting : Rectangular, Hanning, flat-pass, minimum and Force/Response weighting functions

Residual noise : FS;68 dB (+30 dBV to -40 dBV range)
FS;58 dB (-50 dBV range)
FS;53 dB (-60 dBV range)
(at 23°C ±5°C, ±input GND, 1MHz range, Hanning, Filter ON, 32 times averaging)

Residual DC level : Within 3% of full scale in each sense range (at 23°C ±5°C, ±input GND, 1MHz range, Filter ON, after Auto calibration, average value of one frame data)

Frequency flatness: ±0.7 dB
(at 23°C ±5°C, frequency range from 0 to 90%, the level 5/10f of analysis range is standard)

Amplitude flatness:

Sense range (dBV)	Input level (dBV)	(dBV)	Spec (dB)
+30	+10	0	≦±0.7
+20	0	−20	
+10	0	−20	
0	−20	−40	
−10	−20	−40	
−20	−40	−60	≦±1.0
−30	−40	−60	
−40	−60	−80	
−50	−60	−80	
−60	−70	−90	

at 23°C ±5°C, Hanning, DC combination, 32 times averaging, for 500 kHz in 1MHz range.

Level accuracy : Frequency flatness + Amplitude flatness
(at 23°C ±5°C)

Channel-to-channel amplitude/phase difference
: ±0.5 dB / ±5deg
(at 23°C ±5°C, same sense range, frequency range from 0 to 90%)

Trigger

Trigger Mode : Free run, manual hold and release, automatic capture (external and internal triggers), ARM and AUTO ARM modes.

Triggering source : CH.A input signal
CH.B input signal
External TTL signal

Trigger level:
Input signal trigger: Settable by cursor with resolution of ±1/256 of the amplitude range.
External trigger: Input level : −10 V to +10 V
Resolution : ±1/256
Input impedance : 1 MΩ
Min. pulse width: 1 μs
Input connector : BNC on the rear panel

Trigger slope : Positive (+) or negative (−) slope specifiable for both input signal and external trigger signal.

Trigger position : Single channel mode
Range : 0 to 25600% (one frame equal to 100%)
Resolution: One sample data
Dual channel mode
Range : 0 to 25600% (one frame equal to 100%)
Resolution: One sample data

BLOCK : Data fetched in trigger mode can be divided into maximum of 32 blocks and be written into data memory. After completion of writing, block data can be arbitrarily read out.

External Gate

External gate : Data acquisition is controllable with the external TTL-compatible signal.

Averaging

Frequency domain averaging mode:
Normalized sum
Linear sum
Difference
Exponential
Peak
Sweep

Time domin averaging mode: Normalized sum

Amplitude domain averaging mode: Normalized sum

Averaging number : 1 to 8192 selectable in binary steps

Averaging control : Start, stop, +1 (increment by one), erase, and continue

Display and Operational Functions

Display : All information (measurement information, measurement conditions, labels, etc.) can be shown on an 8-inch random scanning CRT display.

Measurement condition selection: Interactive selection using menu

Display functions:

Time domain data - Input signal waveform (CH.A and CH.B): Real-time input waveform, integrated/differenciated real-time input waveform, transient signal waveform, time domain synchronous averaging waveform, orbit display
Cepstrum (CH.A and CH.B): Real-time power cepstrum, averaged power cepstrum (transformed from averaged spectrum)
Pre-envelope (CH.A and CH.B): Real-time pre-envelope, averaged pre-envelope (envelope of averaged data)
Correlation function: Auto correlation function and cross correlation function
Impulse response, ML, SCOT

Frequency domain data (Data for "0" start, averaged 4-decade logarithmic frequency, running zooming, and hold zooming can be displayed in the following modes) -
Spectrum (CH.A and CH.B and cross): Real-time spectrum, averaged spectrum and zoomed spectrum
Transfer function: Gain and phase (Bode diagram); dBMag and phase (Nyquist diagram or Nichols chart); Real part and imaginary part (Nyquist diagram)
Unwrapped phase
Coherence function
Coherent output power
Signal-to-noise ratio
Group delay

Amplitude domain data - Amplitude probability density function (CH.A and CH.B): Complex histogram and averaged histogram

Dual/single display mode: Two combinable data selected from the above data can be displayed simultaneously (BOTH mode).

Superimpose display mode: Two data in the same domain and in the same analyzing range can be superimposed for display.

Display expansion mode: Only signal display can be magnified approx. 40% by displacing the menu display (UPSCALING).

Graticule display mode: Display and erase.

3-D display mode : Up to 14 lines of displayed data can be stacked in 3-D display mode (Nyquist and orbit displays are in 3-D display mode with frequency axis and time axis).

Octave analysis : 1/3-octave band and 1/1-octave band analysis

Label : A string of label characters (40 alphanumeric and special characters) can be displayed in the top display area of the screen.

List mode:
Single mode - In spectrum display mode, the frequencies and levels of 20 spectra identified by the cursor can be listed in numerical form.
Harmonics mode - With the fundamental specified by the cursor, the frequencies and levels of harmonics up to 20th order are listed in numerical form together with its total harmonic distortion (THD) and total harmonic power (THP).

Overall RMS and partial RMS readout: In spectrum display mode, overall RMS value within the entire setup frequency range or partial RMS value of a limited section defined by the cursor is read out.
In time display mode, absolute value of voltage sum is determined.

Auto peak search : This feature automatically searches for and provides readouts of the frequency and amplitude of the maximum signal response in the spectrum display mode, maximum and minimum levels within a single frame in the time domain, maximum level and its delay time for correlation function, and maximum probability value and its voltage in the amplitude domain, and indicates the pertinent points with markers.

Cursor mode:
Single mode - While moving a vertical cursor line continuously from left to right or right to left, this mode provides the readouts of the time, voltage, frequency, level, magnitude, and/or phase at the intersection of the cursor line and signal trace.
Harmonics mode - In the spectrum display mode, this cursor mode indicates the frequency spots (harmonics), which are integer multiples of fundamental frequency identified by the cursor, with bright dots.
Cursor readout units - Time domain data : msec, sec, V
Frequency domain data: mHz, Hz, kHz, %, dB, dBV, V, V^2, deg, CPM, dBV/$\sqrt{Hz}$, V/$\sqrt{Hz}$, V^2/Hz
Amplitude domain data: ±V, V^{-1}

Set reference mode: With an arbitrary point defined as a reference by the cursor this mode operates and displays ±Δf, ±dBR, ±Δt, ±ΔV, ±deg while moving the cursor.

Vertical axis (frequency domain):

Linear	:	1/32 through 512 in binary steps
Logarithmic	:	Spectrum (display: +30 dBV to -60 dBV, display gain: 2 dB/div., 5 dB/div., 10 dB/div.) Transfer function (gain) (display: +250 dB to -240 dB, display gain: 2 dB/div., 5 dB/div., 10 dB/div.)
Phase	:	+180° to -180°, +25600° to -25600° (in unwrapped mode)
Auto Scale	:	Displays the frequency domain data on the adequately scaled CRT.

Horizontal axis (frequency domain): Linear, logarithmic, Nyquist, Nichols

Data storage : A set of data (including measurement conditions) can be stored in internal memory and recalled and displayed with "RECALL" operation later at any time.

Storage of setup conditions (PANEL STORE): Up to 4 setup conditions can be stored in internal memory (stored data is backed up by battery against power off or power intermission.)

Operational modes : +, −, x ÷, ∫dt, d/dt, $x(j\omega)^n$, V/EU, coherence blanking, and equalization
Conversion of open-loop transfer function to closed-loop transfer function or vice versa
Fourier transform and Inverse Fourier transform, Trend removal

Data Output and Interface (Standard)

Analog output : Analog output for X-Y recorder
X axis - single pen mode only
Y axis - single and dual pen modes
Z axis - pen lift control
Recording speed - six speeds

Digital control and data output signals:
GPIB (IEEE-488) interface
Floppy disk interface
Plotter interface
Signal generator interface

HOLD IN/HOLD OUT : Frozen CRT data is output with the TTL signal; or TTL input signal causes the CRT data to hold still.

SAMPLE CLOCK OUT : Sampling clock can be generated.

General Specifications

Supply voltage : 90-126 Vac ±10% (Modifiable to 198-249 Vac)

Operating environment:
Temperature: 0°C to +40°C
Humidity : Less than 85% RH

Power consumption : Not more than 600 VA

Dimensions : Approx. 424(W) x 354(H) x 500(D) mm

Weight : Approx. 43 kg

10.2 ACCESSORIES SUPPLIED

Article name		specification	Parts code	Quantity	Remarks
Input cable		MI-77	DCB-FM0904-1	2	BNC-Alligator clip
Fuse	2.5A	EAWK2.5A	DFT-AA2R5A-1	2	for line voltage of 220/240V
	2A	EAWK2A	DFT-AA2A-1	2	
	5A	EAWK5A	DFT-AA5A-1	(2)	for line voltage of 100/120V
	4A	EAWK4A	DFT-AA4A-1	(2)	
Power cable		MP-43A	DCB-DD0717A-1	2	
AIO Cable			DCB-RR2057X01	1	
Instruction manual			E9407	1	This manual

10.3 PERIPHERAL DEVICES AND ACCESSARIES

Versatile systems use of the TR9407 is made via the standard interface of GPIB, plotter, XY recorder, floppy disk and signal generator along with the other peripheral devices and accessories as shown below.

- o TR9835/R Digital Plotter
- o TR9832 Plotter
- o TR98102 Floppy disk digital data recorder
- o TR98201 Signal Generator
- o TR98202 Signal Generator
- o TQ88091 Optical Actuator Test Head
- o TR7200 series Universal Scanner
- o XY recorder
- o HP-GL plotter (Hewlett Packard 7470A, 7225A)
- o Close-up camera (M-85D, #85-26)
- o TR16025 Transit case
- o TR16902 Trolley
- o TR16901 Cabinet Rack
- o Accelerometers (Endevco)
- o Charge amplifiers (Endevco) (See Tables 10-1 and 10-2)

(1) Interconnection with the signal generator (TR98201)

Output waveforms :
  Full-span simultaneous measurement: Multi-sine, Impulse, Random noise
  Frequency sweep measurement : Sine, Swept Sine
  Miscellaneous : Arbitrary waveforms

Frequency range : 100 µHz to 100 kHz (synchronous with the FFT analyzer)

Output voltage : 2 mV_{p-p} to 30 V_{p-p} (when terminated)

DC offset : Max. -10.0 V to +10.0 V

Output signal ON/OFF : ON : Manual setting or averaging start
OFF: Averaging end

Measurement delay : Interval time (0 to 999.9 sec) from signal generation to the measurement settable in 0.1 sec step.

Sweep : Sine, Swept sine, Linear frequency sweep, Logarithmic frequency sweep, (sweep direction selectable)

Signal sequence : Output waveform, output voltage, dc offset, measurement frequency range, averaging number can be set into six (max.) regions and sequentially executed.

Amplitude compression: Available only at the time of frequency sweep measurement.

Amplitude control : Output signal voltage is controlled to keep the measurement level in Ch.A or Ch.B within the set range.

Overload check : Monitors the maximum peak in Ch.A or Ch.B and, if it exceeds the setup value, the FFT analyzer takes the selected action.

(2) Interconnection with the signal generator (TR98202)

Controlled through the TR13214 PIO INTERFACE (option).

Output waveforms:
Full-span simultaneous measurement: Multi-sine, Swept-Sine, Random-noise, pink filter ON/OFF
Frequency sweep measurement: Sine

Frequency range : 25 mHz to 100kHz
Incompliant with the frequency resolution in the zooming mode.

Output voltage : 5 mV_{p-p} to 10 V_{p-p} (when terminated)

Sweep : Sine, Linear frequency sweep, Logarithmic frequency sweep (sweep direction selectable)

Signal sequence : Output waveform, output voltage, measurement frequency range and averaging number can be set into six (max.) regions and sequentially executed.

(3) Interconnection with floppy disk digital data recorder (TR98102)

PANEL : Panel setup conditions including the measurement conditions, label and signal sequence are stored into file. Max. 400 sets per disk.

ORIGIN data : Analysis data as origin of the information displayed on the CRT. Convertible to another domain or averageable on reproduction. Max. 80 data per disk.

MASS TIME data : 512K word time data file. Convertible into another domain and averageable.
Max. 2 data per disk

FIXED data : Not convertible to another domain nor averageable on reproduction.
Max. 400 data per disk

GRAPHICS data	:	All graphic images on the CRT are recorded as they are. Max. 80 data per disk
CATALOGUE mode	:	List of the contents on the disk. Entitled data are shown entered as a LABEL. Data are reproduced from the catalogue mode display.
Panel sequence	:	Sequence of measurements is programmable.

(4) Interconnection with the XY recorder

X-axis : 1 pen
Y-axis : 1-pen and 2-pen mode
Z-axis : Pen lift control signal
Plot speed: 6 modes

(5) Interconnection with the plotters

Advantest's plotters with the GPIB interface connector (TR9832/9835/9835R) or the HP-GL plotters (7470A, 7475A, 7550A, 9872B, 9872C from HP) via the GPIB cable.

Scaling plots; automatic scaling plots (1 to 6 plots) on A4-sized paper.

(6) Interconnection with the scanner

Switching of the signals over the wide frequency range in the automatic test system in combination with the TR7225 (matrix scanner) and the TR72203 (high-frequency multiplexer unit).

