ADVANTEST®
ADVANTEST CORPORATION

INSTRUCTION MANUAL

TR9404

Digital Spectrum Analyzer

VOL.-1

MANUAL NUMBER 0295 OEF 606

WARNING

This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instruction manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment.
Operation of this equipment in a residential area is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

Before reselling to other corporations or re-exporting to other countries, you are required to obtain permission from both the Japanese Government under its Export Control Act and the U.S. Government under its Export Control Law.

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SECTION 1

GENERAL INFORMATION

1-1. GENERAL

TR9404 Digital Spectrum Analyzer is a sophisticated instrument combining high-speed, high-sensitivity analog design with precision digital computing and signal processing technologies.
The TR9404 incorporates all analyzing functions needed for a dual channel FFT spectrum analyzer: i.e. transfer function, coherence function, correlation function and impulse response analysis, spectrum zooming, and so forth.
The wide-band, high-sensitivity specifications include a measurable frequency range of 0.0025 Hz to 100 kHz, input level range of +30 to -120 dBV (31.6 V to 1 μV rms), and dynamic range of more than 72 dB.
The TR9404 may be used to measure input-output and statistical relationships associated with the analysis of vibration, noise, structures and audio equipment, as well as chemical analysis, somatological researches, communication line instrumentation, semiconductor noise measurements, and many others.

1-2. FEATURES

(1) Ample measuring functions include:
Spectrum analysis, frequency response function analysis (transfer function measurement), phase measurement, correlation analysis, 1/3- and 1/1-octave analysis, oscilloscope, digital storage oscilloscope, signal averager, histogram meter (probability density function measurement), frequency counter, time interval meter, voltage measurement, and distortion measurement.

(2) Ample analyzing and operational functions
<u>Analyzing functions</u>
- Time domain data
- Time domain averaged data
- Complex spectrum
- Power spectrum

- Cross spectrum
- Transfer function
- Transmissibility
- Coherence function
- Coherent output power
- Impulse response
- Amplitude probability density function
- Autocorrelation function
- Cross-correlation function
- Orbit diagram
- Third octave and octave band analysis

Math operational functions

+, −, x, ÷, $\int dt$, d/dt, V/EU, coherence blanking, and equalization

(3) High input sensitivity, wide frequency range and broad dynamic range

The TR9404 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.

(4) Differential input measuring capability

The TR9404 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.

(5) Zoomed spectrum of transient record

The TR9404 contains 64K words time data buffer and can continuously record up to 64K (32K x 2) words of single (dual) channel time data for use in signal analysis.

Using this 64K (32K x 2)-word time record, the TR9404 performs hold zoom in the frequency domain up to a factor of 8 in binary sequence.

(6) Ample display features

- Displays real part, imaginary part, magnitude, phase; Bode and Nyquist diagrams.
- 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 and 400 lines for dual channel.

- 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 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 (except Nyquist and orbit displays).

(7) GPIB, plotter and floppy disk interface provided as standard

The TR9404 has the interface of GPIB, plotter and floppy disk as standard feature. This enables you to put the TR9404 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. TR9834R or TR9831 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.

TR9404 also provides optional interface (opt. 05) of the Signal Generator (TR98201).

(8) Third octave band and full octave band analysis
The TR9404 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 applicaions.

1-3. ACCESSORIES

The following standard accessories are supplied with the instrument. Upon receipt of the instrument be sure to check the quantity and specifications of these accessories:

(1) Input cable MI-77 (BNC - clip) ------- 2

(2) Fuse 4 A (DFT-AA4A-1) ---------------- 2
2 A (DFT-AA2A-1) for 198-249 Vac

(3) Power cable (MP-43A) ----------------- 1

(4) Instruction Manual ------------------- 1

1-4. SPECIFICATIONS

<u>Analyzing functions</u>

- Time domain data
- Time domain averaged data
- Complex spectrum (Realtime spectrum)
- Power spectrum
- Cross spectrum
- Transfer function
- Transmissibility
- Coherence function
- Coherent output power
- Impulse response
- Amplitude probability density function
- Autocorrelation function
- Cross-correlation function
- Orbit diagram
- Third octave and octave analysis

Input Specifications

Input channels : 2

Input mode : Differential or single ended

Input impedance: Approx. 1 MΩ

Input coupling : AC, DC, GND

CMRR : 60 dB min. (DC coupling at 50/60 Hz)

Max. common mode signal voltage: ±10 Vp-p (0 dBV to -60 dBV)
±100 Vp-p (+30 dBV to +10 dBV)

Amplitude range: -60 dBV to +30 dBV (1 mVrms to 31.6 Vrms) at 10 dB steps

Measurement range, coupling mode and residual noise:

<table>
<tr><th>dBV</th><th>rms</th><th>peak</th><th>Residual noise*</th><th>Coupling mode</th></tr>
<tr><td>+30</td><td>31.6 V</td><td>44.7 V</td><td rowspan="8">-80dBFS</td><td rowspan="7">AC or DC coupling</td></tr>
<tr><td>+20</td><td>10.0 V</td><td>14.14 V</td></tr>
<tr><td>+10</td><td>3.16 V</td><td>4.47 V</td></tr>
<tr><td>0</td><td>1.0 V</td><td>1.41 V</td></tr>
<tr><td>-10</td><td>316 mV</td><td>447 mV</td></tr>
<tr><td>-20</td><td>100 mV</td><td>141 mV</td></tr>
<tr><td>-30</td><td>31.6 mV</td><td>44.7 mV</td></tr>
<tr><td>-40</td><td>10.0 mV</td><td>14.1 mV</td><td rowspan="3">AC coupling</td></tr>
<tr><td>-50</td><td>3.16 mV</td><td>4.47 mV</td><td>-72dBFS</td></tr>
<tr><td>-60</td><td>1.0 mV</td><td>1.41 mV</td><td>-65dBFS</td></tr>
<tr><td>AUTO</td><td colspan="4">Settable to the optimum range depending on incoming signal</td></tr>
</table>

*Spectrum mode (GND coupling) value, not overall rms. The 1/f noise is excluded

Max. differential input voltage: ±100 Vp-p

Max. input sensitivity: -120 dBV (1 μVrms)

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 sounded. Message such as "OVERLOAD: CH-A" flashes at bottom left of the CRT display for a few seconds.

Test signal:

Frequency : Sine wave with a frequency which is 64% of each frequency range setting

Level : -3 dBV ±0.2 dB (20 Hz to 100 kHz range)

<u>Analyzing Characteristics</u>

Frequency range : 16 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, and 100 kHz

Realtime analysis range: 1 kHz range

Data buffer memory: 64K words/ch for single channel mode
32K 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
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.

Hold zooming mode: High resolution spectrum analysis is performed on the captured non-stationary signals such as bursts or transient signals. The frequency identified in the 0 start mode by the cursor is centered on the display in the zooming mode. Zooming factors are x2 to x8 in binary sequence.

Number of points of displayed waveform: In time domain data display, arbitrary 2048 points (1024 points for dual channel mode) of data out of 64K words (single channel mode) or 32K 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 2.5 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. Time and frequency calibration in this mode is given as a percentage of full scale.

Input filters : Range switch automatically selects anti-alialing filter (with relloff characteristics of -140dB/oct) except in the 1, 2, 5 and 10Hz ranges, for which 20Hz filter is used.

Dynamic range (except 1/f noise or in ZOOM mode):

Spurious response: ≦ -78dBFS (+30 to -40dBV range)
≦ -70dBFS (-50dBV range)
≦ -60dBFS (-60dBV range)

Harmonic distortion: ≦ -72dBFS

Inter-channel amplitude/phase difference (in the same sensitivity range):

Amplitude difference: Not more than ±0.3 dB (at less than 90% of selected frequency range)
Not more than ±0.5 dB (at less than 90 to 100% of selected frequency range)

Phase difference : ±3 degrees (at less than 90% of selected frequency range)
±5 degrees (at 90 to 100% of selected frequency range)

Weighting: Rectangular, Hanning, minimum and flat-pass

<u>Trigger</u>

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: −5 V to +5 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 3200% (one frame equal to 100%)
Resolution: One sample data
Dual channel mode
Range: 0 to 3200% (one frame equal to 100%)
Resolution: One sample data

Averaging

Frequency domain averaging mode:

- Normalized sum
- Linear sum
- Difference
- Exponential
- Peak
- Sweep

Time domain 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 CRT display.

Measurement condition selection: Interactive selection using menu

Display functions:

Time domain data - Input signal waveform (CH.A and CH.B): Complex input waveform, transient signal waveform, time domain synchronous averaging waveform, orbit display
Correlation function: Auto correlation function and cross correlation function
Impulse response

Frequency domain data - Spectrum (CH.A and CH.B): Complex spectrum, averaged spectrum and zoomed spectrum
Transfer function: Gain, phase/Bode diagram or Nyquist diagram
Real part and imaginary part
Coherence function

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).

3-D display mode : Up to 14 lines of displayed data can be stacked in 3-D display mode (except Nyquist and orbit displays).

Octave analysis : 1/3-octave band and 1/1-octave band analysis

Label : Up to two lines of label characters (40 alphanumeric and special characters per line) can be displayed in the top display area of the screen, with each line position movable in the vertical direction.

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 harmonics 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

Magnitude domain data: $\pm$V, V^{-1}

Set reference mode: With an arbitrary point defined as a reference by the cursor this mode operates and displays $\pm\Delta$f, $\pm$dBR, $\pm\Delta$t, $\pm\Delta$V, $\pm$deg while moving the cursor.

Vertical axis (frequency domain):

Linear : 1 through 8192 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: +160 dB to -80 dB, display gain: 2 dB/div., 5 dB/div., 10 dB/div.)

Phase: $+180^{\circ}$ to -180°

Horizontal axis (frequency domain): Linear, logarithmic, Nyquist

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: 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, ÷, $\int dt$, d/dt, V/EU, coherence blanking, and equalization

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 (Option 05)

General Specifications

Supply voltage : 90-126 Vac $\pm$10% (Modifiable to 198-249 Vac)

Operating environment: Temperature $0^{\circ}C$ to $+40^{\circ}C$
Humidity Less than 85 % RH

Power consumption : Not more than 300 VA

Dimensions: Approx. 424(W) x 221(H) x 500(D) mm

Weight: Approx. 26 kg

1-5. PERIPHERAL DEVICES AND ACCESSARIES

Versatil systems use of the TR9404 is made via the standard interface of GPIB, plotter, XY recorder and floppy disk along with the other peripheral devices and accessories as shown below.

- TR9834R Digital Plotter
- TR9831 Plotwriter
- TR98102 Floppy disk digital data recorder
- TR98201 Signal Generator (via optional interface 05)
- TR7200 series Universal Scanner
- XY recorder
- HP-GL plotter (Hewlett Packard 7470A, 7225A)
- Close-up camera (M-85D, #85-26)
- TR16025 Transit case
- TR16902 Trolley
- TR16801 Cabinet Rack
- Accelerometers (Endevco)
- Charge amplifiers (Endevco) (See Tables 1-1, 1-2)

Table 1-1 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 (°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 1-1 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 ($^{\circ}C$)	-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 1-2 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

SECTION 2

PREPARATION AND GENERAL PRECAUTIONS

2-1. INTRODUCTION

This section describes general handling procedure for TR9404 Digital Spectrum Analyzer, including preparation, cautions in usage and storage method. To ensure proper operation of the instrument, be sure to read these instructions carefully.

2-2. 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.

2-3. SHIPPING PRECAUTIONS

Should it become necessary to repack the instrument for shipment, use the original packing material or equivalent. A carrying case dedicated for the TR9404 is available from us (optional) for transportation convenience.

2-4. 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, 50/60Hz (see Figure 2-1).

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

(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 2-1 and 2-2). 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 2-3(a) and (b)).

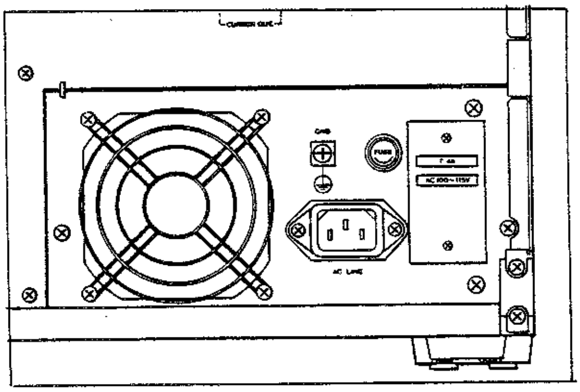
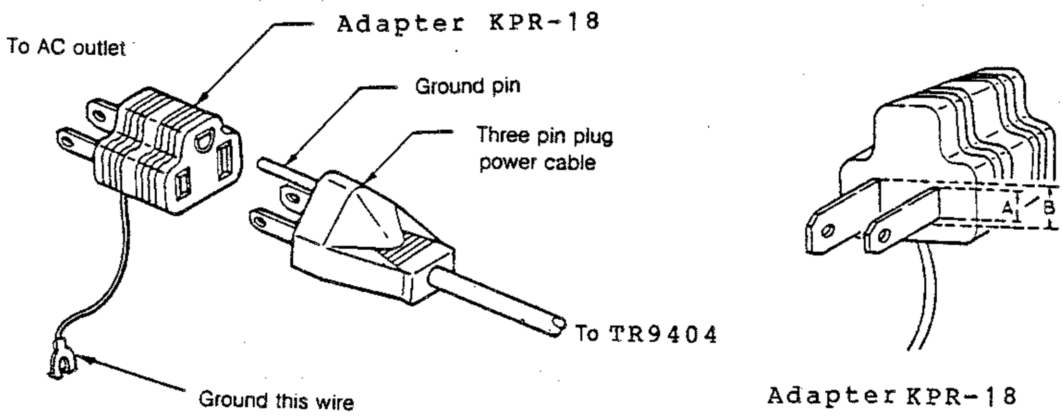
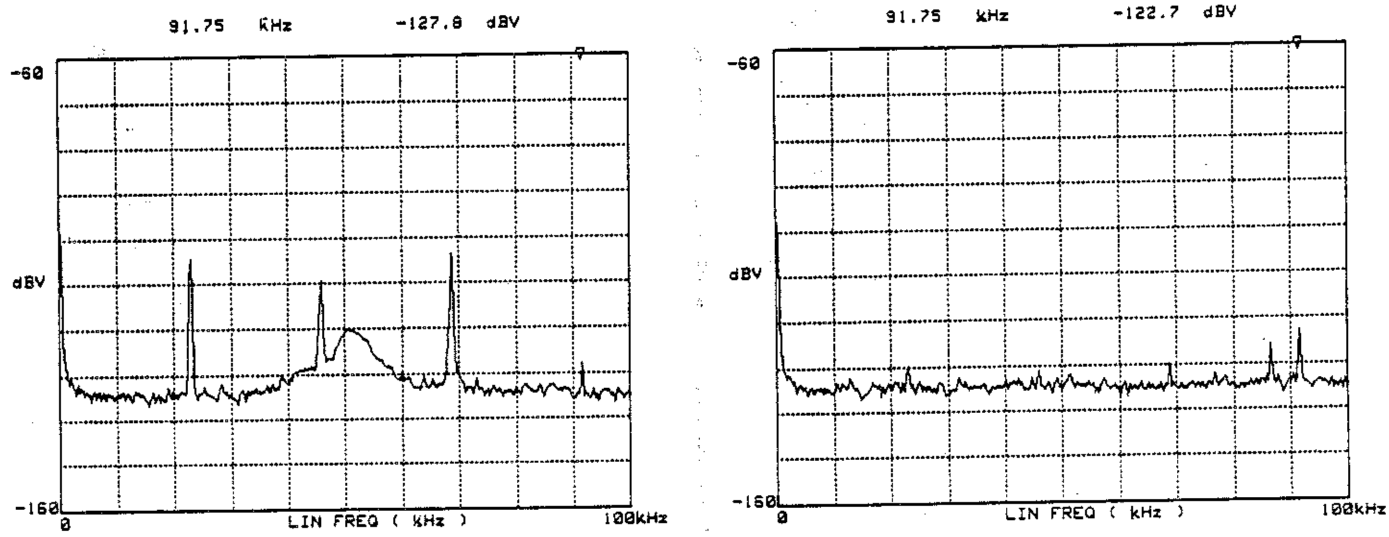


Fig. 2-1 Line voltage plate and GND terminal



(a) (b)

Fig. 2-2 Power cable plug and plug adapter



(a) (b)

Fig. 2-3 Grounding effect ((a): not grounded (b): grounded)

(3) 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	4 A
200-230 Vac	2 A

CAUTION

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

(4) 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 $0^{\circ}C$ and $+40^{\circ}C$, with relative humidity under 85%.

(5) 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.

(6) 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.

(7) 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.

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

(9) 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.

(10) 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 (see Figure 2-4). Removing the CRT filter

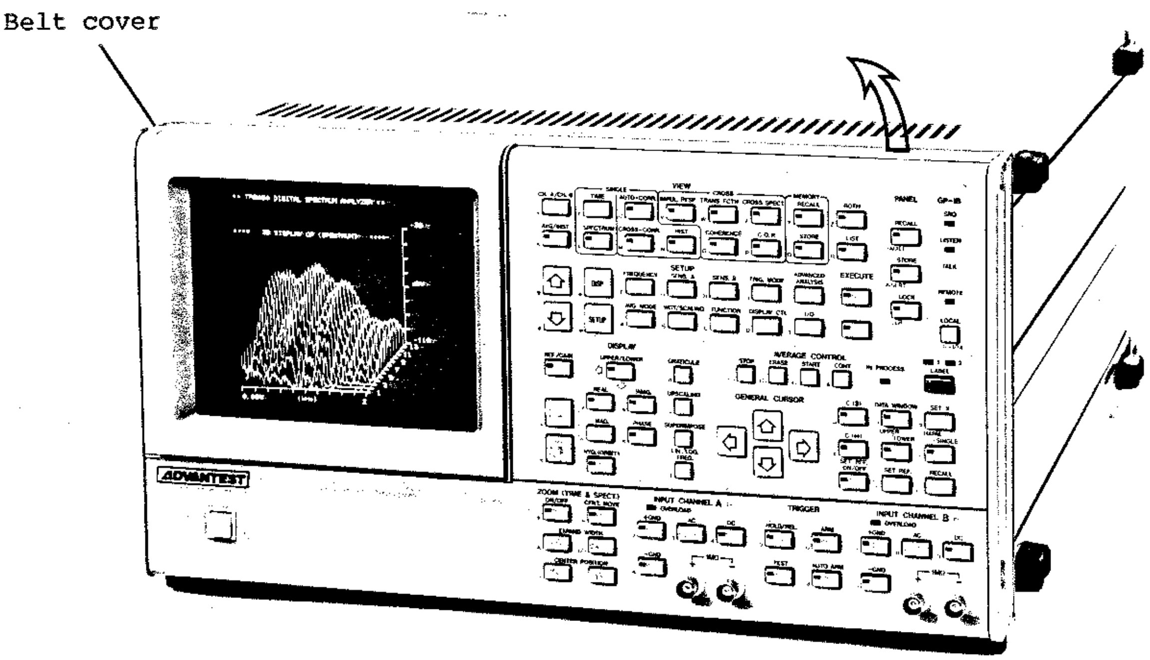


Fig. 2-4 Removing the CRT filter

a. Remove the belt cover with a flat-tipped screwdriver or other adequate tool. The belt cover is mounted without using any screws or bond.

b. Loosen the two screws at the top of the bezel.

c. Remove the bezel by pulling it forward-upward.

(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 TR9404 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 TR9404, 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 2-5. 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 connections to terminals GND1 and GND2 and all other signal cable connections before plugging the analyzer into an electrical outlet and then switching it on.

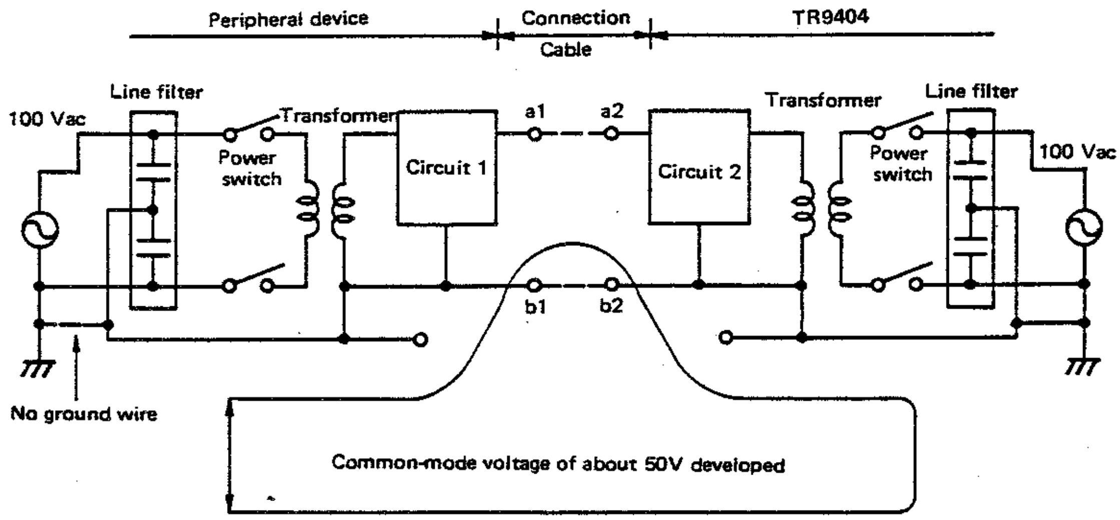


Fig. 2-5 CMV loop in a power supply line

SECTION 3
ANALYZING FUNCTIONS

3-1. INTRODUCTION

TR9404 Digital Spectrum Analyzer has unique analyzing functions in each of the time, frequency and amplitude domains. To secure the powerful analyzing functions of the TR9404, familiarize yourself with the versatile analyzing functions and the relationship between each domain and function of the instrument.

(1) Time domain analysis
- Transient waveform storage
- Time domain/averaging
- Autocorrelation function/averaging
- Cross-correlation function/averaging
- Impulse response

(2) Frequency domain analysis
- Linear spectrum/averaging
- Auto power spectrum/averaging
- Phase spectrum
- Cross spectrum/averaging
- Transfer function
- Coherence function
- Coherent output power
- Third octave and full octave band analysis/averaging

(3) Amplitude domain analysis
- Amplitude probability density function/averaging
- Orbit diagram

3-2. BASIC CONCEPTS OF ANALYZING FUNCTIONS

The TR9404 is basically a dual channel spectrum analyzer comprised of channels A and B. Input/output signal is to be applied to channel A/B. Signals are processed according to this cause-and-effect relationship and the results are displayed.

For example, let us assume a case where we are going to determine the transfer function of a device under test (DUT) as shown in Figure 3-1. The input signal for the DUT must be applied to channel A of the TR9404, whereas the output of the DUT must be applied to channel B of the instrument.

All analyzing and display functions of the TR9404 can be obtained by defining the time series data for the DUT's input and output as Xa and Xb respectively.

Figure 3-2 illustrates the relationship between the input and output of the DUT in question.

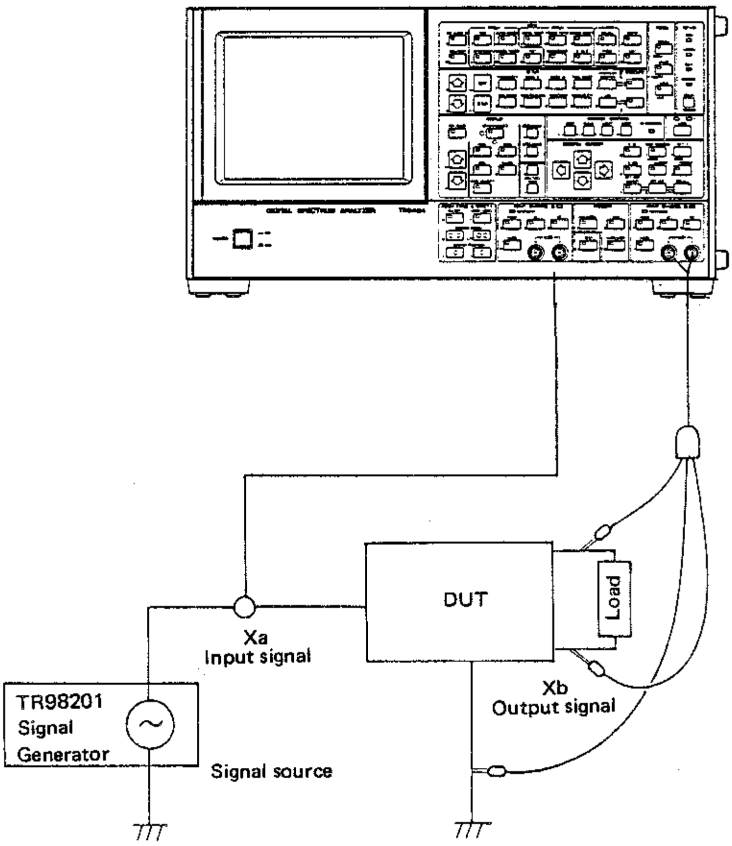


Fig. 3-1 Usage of channels A and B

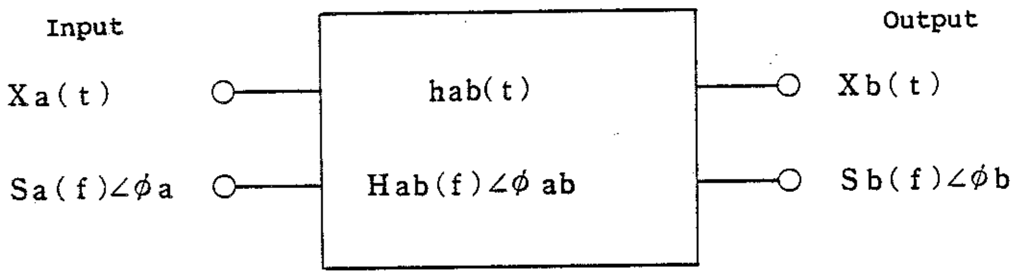


Fig. 3-2 Input-output relationship of a two-terminal network and its circuit symbols

Xa(t) : Input signal to the DUT (time domain)
Xb(t) : Output signal of the DUT (time domain)
Sa(f) : Fourier transform of Xa (frequency domain)
Sb(f) : Fourier transform of Xb (frequency domain)
hab(F): Impulse response of the DUT (time domain)
Hab(f): Transfer function of the DUT (frequency domain)

If each function is defined as above, a vector relationship as shown in Figure 3-3 is obtained.

Xa(t) $\Leftrightarrow$ Sa(f)∠φ

where $\Leftrightarrow$ denotes a Fourier transform pair and ∠φ denotes phase. Similar relationship is also obtained between Xb and Sb, and hab and Hab as well.

From the above discussions, the relationships as shown in Figure 3-4 are obtained in the frequency and time domains. As a result, the transfer function (magnitude and phase information), impulse response, etc. of the DUT shown in Figure 3-1 can be determined by measuring Xa and Xb.

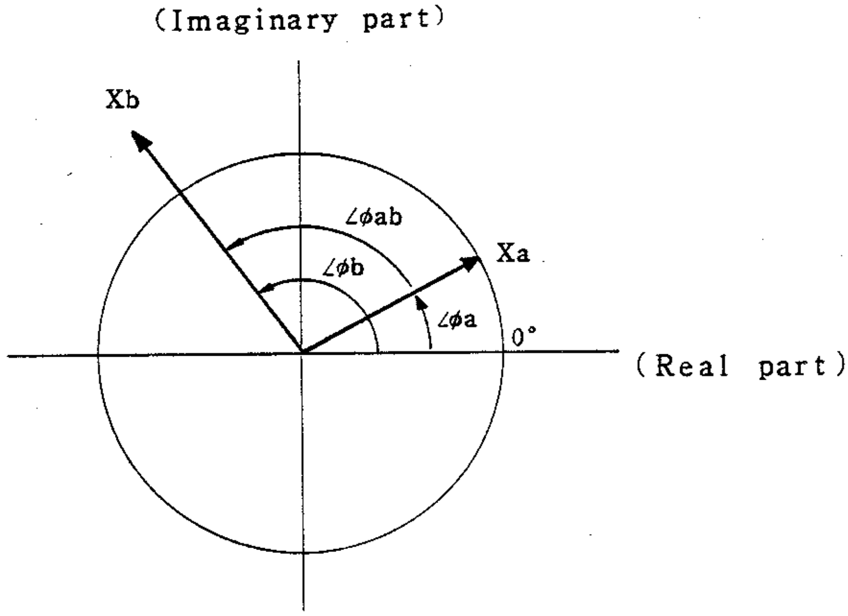


Fig. 3-3 Vector representation of input and output signals

- Frequency domain

  $Sb(f) = Hab(f) \cdot Sa(f)$

  Fourier transform of a linear system output signal is given by the product of the system's transfer function and the Fourier transform of the input signal.

- Time domain

  $$Xb(t) = \int_{-\infty}^{+\infty} hab(\tau)\, Xa(t-\tau)\, d\tau = hab(t) * Xa(t)$$

  (*: convolution)

  Output of a linear system is given by convolutional integration of system's impulse response and input signal.

Fig. 3-4 Input/output signals vs. system functions in the frequency and time domains

The amplitude (absolute value) and frequency information in the frequency domain generally reflects a characteristic which is unrelated to how the time series Xa or Xb is acquired. However, the phase of the input spectrum corresponds to each input time series and phase information is relative to reference time and hence requires T = 0 as a time reference. This time reference depends on the time domain display on the TR9404. The waveform as shown in Figure 3-5(a) (one cycle per frame time, amplitude maximum at T = 0 and equal to the fullscale of the setup sensitivity range) is used as the reference for everything (amplitude, frequency and phase).

Frame time is determined uniquely by frequency range setup. The waveform having just one cycle per frame time corresponds to the first AC spectrum in the selected frequency range. (This is not applicable to the spectrum zooming mode, however.) Any waveform having a longer period (or lower frequency) is considered a DC component in that frequency range. The signal shown in Figure 3-5(a) has the following factors:

Frequency: Fundamental spectrum (1/T)

Amplitude: Full scale (1.0 x selected sensitivity range)

Phase : No advance nor lag (ϕ = 0)

This means that, on the TR9404, the time reference for phase informations is positioned (T = 0) at the leftmost graticule in the time domain. Figure 3-5(b) shows the relationship between another frequency f_2 and its phase when T is assumed as the frame time. While signal f_1 in this figure is the reference for frequency, amplitude and phase within the frame time, signal f_2 has the following factors with respect to f_1:

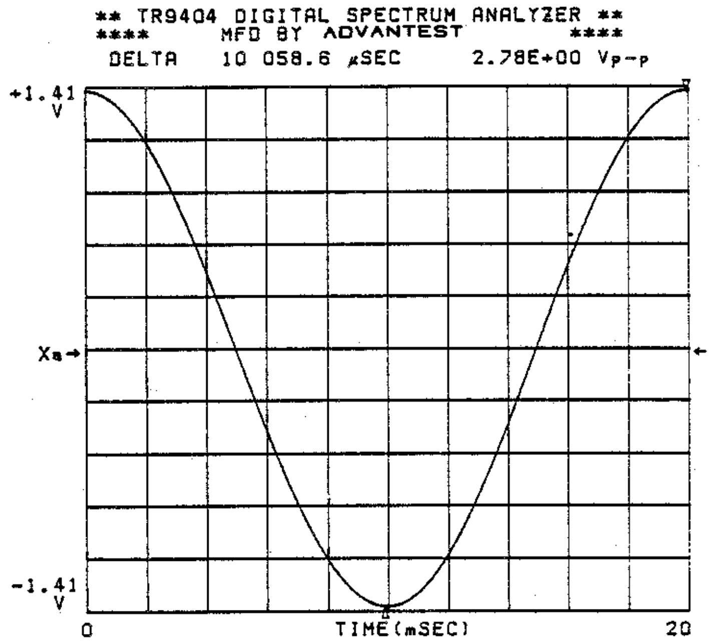
Frequency (or angular velocity or angular frequency): 2 times

Amplitude: 1/2

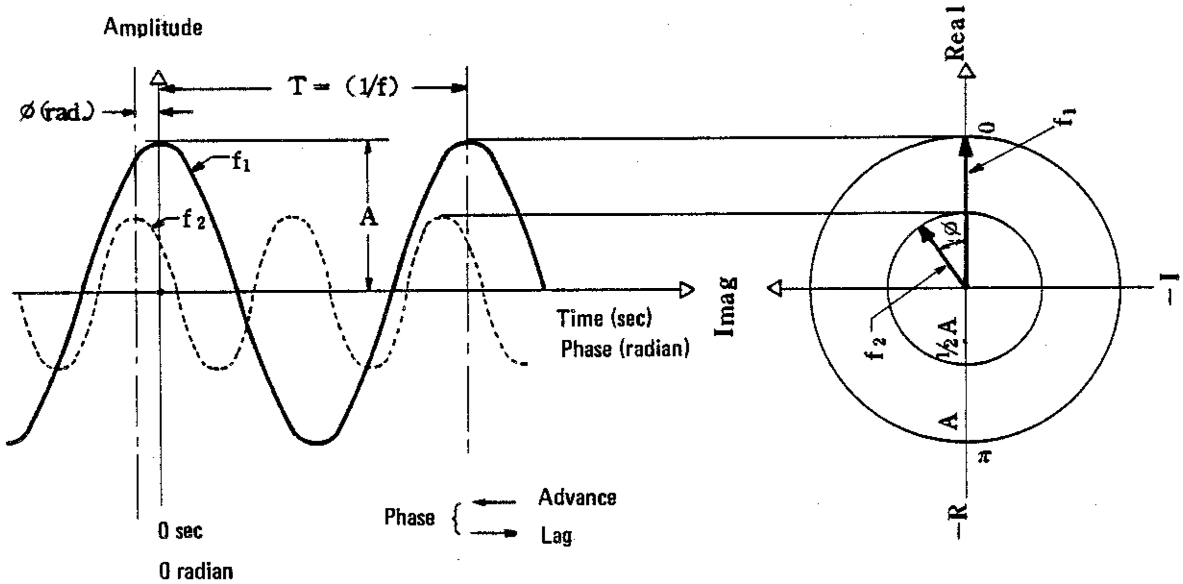
Phase : Advanced by ϕ (or lagged by $2\pi - \phi$)

The frequency, amplitude and phase can be determined from the following relationship defined in Figure 3-2:

$Xa(t) \Longleftrightarrow Sa(f) \angle \phi a$



(a) Time series signal vs. frame time



(b) Frame time vs. phase

Fig. 3-5 Relationship between input signal frame time and phase

Figures 3-6 (1) through (3) show the phase relationships on the time axis, phase spectra on the frequency axis, and power spectra on the frequency axis of signal waveforms $\cos(2\pi f_0 t)$, $\cos(2\pi f_0 t-\phi)$, and $\sin(2\pi f_0 t)$ respectively.

Figure 3-6 (4) and (5) show waveforms of two sine waves with different phases composed on the time axis and their phase spectra and power spectra on the frequency axis. As shown in these figures, the same power spectrum can result from different waveforms and phase spectra. For example, if it is assumed that signal Xa and Xb in Figure 3-1 and 3-2 correspond to (4) and (5) in Figure 3-6 respectively, difference exists in the input and output phases of the DUT although their amplitudes are identical. This means that signal f_0 is subject to no phase variation, whereas the output phase of signal f_1 has a phase lag of 90° ($\pi/2$) or phase advance of 270° ($3\pi/4$) with respect to the input phase. Therefore, we can see that the DUT has phase distortion though it has no amplitude distortion.

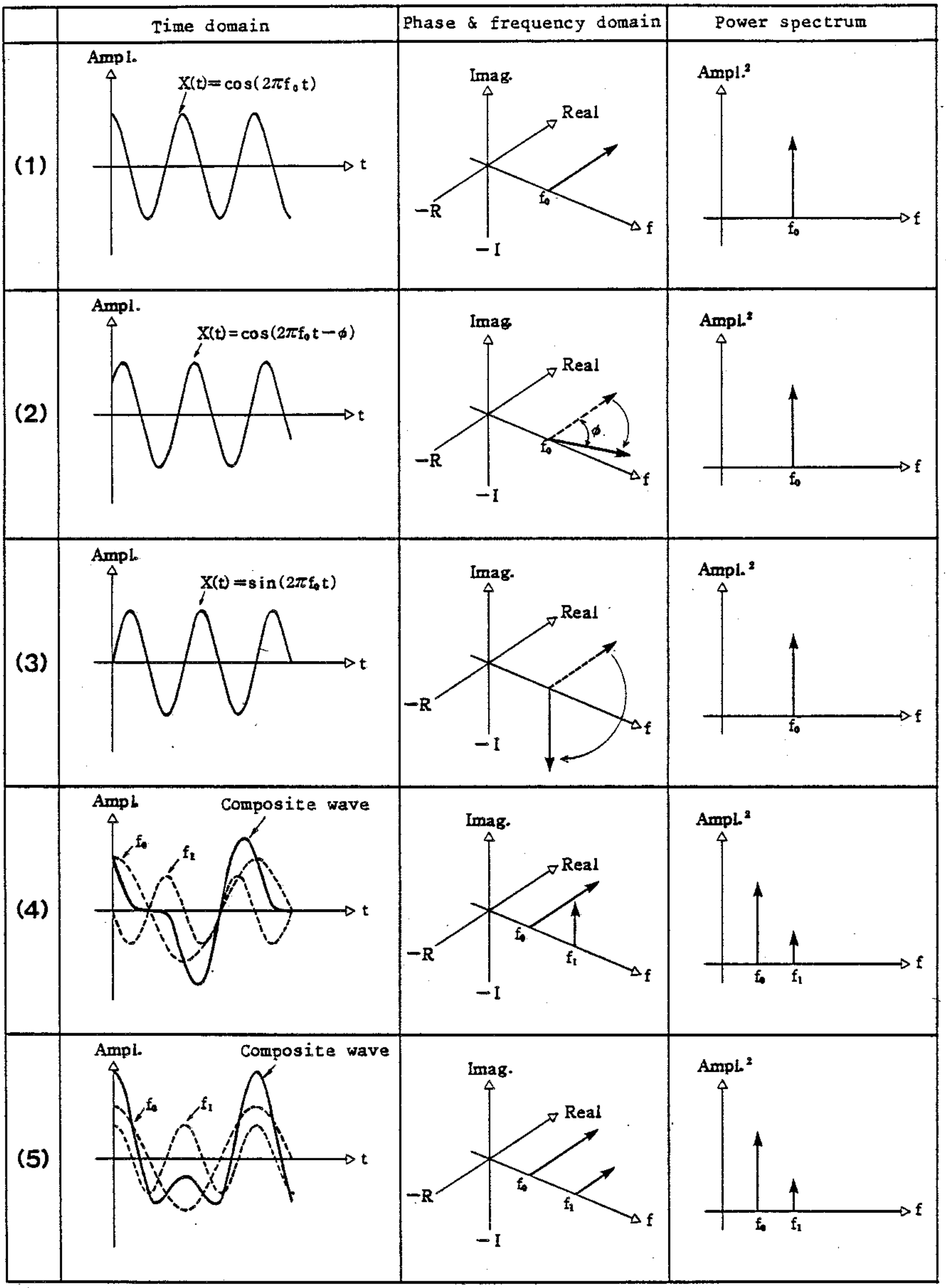


Fig. 3-6 Relationship between time, phase and frequency domains

3-3. ANALYZING FUNCTIONS

In the preceding section we looked at the fact that time series data Xa and Xb applied to channels A and B are the basis of all the analyzing functions the TR9404 provides. We also discussed that the phases of Xa and Xb are not absolute but relative, depending on the display timing on the TR9404 or the time lag of Xb with respect to Xa.

Figure 3-7 shows a flow of other analyzing functions introduced on the basis of Xa and Xb. From this diagram you will know the purposes of individual analyzing functions in the time, frequency and amplitude domains.

Of the analyzing functions in the time domain, the auto correlation function, cross correlation function and impulse response use delay time (τ) or time difference as their parameters. Also from this diagram we understand the importance of the fast Fourier transform (FFT), inverse fast Fourier transform (IFFT) and averaging techniques for the TR9404.

The definitions and display symbols for the analyzing functions of the TR9404 are listed in Table 3-1. The table indicates that there are some functions permitting analysis and display in the real part, imaginary part, magnitude and phase domains, and other functions having only real part such as input time series data or correlation function. The symbols shown on the right below the line —-— in the table denote the functions when shown on the display.

These function symbols are shown in the left and center display areas on the CRT together with pertinent data for easy identification of the current analyzing function.