Combination of the TR7220 Universal Scanner (which affords up to ten switch cards) and the three types of switch cards serve as plural scanners. (Out of three types of cards, multiplexer cards and actuator cards provide the channel expandability up to the 100 channels (= 10 ch x 10 cards) and the matrix cards up to 160 channels.)

(7) Interconnection with the Optical Actuator Test Head

In combination with the TQ88091 Optical Actuator Test Head (with the optical source of the helium neon laser and the optical sensor of the photodiode), response and the magnitude of displacement of the vibrating body (DC to 50 kHz) is measured by converting the displacement to voltage.

(8) Interconnection with a computer

Connection with the GPIB (IEEE 488) implemented computer controls the input and output of the data via the GPIB cable.

Table 10-1 Accelerometers by Endevco (Recommended)

Model	22	222C	23	2250A	2264-200
Features	Very small, light, thin, piezoelectric type	Small, light, piezoelectric type	Small, light, piezoelectric triaxial type for the burst	Small, light, piezoelectric type with resident charge-converter	Small, semi-conductor gauge type
Charge sensitivity (PC/G) or voltage sensitivity (mV/G)	0.4	1.3	0.4	10mV/G±5%	2.5mV/G
Capacitance (pF)	240	420	240		
Frequency range (Hz) ±3dB	5 to 10000	20 to 8000	5 to 10000	4 to 15000	0 to 1200
Resonance frequency (Hz)	54000	32000	50000	80000	4700
Acceleration range (G)	0 to 2500	0 to 2000	0 to 2000	0 to 500	-200 to +200
Operating temperature ($^{\circ}C$)	-73 to +204	-73 to +177	-73 to 240	-50 to +125	-18 to +66
Dimensions (mm)	3.6 x 2.4	6.4 x 3.2	7.6 x 6.4 x 5.1	5.8 x 3.8	10 x 4.6 x 10
Weight(g)	0.14	0.5	0.85	0.3	1.0
Mounting	Adhesive	Adhesive	Adhesive	Adhesive	Adhesive/screws
Signal return, connection to case	Grounded	Grounded	Grounded	Grounded	
Case connection to structure	Insulated	Insulated	Insulated	Insulated	Insulated
Output	Fixed cable	Fixed cable	Fixed cable	Fixed cable	Fixed cable
Seal	Silicon	Silicon	Silicon	Epoxy	Epoxy

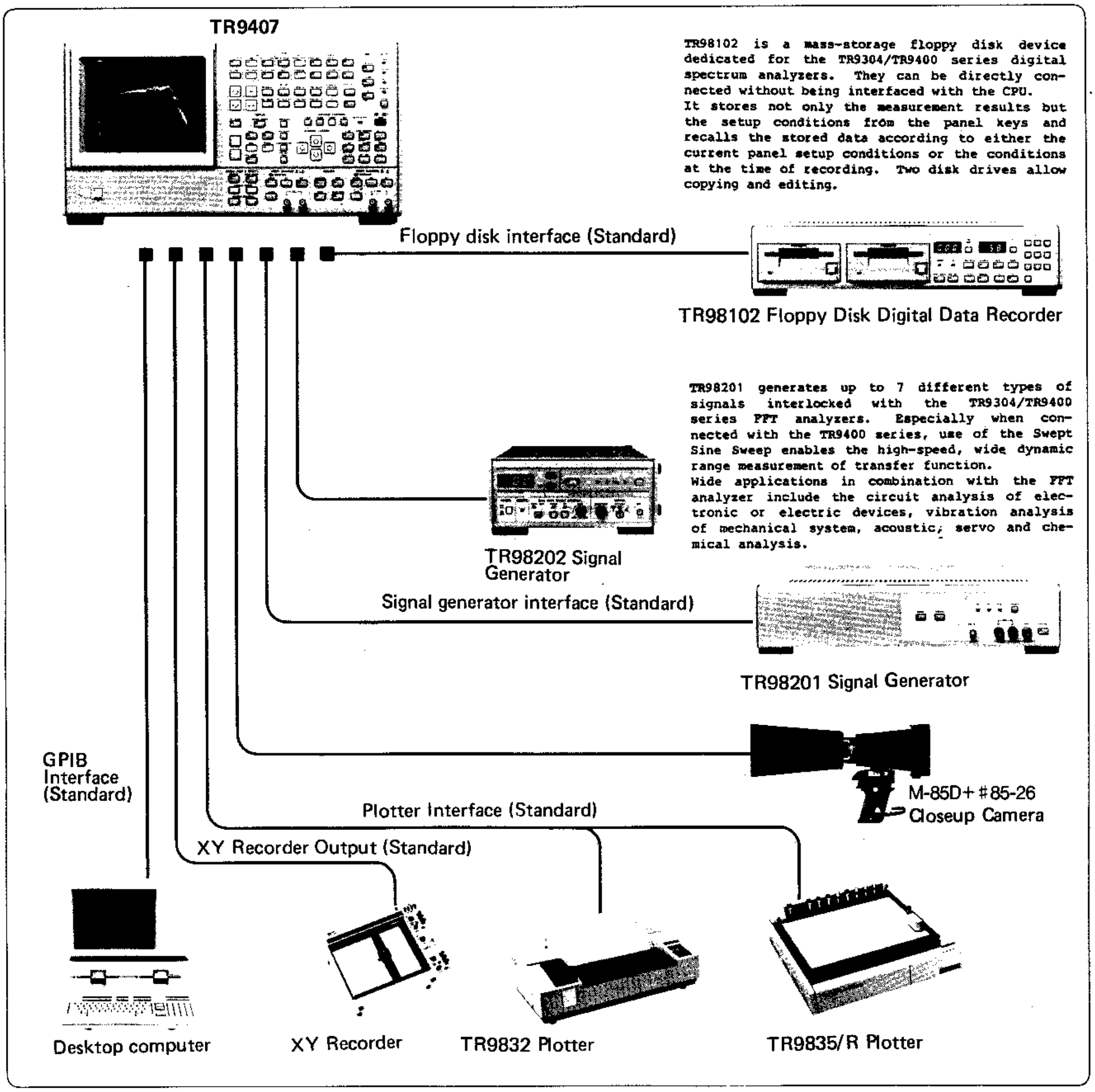
Table 10-1 Accelerometers by Endevco (Cont'd)

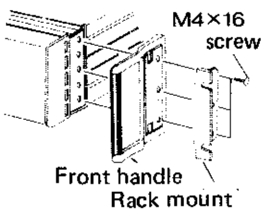
Model	2220C	226C	7701/7703/100	215E	5241
Features	Small, piezoelectric type for high resonance frequency	Small, piezoelectric type	General-purpose piezoelectric type	High-sensitivity piezoelectric type	High-sensitivity for low frequency with resident amp
Charge sensitivity (PC/G) or voltage sensitivity (mV/G)	2.8	2.8	100	170	790mV/G±5%
Capacitance (pF)	750	800	2800	10000	
Frequency range (Hz)	5 to 10000	3 to 6000	1 to 5000	4 to 8000	0.2 to 2000
Resonance frequency (Hz)	50000	24000	20000	32000	9000
Acceleration range (G)	0 to 5000	0 to 2000	0 to 2000	0 to 1000	0 to 10
Operating temperature (°C)	-54 to +177	-54 to +177	-54 to +260	-54 to +177	+125 (Max.)
Dimensions (mm)	9.5 x 5.3	9.5 x 8.4	15.9 ø x 19.8H	15.9 ø x 20.3H	31.7 ø x 34.9H
Weight (g)	2.3	2.8	29	32	170
Mounting	Center hole, 2-56 screwed	Adhesive	Stud	10-32 stud	4-hole flange
Signal return, connection to case	Grounded	Grounded	Grounded (7701-100) Insulated (7703-100)	Grounded	Insulated
Case connection to structure	Grounded	Grounded	Grounded	Grounded	Grounded
Output	Side connector	Top connector	Side connector	Side connector	Side connector (3P)
Seal	Epoxy	Epoxy	Hermetically sealed	Hermetically sealed	Hermetically sealed

Table 10-2 Charge Amplifiers by Endevco

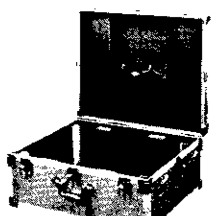
Model	2721B/BMI	2735	4470/4477.2	6634A
Features	Small, low price	General purpose	Universal plug-in type signal conditioner	Conditioner with monitoring capabilities
Frequency response (Hz)	3 to 10000 (BMI type: 1 to 10000)	2 to 20000	2 to 20000	10 to 10000
Range/Sensitivity	1 to 1000mV/G	0.1 to 3000G fullscale	1 to 3000G fullscale	5 to 150G fullscale
Maximum capacitance (pF)	30000	100000	100000	20000
Detector	Piezoelectric type (1 to 110 pC/g)	Piezoelectric type	Piezoelectric type (semiconductor gauge by plug-in replacement)	Piezoelectric type
Maximum output voltage	±10V	±10V	±2.5V	±10V
Input	Grounded	Grounded or floating	Grounded	Grounded or differential
Power supply	15Vac	100Vac	100Vac	100Vac
Dimensions (mm) (width x height x depth)	44 x 76 x 128	70 x 124 x 400	85 x 124 x 373	69 x 125 x 435
Weight (kg)	0.45	2.5	2.7	2.0

10.3 PERIPHERAL DEVICES AND ACCESSARIES





Rack mount (A02604)
Front Handle (A02612)



TR16025 Transit Case

Test Cart
TR16902 (max.30kg)
TR16903 (max.55kg)

TR16801 Cabinet Rack
(Contact for more information)

DEFINITIONS AND PURPOSES OF ANALYZING FUNCTIONS

The definitions and purposes of TR9400 series analyzing functions are described in the following:

Xa : Time series data on channel A
Defined as a data block digitized by an A/D converter in the input section and truncated by frame time determined by the selected frequency range.

<Xa> : Average Xa (time averaging or signal enhancement)
Averaging in the time domain is used to extract a periodical signal from noisy input by improving signal-to-noise ratio. To average time series data correctly, a trigger signal is needed for synchronization. The trigger signal is used to maintain relative phase of the signal to be sampled.

When averaging is performed N times, signal-to-noise ratio is improved by $\sqrt{N}$ times, which is expressed in decibel as

$$20 \log_{10}\sqrt{N} \text{ (dB)}.$$

The TR9400 series uses the normalized time averaging method for averaging in the time domain.

$$\langle Xa\rangle_N = \langle Xa\rangle_{N-1} + \frac{Xa,_N - \langle Xa\rangle_{N-1}}{N}$$

Since, as known from the above equation, the signal is subject to normalized averaging corresponding to the current average number N, an average up to any number of repetitions can be determined correctly.

Sa : Fourier spectrum for Xa (complex spectrum for Xa)

$$Sa(f) = \int_{-\infty}^{+\infty} Xa(t)\,\{\cos(2\pi ft) - j\sin(2\pi ft)\}\,dt$$

t: time
f: frequency

Complex spectrum Sa(f) is obtained by exercising Fourier transform on a time-domain signal Xa(t), and includes a real part and imaginary part for each frequency. The real and imaginary parts of the spectrum are treated as magnitude and phase information respectively. When averaging complex spectrum, a trigger signal is needed as is the case with time averaging <Xa>.

This function is useful when you wish to extract discrete components of revolutions of a rotating body from random noise or signal components from background noise.

Gaa : Power spectrum
Power spectrum is a typical name for frequency spectrum determination. Its unit is expressed as square magnitude (V^2), and can be obtained as a product of Sa(f) and Sa(f)* (complex conjugate of Sa(f)) as follows:

$$\begin{aligned} Gaa &= Sa \cdot Sa^* \\ &= [Re(f) + jIm(f)] \cdot [Re(f) - jIm(f)] \\ &= Re^2(f) + Im^2(f) \end{aligned}$$

Gaa is a real function having only magnitude information. It has no imaginary part and hence has no phase information.

This means that averaging can be performed on Gaa irrespective of trigger position without the need for synchronization signal.

<Gaa> : Average power spectrum
Average power spectrum can be obtained by averaging each power spectrum at each frequency. A spectrum magnitude at a certain frequency is expressed by the following formula:

$$\sqrt{<Gaa(fx)>} = \sqrt{\frac{1}{N} [Gaa_1(fx) + Gaa_2(fx) + \ldots + Gaa_N(fx)]}$$

In other word, this averaging responds to the RMS values effective value) at a certain frequency.

However, this averaging does not reduce noise level while it can smooth random noise component.

Gab : Cross spectrum
At each frequency, the magnitude indicates the product of the magnitudes of two signals, and the phase value indicates the relative phase difference between two signals.

Cross spectrum is obtained as a product of Sa* (complex conjugate of Sa which is a Fourier spectrum of Xa) and Sb (Fourier spectrum of Xb) as follows:

$$\begin{aligned} Gab &= Sb \cdot Sa^* = [Re(b) + jIm(b)] \cdot [Re(a) - jIm(a)] \\ &= [Re(b) \cdot Re(a) + Im(b) Im(a)] + j[Im(b) \cdot Re(a) - \\ &\quad Re(b) \cdot Im(a)] \end{aligned}$$

Unlike power spectrum which is a positive real value, cross spectrum can be a positive or negative complex value.