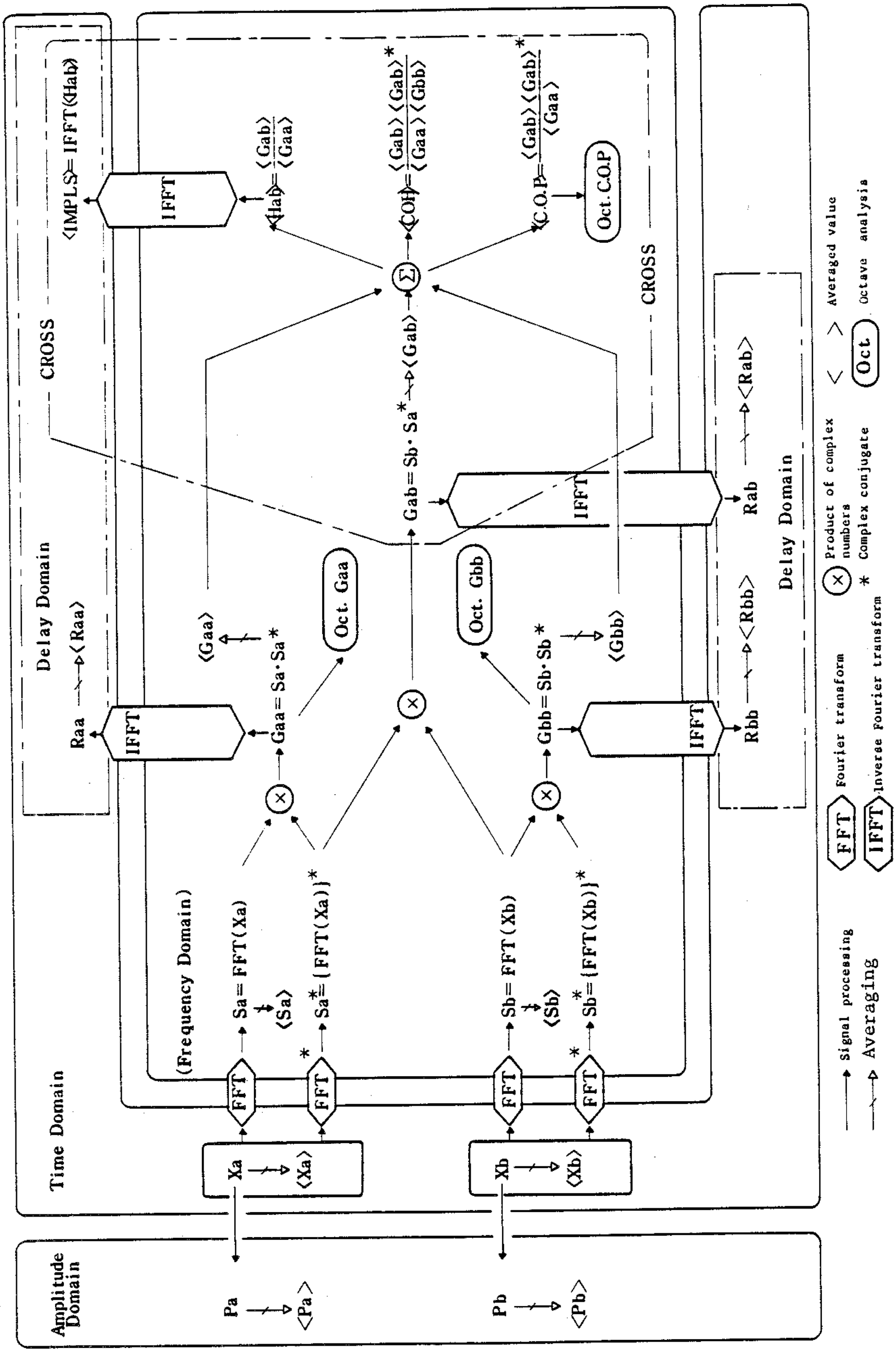


Fig. 3-7 Analyzing functions vs. time, frequency and amplitude domains

Analyzing capability		Definition of function	Functions & their symbols used in DISPLAY section			
			Real	Imaginary	Magnitude	Phase
Time		Xa	Xa Xa	—	—	—
Averaged Time		⟨Xa⟩	⟨Xa⟩ ⟨Xa⟩	—	—	—
Spectrum	Complex	$Sa = FFT(Xa) = \lvert Sa \rvert [\cos(\phi a) + j\sin(\phi a)]$	$\lvert Sa \rvert \cos\phi a$ Sa Real , ⟨Sa⟩ Real	$\lvert Sa \rvert \sin\phi a$ Sa Imag , ⟨Sa⟩ Imag	$\lvert Sa \rvert$ ⟨Sa⟩ Mag	ϕa Sa Phase , ⟨Sa⟩ Phase
	Power	$Gaa = Sa \cdot Sa^{*} = \lvert Sa \rvert^2$	—	—	Gaa Gaa Mag , ⟨Gaa⟩ Mag	—
Cross Spectrum		$Gab = Sb \cdot Sa^{*} = \lvert Sb \rvert \cdot \lvert Sa \rvert [\cos(\phi b - \phi a) + j\sin(\phi b - \phi a)]$	$\lvert Gab \rvert \cos(\phi b - \phi a)$ Gab Real , ⟨Gab⟩ Real	$\lvert Gab \rvert \sin(\phi b - \phi a)$ Gab Imag , ⟨Gab⟩ Imag	$\lvert Gab \rvert$ Gab Mag , ⟨Gab⟩ Mag	$\phi b - \phi a$ Gab Phase , ⟨Gab⟩ Phase
Transfer Function		$\langle Hab \rangle = \frac{\langle Gab \rangle}{\langle Gaa \rangle} = \frac{\lvert Gab \rvert}{\lvert Gaa \rvert}[\cos(\phi b - \phi a) + j\sin(\phi b - \phi a)]$	$\lvert \langle Hab \rangle \rvert \cos(\phi b - \phi a)$ ⟨Hab⟩ Real	$\lvert \langle Hab \rangle \rvert \sin(\phi b - \phi a)$ ⟨Hab⟩ Imag	$\lvert \langle Hab \rangle \rvert$ ⟨Hab⟩ Mag	$\langle \phi b - \phi a \rangle$ ⟨Hab⟩ Phase
Coherence		$\langle COH \rangle = \frac{\langle Gab \rangle \langle Gab \rangle^{*}}{\langle Gaa \rangle \langle Gbb \rangle}$	COH COH	—	—	—
Coherent Output Power		$\langle C.O.P \rangle = \frac{\langle Gab \rangle \langle Gab \rangle^{*}}{\langle Gaa \rangle}$	—	—	⟨C.O.P⟩ ⟨C.O.P⟩	—
Impulse Response		⟨Impls⟩ = IFFT(Hab)	⟨IMPLS⟩ ⟨IMPLS⟩	—	—	—
Auto-Correlation		$Raa = \frac{\sum_t Xa(t) \cdot Xa(t+\tau)}{\sum_t \{Xa(t)\}^2}$	Raa Raa , ⟨Raa⟩	—	—	—
Cross-Correlation		$Rab = \frac{\sum_t Xa(t) \cdot Xb(t+\tau)}{[\sum_t \{Xa(t)\}^2 \cdot \sum_t \{Xb(t)\}^2]^{1/2}}$	Rab Rab , ⟨Rab⟩	—	—	—
Histogram		$Pa = \frac{Prob[X < \tilde{X}_a < X + \Delta X]}{\Delta X}$	Pa Pa	—	—	—

Uppercase letters: Function ⟨ ⟩ : Average | | : Absolute value j : $\sqrt{-1}$

Lowercase letters: Channel * : Complex conjugate τ : Delay $\tilde{X}$: Amplitude

Note: Symbols given below line —·—·— are displayed in the leftmost center on the CRT

Table 3-1 Definitions of analyzing functions

3-4. DEFINITIONS AND PURPOSES OF ANALYZING FUNCTIONS

The definitions and purposes of TR9404's 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 uniquely 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 perform meaningful averaging of time function, 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 TR9404 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)

In general, when t and f are used as time and frequency variables respectively, Xa(t) is expressed as Sa(f) in the frequency domain as far as Xa(t) is a real function of time. In this case, Xa(t) is not necessarily a periodical function, and Sa(f) includes amplitude and phase information at all frequencies of Xa(t).

$$Sa(f) = \int_{+\infty}^{+\infty} Xa(t) \left\{ \cos\ (2\pi ft) - j\sin\ (2\pi ft) \right\} dt$$

Complex spectrum Sa(f) is obtained by exercising Fourier transform on a time-domain signal, and includes a real part and imaginary part for each frequency. Usually, 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>. Spectrum phase depends on trigger conditions; the same signal may have different phases depending on trigger point. Therefore, averaging of complex spectrum requires a trigger signal while averaging of auto power spectrum requires no particular trigger signal.

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

Since this averaging function is obtained from a series of power spectrum Gaa, it is called average power spectrum. Average power spectrum can be obtained by determining the RMS values of each power spectrum at each frequency. A spectrum magnitude at a certain frequency is expressed by the following formula:

$$\sqrt{Gaa(fx)} = \sqrt{\frac{1}{N}\,[Gaa_1(fx) + Gaa_2(fx) + \dots + Gaa_N(fx)]}$$

As known from this formula, this averaging does not reduce noise level while it can smooth random noise component.

Gab : Cross spectrum

Cross spectrum is useful to determine the magnitude and phase information for common frequency components of two signals.
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:

$$\begin{aligned} Gab = Sb\, Sa^* &= [Re(b) + jIm(b)]\cdot[Re(a) - jIm(a)] \\ &= [Re(b)\, Re(a) + Im(b)\, Im(a)] + j[Im(b)\, Re(a) - Re(b)\, Im(a)] \end{aligned}$$

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 can be determined from the phase value at the frequency in question.

<Gab>: Average Cross spectrum

If cross spectrum at a certain frequency is given by Gab(f), it is equivalent to the following equations:

$$\langle Gab(f)\rangle = \frac{1}{N}\left\{Gab_1(f) + Gab_2(f) + \cdots\cdots + Gab_N(f)\right\}$$

<Hab>: Transfer function

As shown in Figure 3-2, a transfer function provides the frequency response of a system (such as a filtering network of a power supply circuit) 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:

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

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 <Gab>.
- 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 depending on display mode.

<COH> : Coherence function

The coherence function when used on a transfer function measurement is the fraction of output power attributable to an input signal. It exhibits the accuracy with which the transfer function of a noisy system is being measured at each frequency point. It can also be used to calculate S/N ratio at any output or to call attention to nonlinearities in the system under test.

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

$$\langle COH\rangle = \frac{\langle Gab\rangle\langle Gab\rangle^*}{\langle Gaa\rangle\langle Gbb\rangle}$$

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 contributon 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.

A coherence function can thus be used to evaluate a transfer function. Since, in a multi-input system, coherence function gives a contribution factor of the input to the output, it is advisable that the coherence function be observed whenever a transfer function is to be determined.

<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.

$$\langle C.O.P.\rangle = \langle COH\rangle\cdot\langle Gbb\rangle = \frac{\langle Gab\rangle\langle Gab\rangle^*}{\langle Gaa\rangle}$$

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 determined as an inverse Fourier transform of power spectrum Gaa, and is generally expressed by the following integral formula:

$$Raa(\tau) = \int_{-\infty}^{\infty} Gaa(f) e^{j2\pi f\tau} df$$

Autocorrelation function takes the maximum value at $\tau = 0$ which is equal to the square average of an input signal. However, it 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.

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 measurment or to determine propagation paths of signals.

Cross correlation can be determined as an inverse Fourier transform of cross spectrum Gab, and is generally expressed by the following integral formula:

$$Rab(\tau) = \int_{-\infty}^{\infty} Gab(f) e^{j2\pi f\tau} df$$

However, it 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.

<IMPLS>: Impulse response

Impulse response is an expression of the transfer function of a system in the time domain. In some cases, it may have a higher sensitivity to signal delay time rather than cross correlation function. In general, if input Xa(t) is applied to a system having impulse response hab(t), its output Xb(t) is given by the following formula:

$$Xb(t) = \int_{-\infty}^{\infty} hab(\tau)\ Xa(t-\tau)d\tau$$

The impulse response provides all description of the linear function relationship between the input and output of the system.

Since the expression of an impulse response in the frequency domain is a transfer function, the impulse response can be determined as an inverse Fourier transform of the corresponding transfer function:

<IMPLS> = IFFT(<Hab>)

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:

$$Pa = \frac{Prob[Xa<\tilde{X}a<(Xa + \Delta Xa)]}{\Delta Xa} = \frac{1}{Ti}\Sigma\Delta ti = \frac{Tx}{T}$$

Where Δti is the time duration in which Xa stays within the range of x at i'th time, and $Tx = \Sigma \Delta ti$.
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 $Xa < \tilde{X}a < Xa + \Delta Xa$ in time T (in this case the frame time). On the display of the TR9404, therefore, the X axis represents voltage values of ΔXa 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 TR9404 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 TR9404, <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.

SECTION 4
OPERATION

4-1. INTRODUCTION

TR9404 Digital Spectrum Analyzer allows the operator interactive operations: that is, the operator sets up measurement conditions and performs various analyses while responding to messages or menus shown on the display. This means that the operator can proceed his measurement, analysis and observation concentrating his attention on the display.
All function setup and execution is accomplished by key entry, and entry results are stored in internal memory. Each key entry is audibly confirmed by electronic "pip" tone. If the instrument is switched off, all setup conditions are kept intact about one week by internal back-up battery, so that measurement can be restarted under the same measurement conditions when the instrument is repowered.
This section describes controls and connections on the front and rear panels of the analyzer, display format and basic operating procedures for proper operation of the instrument.

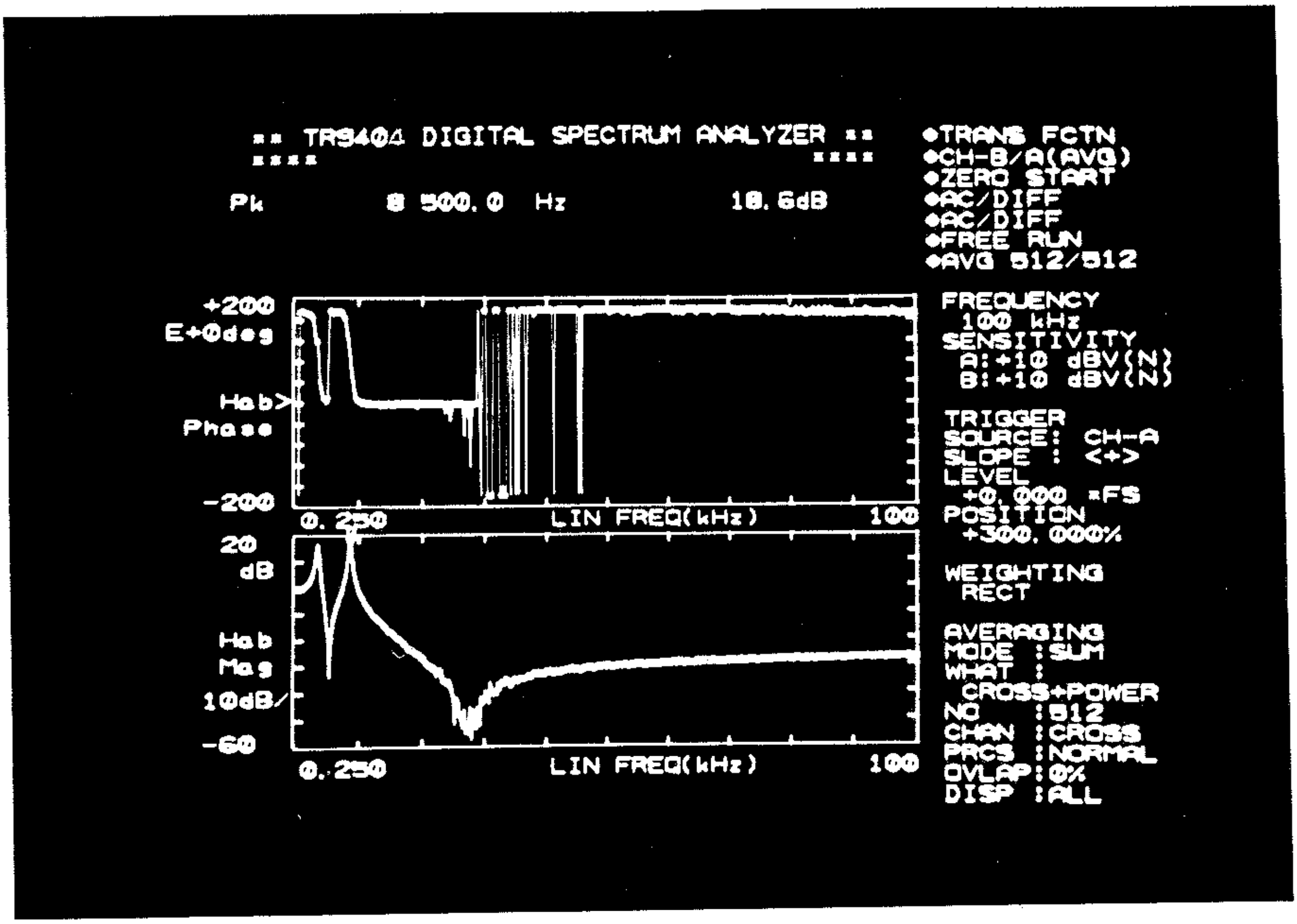
4-2. PANEL DESCRIPTION

The front panel consists of a POWER switch, CRT display, and control functions (see Figure 4-2). This section describes the display format for the CRT display and individual control functions.

The rear panel of the analyzer is divided into a power supply section, digital I/O section including the GPIB interface, and analog output section including the X-Y recorder output. The GPIB interface, digital I/O functions and X-Y recorder interface will be described in SECTIONs 5 and 6.

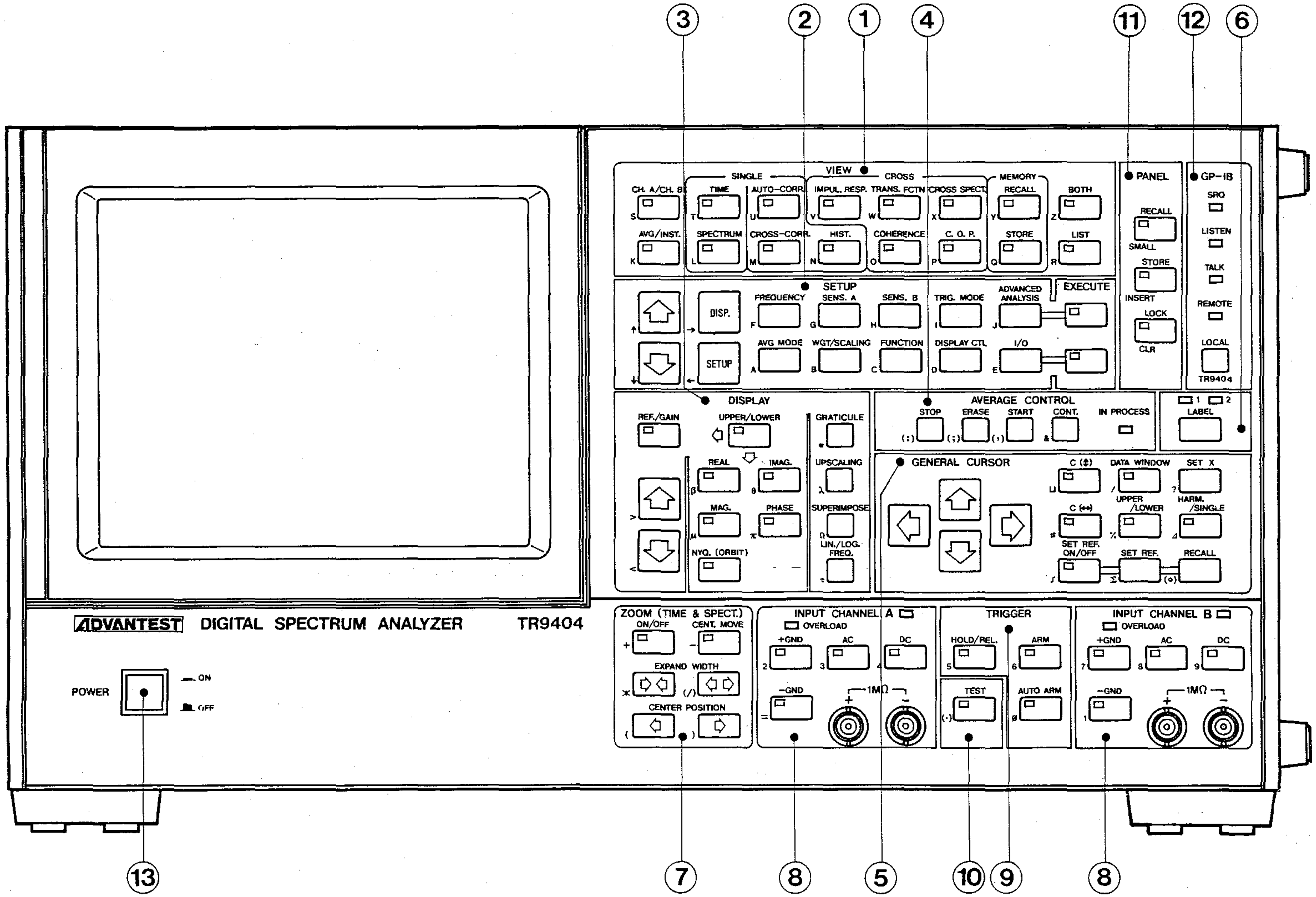
4-2-1. Display Format

The TR9404 uses a large random access scan CRT measuring approximately 140 mm by 115 mm (see Figure 4-1.) and providing clear and definite character and data display. The interactive operation capability reduces the burden to the operator of cumbersome setup operations or probability of entry error. Since the display shows all pertinent setup conditions as well as resultant data, all information necessary for later analysis can be obtained from a single photograph of the pertinent picture.