Cross spectrum corresponds to cross correlation function expressed in the frequency domain, and is applicable to the measurement of delay time, as is the case with cross correlation function. For example, if the propagation time or propagation path of a signal depends on frequency, delay time τ can be determined from the phase value θ at the frequency f in question.

$$\tau = \frac{\theta}{2\pi f}$$

$\langle Gab \rangle$: Average Cross spectrum
The following equation applies to average cross spectrum Gab(f) in each frequency.

$$\langle Gab(f) \rangle = \frac{1}{N}\{Gab_1(f) + Gab_2(f) + \dots\dots + Gab_N(f)\}$$

Hab : Transfer function
A transfer function provides the frequency response of a system (such as a filtering network) in terms of input-output relationship.

It contains magnitude and phase information. Transfer function is determined as a ratio of output Fourier spectrum to input Fourier spectrum as follows:

$$\langle Hab \rangle = \langle Sb/Sa \rangle$$

It may also be expressed as follows:

$$\langle Hab \rangle = \left\langle \frac{Sb\ Sa^*}{Sa\ Sa^*} \right\rangle = \frac{\langle Gab \rangle}{\langle Gaa \rangle}$$

This means that transfer function is also expressed as a ratio of the cross spectrum to input power spectrum of a system.

The transfer function determined by the latter method has the following features:

- Permits measurement of both magnitude and phase since it uses cross spectrum $\langle Gab \rangle$.
- Applicable to any type of input signals.

The inverse Fourier transform of a transfer function is called impulse response.

A transfer function may be observed in the form of a Bode or Nyquist diagram or Nichols chart.

<COH> : Coherence function
The coherence function gives cause-and-effect relationships between input and output of a system and can take a value between 0.0 and 1.0

$$<COH> = \frac{<Gab><Gab>^*}{<Gaa><Gbb>}$$

The coherence function is defined as the squared magnitude of the cross spectrum divided by the magnitude squared of both the input and output spectra.

If the coherence value at a certain frequency is 1.0, the output of the system is caused only by its input. If it is 0.0 the output has nothing to do with the input. If it is a value between 0.0 and 1.0, say 0.3, the degree of contribution of the input in question to the output is 0.3, and the remaining effect of 0.7 is caused by other input or noise interference.

When the coherence function value is less than unity, the main likely reasons are:

(1) The measurement is being effected by the addition of noise.
(2) The measured system is not linear (for example, when the input signal amplitude is too large).
(3) An input apart from the input whose output is being observed is contributing to the measurement (for example: there is a time delay between the input and output signals).
(4) Frequency resolution is insufficient (for example, sharp resonance points)

Therefore, it is recommended that the coherence function always be measured whenever a transfer function is measured.

This quantity could not be measured in conventional servo analyzers.

Since transfer functions are measured at higher degrees of precision the nearer the coherence function is to unity, this coherence function is also useful in checking the suitability of the measuring method and measuring position.

The coherence function also serves as a guide to the averaging count. The coherence function always has a value of 1 when the averaging count is 1. The real value is then approached as the averaging count is increased.

Considerable variation of the coherence function between 0 and 1 in this case indicates that the averaging count is still too low.

<Hab> GDelay : Group delay obtained from <Hab>
The transfer function <Hab> phase is differentiated by frequency to determine the group delay (envelope delay) of the system.

$$\tau g(f) = -\frac{1}{2\pi}\frac{d\phi(f)}{df}$$

where $\phi(f)$ is the phase (in radians).

This quantity corresponds to phase inclination.

Therefore, the group delay is a constant value when phase variation is linear.

<SNR> : Signal-to-noise ratio
The ratio of the signal component power spectrum to the noise component power spectrum is calculated from the coherence function using the following equation.

$$\langle SNR\rangle = \frac{\langle Gss(f)\rangle}{\langle Gnn(f)\rangle} = \frac{\langle C.O.P.\rangle}{\langle Gbb\rangle - \langle C.O.P.\rangle} = \frac{\langle C.O.H.\rangle}{1 - \langle C.O.H.\rangle}$$

<C.O.P.>: Coherent output power
Coherent output power can be determined by multiplying the coherence function by the output power spectrum of the system. It is essentially an output power spectrum caused only by the input of the system.

$$\langle C.O.P.\rangle = \langle COH\rangle \langle Gbb\rangle$$

<IMPLS> : Impulse response
System output expressed in time domain when a unit impulse input is applied. When input Xa(t) is applied to the impulse response hab(τ) system, the output Xb(t) is expressed as:

$$Xb(t) = \int_{-\infty}^{+\infty} hab(\tau) Xa(t - \tau) d\tau$$

The impulse response is determined as the inverse Fourier transform of the transfer function.

$$<IMPLS(\tau)> = IFFT\{<Hab>\}$$

> NOTE
> The impulse response may indicate time delays between input and output signals at higher sensitivity than the cross-correlation function.

<ML> : Maximum likelihood
The maximum likelihood is a result of Fourier transform obtained by multiplying cross spectrum phase by signal-to-noise ratio, and is used to measure time delay τ corresponding to the size of the S/N ratio.

$$<ML(\tau)> = IFFT\left\{<SNR> \frac{<Gab>}{|<Gab>|}\right\}$$

<SCOT> : Smoothed coherence transform
Inverse Fourier transform of a complex coherence function.

$$<SCOT(\tau)> = IFFT\left\{\frac{<Gab>}{\sqrt{<Gaa><Gbb>}}\right\}$$

The smoothed coherence transform is useful in measuring system time delay τ when the S/N ratio is large and when sinewave components are included.

> NOTE
> When the time delay τ is to be measured, first test
>
> <Rab> Cross correlation function
> <IMPLS> Impulse response
> <ML> Maximum likelihood
> <SCOT> Smoothed coherence transform
>
> and select the one which best matches the actual signal to be measured and which enables that signal to be measured most effectively.

Raa : Autocorrelation of Xa
On a random signal varying with time, a considerably strong correlation may be found between two points with relatively small time difference (τ). However, the correlation between those points will be weakened as the time difference increases. If a periodical signal is contained in a random signal, on the other hand, correlation between two points will be strengthened at a regular interval.

Autocorrelation is a function of time difference τ, and may be used to analyze the likelihood of randomness or to extract a periodical signal from random signals by improving signal-to-noise ratio.

Autocorrelation function can be mathematically determined as an inverse Fourier transform of power spectrum Gaa, and is generally expressed by the following integral formula:

$$Raa(\tau) = \int_{-\infty}^{+\infty} Gaa(f) e^{j2\pi f\tau} df$$

In the FFT analyzer, the autocorrelation is normalized by the squared sum of time series data.

$$Raa(\tau) = \frac{\sum_t Xa(t)\cdot Xa(t+\tau)}{\sum_t \{Xa(t)\}^2}$$

NOTE

Autocorrelation function does not correspond to the IFFT of the power spectrum due to the circulative nature of FFT, but corresponds to the IFFT of the power spectrum of the original time-series plus zeros.

The TR9400 series obtains autocorrelation function correctly through this process.

Rab : Cross correlation
Cross correlation function is used to determine the degree of interdependence between two time functions in a quantitative manner. It is used to determine velocity or distance by delay time measurement or to determine propagation paths of signals.

Cross correlation can be mathematically determined as an inverse Fourier transform of cross spectrum Gab, and is generally expressed by the following integral formula:

$$Rab(\tau) = \int_{-\infty}^{+\infty} Gab(f)\, e^{j2\pi f\tau} df$$

In the FFT analyzer, the cross correlation is normalized by the squared sum of the I/O time series data.

$$Rab(\tau) = \frac{\sum_t Xa(t)\cdot Xb(t+\tau)}{[\sum_t \{Xa(t)\}^2 \cdot \sum\{Xb\ (t)\}^2]^{1/2}}$$

NOTE

Cross correlation function does not correspond to the IFFT of the cross spectrum due to the recursive nature of FFT, but corresponds to the IFFT of the cross spectrum of the original time-series on each channel plus zeros.

The TR9400 series obtains cross correlation function correctly through this process.

Ca : Real cepstrum of Gaa

Calculation of the log mag of the power spectrum Gaa, and conversion into the quefrency domain by a Fourier transform.

$$Ca(\tau) = IFFT\{Log\ Gaa\}$$

The low level region is expanded by "taking a logarithm" (a non-linear operation), the power spectrum repetition pattern is sampled effectively and transformed into a quefrency domain peak.

Complex power spectrum envelopes are also determined by filtering (shortpass lifter) in the quefrency domain and retransforming into frequency domain.

Za : Pre-envelope of Xa
The real part of the pre-envelope corresponds to the original time series, and the imaginary part corresponds to a Hilbert transform of that time series.

$$\hat{X}a(t) = -\frac{1}{\pi}\int_{-\infty}^{+\infty} Xa(\tau)\frac{d\tau}{\tau - t}$$

$$Za(t) = Xa(t) + j\hat{X}a(t)$$

The sum Zaa of the squares of the real and imaginary parts is the original time series envelope with a unit of energy (V^2). The transient response energy attenuation time is determined from the envelope.

Pa : Histogram or probability density function of Xa
Probability density function is used to analyze statistical nature of signals, and represents a probability at which a time series exists within a certain range of amplitude.

If the estimate of probability at which Xa(t) takes values between amplitudes Xa and Xa + ΔXa is expressed by sample data over time T, the probability density of random signal Xa(t) is given by the following:

$$Pa = \frac{\mathrm{Prob}[Xa<\tilde{X}a<(Xa + \Delta Xa)]}{\Delta Xa} = \frac{1}{T}\sum_i \Delta ti = \frac{Tx}{T}$$

Where ti is the time duration in which Xa stays within the range of x at i'th time, and Tx $=\sum \Delta$ti.

That is, Pa is given as a ratio of Tx and T, Tx being the time duration in which Xa(t) takes a value between Xa < Xa < $\tilde{X}$a + ΔXa in time T (in this case the frame time). On the display of the TR9400 series, therefore, the X axis represents voltage values of Xa and the Y axis represents its probability density.

The readout unit is○.○○ V^{-1}

Cumulative distribution function (CDF) can be determined by integrating an amplitude probability density function. CDF provides a probability at which a momentary level of a signal is below a certain magnitude. However, the TR9400 series has no capability of operating CDF.

<Pa> : Average probability density function
In the equation for <Pa>, if time T approaches to infinite, the conjectured value <Pa> approaches to a true probability.

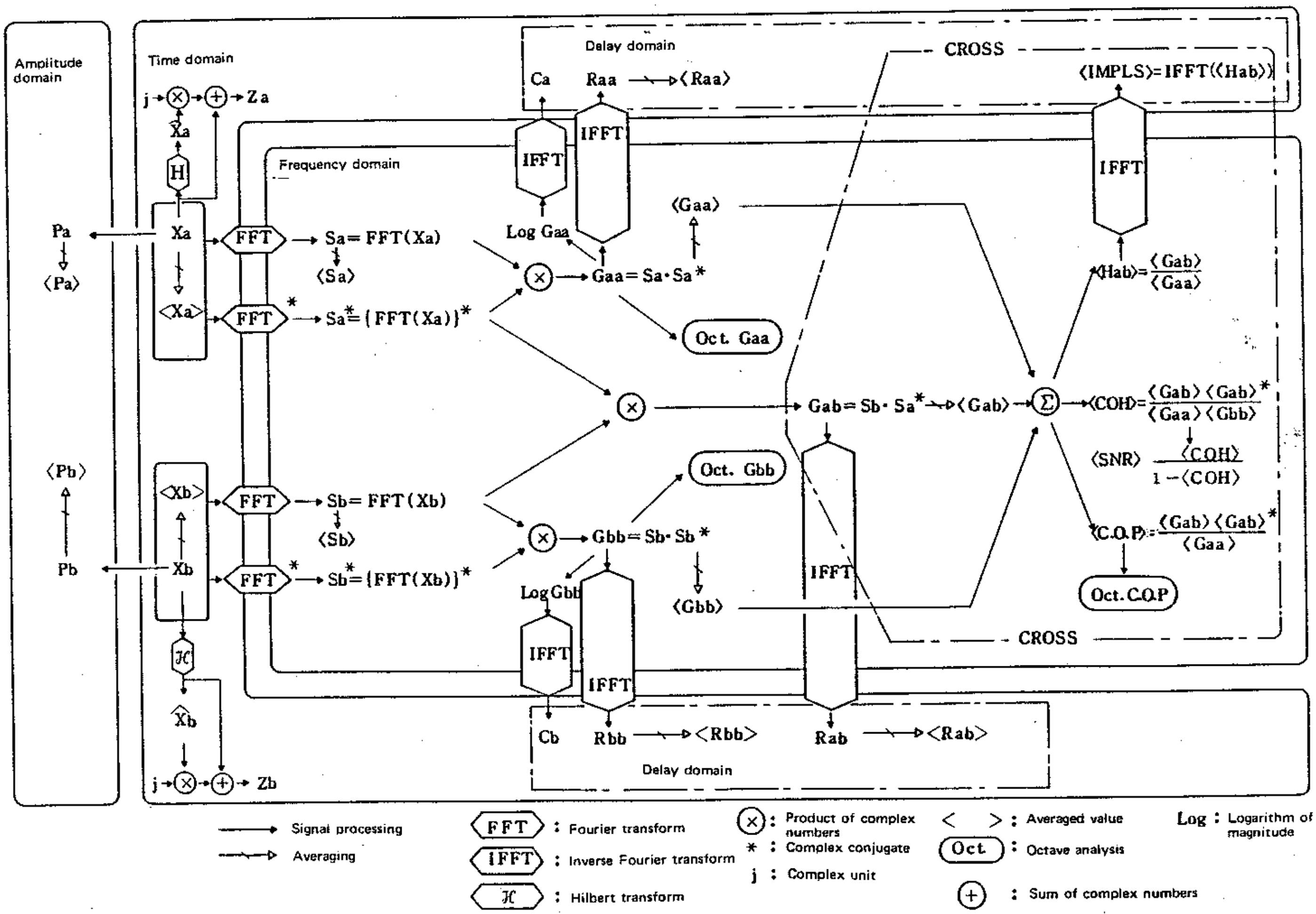
If it is assumed that the frame time is Tf and Pa is averaged over 16 frame times, the mean probability density can be determined from the same equation with time T increased 16 times as large.