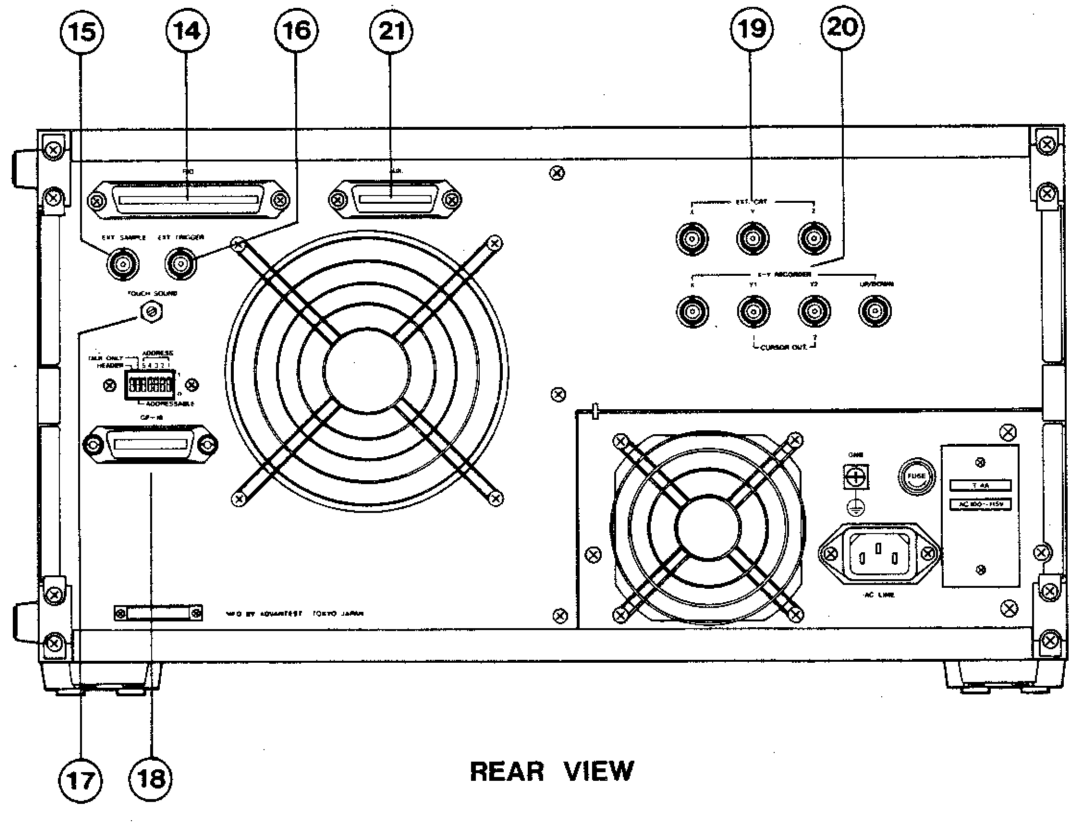
Actual size

Fig. 4-1 Display example on the TR9404



FRONT VIEW

Fig. 4-2 Front panel



REAR VIEW

Fig. 4-3 Rear panel

4-2-2. Control Section

The control section consists of the following twelve subsections:

VIEW	①
SETUP	②
DISPLAY	③
AVERAGE CONTROL	④
GENERAL CURSOR	⑤
LABEL	⑥
ZOOM	⑦
INPUT CHANNEL (A and B)	⑧
TRIGGER SECTION	⑨
TEST	⑩
PANEL	⑪
GPIB	⑫

The control section consists entirely of light-touch pushbutton keys. When an accessible key is operated, the key entry is audibly confirmed by electronic "pip" tone. If an inaccessible key is operated, it is audibly alerted by low "beep" tone. If a key with a lamp is operated, the light goes either on or off depending on the preceding status.

The keys with a lamp include two types. For one type, the light comes on only when the key is in active state. For the other type, the key has a double function, and the lamp within the key comes on when one of the functions is selected. The latter type includes the following nine keys:

CH. A/CH. B and AVG/INST. in the VIEW section

UPPER/LOWER and REF./GAIN in the DISPLAY section

SET REF. ON/OFF, UPPER/LOWER and HARM./SINGLE in the GENERAL CURSOR section

ON/OFF in the ZOOM section

HOLD/REL. in the TRIGGER section

When the lamp in these keys is on, the function indicated on the left-hand side of the slash (/) is selected; when the light remains off, the function indicated on the right-hand side of the slash is selected.

For example, if the lamp of the CH. A/CH. B key is lit, it means that the data on channel A is shown on the display, whereas the data on channel B is shown on the display if the lamp remains off.

The control section includes the following three types of keys:

- Keys with no lamp
- Keys whose light comes on only when the key function is activated
- Keys whose light comes on or off depending on the selected function of the key

① VIEW section

The control keys in the VIEW section are used to select data types to be shown on the display or to store or read displayed data into or from internal buffer.

Single channel data:

- Time domain data on channels A and B
- Averaged time domain data on channels A and B
- Power spectrum of channels A and B
- Averaged power spectrum of channels A and B
- Phase spectrum of channels A and B
- Histogram of channels A and B
- Auto correlation function of channels A and B

Cross channel data:

- Cross correlation function
- Transfer function
- Coherence function
- Coherent output power
- Impulse response

Any of the above types of data can be selected and shown on the display by operating the appropriate keys in the VIEW section. Also up to two single-channel data and one cross-channel data can be stored in the buffer and recalled at any time with the RECALL key.

② SETUP section

The control keys in this section are used to set up various measurement conditions and to deliver them on the display. Setup conditions consist basically of the following nine menus:

- Frequency range
- Channel A input sensitivity range
- Channel B input sensitivity range
- Trigger condition
- Averaging condition

- Weighting (window function) and scaling conditions
- Arithmetic and logical operational functions
- Display control
- I/O device selection
- Advanced analysis mode selection

Menus for any of these measurement conditions can be acted upon with the ⇧ or ⇩ key and SETUP key in the interactive mode, and the selected menu is shown in the right display area on the screen.

③ DISPLAY section

Control keys in the DISPLAY section are used to select data type and scaling system for the data selected with VIEW section operations.

For frequency domain data, the following data types and scaling systems are selectable:

- Power spectrum and magnitude
- Phase
- Real/imaginary part
- Dynamic range selection
- Reference level setting
- Linear/logarithmic switching on the frequency axis
- Bode/Nyquist diagram display selection

For time domain data, the following control is available:

- Enlargement of the amplitude axis and reference level control

For amplitude domain data, the following control is available:

- Enlargement of the vertical axis (probability density)

In addition, this section also provides such features as superimposition of two data, data zooming by erasing menu, and graticule erasure.

4 AVERAGE CONTROL section

Control keys in this section are used to average the data selected with the VIEW section operations under the conditions selected with the AVG MODE key in the SETUP section.

5 GENERAL CURSOR section

Control keys in this section are used to obtain direct readout of arbitrary data point on the display by controlling the cursor, provide harmonic display, or set up trigger position, trigger level and coherence blanking level.

6 LABEL section

The LABEL function makes the top two lines of character display area on the CRT available to the user. The operator can optionally enter alphanumeric labels in this display area as an identification of date, test personnel name, test number, and so forth. Once a label is entered, it can be moved in the vertical direction with the ⇧ or ⇩ key in the GENERAL CURSOR section so that labels can be attached to arbitrary points of displayed signal responses. Labels can be recorded on photographs, floppy disk or plotter for use in later analysis of measurement information.

The front panel keys identified by alphabetic or numeric characters provided at the bottom left corner of each key may be used to enter label characters.

7. ZOOM (TIME & SPECT) section

Control keys in this section are used to provide frequency domain data for higher resolution analysis or expand the time axis display for time domain data.

For frequency domain data requiring no zoom-in (Zero Start mode), the available frequency range is from DC to the maximum frequency of the selected frequency range due to the nature of discrete Fourier transform. However, if the Zoom mode is selected, the signal of interest once captured can be analyzed with a higher resolution including its adjacent spectra (hold zooming mode). Magnification can be controlled by a factor of 2, 4, 8, with EXPAND WIDTH keys.

For time domain data, the Zoom mode allows for high-resolution display of leading or trailing edge waveform of transient phenomena or high frequency portions of burst signals by a factor of 2, 4, 8, 16.

8. INPUT CHANNEL A and B section

This section consists of two subsections for channels A and B. Control keys in this section are used to select input coupling modes on each channel.

Time series signals applied to channels A and B are defined as Xa and Xb respectively, and all analyzing functions are executed based on these two signals.

The input modes include the single ended input mode requiring only one input connector (as is the case with an oscilloscope) and the differential input mode requiring two input connectors.

These input modes may be selectively used depending on individual input signal types or transducers for higher precision measurement.

The input coupling modes include the AC coupling, DC coupling, GND, and TEST modes. In the GND mode, either the positive or negative input terminal is always grounded. In the TEST mode, the incoming signal is secluded and an internal reference signal is capacitively coupled for functional testing.

(9) TRIGGER section

The function of this section, when combined with the TRIG. MODE switch function in the SETUP section, may be effectively used to capture less repetitive signal waveforms such as impact waves. It may also be used to obtain stationary waveform or signal response trace on the display. The trigger source may be input signal of either channel A or B, or external trigger signal coupled to the rear EXT. TRIGGER connector.

(10) TEST section

If the TEST key in this section is pressed, the input signals are disconnected from both channels A and B of the analyzer's input and, instead, an internal test signal source with a frequency of 64% of the selected frequency range* and a level of -3.0 dBV $\pm$0.2 dB is applied to the both inputs.

*: (e.g. 64 kHz in the 100 kHz range, 1.28 kHz in 2 kHz range)

(11) PANEL section

All front panel controls of the TR9404 consist of light-touch pushbutton keys. The LOCK key in the PANEL section is used to lock up all the key functions on the front panel to prevent alteration of measurement condition setup by inadvertent touch on the keys.

The TR9404 can store up to six sets of entire measurement condition setup in its internal memory. The STORE and RECALL keys in the PANEL section are used to store or recall these measurement condition data into or from the internal memory respectively. This storage capability will be extremely convenient when there are multiple measurement objects requiring different measurement condition setups.

(12) GPIB section

The functions of this section are used to set up an instrumentation system using the General-Purpose Interface Bus (GPIB) or to transfer data to external devices. For further details see SECTION 5. GPIB INTERFACE.

4-2-3. Power Supply

(13) POWER ON/OFF

This pushbutton switch controls the power supply to the analyzer; a first depression of this switch turns on the power, and a second depression turns it off.

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 10 seconds after power on.

In order to back up the internal memory against power off, the analyzer contains a Ni-Cd battery cell. 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

- 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.
- 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.

4-2-4. Rear Panel

(14) PIO (Peripheral Input Output)

This connector is used to connect TR98102 Floppy Disk Digital Data Recorder or dedicated maintenance tool.

TR98102 is an external data storage unit designed for the TR9404 and permit easy data saving and transfer.

(15) EXT. SAMPLING (External Sampling)

For both channels A and B, input signals are usually sampled by a clock generated by an internal crystal oscillator.

If data sampling synchronized with the input event is required (e.g. order ratio analysis for rotating body), the sampling clock input from this EXT. SAMPLING connector is to be used.

In this case, the time and frequency axes do not provide absolute scales but relative scales on the CRT.

(16) EXT. TRIGGER (External Trigger Input)

This connector accepts an external trigger signal to trigger and capture the incoming signal.

(17) TOUCH SOUND

If an accessible key on the front panel of the analyzer is pressed, it is audibly confirmed by electronic "pip" tone; if an inaccessible key is pressed, it is audibly alerted by low "beep" tone. The TOUCH SOUND screwdriver control can be used to adjust these "pip" and "beep" sounds at the desired tonal level.

(18) GPIB

The GPIB section on the rear panel consists of a 24-pin GPIB interface connector and an ADDRESS switch.

(19) EXT. CRT (External CRT Drive)

These connectors are used to drive an external CRT display such as an oscilloscope to yield the same data as that obtained on the CRT display. They are, however, intended only for display test purpose and may not be used to drive a large external random scan CRT display or video display.

(20) X-Y RECORDER

These connectors are used to attach an X-Y recorder. All data displayed on the analyzer can be plotted on the X-Y recorder through these connectors.
The attachable X-Y recorder may be of any recording speed, sensitivity or number of pens, provided that it has pen up/down control capability. The recording speed is selectable from six steps between SLOW and FAST.

(21) AUX. (Auxiliary)

This connector is provided for manufacturing purpose and is not available to the user.

4-3. SELF DIAGNOSTICS FEATURE

The TR9404 contains a self diagnostic feature to check for proper operation of the internal electrical circuits and parts.
When the analyzer is switched on, all LED indicators on the front panel come on approximately one second later. This allows you to visually check for defective LED indicators.

If everything is normal, the self diagnostics sequence is completed approximately 10 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 (see Figure 4-4). 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 as shown in Figure 4-5 upon the end of the diagnostic sequence. The example shown in Figure 4-5 deliberately shows all the possible defective locations. In actual cases, however, only the defective block name and the detail of the defect will be shown. If the display shows any fault message, notify your nearest ADVANTEST representative.

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 TR9404 power turn-on.

(2) The internal circuitry being damaged.

In case of (1), making the TR9404 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.

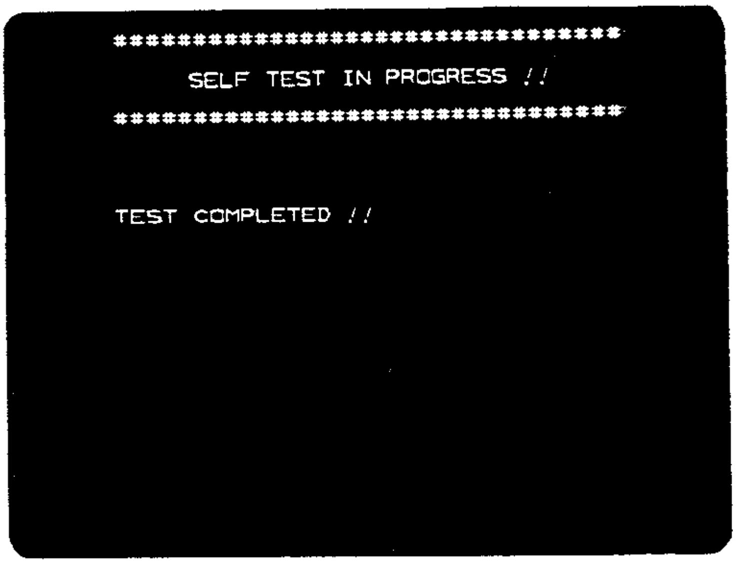


Fig. 4-4 Self test busy message

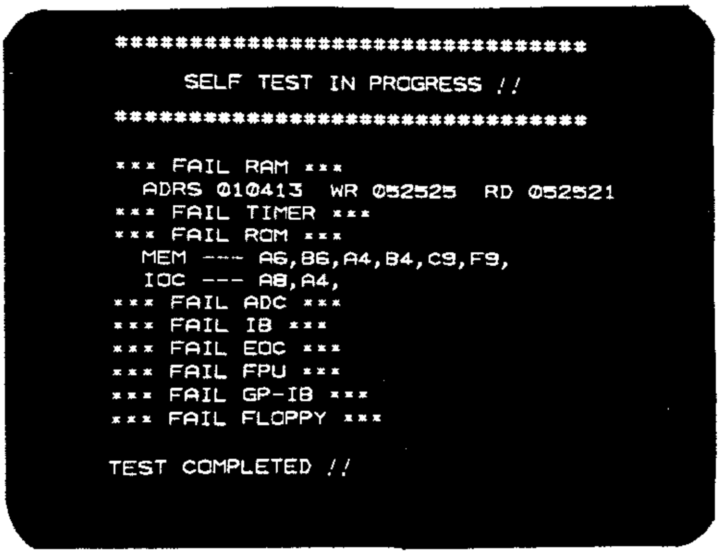


Fig. 4-5 Fault message display indicating defective locations (all possible defective locations are shown here.)

4-4. KEY FUNCTIONS

4-4-1. INPUT CHANNEL Section

The INPUT CHANNEL section consists of completely independent two input channels: INPUT CHANNEL A and INPUT CHANNEL B. The major input specifications are shown below:

Input channels	: 2
Input mode	: Differential or single ended type
Input impedance	: Approx. 1 MΩ
Input coupling mode	: AC, DC, GND
Common mode noise rejection	: 60 dB or more (at 50/60Hz, DC coupled)
Max. common mode voltage	: ±10 Vp-p (0 dBV to -60 dBV) ±100 Vp-p (+30 dBV to +10 dBV)
Input magnitude range	: -60 to +30 dBV (1 mV to 31.6 Vrms) in 10 dB steps
Max. differential input voltage	: ±100 Vp-p
Max. input sensitivity	: -120 dBV (1 μVrms)

Overload indicator : If a differential voltage exceeding 95% of the selected amplitude range or a common mode voltage exceeding the specified level (regardless of the selected amplitude range) is applied, the OVERLOAD indicator lamp on the front panel comes on for approximately 0.5 sec. and an alarm buzzer sounds. Message such as "OVERLOAD: CH-A" flashes in the bottom left of the display for a few seconds.

Input filter : Antialiasing filter (roll-off response: -140 dB/oct) is automatically selected according to the selected frequency range (however, only a 20 Hz filter is selected for 1, 2, 5, and 10 Hz ranges.)

dBV	rms	peak	Residual noise	Input coupling
+30	31.6 V	44.7 V	-80 dB max.	AC or DC coupling
+20	10.0 V	14.14 V		
+10	3.16 V	4.47 V		
0	1.0 V	1.41 V		
-10	316 mV	447 mV		
-20	100 mV	141 mV		
-30	31.6 mV	44.7 mV		
-40	10.0 mV	14.1 mV		AC coupling
-50	3.16 mV	4.47 mV	-72 dB max.	
-60	1.0 mV	1.41 mV	-65 dB max.	
AUTO	Optimum range is selected with the incoming signal level			

The input section configuration of the TR9404 is shown in Figure 4-6; the input amplifier circuit configuration is shown in Figure 4-7; the INPUT CHANNEL section panel features are shown in Figure 4-8.

The input circuit configurations as shown in Figures 4-6 and 4-7 are provided for both input channels A and B of the TR9404 each.

As shown in Figure 4-8, INPUT CHANNEL A and INPUT CHANNEL B are located on the left and right side of the TRIGGER and TEST subsections respectively. As mentioned in SECTION 3, connect the input signal to a device under test (DUT) to INPUT CHANNEL A, and connect the output signal of the DUT to INPUT CHANNEL B. If this connection is reversed, the results of all cross channel analyses, such as transfer function, cross correlation function or cross spectrum, will be reversed.

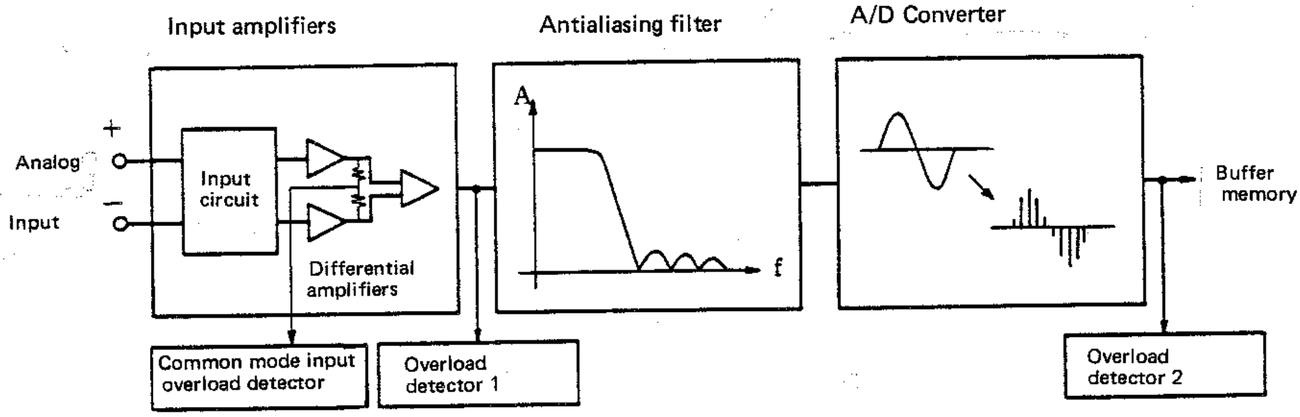
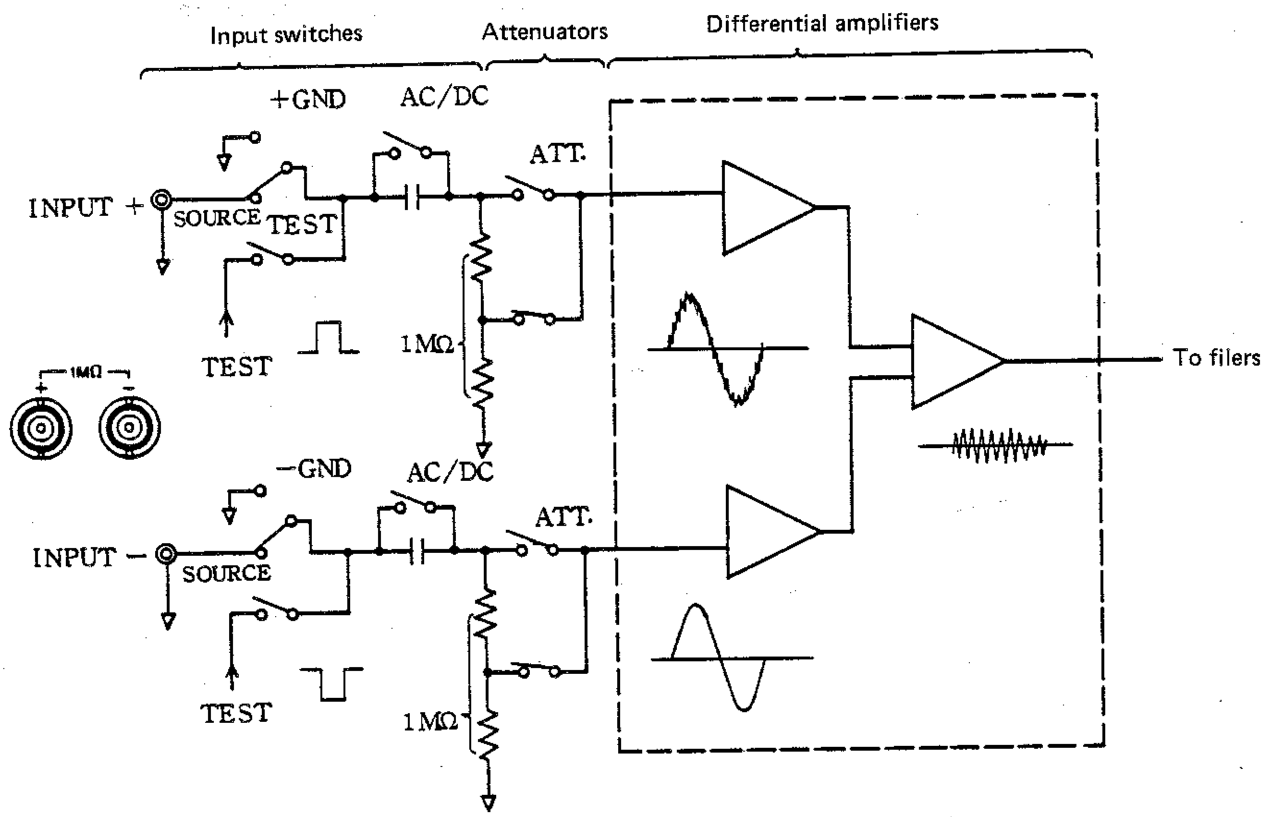