On the TR9400 series, <Pa> is operated by using the normalized histogram averaging method. Refer to <Xa> time averaging mentioned earlier.

OctGaa : Third octave and full octave analysis
Analysis of noise or acoustic signals may require the octave analysis technique. While octave analysis includes 1/1-, 1/3- and 1/8-octave analysis methods, the 1/1- and 1/3-octave techniques are of general use.

For 1/3-octave analysis, the narrow-band spectrum obtained from power spectrum is divided into sub-bands of 1/3-octave each. Each sub-band spectrum is weighted according to Class III of the American National Standards Institute and in the maximum proximity to the response of the filter of B.& K. Inc. (Denmark) and is displayed in the form of a graph.

The 1/1-octave response is determined from the result of 1/3-octave analysis by operation.



Analyzing functions vs time, frequency and amplitude domains

LIST OF MENUS (1)

FREQUENCY

FREQ RANGE
SAMP CLK
INT #
EXT

⇨ 1 MHz #
500 kHz
200
100
50
20
10
5
2
1
500 Hz
200
100
50
20
10
5
2
1

FRAME TIME
400 μSEC

SENS. A

SENSITIVITY
MAX INPUT
A: ± 44.7 V
B: ± 44.7 V

CH-A
NORMAL A#
INVERT

ACTIVATE

AUTO
(dBV)
⇨ +30 A#
+20
+10
0
-10
-20
-30
-40
-50
-60

TRIG. MODE

AUTO CAL
ON
EXT GATE
OFF

TRIGGER
SOURCE
CH-A
SLOPE
<+>
LEVEL
+0.078 *FS
POSITION
+200.00 %
BEEP ON TRIGGER
OFF
MARKER
OFF

ARM MODE
NORMAL
ARM LENGTH
⇨ 256K
BLOCK NO.
0
INTERCHAN DELAY
0/1024

AVG MODE

AVG MODE
⇨ SUM (N) #
SUM (L)
DIFF
EXP
PEAK
SUM (T)
AVG WHAT ?
CROSS+POWER
AVG NUMBER
2
AVG CHANNEL
CH-A
CH-B
DUAL
CROSS #
AVG PROCESS
NORMAL #
+1 AVG
SWEEP
OVERLAP
0 % #
50%
DISPLAY
ALL #
1/2
END

ADVANCED ANALYSIS — Advanced Analysis Functions

ADVANCED SELECT
⇨ LIST

ADVANCED LIST
3D DISPLAY: D
OCTAVE : D
SERVO : D
G-DELAY : D
SNR : D
ML : D
SCOT : D
CEPSTRUM : D
P-ENVELOPE: D

ADVANCED SELECT
⇨ SERVO
<ENABLE>

ANALYSIS LINE
4-DECADE
SENS CTRL
CH-A: AUTO
CH-B: AUTO
WEIGHTING CTRL
AUTO
SG OPERATION
ON-KEY
NON-STOP AVG
STOP
AVG NUMBER
2
AVG PROCESS
SWEEP
AMPLITUDE CTRL
OFF
CTRL LEVEL (F)
+00.0±0.0 dBV
OVER LEVEL (Vpp)
CH-A: +02.0E-3
CH-B: +02.0E-3
OVER & SERVICE
CONT

ADVANCED SELECT
⇨ 3D DISPLAY
<DISABLE>

3D DISP TRIG.
AUTOMATIC #
DATA WINDOW
AVERAGING
AUTO ARM
GP-IB
START LINE NO.
1/32
ANGLE FACTOR
0 (90°)
3D DISP SOURCE
SYSTEM #
FLOPPY
3D DISP OUTPUT
CRT #
HARD COPY
STACK LINE NO.
16

ADVANCED SELECT
⇨ OCTAVE
<DISABLE>

OCT MODE
STATIONARY #
TRANSIENT
VIEW POWER

ANALYSIS CHAN
CH-A #
CH-B
DUAL

BANDWIDTH
1/3 OCT #
1/1 OCT

A-WEIGHTING
OFF

ADVANCED SELECT
⇨ G-DELAY
<DISABLE>

ADVANCED LIST
3D DISPLAY: D
OCTAVE : D
SERVO : D
G-DELAY : D
SNR : D
ML : D
SCOT : D
CEPSTRUM : D
P-ENVELOPE: D

ADVANCED SELECT
SNR
⇨ <DISABLE>

ADVANCED LIST
3D DISPLAY: D
OCTAVE : D
SERVO : D
G-DELAY : D
SNR : D
ML : D
SCOT : D
CEPSTRUM : D
P-ENVELOPE: D

ADVANCED SELECT
ML
⇨ <DISABLE>

ADVANCED LIST
3D DISPLAY: D
OCTAVE : D
SERVO : D
G-DELAY : D
SNR : D
ML : D
SCOT : D
CEPSTRUM : D
P-ENVELOPE: D

ADVANCED SELECT
SCOT
⇨ <DISABLE>

ADVANCED LIST
3D DISPLAY: D
OCTAVE : D
SERVO : D
G-DELAY : D
SNR : D
ML : D
SCOT : D
CEPSTRUM : D
P-ENVELOPE: D

ADVANCED SELECT
⇨ CEPSTRUM
<DISABLE>

ANALYSIS CHAN
CH-A #
CH-B
DUAL
VIEW
DOMAIN
QUEFRENCY #
FREQUENCY
THRESHOLD
OFF

-774 dBFS
LIFTERING
SHORTPASS #
LONGPASS
MEMORY (A/B)

0/511

ADVANCED SELECT
⇨ P-ENVELOPE
<DISABLE>

ANALYSIS CHAN
CH-A #
CH-B
DUAL
VIEW
DOMAIN
TIME #
FREQUENCY

DISP.

FREQUENCY
20 kHz
SENSITIVITY
A: +10dBV (MAN)
B: -10dBV (AUTO)

TRIGGER
SOURCE: CH-A
SLOPE : <+>
LEVEL
+0.250 *FS
POSITION
+603.32 %

WEIGHTING
RECT

AVERAGING
MODE : SUM (N)
WHAT :
CROSS+POWER
NO : 16
CHAN : CROSS
PRCS : SWEEP
OVLAP: 0 %
SIGNAL:
SWEPT SINE

INTERCHANNEL
DELAY
0/1024

INTEGRAL &
DIFFERENTIAL
A: NORMAL
B: NORMAL

FUNCTION
NO-OPERATION

STEP (D. WINDOW)
42/1024
COH BLANK
0.82
OVERLAP
0%: 0/0
50%: 0/0

WGT/SCALING

WEIGHTING
⇨ RECT #
HANNING
MINIMUM
FLAT-PASS
FORCE/RESP.
F: 10 (ST)
15 (SP)
R: 10 (ST)
521 (SP)
+0.500 *FS
READ OUT
FREQ UNIT
Hz #
CPM
VERT UNIT
NORMAL #
PER Hz

SCALING
KEY #
CURSOR
OFF
TIME/CH-A
1 EU=
0.00E 00 V
EU =EU

FUNCTION

FUNCTION
⇨ OFF

<U+L>
OPEN/CLOSED
OFF

Ho/(1+Ho)
∫Xxdt
OFF/CH-A
OFF/CH-B
dXx/dt
OFF/CH-A
OFF/CH-B
(VIEW)(jω)ⁿ
OFF
EQUALIZE
OFF
COH BLANK
OFF
OVERALL
OFF
TREND REMOVAL
OFF/CH-A
OFF/CH-B
SMOOTHING
OFF

DISPLAY CTL

DISP CTRL
LOWER
AUTO SCALE
ON
DISP MODE
TIME

Mag
Mag²
dBMag L#
NICHOLS
DISP GAIN
(dB/DIV)
2
5
10 L#

DATA WINDOW
AUTO
STEP (D. WINDOW)
15/1024

RE-SAMPLING
UNIFORM
LEVEL MONITOR
⇨ ON
OVERALL

LIST OF MENUS (2)

```
I/O SELECT
  TIMER

TIMER EDIT
⇨ OFF          #
  ON
```

```
I/O SELECT
⇨ XY-RCDR

CALIBRATION
   O-O
RECORD MODE
   CURSOR      #
   ALL
   SIGNAL
   FRAME
PEN MODE
   ONE         #
   TWO
PLOT SPEED
   SLOW        #
   2
   3
   4
   5
   FAST
```

```
I/O SELECT
⇨ PLOTTER

PLOT MODE
   ALL
   SIGNAL
   FRAME+MENU#
PEN SELECTION
   AUTO
PAPER ADVANCE
   OFF
SCALING
   OFF
PLOT SIZE(mm)
   Xmin:020
   Ymin:005
   Xmax:200
   Ymax:240
PLOTTER TYPE
   HP-GL
PLOT ANGLE
   NORMAL
```

```
I/O SELECT
   FLOPPY

FLOPPY MODE
⇨ READ            #
   WRITE
   EDIT
   CATALOGUE

DISPLAY SOURCE
   FLOPPY         #
   PANEL

DATA OUT
   CRT

OVERLAY NUMBER
   0
```

```
I/O SELECT
   FLOPPY

FLOPPY MODE
   READ
   WRITE          #
   EDIT
   CATALOGUE

WRITE MODE
   ORIGIN         #
   FIXED
   MASS TIME
   GRAPHICS
   PANEL

WRITE TRIG.
⇨ DATA
   ARM
      CH-A

M.TIME FCTN
   OFF
   K=+1.00
```

```
I/O SELECT
   FLOPPY

FLOPPY MODE
   READ
   WRITE
⇨ EDIT            #
   CATALOGUE

EDIT MODE
   COPY(D1→D0)  #
   READ&WRITE
   EDIT(M.TIME)

M.TIME E.MODE
 FROM
   DRIVO(FRONT)
   CH-A

 TO
   DRIVO(FRONT)
   CH-A
```

```
NO.  TYPE                  LABEL                        SEQ.
 1 XaXb  :M     /XYZ/ → 16Kword Time Record         :    0
 2                     WRITE AVAILABLE              :  160
 3 PANEL :P     /XYZ/ → 16Kword Time Record         :  170
  (S: ALL        OFF                    0000:00.0       )
 4 PANEL :P     /XYZ/ → 16Kword Time Record         :  171
  (S: ALL        OFF                    0000:00.0       )
 5 PANEL :P     /XYZ/ → 16Kword Time Record         :  172
  (S: ALL        OFF                    0000:00.0       )
 6 PANEL :P     /XYZ/ → 16Kword Time Record         :  173
  (S: ALL        OFF                    0000:00.0       )
 7 PANEL :P     /XYZ/ → 16Kword Time Record         :  174
  (S: ALL        OFF                    0000:00.0       )

⇨CATALOGUE MODE:              EXIT
 DRIVE SELECT:                DRIVO(FRONT)

 WRITE PROTECT:               OFF

 PANEL SEQ. TIMER START:      OFF
  START TIME:                 00:00
 PANEL SEQUENCE:              OFF
  LOOP:     1
  FROM:     1
  TO:       1

 SETUP LINE:      1
 SETUP  ZOOM  AVG  TRIGR  ADVNC  PLOT  FLPY  INTERVAL   SCAN
  ALL    OFF  OFF   OFF    OFF    OFF   OFF  0000:00.0 OFF
```

```
I/O SELECT
⇨ SIGNAL G.

FUNCTION
  SINE
FREQ (LINE)
  CURSOR
  1
AMPLITUDE
  43.1E-1 Vpp
OFFSET
  +00.0E-0 V
OUTPUT MODE
  LIN SWEEP
SYNC OUT
  PER 1    CYCLE
INTERVAL TIME
  .2 SEC
OUTPUT CYCLE
  1
LINE CTRL
  Fmin :  1
  Fmax :  400
  STEP :  1
  DIREC:  U⇨L
  RANGE:  NORMAL
SEQUENCE
  ?
```

```
I/O SELECT
   SIGNAL G.

FUNCTION
⇨ SINE
FREQ (LINE)
   MANUAL
   20
AMPLITUDE
   01.5E-0 Vpp
OFFSET
   00.0E-0 V
OUTPUT MODE
   CONT
SYNC OUT
   PER 1    CYCLE
INTERVAL TIME
   .0 mSEC
OUTPUT CYCLE
   1
PHASE(deg)
   START: 0
   STOP : 0
   RANGE: NORMAL
SEQUENCE
  (A)
```

```
I/O SELECT
⇨ SIGNAL G.

FUNCTION
   MULTI-SINE
AMPLITUDE
   01.0E-3 Vpp
OFFSET
   0.00 V
OUTPUT MODE
   CONT
SYNC OUT
   PER 1      FRAM
INTERVAL TIME
   .0 mSEC
OUTPUT FRAME
   1
RANGE CTRL
   NORMAL
SEQUENCE
  (C)
```

```
I/O SELECT
   SIGNAL G.

FUNCTION
⇨ WG MULTI-SINE
AMPLITUDE
   01.5E-0 Vpp
OFFSET
   00.0E-0 V
OUTPUT MODE
   CONT
SYNC OUT
   PER 1     FRAME
INTERVAL TIME
   .0 mSEC
OUTPUT FRAME
   1
RANGE CTRL
   NORMAL
SEQUENCE
  (C)
```

```
I/O SELECT
   SIGNAL G.

FUNCTION
⇨ IMPULSE
AMPLITUDE
   02.5E-0 Vpp
OFFSET
   00.0E-0 V
OUTPUT MODE
   CONT
SYNC OUT
   PER 1     FRAME
INTERVAL TIME
   .0 mSEC
OUTPUT FRAME
   1
RANGE CTRL
   NORMAL
SEQUENCE
  (C)
```

```
I/O SELECT
⇨ SIGNAL G.

FUNCTION
   SWEPT SINE
FREQ (LINE)
   MANUAL
   200
AMPLITUDE
   01.0E-0 Vpp
OFFSET
   +00.0E-0 V
OUTPUT MODE
   LIN SWEEP
SYNC OUT
   PER 1     FRAME
INTERVAL TIME
   .0 SEC
OUTPUT FRAME
 . 1
LINE CTRL
   Fmin :  4
   Fmax :  400
   WIDTH:  40
   DIREC:  U⇨L
   RANGE:  NORMAL
SEQUENCE
   D.E.F
```

```
I/O SELECT
   SIGNAL G.

FUNCTION
⇨ RANDOM
AMPLITUDE
   01.0E-3 Vpp
OFFSET
   0.00 V
OUTPUT MODE
   CONT
P.D.F
   GAUSS      #
   POISSON
TYPE
   RANDOM
INTERVAL TIME
   .0 mSEC
OUTPUT FRAME
   1
RANGE CTRL
   NORMAL
SEQUENCE
  (C)
```

```
I/O SELECT
   SIGNAL G.

FUNCTION
⇨ MEMORY
AMPLITUDE
   01.0E-3 Vpp
OFFSET
   0.00 V
OUTPUT MODE
   CONT
SYNC OUT
   PER 1      FRAM
INTERVAL TIME
   .0 mSEC
OUTPUT FRAME
   1
READ/WRITE
   READ
FILTER
   OFF
RANGE CTRL
   NORMAL
SEQUENCE
  (C)
```

```
I/O SELECT
   SIGNAL G.

FUNCTION
⇨ SEQUENCE
SEQUENCER
   OFF
A: WG MULTI-SINE
AMP: 01.0E-1 Vpp
MODE:   CONT
RANGE:  NORMAL
Fmin :  1
Fmax :  400
AVG NO: 1
B: SWEPT SINE
AMP: 01.0E-1 Vpp
MODE:   SWEEP
RANGE:  MIDDLE
Fmin :  40
Fmax :  200
AVG NO: 1
C: SINE
AMP: 01.0E-1 Vpp
MODE:   SWEEP
RANGE:  START
Fmin :  80
Fmax :  100
AVG NO: 1
```

```
ADVANCED SELECT
⇨ SERVO
  <ENABLE>

ANALYSIS LINE
  4-DECADE
SENS CTRL
  CH-A: AUTO
  CH-B: AUTO
WEIGHTING CTRL
  AUTO
SG OPERATION
  ON-KEY
NON-STOP AVG
  STOP
AVG NUMBER
  2
AVG PROCESS
  SWEEP
AMPLITUDE CTRL
  OFF
CTRL LEVEL (F)
  +00.0±0.0 dBV
OVER LEVEL (Vpp)
  CH-A: +02.0E-3
  CH-B: +02.0E-3
OVER & SERVICE
  CONT
```

4-DECADE : Logarithmic frequency analysis (1116 lines).

NORMAL : Linear frequency analysis (400 lines).

AUTO : Automatically selects optimum sensitivity range for each channel. SENS CTRL is not available on the TR9402.

MANUAL : Selects input sensitivity range by menu. Fixed.

AUTO : Automatically selects the window function according to the signal from the signal generator.

MANUAL : Use "WGT/SCALING" menu to select the window function.

ON-KEY : Starts to generate the signal from the signal generator with the TR98201 OPERATE key.

ON-AVG : Start of averaging with the START key triggers the signal generation. End of averaging stops the signal generation.

STOP : Preset number of averagings are performed.

NON-STOP : Preset number of averagings are repeated infinitely. If AVG NO. is 8 or more, the buzzer sounds at each end of averagings. Use STOP key to stop averaging.

1–8192 : Selection of the averaging number

NORMAL : Simultaneous averaging of the 400 lines (396 or 360 in the 4-decade log frequency analysis)

SWEEP : Sweeping the sine or swept-sine waves from the signal generator increments the averagings.

+1 AVG : Averaging of a transient signal. Incremented one at a time with the CONT key.

- With the TR9402, the following capabilities are not provided.

OFF : Amplitude control is not performed.

MONITOR : Compares the peak-to-peak time domain value in the designated channel in the OVER LEVEL value. If it exceeds that level, necessary action selected from the OVER & SERVICE is taken with the display of
OVERLOAD: OVER LEVEL.

```
ADVANCED SELECT
⇨ SERVO
  <ENABLE>

ANALYSIS LINE
  4-DECADE
SENS CTRL
  CH-A: AUTO
  CH-B: AUTO
WEIGHTING CTRL
  AUTO
SG OPERATION
  ON-KEY
NON-STOP AVG
  STOP
AVG NUMBER
  2
AVG PROCESS
  SWEEP
AMPLITUDE CTRL
  OFF
CTRL LEVEL (F)
  +00.0±0.0 dBV
OVER LEVEL (Vpp)
  CH-A: +02.0E-3
  CH-B: +02.0E-3
OVER & SERVICE
  CONT
```

CONSTANT : Frequency domain amplitude in the selected channel is controlled to the value set up in the CTRL LEVEL. If it is not controllable within the error allowance, the message of
ERROR: AMPLITUDE CONTROL
is displayed and the OVER & SERVICE procedure is followed. Also controlled is the peak-to-peak value in Channel A to be within the OVER LEVEL.

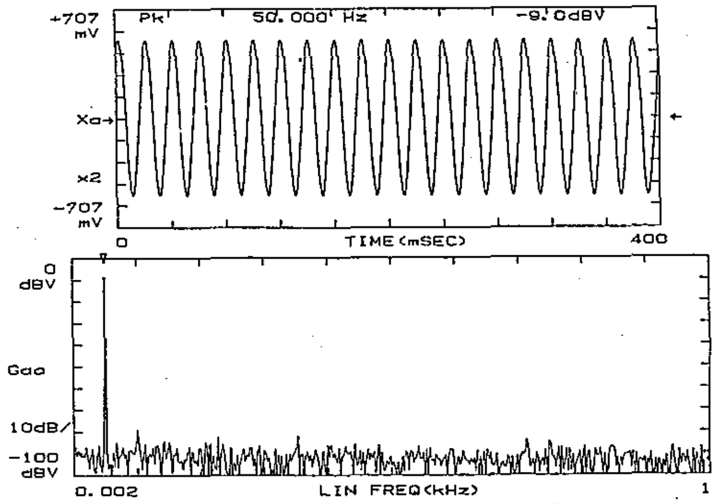
MEMORY : Amplitude is controlled so that the frequency domain amplitude in the designated channel is equal to the amplitude stored in the memory of the corresponding domain (up to -99.9 dBV).
Gaa: Memory (A)
Gbb: Memory (B)
Allowance of error is given in 2 digits following the ± in the CTRL LEVEL. Also controlled is the peak-to-peak value in channel A to be within the OVER LEVEL.

CONTROL LEVEL : The first three digits: Amplitude to control
The two digits following ±: Error Allowance

OVER LEVEL : Maximum voltage peak-to-peak to apply to DUT.

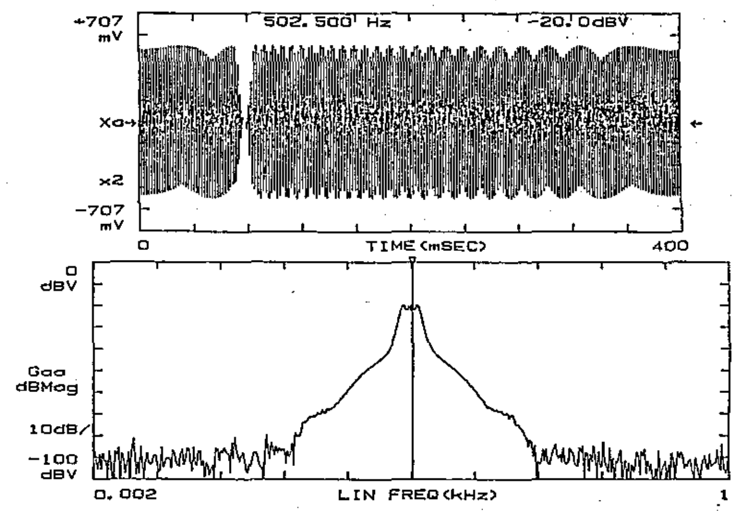
	AMPLITUDE CTRL: CH-A(B) MONITOR	During the SWEEP AVG
CONT	When the peak-to-peak value from the signal generator exceeds the OVER LEVEL (Vpp), "OVERLOAD: OVER LEVEL" is displayed.	Averaging goes on even when the amplitude is not controllable within the allowance or it exceeds the OVER LEVEL.
SKIP	(Ditto)	Averaging is not performed at this frequency and steps into next frequency.
BEEP ON	When the signal exceeds OVER LEVEL (Vpp), the buzzer sounds along with the message display of "OVERLOAD: OVER LEVEL".	Averaging is not performed at this frequency and steps into next frequency and the buzzer sounds.
SWEEP STOP	(Ditto) Moreover, the signal generator stops the output (OPERATE key lamp OFF)	Averaging ends up.

Sine



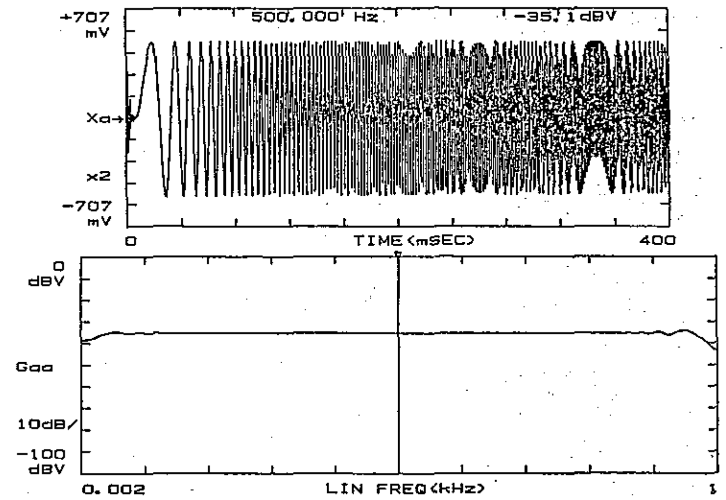
−9.0 dB

Swept-Sine (WIDTH: 4)



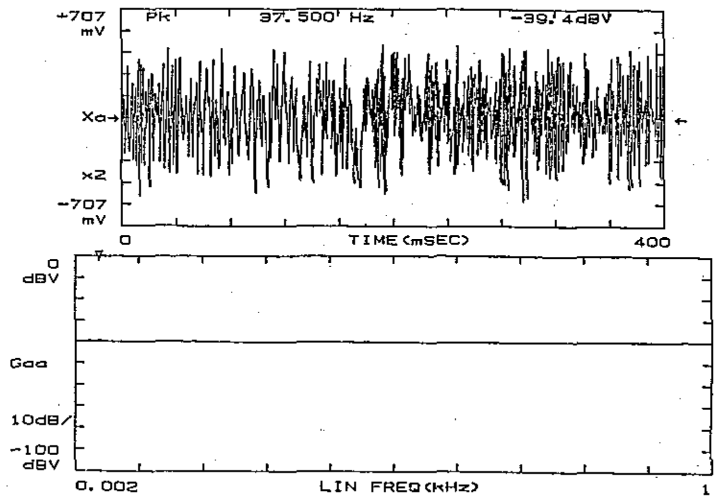
−20 dB

Swept-Sine (WIDTH:400)