Fig. 4-6 Input section configuration



↓: common ground
The INPUT is alive when both GND and TEST switches are set at OFF

Fig. 4-7 Input amplifier circuit configuration

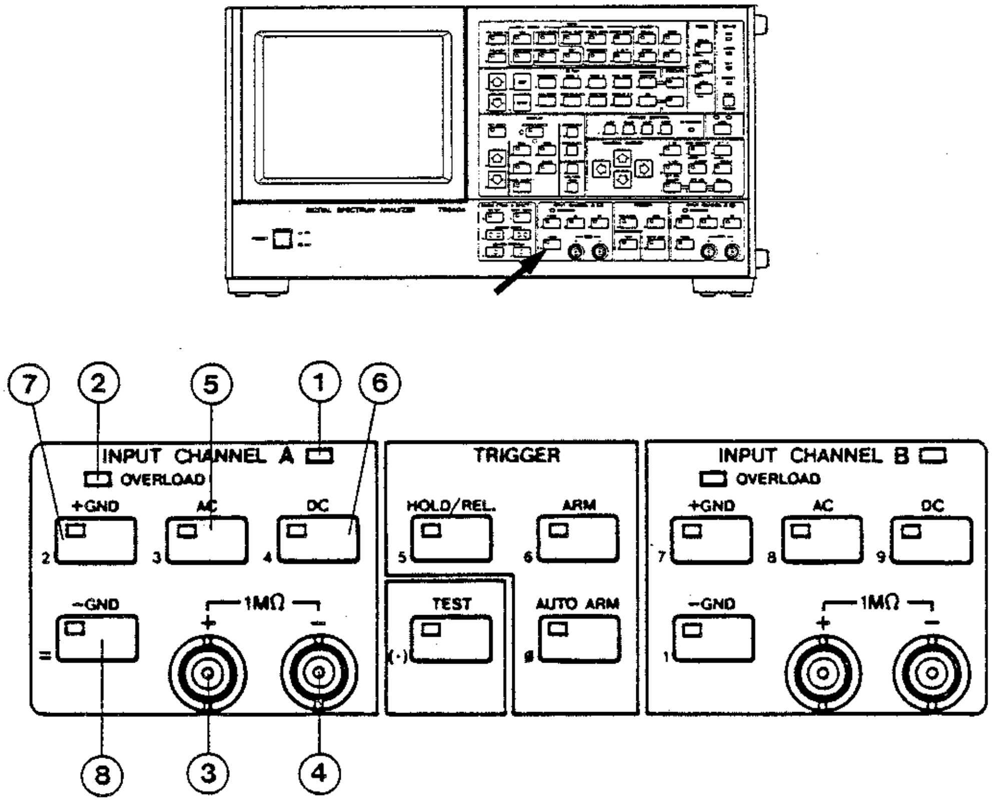


Fig. 4-8 INPUT CHANNEL section panel features

(1) ACTIVATE indicator lamp

The channel on which this indicator lamp illuminates is "active", or accessible. If the SENS. A key in the SETUP section is pressed when channel A is active, the SENS.A menu as shown in Figure 4-9 is shown on the display. To deactivate channel A, move the pointer (⇨) to "ACTIVATE" with the ⇧ key, then press the SETUP key. This will change the "ACTIVATE" message into "DEACTIVATE" message and turn off the ACTIVATE indicator lamp on channel A.

Once channel A is deactivated, no data input nor analysis will take place on channel A even if an input signal is applied to it. To activate channel A again, use the ⇩ key to move the pointer (⇨) to the desired input sensitivity item in the menu. This will automatically activate channel A, with the ACTIVATE indicator lamp (1) on channel A turned on. The same is applicable to channel B as well.

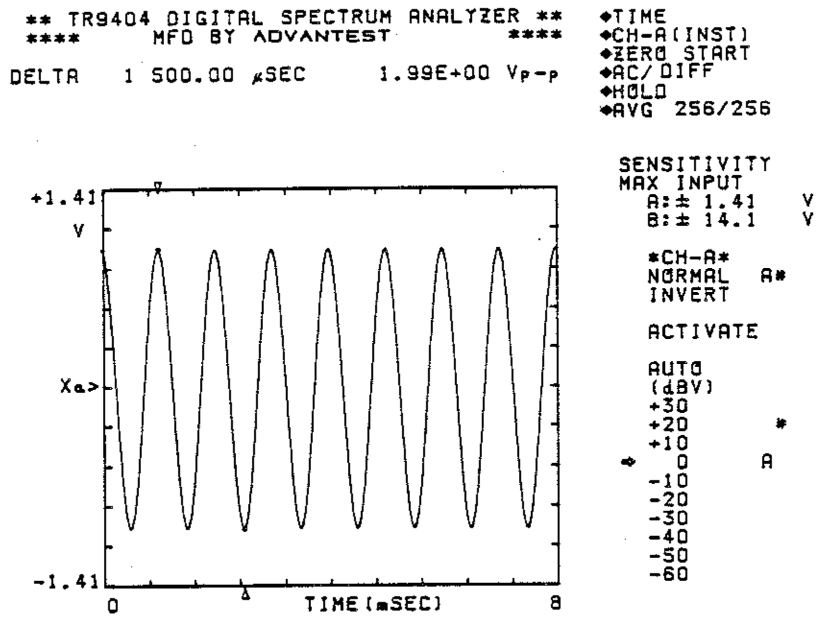


Fig. 4-9 SENS. A menu

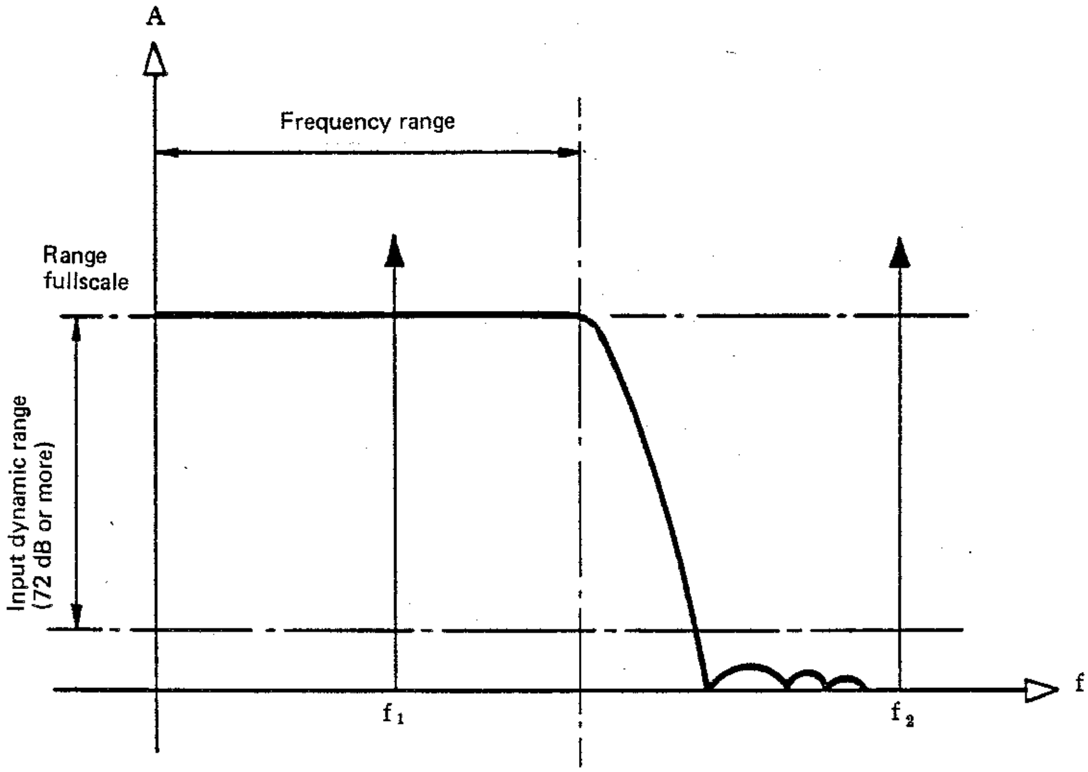


Fig. 4-10 Illustration for input overload detection 1

② OVERLOAD indicator lamp

The OVERLOAD indicator lamp comes on if the magnitude of an input signal exceeds the selected sensitivity range. On the TR9404, differential input overload is detected by overload detector 1 that follows the input amplifier and by overload detector 2 that follows the A-D converter (see Figure 4-6). In addition, a common-mode input overload detector is also provided.

Overload detector 1 detects an input signal magnitude exceeding the selected sensitivity range (see Figure 4-10). Since overload detector 1 is sensitive to a frequency range of up to approximately 300 kHz regardless of the selected frequency range, it responds to an overload input whose frequency is beyond the selected frequency (e.g. f_2 in Figure 4-10).
The threshold level for overload detection is set at more than twice the sensitivity range but the input amplifier and antialiasing filter are designed to operate normally even within that range.
If the sensitivity is set up at 0 dBV, overload detector responds to a signal exceeding (1.41 V peak) x 2 = 2.8 V peak.
If overload detector 1 were not existent, signal f_2 (in Figure 4-10) would saturate the input amplifier, causing intermodulation with other signal responses. However, since f_2 is suppressed by the following antialiasing filter, the spectrum of f_2 itself would not appear on the display. To ensure correct measurement results, therefore, input overload detection is needed for large signals even outside the frequency range setup.
Overload detector 2 is effective to an input signal which is a composite waveform of signals f_3 and f_4 (see Figure 4-11).
The magnitude of the composite signal is smaller than that of f_3 as shown in Figure 4-11(a), depending on the frequency ratio and phase lag between f_3 and f_4. This is often the case for the measurement of pulse signals or measurement using a hammer kit. In this case, a problem arises if f_3 is within the selected frequency range and f_4 is outside the range.

For instance, if the frequency range setup for measurement is 10 kHz, f_3 is 6 kHz and f_4 is 18 kHz, and f_3 and f_4 are composed as shown in Figure 4-11(a), overload detector 1 does not respond to the composite signal as its magnitude is smaller than the full scale of the A/D converter. The following antialiasing filter attenuates frequency f_4 (18 kHz) which is outside the setup frequency range. The output of the antialiasing filter thus contains only f_3, which causes an overload to the following A/D converter. This overload is detected at the output of the A/D converter by overload detector 2.

The common-mode input overload detector detects common-mode overvoltage input when the inputs are in the differential mode. If an input overload is detected by overload detector 1, 2, or common-mode input overload detector, the OVERLOAD indicator lamp (2) illuminates and an alarm buzzer gives off a continuous "pip" sound until the cause of the overload is removed. At the same time, the display shows an overload message

"OVERLOAD: CH-A"

in the bottom display area (see Figure 4-12). These overload detecting functions are identical for both channels A and B.

3 4 Input Connectors

These BNC connectors accept the input signal of interest for measurement. They may be applicable to either the differential or single-ended input modes. The input signal connection procedure and input mode descriptions are given in paragraph 4-4-2 "Input Connection".

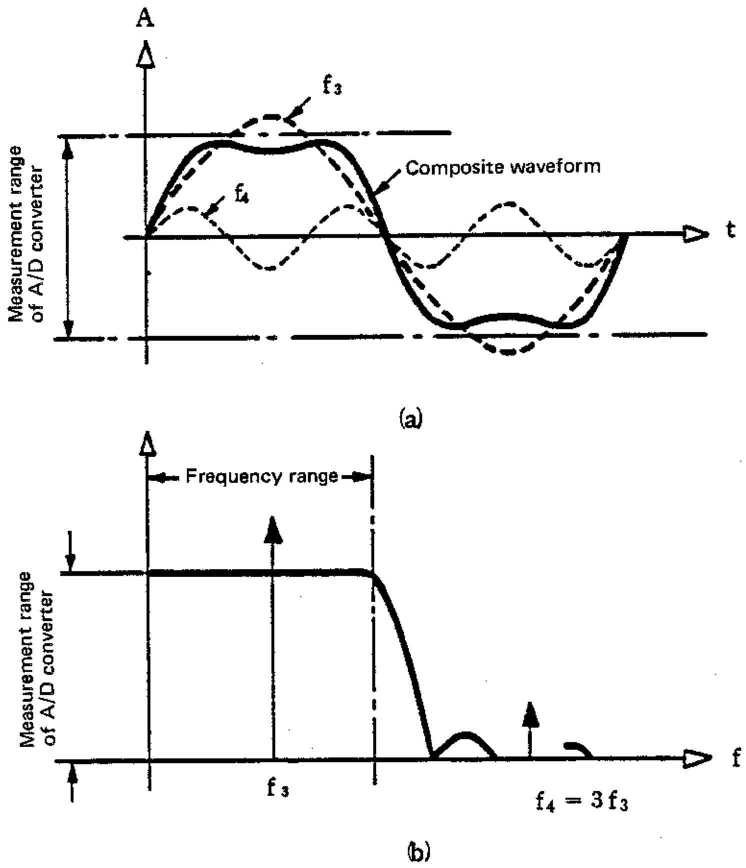


Fig. 4-11 Illustration for overload detector 2

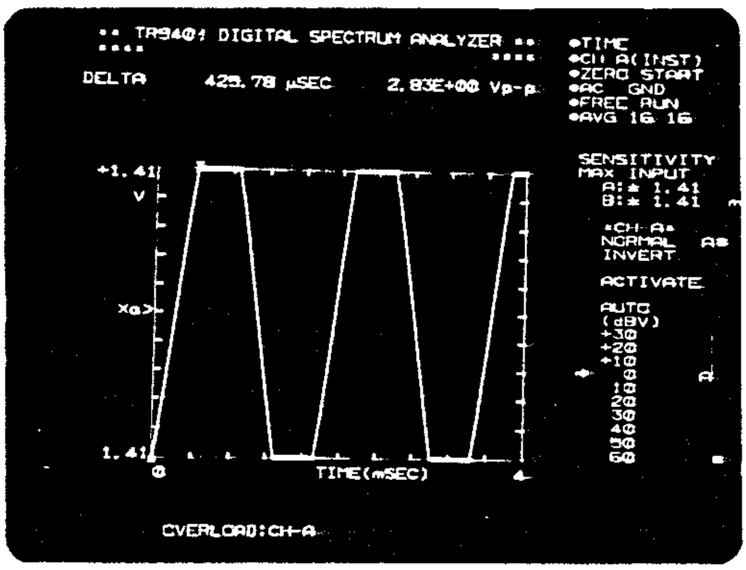


Fig. 4-12 Overload message display

⑤ AC (AC coupling) key

⑥ DC (DC coupling) key

⑦ +GND key

⑧ -GND key

These four keys are used to select input coupling modes. The operations of each key are illustrated in Figure 4-7.

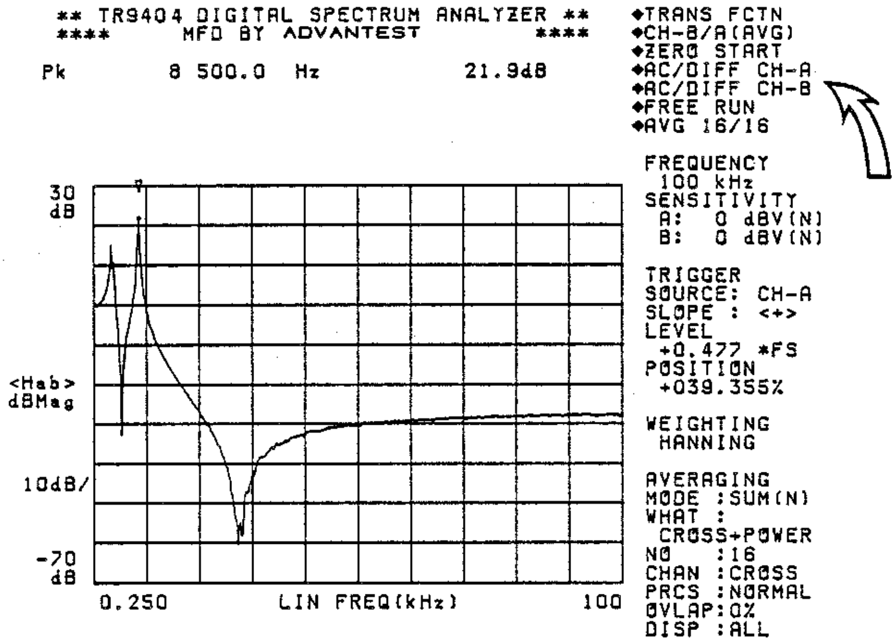
The DC coupling mode directly couples the input signal to the input amplifier, and is useful to capture transient signals and other irregular signals. In the higher sensitivity ranges (-40 dBV or below), however, the input coupling mode is automatically switched into the AC mode. In these sensitivity ranges, the DC key remains inoperative, and the lamp within the AC key continues to glow even if the DC key is operated. The AC coupling mode is also 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.

With the AC coupling mode each input connector is capacitively coupled with input amplifier (see Figure 4-7). The cutoff frequency is 0.5 Hz (at -3 dB).

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 signals whose mean level is always constant. 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 (see Figure 4-7). With the both differential inputs grounded, the Differential Average mode (to be described later) is effectively used to enhance the dynamic range of the analyzer by subtracting very small noise generated inside the instrument from the input signals.

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 (see Figure 4-13).

The usage of these four keys and TEST mode is summarized in Figure 4-14. Figure 4-14 (a) and (e) indicate the differential input mode, while (b), (c), (f) and (g) indicate the usages in the single-ended input mode.