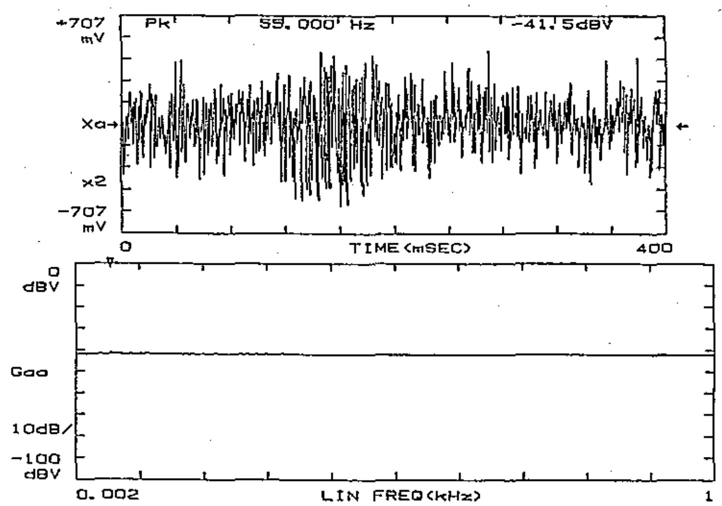
−35.1 dB

Weighted Multi-Sine



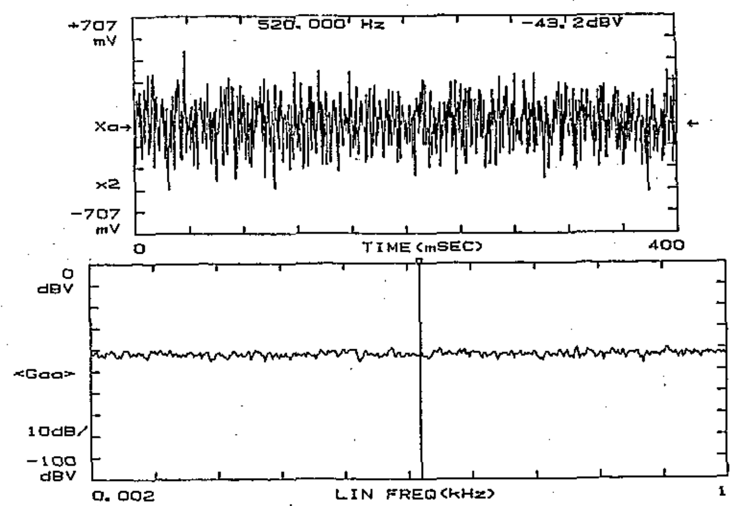
−39.4 dB

Multi-Sine



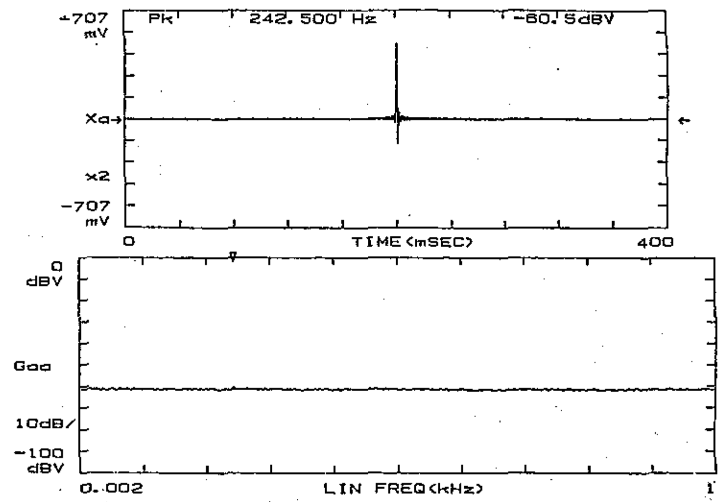
−41.5 dB

Random



−43 dB

Impulse



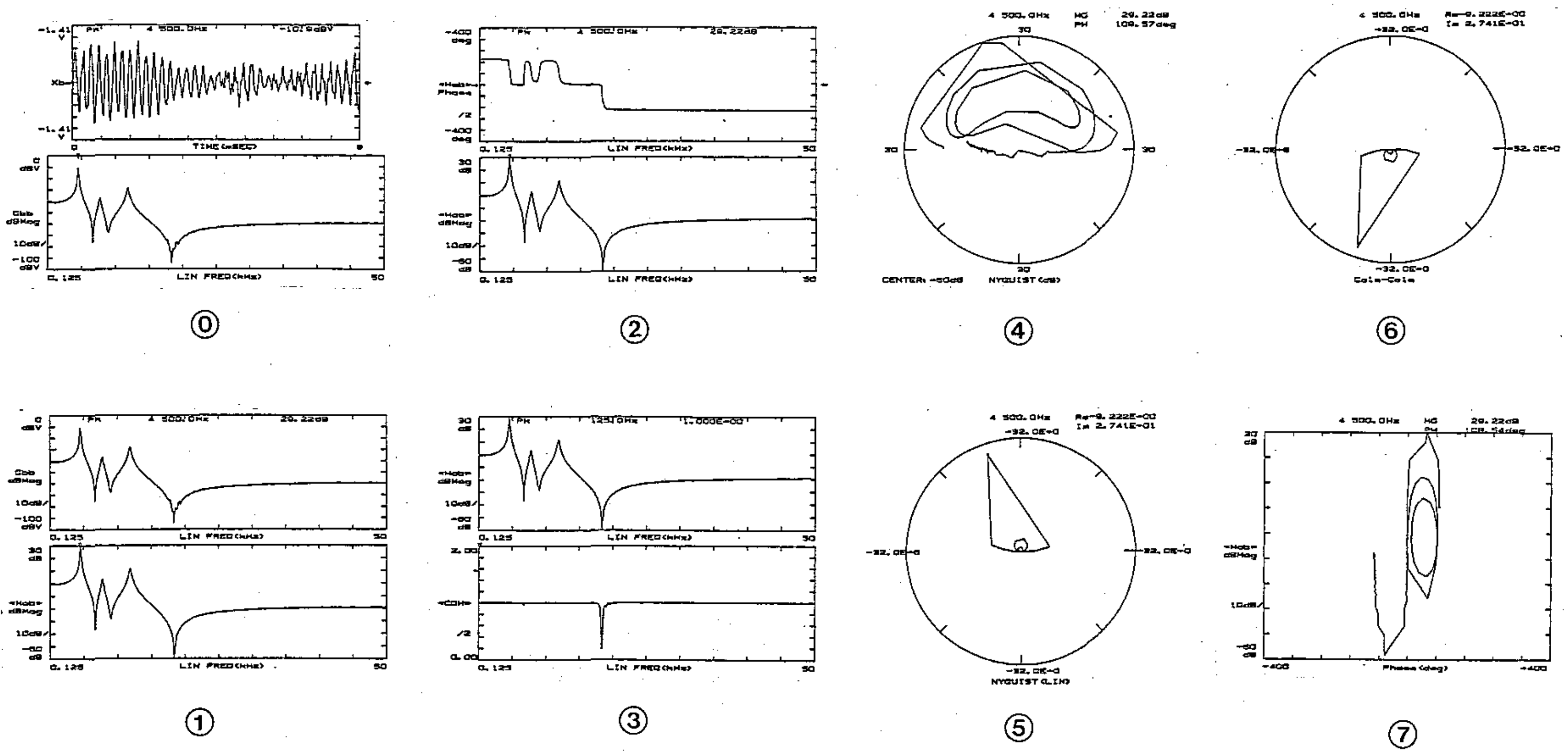
−60 dB

Simplified Error Codes for the Floppy Disk

10, 19	This data is not written in this mode.
18	Fail to find the data to be filed.
20 - 27	Hardware trouble (*)
30	Timeout error (*)
40	Disk is not inserted.
41, 42	Mass-time edit error
50	Power supply abnormal
60	Software error (*)
61	Data field error
62, 63	Not initialized correctly. Initialize it.
64	TR98102 cannot read this data. Initialize it.
65	Unusable track is detected. Initialize it.
66, 69	Write protected
67	Seek error (*)
70, 71	Error during initialize. Check PIO bus cable or termination.
74	Not writable in MASS TIME.
75	Error in data write (*)
76, 78, 79, 82	Not executable due to insufficient memory capacity
80, 85	Check sum or parity error. Data is not correctly written and the file cannot be read.
81, 86, 87, 88	File is not correctly written. This file cannot be read.
90	TR98102 cannot read this data. Initialize it.
91	TR9400 series cannot read this data.
92	Attempted to read the data before being written.
93	This file is not data and cannot be copied.
94	This file is not data and cannot be read.
95	This file cannot be read.
96	No buffer is available (*)

(*) May be derived from the hardware trouble(s). Contact your nearest representative of Advantest Corporation.

Menu Items		Setup of the Panel Keys	Text page	SIGNAL G. Menu: OUTPUT MODE SWEEP	SIGNAL G. Menu: Output Signal	SIGNAL G. Menu: AMPLITUDE	Frequency Response Analysis (Servo) Menu: SERVO	Frequency Response Analysis (Servo) Menu: ANALYSIS LINE	Frequency Response Analysis (Servo) Menu: AVG. NO.	Frequency Response Analysis (Servo) Menu: SENS. CTRL	Frequency Response Analysis (Servo) Menu: WGT CTRL	Frequency Response Analysis (Servo) Menu: SG OPERATION
Multi-Sine	Linear frequency analysis	LOCAL, LOCAL, AVG MODE (A)	3-16		MULTI–SINE	02.0E-3Vpp Change, as needed, to the optimum value, observing the CH-B spectrum (Gbb) display.	ENABLE (Lamp turns ON)	NORMAL	8	AUTO Unavailable with TR9402	AUTO	ON-KEY
	Log frequency analysis	LOCAL, LOCAL, WGT/SCALING (B)	3-23					4-DECADE				
Sine	Linear frequency analysis	LOCAL, LOCAL, FUNCTION (C)	3-27	LIN SWEEP Step: 7	SINE			NORMAL	2			
		LOCAL, LOCAL, DISPLAY CTL (D)	3-27	LOG SWEEP 80 lines/decade								
	Log frequency analysis	LOCAL, LOCAL, I/O (E)	3-33	LIN SWEEP Step: 9				4-DECADE				
		LOCAL, LOCAL, FREQUENCY (F)	3-33	LOG SWEEP 80 lines/decade								
Swept-Sine (SSS scheme)	Linear frequency analysis	LOCAL, LOCAL, SENS. A (G)	3-37	LIN SWEEP Width: 80	SWEPT–SINE			NORMAL	4			
		LOCAL, LOCAL, SENS. B (H)	3-37	LOG SWEEP 20 lines/decade								
	Log frequency analysis	LOCAL, LOCAL, TRIG. MODE (I)	3-48	LIN SWEEP Width: 80				4-DECADE				
		LOCAL, LOCAL, ADVANCED ANALYSIS (J)	3-48	LOG SWEEP 20 lines/decade								



Measurement Results through a Simplified Key Operation

⓪ LOCAL LOCAL AUTO ARM (9) Xb and Gbb (Time data and Spectrum on channel B. Used for the optimization of the magnitude of the signal from the S.G.)

① LOCAL LOCAL −GND (1) Output power spectrum and the transfer function (Checkup of the sweep with the Gbb.)

② LOCAL LOCAL +GND (2) Bode diagram (Observation of gain and phase of the transfer function.)

③ LOCAL LOCAL AC (3) Coherence function (Confidence verification of the transfer function measurement result.)

④ LOCAL LOCAL DC (4) Nyquist display of the transfer function (dBMag, Phase)

⑤ LOCAL LOCAL HOLD/REL. (5) Nyquist display of the transfer function (Real, Imag)

⑥ LOCAL LOCAL ARM (6) Nyquist display of the transfer function (Real, −Imag) (Cole-Cole plot)

⑦ LOCAL LOCAL +GND (7) Nichols diagram (Stability check for the feedback system.)

Preset values for Signal Sequence

Preset conditions for measurement:				
Frequency range			100 kHz	
Signal sequence (A B C)	Sequence A: Swept-sine	Setting item	Lin. frequency analysis	Log. frequency analysis
		AMPLITUDE*	02.0E-3Vpp	
		OUTPUT MODE*	LIN SWEEP	
		WIDTH	80	
		(Fmin, Fmax)*	(1,120)	(41,400)
		RANGE*	NORMAL, L U	STOP, U L
	Sequence B: Swept-sine	AMPLITUDE*	02.0E-3Vpp	
		OUTPUT MODE*	LIN SWEEP	
		WIDTH	80	
		(Fmin,Fmax)*	(121,240)	(41,400)
		RANGE*	NORMAL, L U	MIDDLE, U L
	Sequence C: Swept-sine	AMPLITUDE*	02.0E-3Vpp	
		OUTPUT MODE*	LIN SWEEP	
		WIDTH	80	
		(Fmin,Fmax)*	(241,400)	(4,400)
		RANGE*	NORMAL, L U	MIDDLE, U L
SERVO menu			ENABLE	
	ANALYSIS LINE		NORMAL	4-DECADE
	SENS CTRL		AUTO	
	WEIGHTING CTRL		AUTO	
	SG OPERATION		ON-KEY	
	AVG NO.*		4	

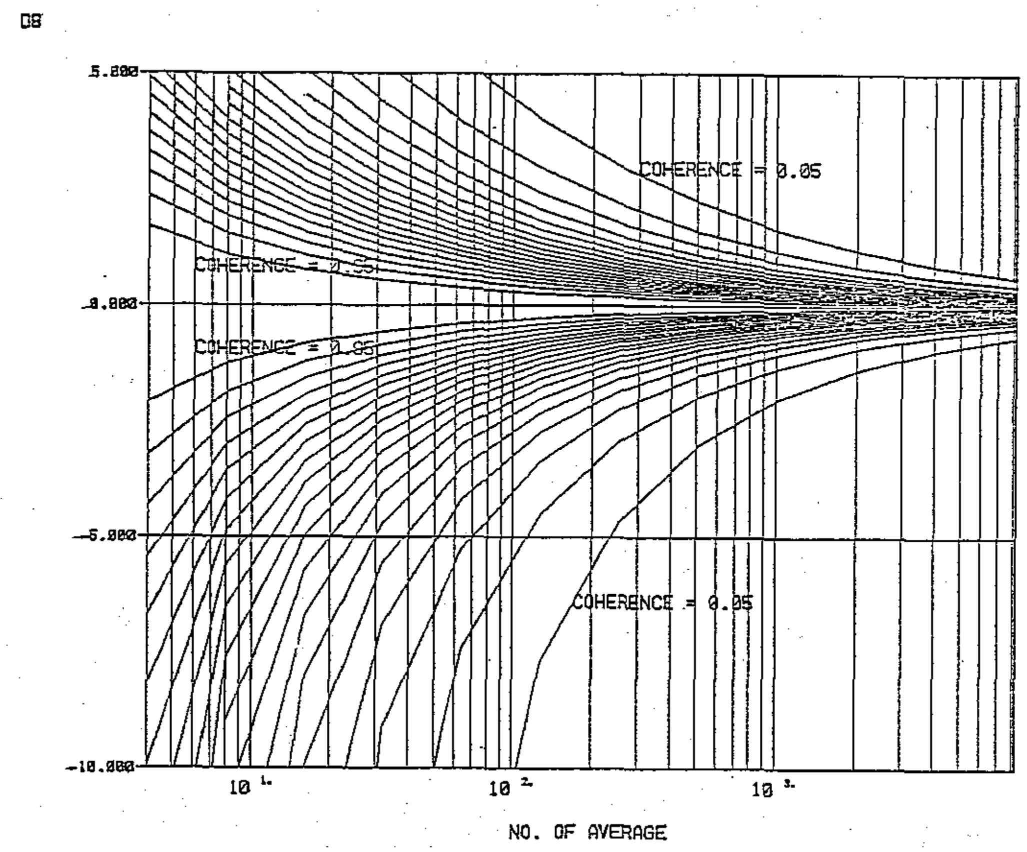
* marked items are settable from the SIGNAL SEQUENCE menu, too.

CONFIDENCE LIMIT OF TRANSFER FUNCTION

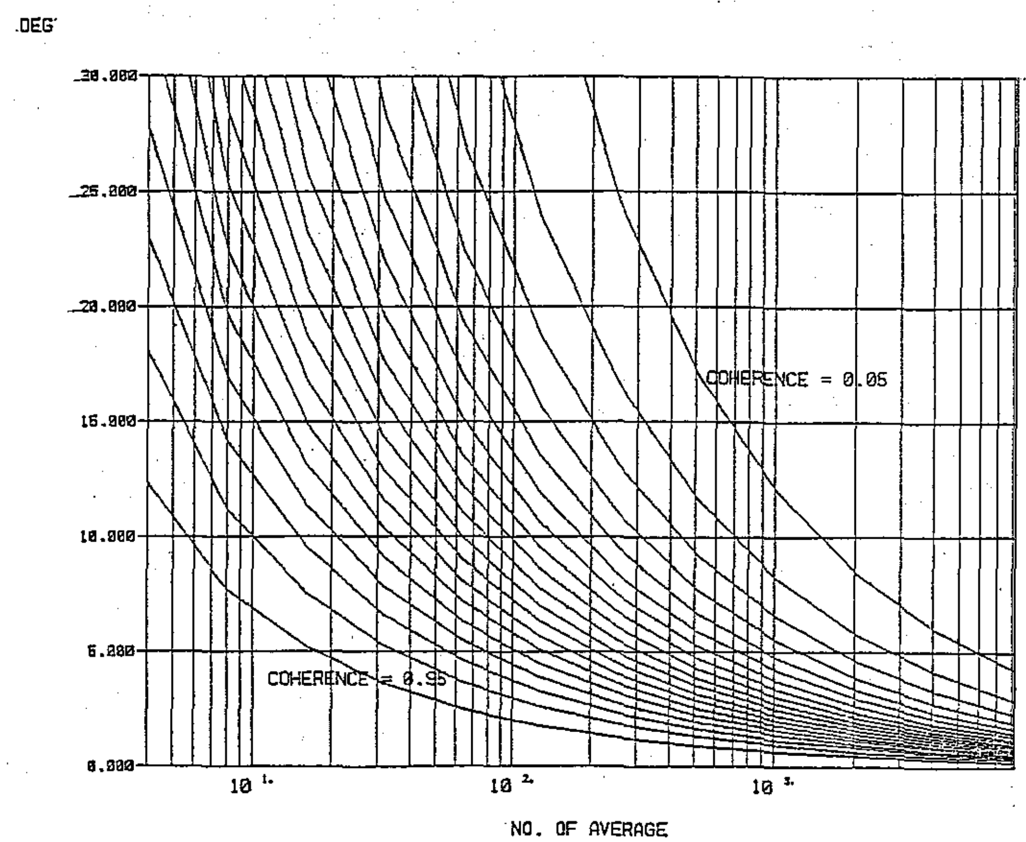
Measurement of the coherence function is indispensable at the time of transfer function measurement.

With the coherence function of 0.9, chances are 90% that the real value lies between +0.76 dB, −0.83 dB and ±5.23° provided the 32 averages are performed. Diagram on the right also demonstrates that 8,192 averages would keep the error down within ±1 dB.

TRANSFER FUNCTION CONFIDENCE LIMIT (90%)



TRANSFER FUNCTION CONFIDENCE LIMIT (90%)



COMMANDS FOR AUTOMATIC PLOTTING

(1) Commands for automatic vertical plotting

[Command format]

```
V x y
│ │ └── Plotting order (plot position)
│ └──── Number of plots
└────── Vertical plotting
```

This means that plotting in the position of the yth plot of x plots drawn vertically on A4-sized paper

Number of plots	Command name
1	V11
2	V21, V22
3	V31, V32, V33
4	V41, V42, V43, V44
5	V51, V52, V53, V54, V55
6	V61, V62, V63, V64, V65, V66

(2) Commands for automatic horizontal plotting

[Command format]

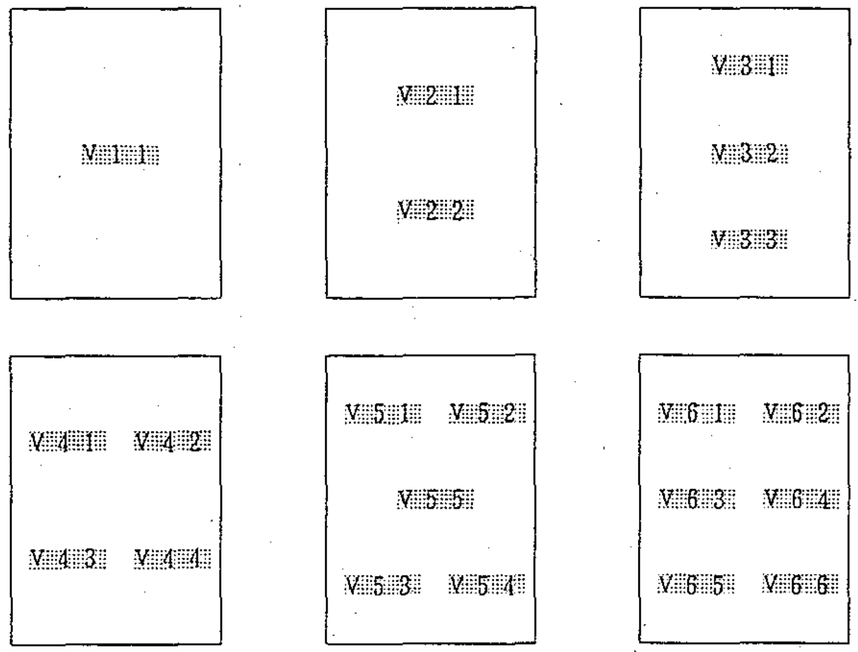
```
H x y
│ │ └── Plotting order (plot position)
│ └──── Number of plots
└────── Horizontal plotting
```

This means that plotting in the position of the yth plot of x horizontal plots on A4-sized paper

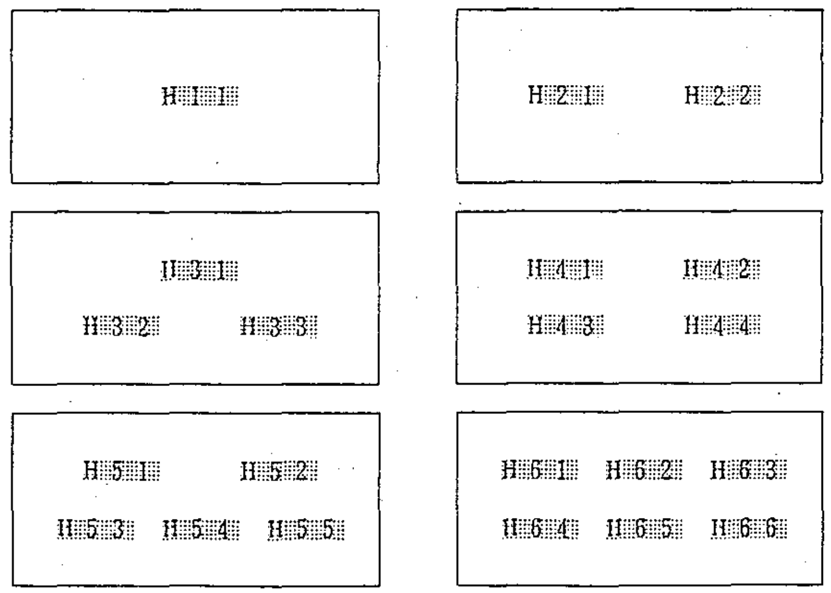
Number of plots	Command name
1	H11
2	H21, H22
3	H31, H32, H33
4	H41, H42, H43, H44
5	H51, H52, H53, H54, H55
6	H61, H62, H63, H64, H65, H66

Types of plot on A-4 sized paper (1-6 plots)

(1) Plot in vertical direction



(2) Plot in horizontal direction

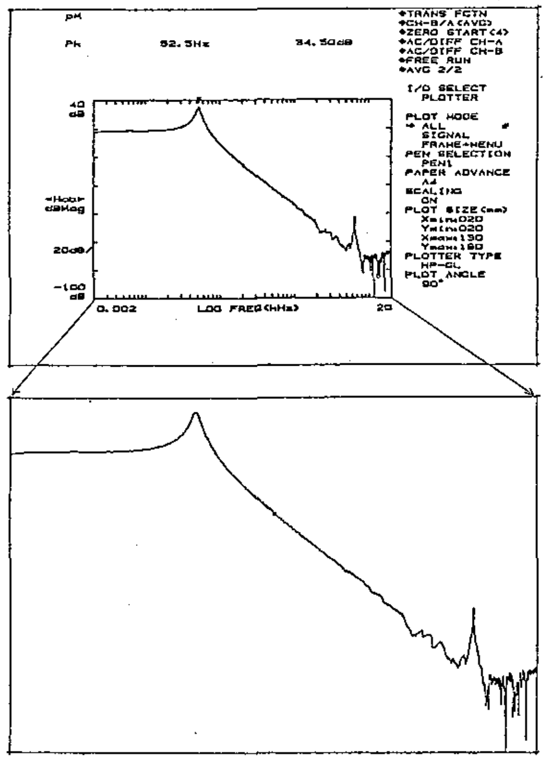


MARKER PLOT

Only the trace on the screen can be enlarged and plotted by PLOT SIZE in the plotter menu.

When the vertical cursor and reference cursor are set ON, the traces between these two cursors are enlarged by PLOT SIZE.

Since only the trace scale can be set as desired, plotting on the special paper and logarithmic graph on the market is facilitated.



(1) Plotting the whole trace

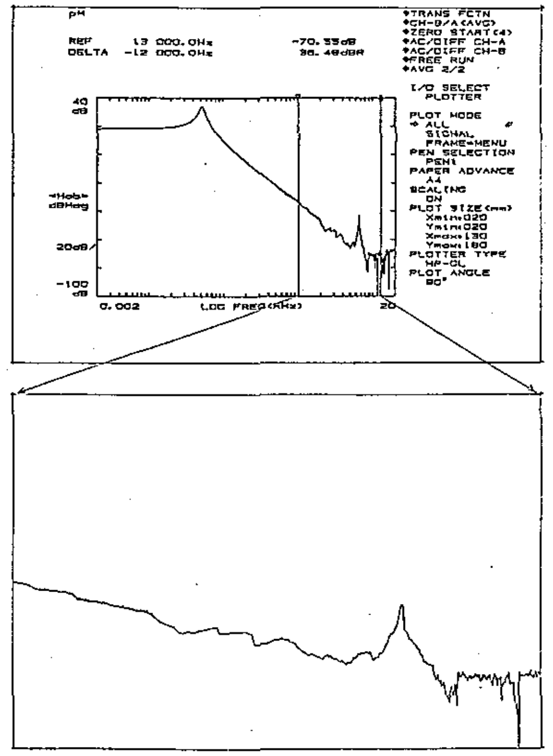
① UPSCALING Cancel the upscaling function

② I/O PANEL RECALL CROSS-CORR. M
Display the plotter menu.
Select SIGNAL from the PLOT MODE item.