Modes displayed include: AC/DIFF

DC/DIFF

AC/+GND

DC/-GND

AC/±GND

AC/TEST

Fig. 4-13 Input mode display

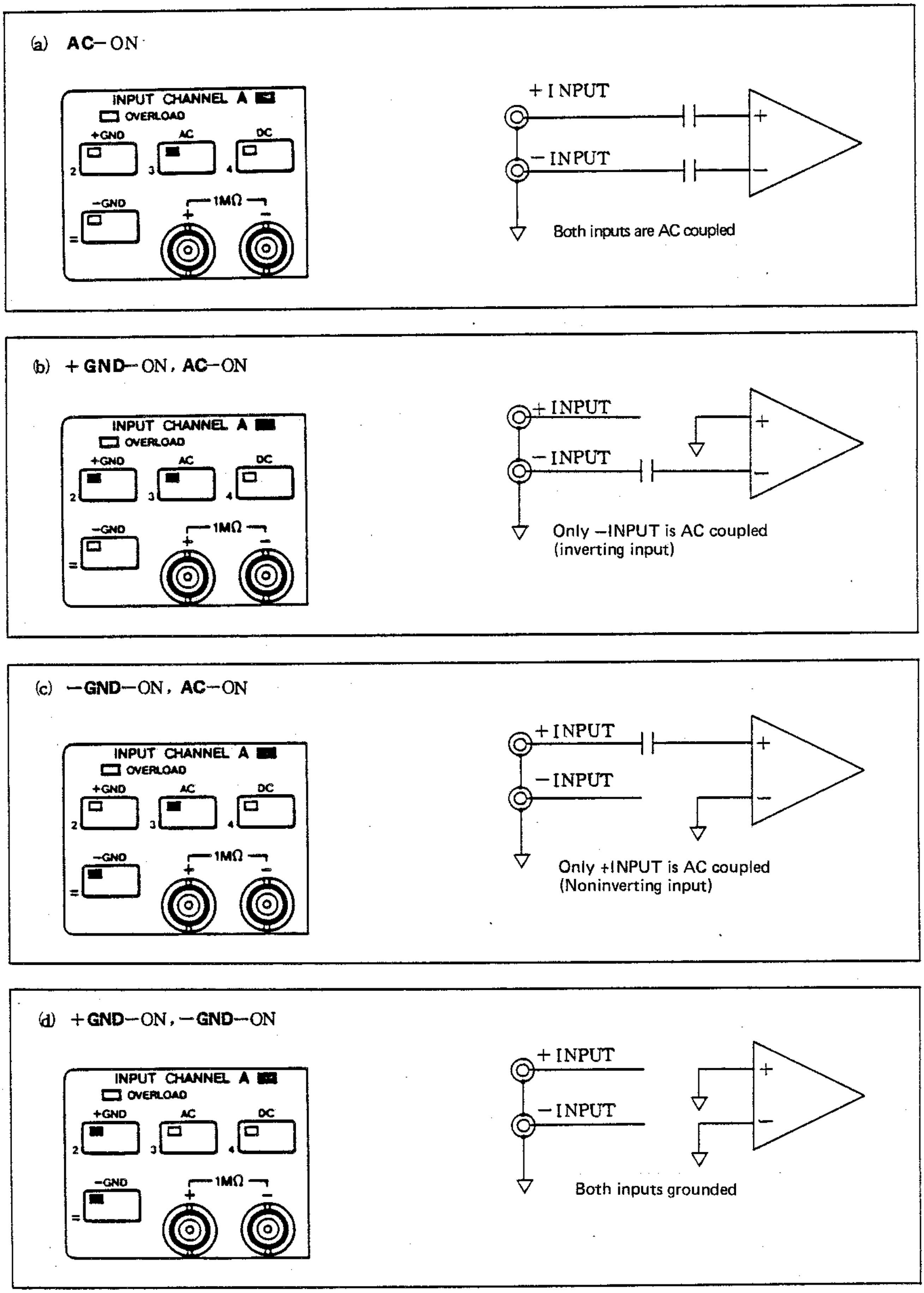
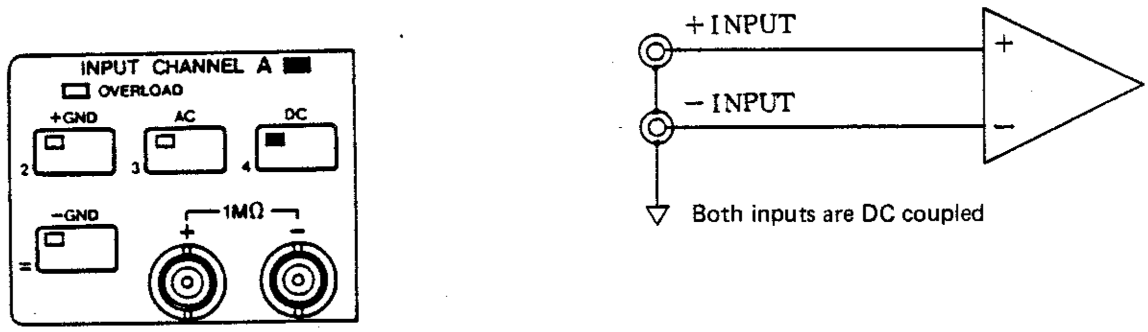
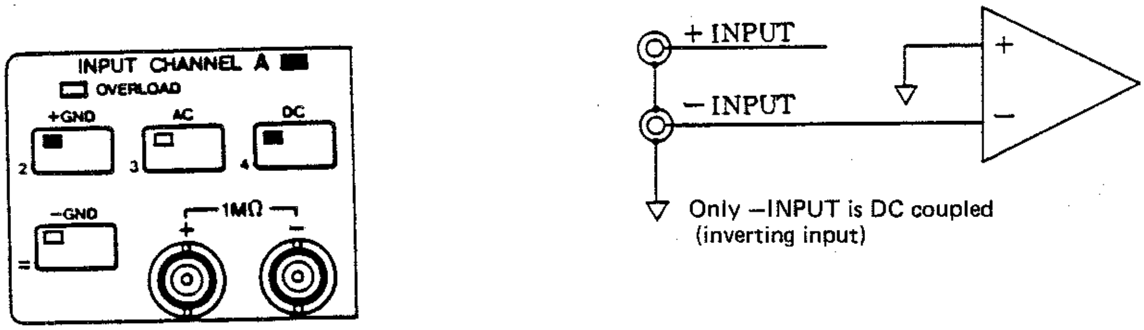


Fig. 4-14 Usages of input coupling mode control keys (AC, DC, +GND and -GND)

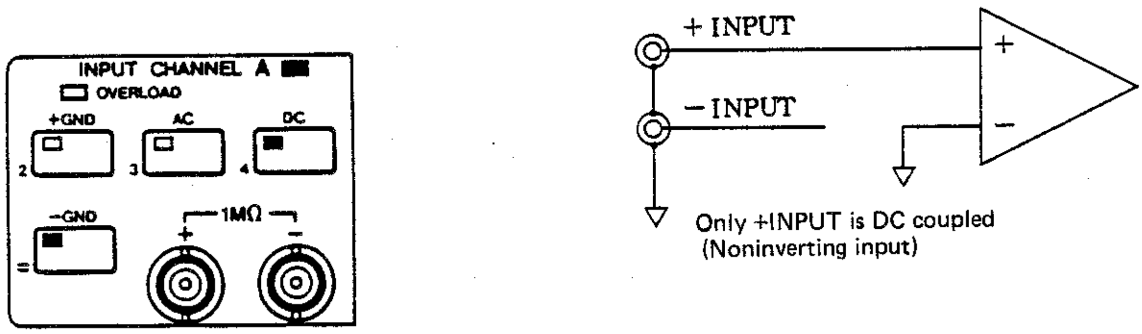
(e) **DC**—ON



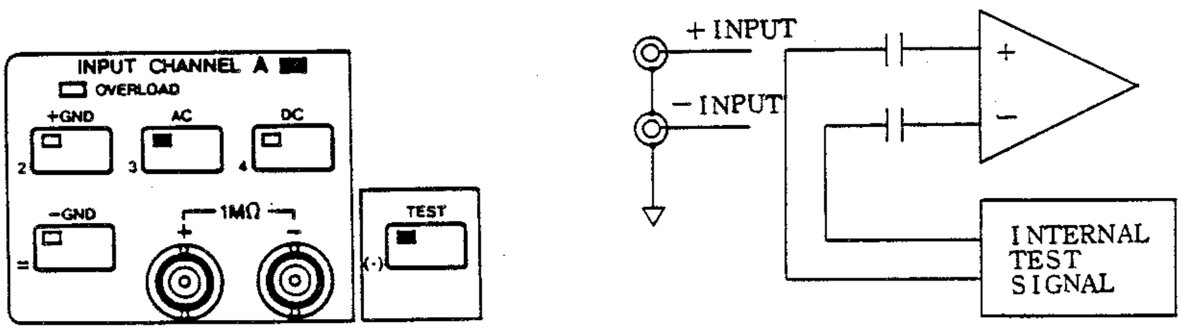
(f) **+GND**—ON, **DC**—ON



(g) **−GND**—ON, **DC**—ON



(h) **TEST**—ON



* INPUT CHANNEL B can also be set up in the same way TEST switch affects the both channels.

Fig. 4-14 (Cont'd)

4-4-2. Input Connection

(1) Signal source

As shown in Figure 4-8, each input channel of the TR9404 has two BNC connectors each. The outer conductors of both ⊕ and ⊖ connectors are connected to the input common ground. The center conductor of each BNC connector is coupled to the common ground via a resistor of approximately 1 MΩ.

The signals applied to the ⊕ and ⊖ connectors go through input selectors and attenuators, then couple to a differential amplifier. The differential amplifier cancels the common mode signal component from the ⊕ and ⊖ input signals and amplifies only the differential component of the signals. The differential input mode is effective for the following three types of input signal sources to ensure measurement of high sensitivity and large dynamic range which would otherwise be degraded by common mode noise or common mode signal component:

a. Signal source is floated from the common ground:

This type of signal source is illustrated in Figure 4-15(a), wherein signal source Es is floated from the common ground by bias signal (common mode signal) Ec. It is found in the output of an AC bridge or the intermediate point of a feedback loop.

b. Signal source is located apart from the instrument or transducer or sensor is mounted directly on a large DUT, in which cases the input signals are often interfered by common mode noise from AC line or other noise sources. This type of signal source is illustrated in Figure 4-15(b), in which the input signal is interfered by earth current or current passing through the DUT.

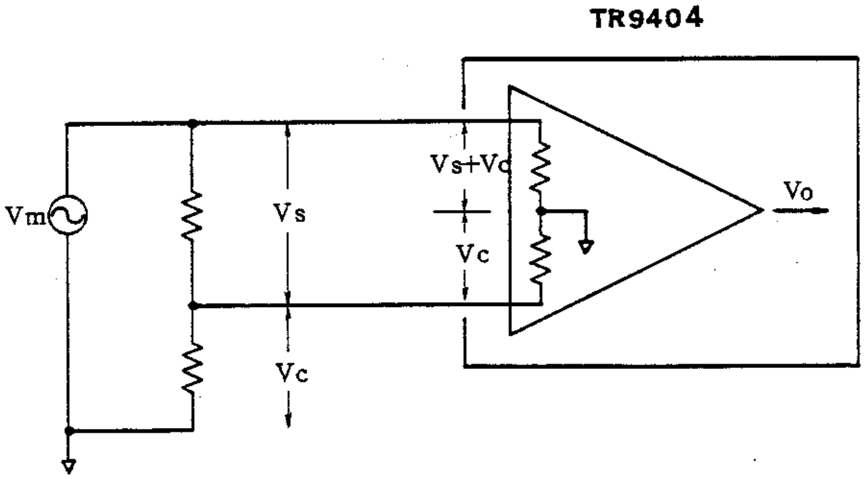
c. The output of the signal source is balanced:
This type is often found in the output of audio amplifiers or test oscillators (see Figure 4-15(c)).
In the differential input mode, to what extent the common mode voltage, Vc, shown in Figure 4-15(a) and (b) is suppressed is the most critical problem. In other words, the ratio of common mode noise or voltage, Vc, to the differential voltage at the output of the differential amplifier is the major concern. This ratio is called the common mode noise rejection ratio (CMRR) and is defined as follows:

$$\mathrm{CMRR(dB)} = 20\log\frac{Vn(f)}{Vc(f)}$$

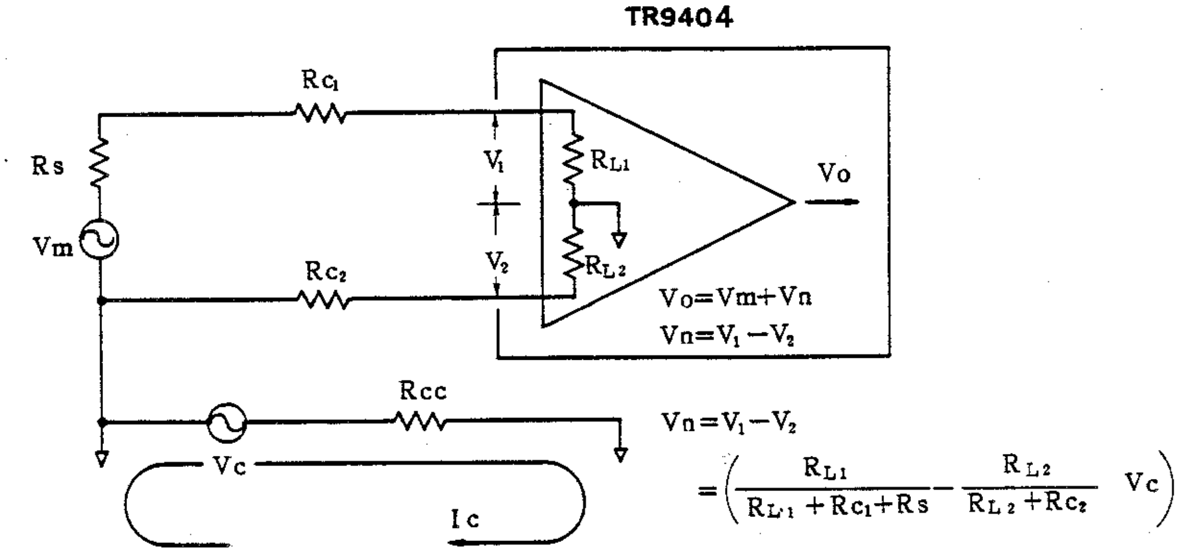
where Vc(f): Common mode noise
Vn(f): Differential amplifier output caused by Vc(f)

A typical CMRR of the TR9404 and its frequency response is shown in Figure 4-16. This response may depend on the impedance of the signal source or the sensitivity range used.

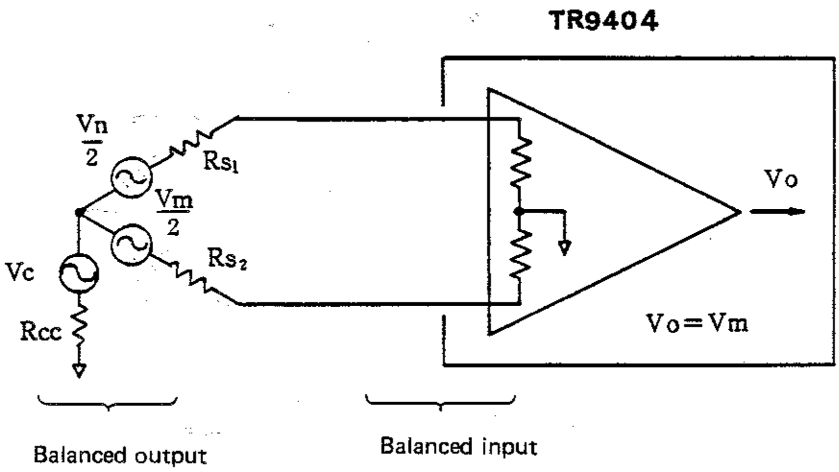
For example, if the common mode noise, Vc, is a line frequency of 50 or 60 Hz with its magnitude of ± 10 Vp-p, differential output Vn caused by common mode noise Vc is approximately ± 1 mV p-p in the DC coupling mode, and approximately ± 10 mVp-p in the AC coupling mode. If, at this time, the measurement signal voltage Vm is assumed to be 1 Vrms, the sensitivity range can be set up depending entirely on the magnitude of Vm, irrelevant to the magnitude of Vc. This means that measurement can be done in the 0 dBV range so far as no overload takes place (as Vm = 1 Vrms). If this input signal was measured in the single-ended input mode, the sensitivity range must have been set up at 10 Vrms, or +20 dBV (which is the sum of 1 Vrms and approx. 7 Vrms which is the rms value of Vc), resulting in a large loss of dynamic range caused by common mode noise Vc.
It should be noted here that the applicable common mode voltage depends on the sensitivity range setup: i.e. maximum common mode noise voltage (CMVmax) applicable is ± 100 Vp-p in a sensitivity range of +30 dBV (31.6 Vrms) to +10 dBV (3.16 Vrms), and +10 Vp-p in a sensitivity range of 0 dBV (1.0 Vrms) to -60 dBV (1.0 mVrms).



(a) Floating signal source



(b) Signal source liable to common mode noise



(c) Balanced signal source

Fig. 4-15 Common mode voltage of different signal sources

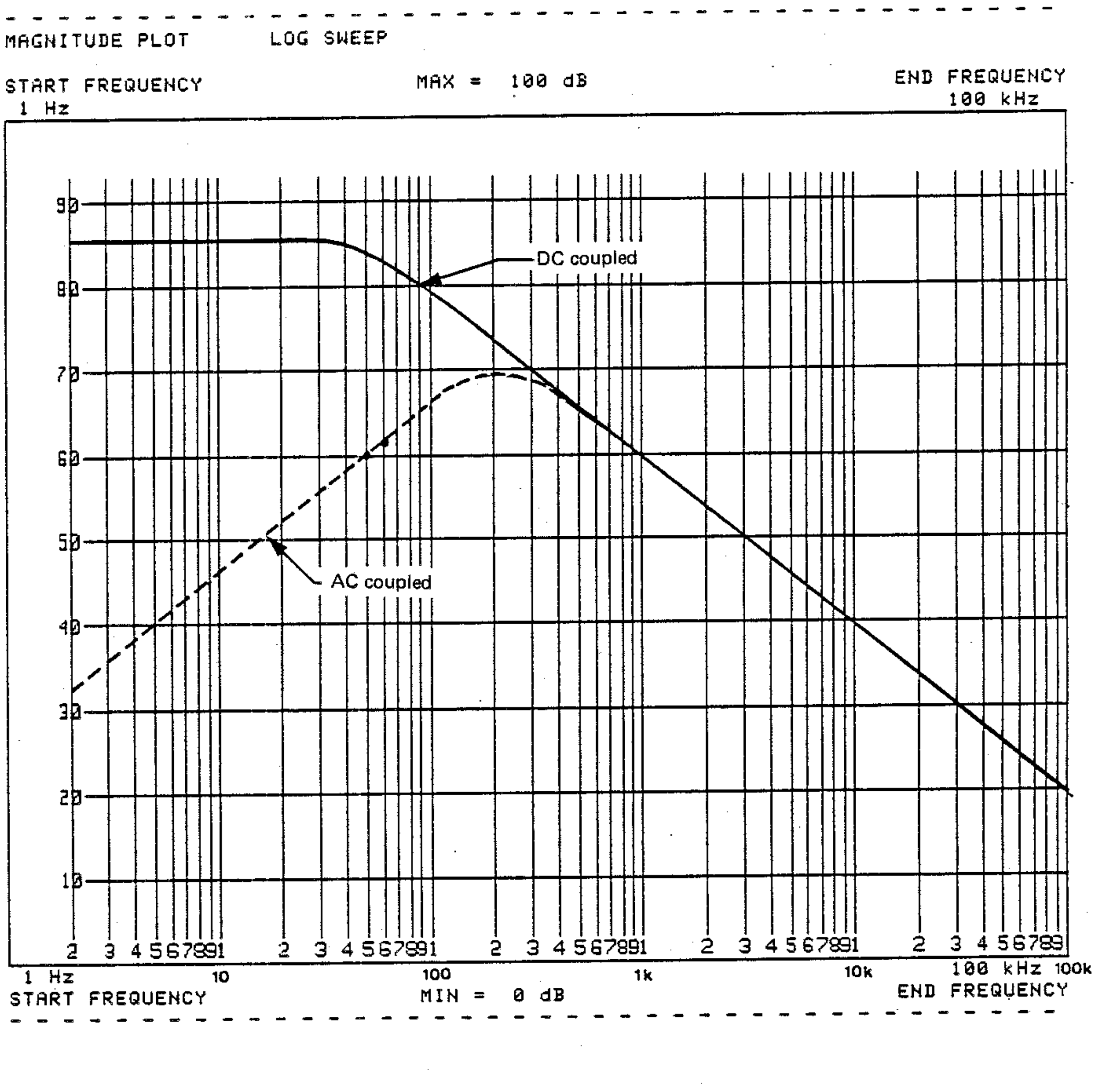


Fig. 4-16 Example of CMRR response in a sensitivity range of +0 dBV to -60 dBV

(2) Input connection for differential input mode

Differential input connecting cables (MI-77) are supplied with the TR9404 as the standard accessory. The configuration of the input cable is shown in Figure 4-7.

Several differential input connecting methods using the MI-77 cables are illustrated in Figure 4-13. In that Figure, (a) or (e) would be most adequate for differential input connection, use appropriate extension cables whose configuration is to be compatible with that of the supplied MI-77 cable shown in Figure 4-17.

(3) 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 single-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 4-19.

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 4-20(a) or (b).), connect one end of the cable to either the + or − input connector on the TR9404. If it is connected to the + connector and the -GND mode is selected as shown in Figure 4-20(a), the input of the instrument becomes an inverting input.

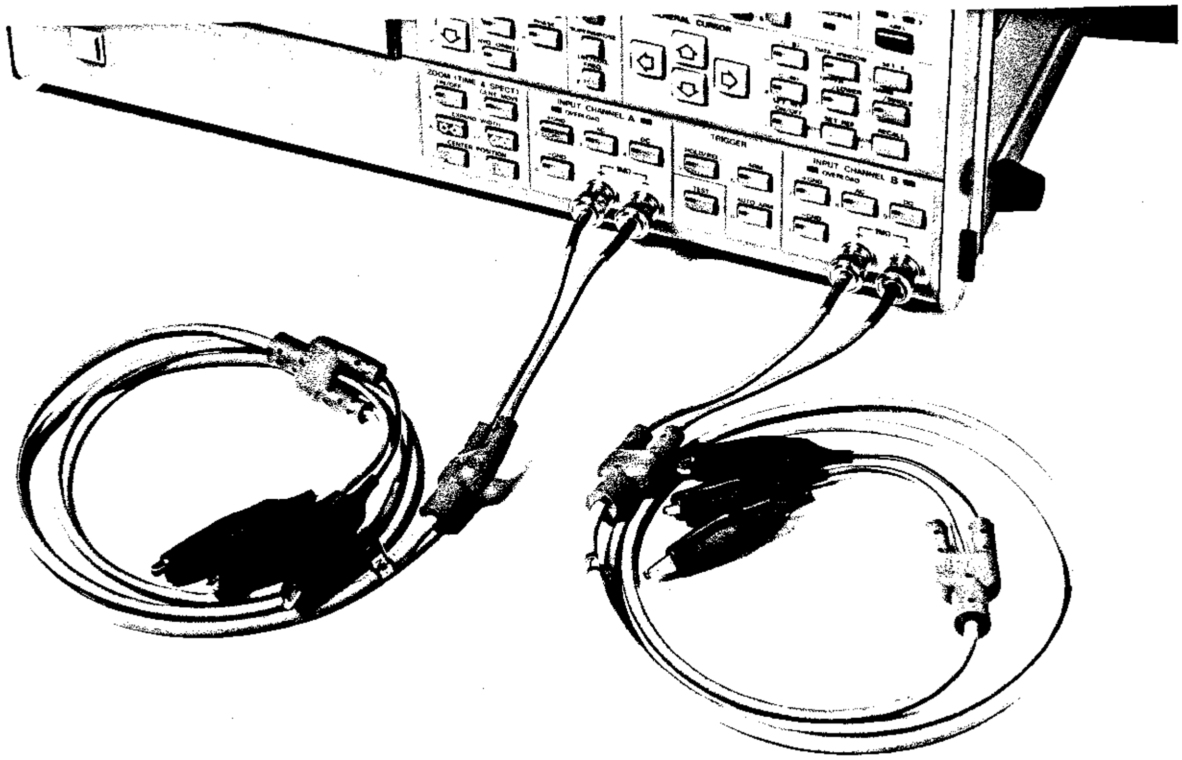
If the cable is connected to the ⊖ input and the +GND mode is selected as shown in Figure 4-20 (b) the input of the instrument is a noninverting input. When the single-ended input mode is used, care should be taken for the input signal polarity, especially when making analysis of phase information, cross correlation function or magnitude probability density function. Also in this mode, 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 4-21), the input may be affected by the other input due to induction (Figure 4-21 (a)) or by external noise interference (Figure 4-21 (b)). This may result in appreciable measurement error.