③ Set a plot size.

④ LABEL Select the label mode (LABEL lamp goes on) and enter pM at the upper left corner of the screen.

⑤ Press the EXECUTE key in the I/O section.



(2) Plotting the trace between cursors

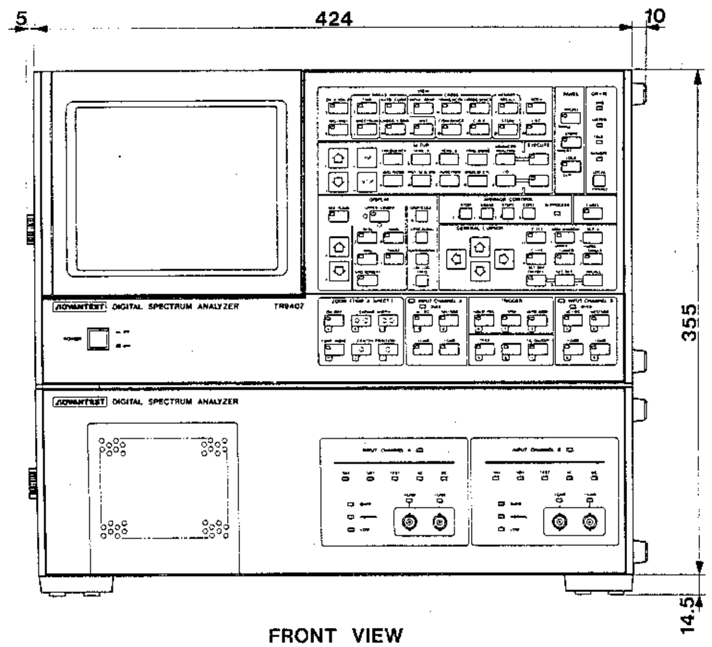
Press UPSCALING, then press the following keys:
C (↔) SET REF. ON/OFF SET REF.

Only the trace between the vertical and reference cursors is plotted on the scale set by PLOT SIZE.

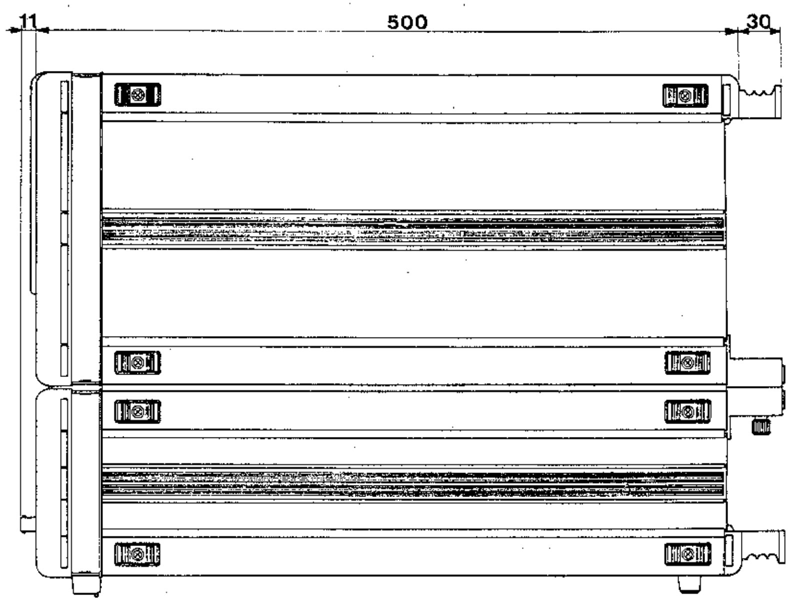
ALPHABETICAL INDEX

ALPHABETICAL INDEX (Cont'd)

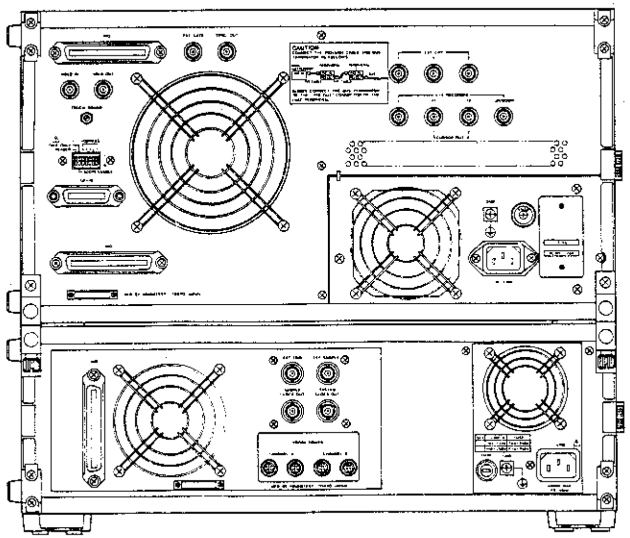
ALPHABETICAL INDEX (Cont'd)



FRONT VIEW



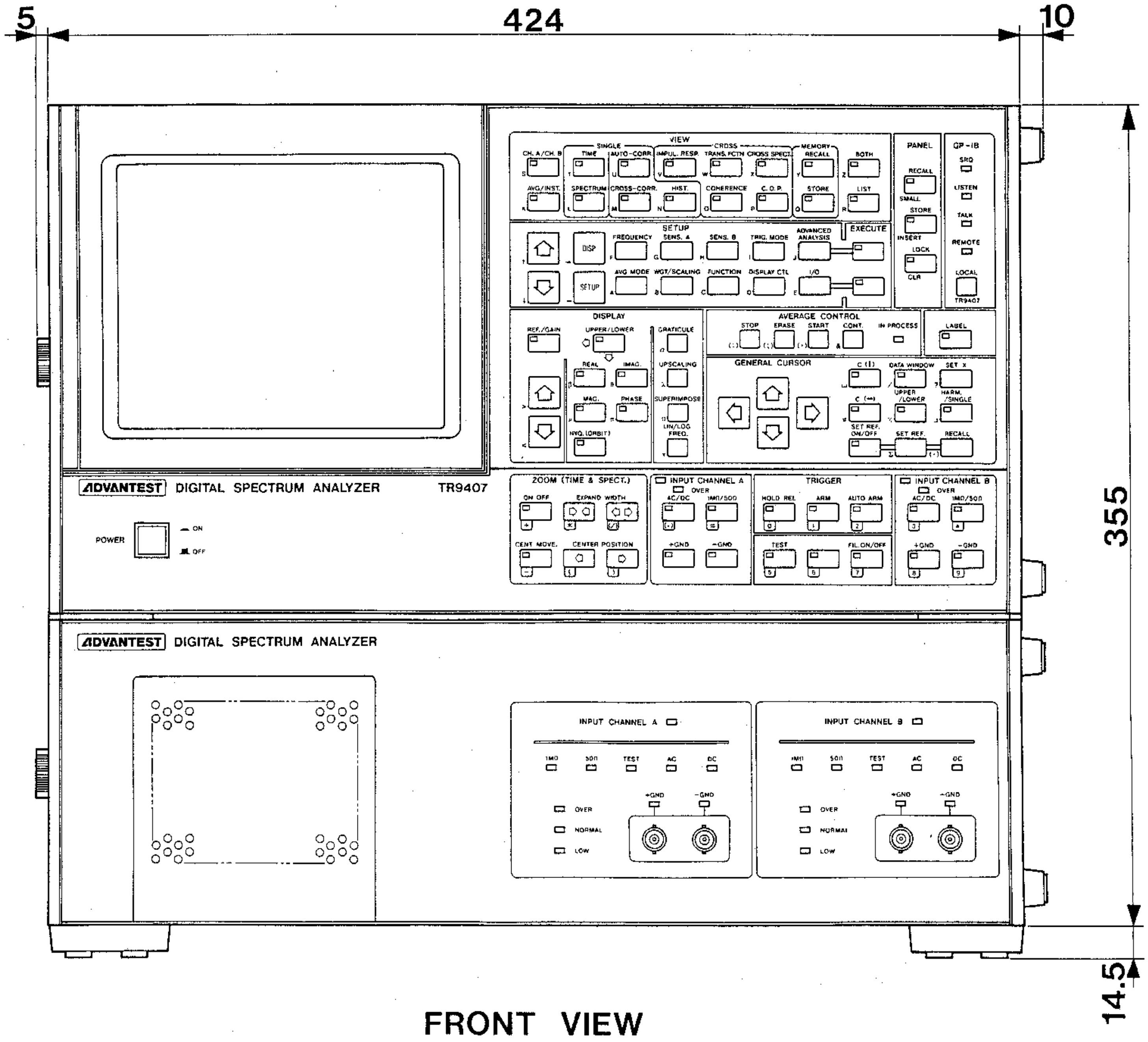
SIDE VIEW



REAR VIEW

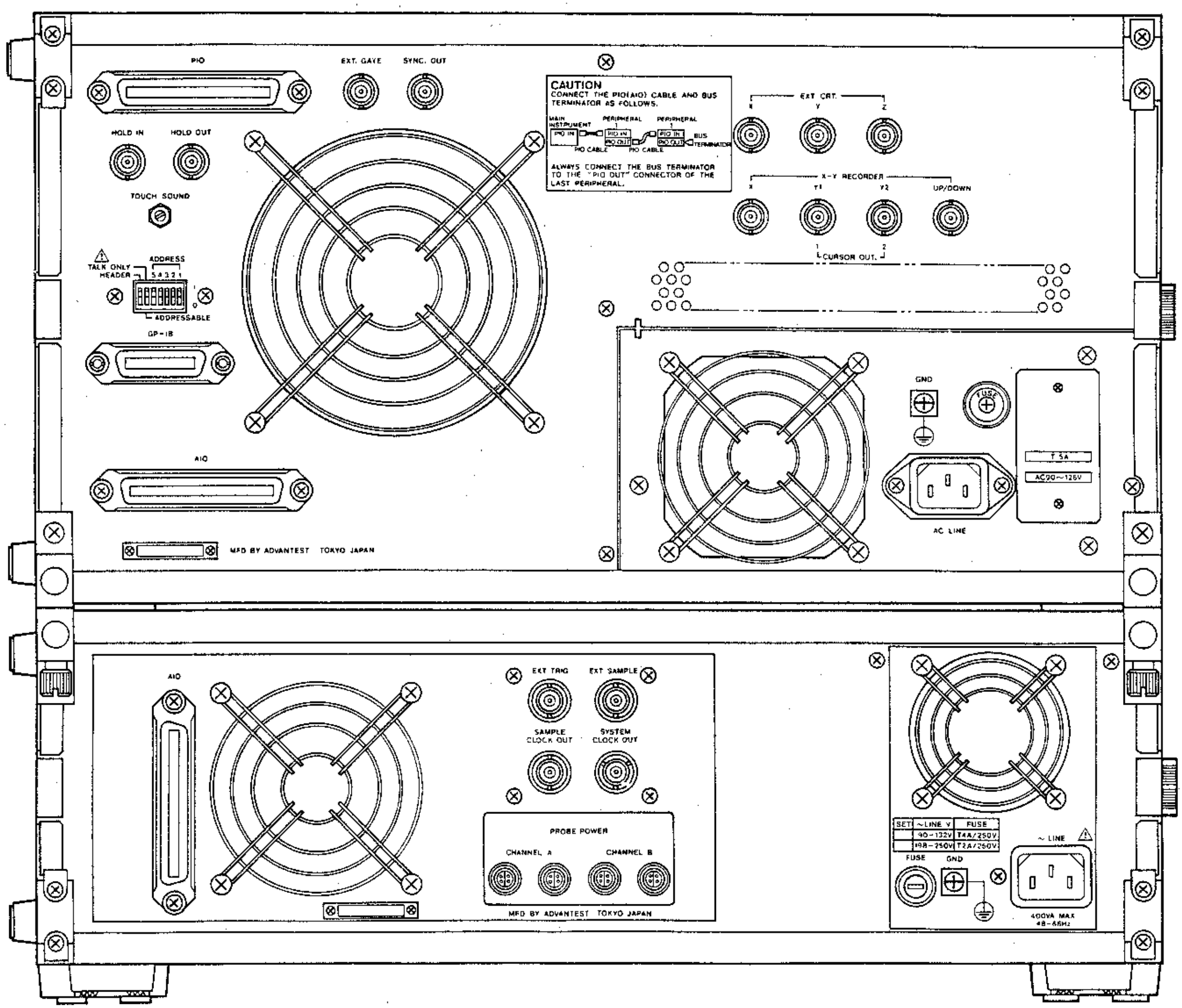
TR9407
EXTERNAL VIEW

9407EXT1－603－A



FRONT VIEW

9407EXT2-603-A



REAR VIEW

9407EXT3-603-A

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   (h) any negligent act or omission of the Purchaser or any third party other than Advantest.

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Advantest's maintenance agreement provides the Purchaser on-site and off-site maintenance, parts, maintenance machinery, regular inspections, and telephone support and will last a maximum of ten years from the date the delivery of the Product. For specific details of the services provided under the maintenance agreement, please contact the nearest Advantest office listed at the end of this Operation Manual or Advantest 's sales representatives.

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