NOTE

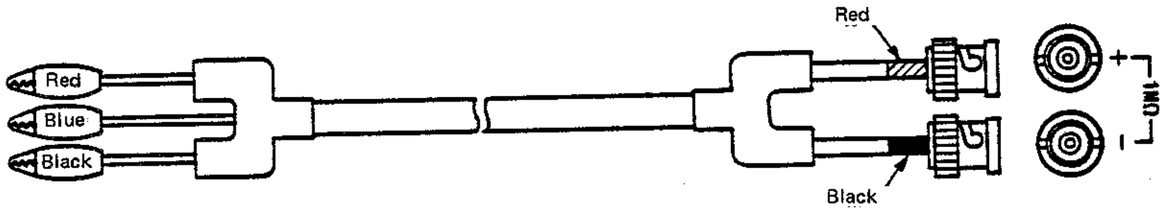
The tradeoff in the implementation of the TR9404 in the high-sensitivity range is that the single-ended input scheme may be subject to line voltage noise in the system or peripheral device noise introduced through the interconnection cables because of its nature of high sensitivity.

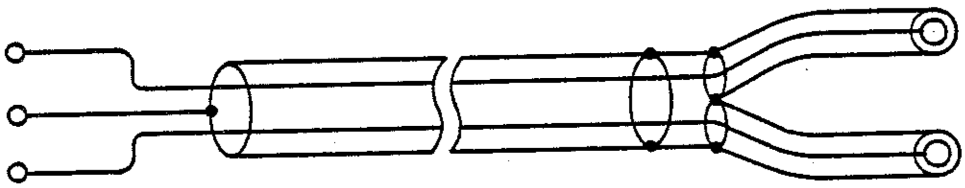
In the systems configuration, therefore, the least possible cable connections are recommended to lessen the noise contribution. (Disconnect the unused cables.)

For the measurement under these circumstances, differential input mode is suggested instead of single-ended mode.



(a)





(b)

Fig. 4-17 MI-77 cable and its configuration

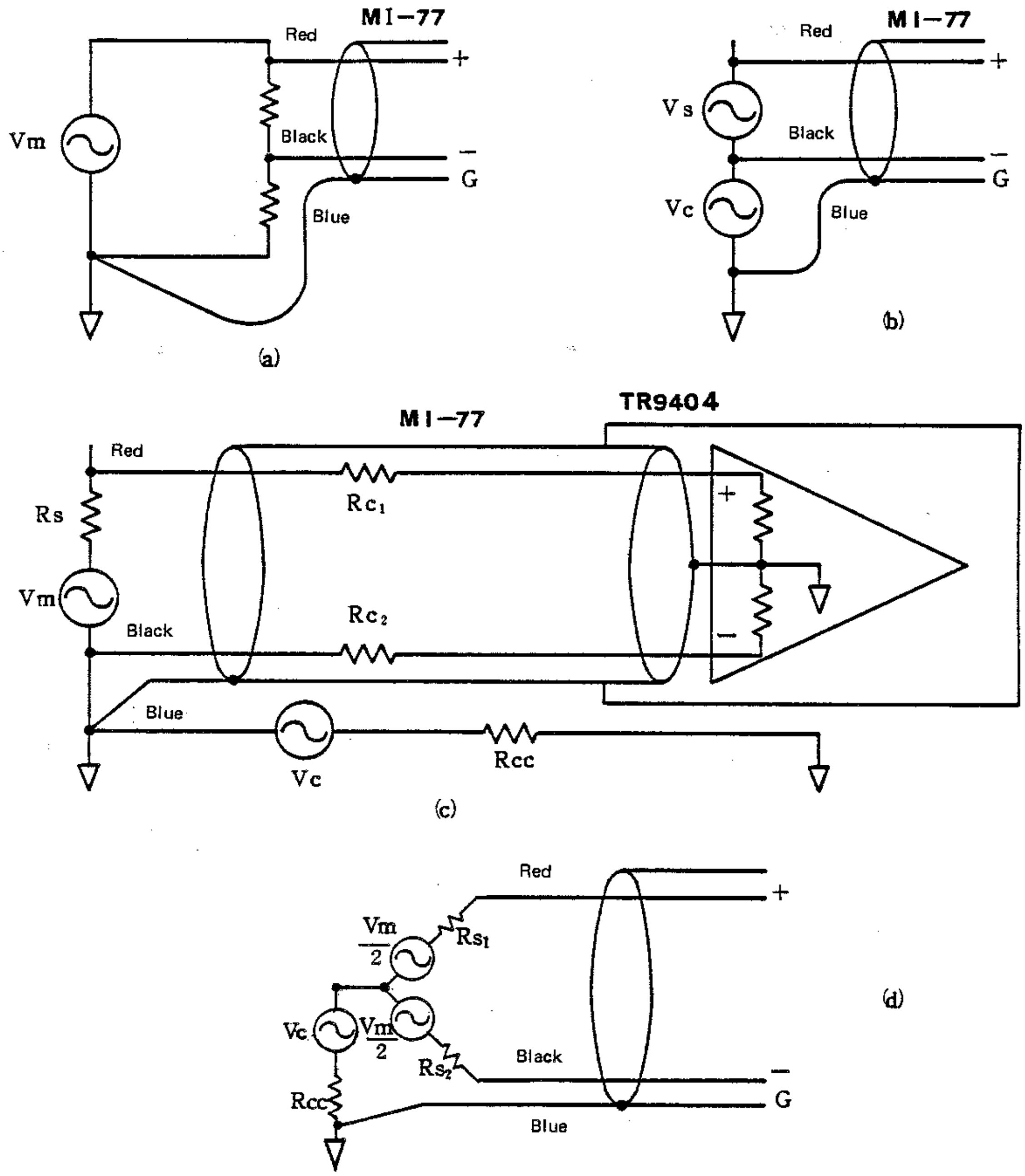


Fig. 4-18 Differential input connection using MI-77 cable

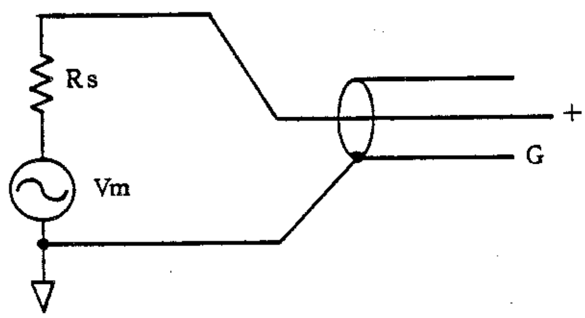
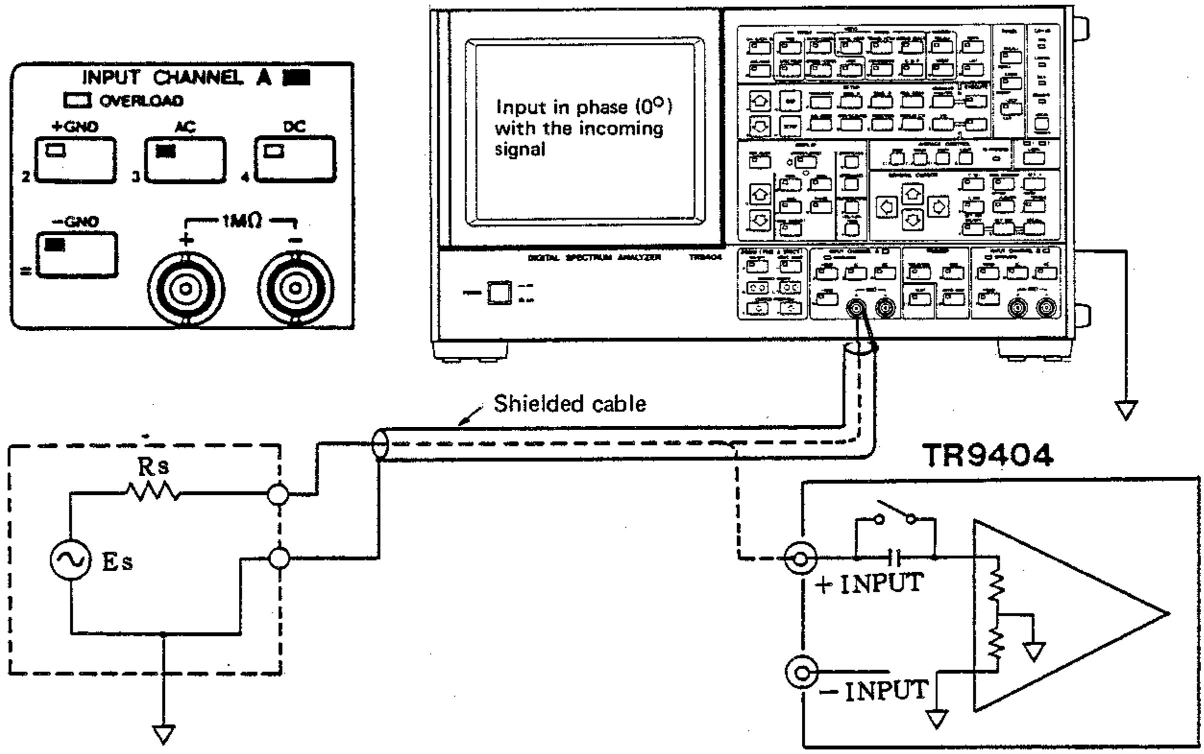


Fig. 4-19 Signal source applicable to the single ended input mode

(a) Single-ended input (Noninverting input)



(b) Single-ended input (Inverting input)

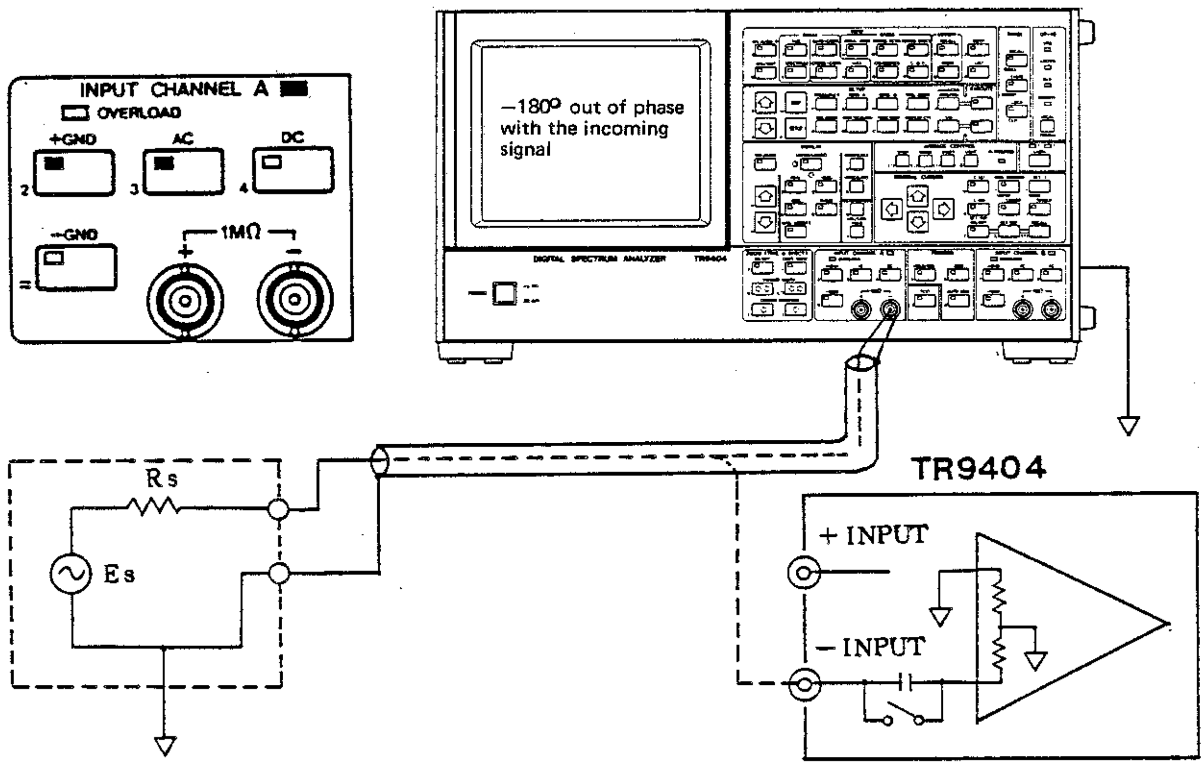
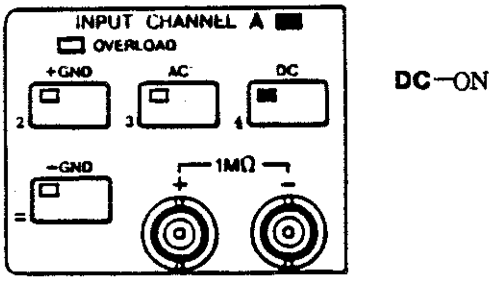
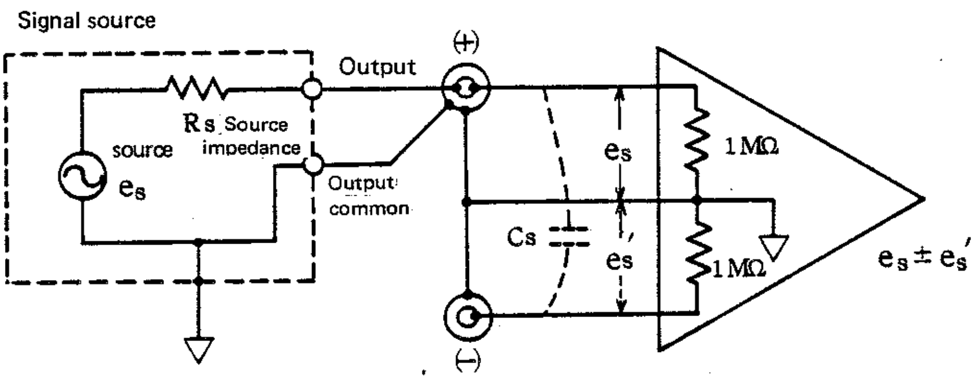


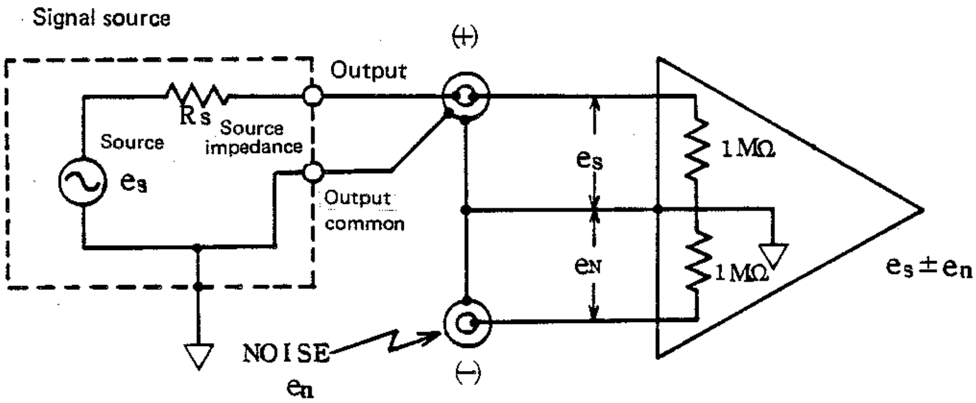
Fig. 4-20 Single-ended input connection



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



(b) The correct level is not obtained because -INPUT is directly interfered 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.

Fig. 4-21 Wrong usage of single-ended input mode

4-4-3. TEST Section

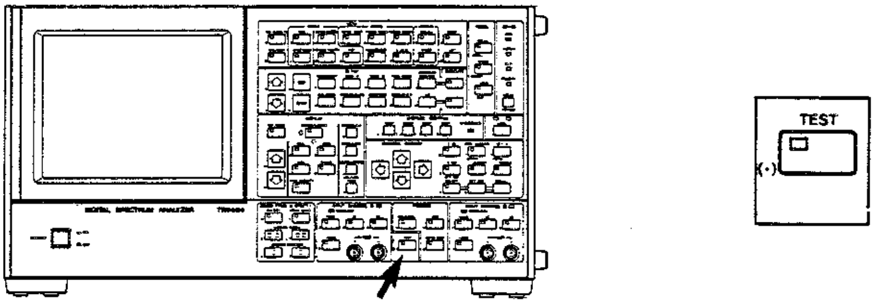


Fig. 4-22 TEST section panel

The TEST mode allows you to make easy checkout of the functions and analog performances of the TR9404 Analyzer. When the TEST key is pressed, the input signals are disconnected from the analyzer's inputs and, instead, a test signal (sine wave with a frequency of 64% of the selected frequency range and a level of -3 dBV $\pm$0.2 dB) is applied to both channel A and B inputs.

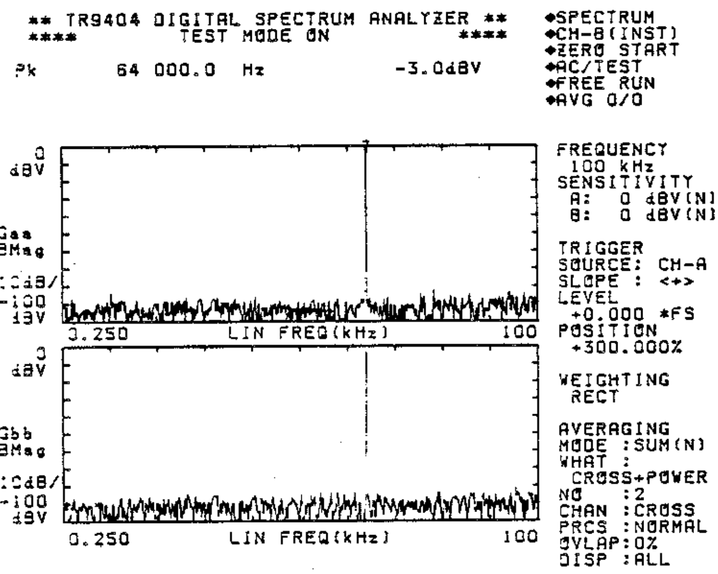


Fig. 4-23 Test signal

If, for example, the 100 kHz range is selected, a single spectrum signal of 64 kHz, -3 dBV ±0.2 dB is applied to both channels A and B. When the TEST mode is selected, both channels A and B are placed in the differential input mode (both +GND and -GND are off) plus AC coupling mode. To deactivate the TEST mode, press the TEST key again.

CAUTION
When the TEST mode is dropped by pressing the TEST key (the lamp within the TEST key goes off), the input coupling condition remains in the differential input, AC coupling mode. Note that the input coupling condition does not return to that selected before the TEST mode is entered.

A simplified checkout procedure for the TR9404 using the TEST mode is described in the following steps:

① Press the [TEST] key. The lamp within the [TEST] key comes on and the inputs of the analyzer are placed in the differential, AC coupled mode.

② Press the [SENS. A] and [SENS. B] keys in the SETUP section, and select the "0 dBV" range for each channel.

③ Press the [FREQUENCY] key in the SETUP section to ON, then set up "100 kHz".

④ Press the [SPECTRUM] and [CH. A/CH. B] keys in the VIEW section to select the SPECTRUM mode and CH-A.

⑤ Press the C (↔) key in the GENERAL CURSOR section to ON, and use the  or  key to position the cursor to 64 kHz. If the C (↔) key is pressed again to OFF, the Auto Peak Search mode is entered, and the (▽) is automatically positioned to 64 kHz.

If, at this time, the level readout is -3 dBV ±0.2 dB, the 100 kHz range of CH.A is normal.

⑥ Press the CH. A/CH. B key in the VIEW section to select CH-B. If, at this time, the level readout is -3 dBV ±0.2 dB, then the 100 kHz range of CH.B is normal.

⑦ While reducing the frequency range from 100 kHz, 50 kHz, 20 kHz, down to 20 Hz with the FREQUENCY key in the SETUP section, verify that a test signal level readout of -3 dBV ±0.2 dB is always obtained on the display at a frequency of 64% of the selected frequency range (e.g. 64 kHz for 100 kHz range, 32 kHz for 50 kHz range, and so forth).

Along with the self diagnostic test described earlier, the above test steps will let you check out the analog circuits, logic functions, and software for correct operations.

4-4-4. VIEW Section

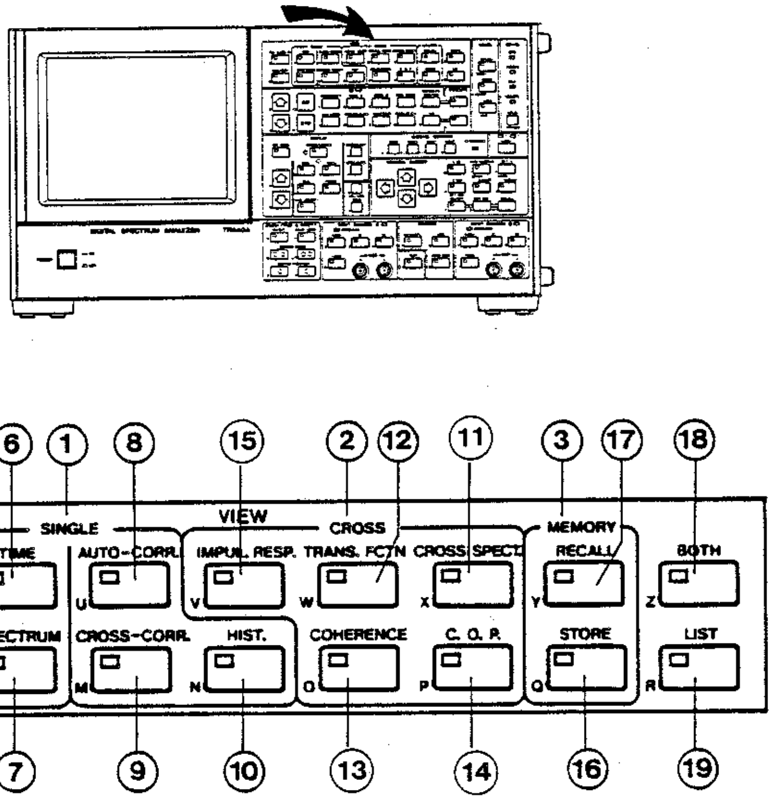


Fig. 4-24 VIEW section panel

The VIEW section provides the following functions:

- Selecting information to be shown on the display.
- Temporarily storing displayed information in a buffer or reading information from the buffer and delivering it to the display.
- Selecting display information for channel A or B.
- Selecting between instantaneous data and averaged data, and controlling the average buffer.
- Selecting between the Single Display and Dual Display modes.
- Selecting between graphic and numerical data (list display mode).

The VIEW section contains the control functions for all the analyzing features the TR9404 provides. Carefully study Paragraph 3-3 "ANALYZING FUNCTIONS" and paragraph 3-4 "DEFINITIONS AND PURPOSES OF ANALYZING FUNCTIONS" before proceeding with the operation of the VIEW section.

The descriptions in this paragraph will not be concerned with technical meanings of measurement data.

① SINGLE

② CROSS

CROSS data, enclosed by —·— in Figure 3-7, is the capabilities related to the channel A (time series data Xa) and channel B (time series data Xb). The amounts of <Gaa> <Gbb> <Gab> (which corresponds to CROSS + POWER of the averaging) are simultaneously averaged.

In contrast, the analyzing functions available independently for Xa and Xb each are defined as "SINGLE" functions, and are encircled with another line on the VIEW section panel.

NOTE

Although cross correlation is related to both channels, it is included in the SINGLE functions as it does not correspond to the IFFT of the <Gab> averaged by CROSS + POWER.

The ten keys enclosed in the SINGLE and CROSS Function boxes on the VIEW section panel provide the most basic analyzing functions of the Analyzer. In addition, combining these key functions with the AVG/INST. and CH. A/CH. B keys provides more than 40 different analyzing functions in all (see Fig.4-26). Moreover, the 1/1- and 1/3-octave analysis and three-dimensional display are available.

③ MEMORY

The MEMORY function may be used to store and recall analysis results obtained by those analyzing function to or from the internal buffer, or to compare old data with new data by using the BOTH display mode. However, this is not usable in such modes as

- Single-channel mode data of
  Xa, Xb, Gaa, Gbb, <Xa>, <Xb>, <Gaa>, <Gbb> or
- Following averaged data of
  <Xa>, <Xb>, <Sa>, <Sb>, <Raa>, <Rbb>

The internal buffer has a capacity of approximately 2K words. For SINGLE functions, each one word of data on channels A and B is automatically stored in CH-A buffer and CH-B buffer respectively. At this time, measurement condition and label information is also stored simultaneously. Old data is sequentially updated by new data word by word. If an old data is a CROSS function analysis data, it is discarded when a new SINGLE function data is written in the buffer. If an old data is a SINGLE function analysis data on one channel, it is updated by a new Single function data on the same channel, but an old data on the other channel will remain in the buffer as it is.

CROSS function analysis data including cross correlation uses the entire buffer space as shown in Figure 4-24(b). Therefore, old data, whether it is a SINGLE data or CROSS data, is discarded when a new CROSS data is stored in the buffer. This means that only one CROSS function data word can be stored in the buffer at a time.

④ CH.A/CH.B (Channel A/Channel B)

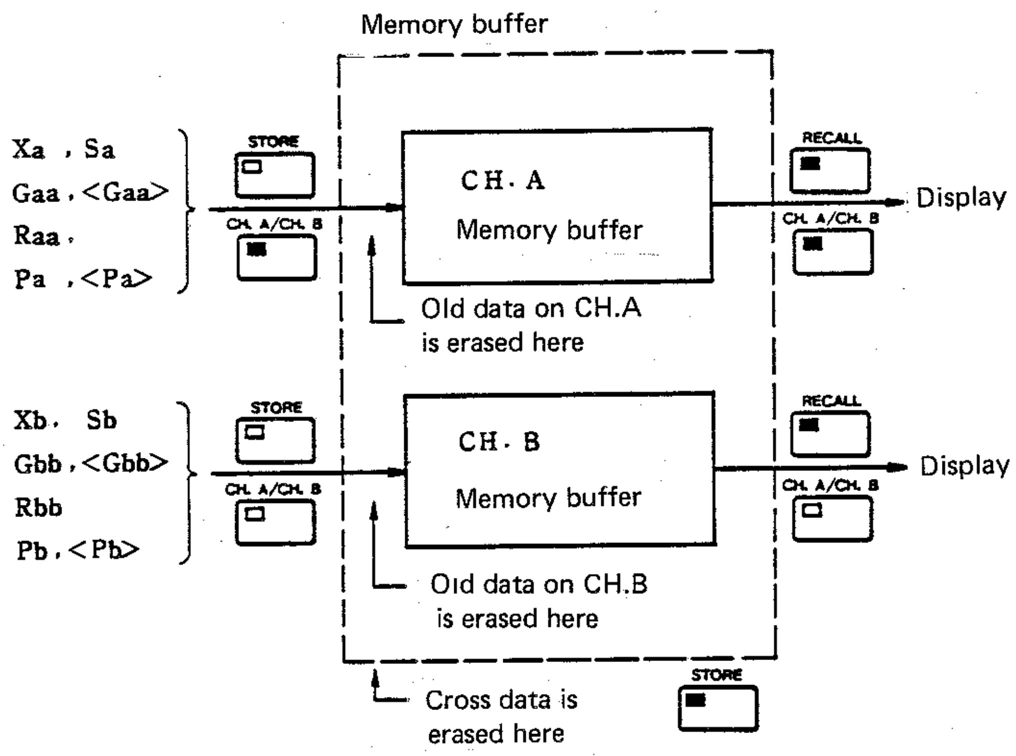
This key is used to determine whether SINGLE function data of channel A or channel B is to be shown on the display. If the lamp within the CH. A/CH. B key is on, data on channel A is selected; if the lamp is off, data on channel B is selected. The function of this key, therefore, has nothing to do with CROSS function data.

When data for the LOWER display is set up for "INST." mode (or "UPSCALING" or "LIST" mode) and "SENS.A" is selected, pressing CH. A/CH. B (CH.A) key will switch the menu to "SENS.B" automatically. In the same way, when "SENS.B" is selected as menu, pressing CH. A/CH. B (CH.B) key will set the menu to "SENS.A" automatically.

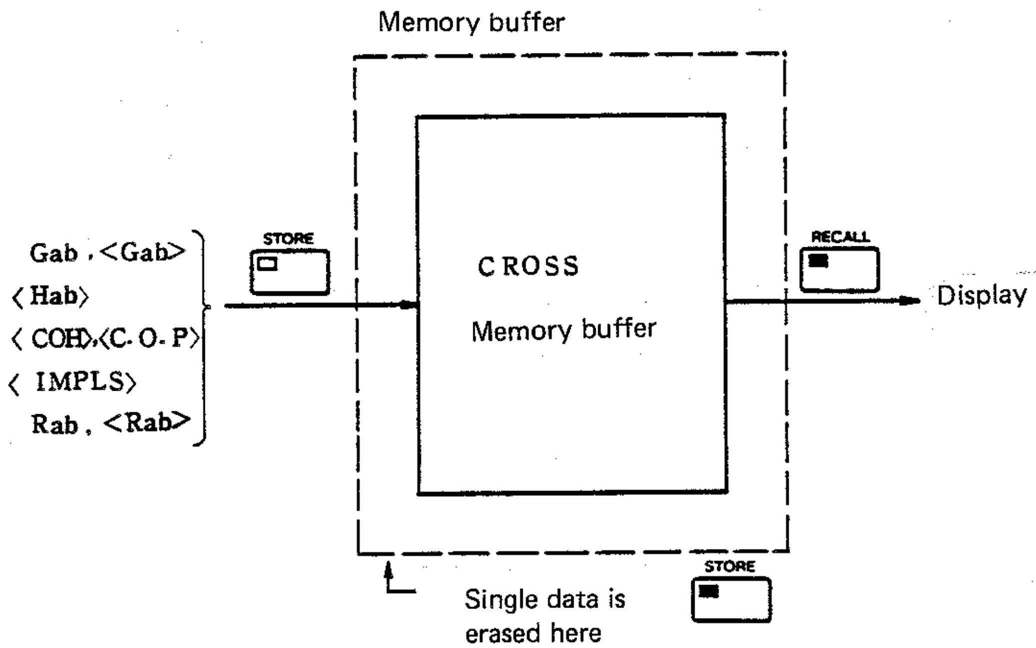
⑤ AVG/INST. (Average/Instantaneous)

This key is used to select between averaged data display and instantaneous data display, whether the data is a SINGLE channel data or CROSS channel data. When the AVG mode is selected, the lamp within the key comes on; when the INST mode is selected, the light turns off.

Some analyzing functions yield no instantaneous data. For example, the CROSS functions produce no instantaneous data except for the cross spectrum function. Therefore, the AVG mode will be automatically entered if the TRANS. FCTN, COHERENCE, C.O.P., or IMPUL. RESP. function is selected. Table 4-1 shows the relations between VIEW mode functions, data assignments to channels A and B, display units, and AVG/INST data types.



(a)



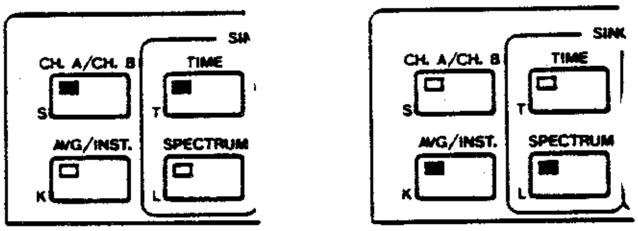
(b)

Fig. 4-25 Implementation of memory buffer

Table 4-1 Relations of VIEW modes, functions, data assignments, readout units and AVG/INST data types

Data mode	VIEW mode	Analyzing function	Analyzing function: Instant (AVG/INST.) CH. A/CH. B		Avaraging (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
	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
	AUTO-CORR.	Auto correlation function	Raa	Rbb	<Raa>	<Rbb>	Lag sec, msec	±1.0 (Dimensionless)
	HIST.	Amplitude probability density function (histogram)	Pa	Pb	<Pa>	<Pb>	V, mV	/V
	CROSS-CORR.	Cross correlation function	Rab		<Rab>		Lag sec, msec	±1.0 (Dimensionless)
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 dBV/$\sqrt{Hz}$, V^2/Hz, V^4/Hz
			Gab Imag		<Gab> Imag			
	TRANS. FCTN	Transfer function	-		<Hab> Mag		Hz, kHz CPM	dB, 1.0 - 0 (Dimensionless)
					<Hab> Phase			degree
					<Hab> Real			±1.0 (Dimensionless)
					<Hab> Imag			
	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
	IMPUL. RESP.	Impulse response	-		<IMPLS>		Lag sec, msec	±1.0 (Dimensionless)

The example shown in Figure 4-26(a) indicates that instantaneous time data on channel A is shown on the display. The example shown in Figure 4-26(b) indicates that an averaged (or being averaged) signal response on channel B is shown on the display.



(a) (b)

Fig. 4-26 VIEW section setup examples

When using the AVG mode, the $\overset{\text{AVG MODE}}{\boxed{}}$ key in the SETUP section and the average buffer have a significant role. If the $\overset{\text{AVG MODE}}{\boxed{}}$ key in the SETUP section is operated, the pertinent setup must be made for items "AVG WHAT?" (data to be averaged) and "AVG CHANNEL" (channel on which averaging is to be made) in the averaging condition menu shown on the display (see item 4-4-5 SETUP section).

"AVG WHAT?" includes the following mode menus:

- "TIME" (time series data averaging)
- "AUTO-CORR" (auto correlation function averaging)
- "CROSS-CORR" (cross correlation function averaging)
- "HIST" (amplitude probability density averaging)
- "POWER SPECT" (auto power spectrum averaging)
- "COMPLEX SPECT" (complex spectrum averaging)
- "CROSS + POWER" (CROSS function data averaging)

"AVG CHANNEL" includes the following mode menus:

- "CH-A" (averaging on channel A; no averaging performed on channel B)
- "CH-B" (averaging on channel B; no averaging performed on channel A)
- "DUAL" (simultaneous, independent averaging on channels A and B. For auto correlation function, averaging is made on either channel A or B, however.)
- "CROSS" (CROSS function data averaging)

Averaging is executed with use of the above two menus.

Table 4-2 shows relationships between data modes, objective data for averaging, AVG WHAT?, and AVG CHANNEL.

The usage of the average buffer greatly differs depending on the objective data for averaging or AVG WHAT? menu. It is illustrated in Figures 4-27 and 4-28.

Averaging for SINGLE mode data <Xa>, <Xb>, <Sa>, <Sb>, <Mag., Phase, Real, Imag.>, <Gaa>, <Gbb>, <Pa>, and <Pb> can use the average buffer divided into individual spaces for channels A and B. For the above SINGLE function data, therefore, averaging can be executed on channel A or channel B, or simultaneously for both channels A and B. The contents of the average buffer space for which no averaging was executed are maintained as they are. On the channel on which averaging is executed, the result of averaging replaces the old data in the average buffer of the same channel, so that the contents of the average buffer on the other channel remain intact. The only exception is the result of amplitude probability density function averaging.

If the averaged data on channel B (Pb) is written into part of the average buffer on channel A, the previous contents of the average buffer on channel A will be discarded. As a result, if < Pa > and < Pb > are executed simultaneously, the both data are written into the average buffer on channel A, and the contents of the channel-B average buffer remain intact.

SINGLE mode data < Raa >, < Rbb >, and < Rab > use the entire average buffer space as shown in Figure 4-28. In this case, therefore, old data in the average buffer is updated by new averaged correlation function data. If averaging is executed on an auto correlation function (by AUTO-CORR) in the DUAL mode, the average buffer on channel A is automatically selected for storage of the averaging result.

CROSS function data < Gab>, Hab, COH, C.O.P., and IMPLS also use the entire space of the average buffer. However, the data actually written into the average buffer are < Gab>, < Gaa>, or < Gbb>(cross spectra and auto power spectra on channels A and B). The reason for this is explained from the following formulas (refer to Figure 3-7 in CHAPTER 3):

$$\text{Transfer function } (\langle Hab \rangle) = \frac{\langle Gab \rangle}{\langle Gaa \rangle}$$

$$\text{Coherence function } (\langle COH \rangle) = \frac{\langle Gab \times Gab^{*} \rangle}{\langle Gaa \times Gbb \rangle}$$

$$\text{Coherent output power } (\langle C.O.P. \rangle) = \frac{\langle Gab \rangle \langle Gab \rangle^{*}}{\langle Gaa \rangle}$$

$$\text{Impulse response } (\langle IMPLS \rangle) = \text{IFFT } (\langle Hab \rangle)$$

The operations given by the above formulas are executed before the result of averaging is shown on the display. It is possible, therefore, to display $\langle Gaa \rangle$ and $\langle Gbb \rangle$ if they exist in the average buffer for CROSS analysis function.

Table 4-2 Relationship between data modes, analyzing functions, "AVG WHAT?" and "AVG CHANNEL"

Data mode	Averaging analysis		AVG WHAT?	AVG CHANNEL	Remarks
SINGLE	Time series data	<Xa> / <Xb>	TIME	CH-A / CH-B, DUAL	● <Sx>Mag.,<Sx>Phase.,<Sx>Real and<Sx>Imag. can be obtained after <Sa> and <Sb> are executed ● Execution of <Xx> and <Sx> requires synchronization in the time domain
	Complex spectrum	<Sa> / <Sb>	COMPLEX SPECT	CH-A / CH-B, DUAL	
	Auto power spectrum	<Gaa> / <Gbb>	POWER SPECT	CH-A / CH-B, DUAL	
	Amplitude probability density function (histogram)	<Pa> / <Pb>	HIST	CH-A / CH-B, DUAL	
	Auto correlation function	<Raa> / <Rbb>	AUTO-CORR	CH-A / CH-B	
	Cross correlation function	<Rab>	CROSS-CORR	CH-A / CH-B	
CROSS	Cross spectrum	<Gab>	CROSS+POWER	Selection of CH.A, CH.B or DUAL is automatically set to the CROSS mode	● <Gaa> and <Gbb> can be determined with this averaging function
	Transfer function Coherence function Coherent output power Impulse response	<Hab> <COH> <C.O.P.> <IMPLS>	CROSS+POWER		● <Gaa>, <Gbb> and <Gab> can be determined with this analyzing function ● Upon execution of this analyzing function, the lamp within the AVG/INST key comes on ● If averaging is executed in <IMPLS> mode, the <Hab> mode is automatically selected ● After averaging of <Gab> and <Hab> is executed, the Mag., Phase, Real and Imag. of each can be obtained

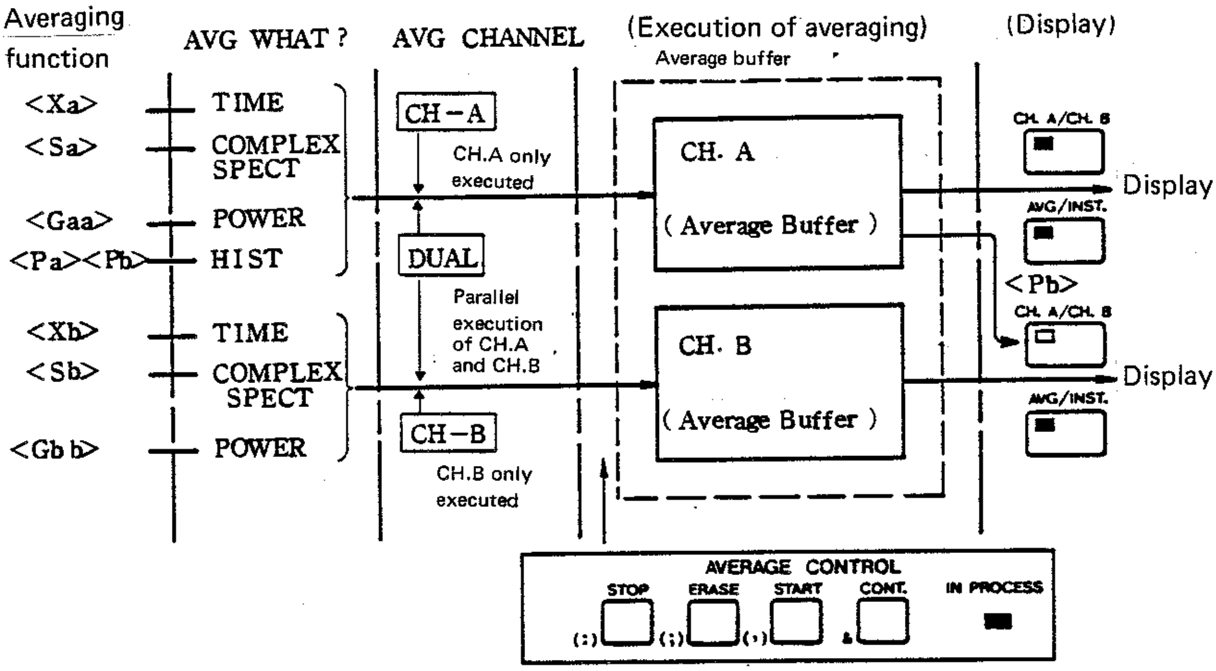


Fig. 4-27 Usage of average buffer (for SINGLE function data averaging)

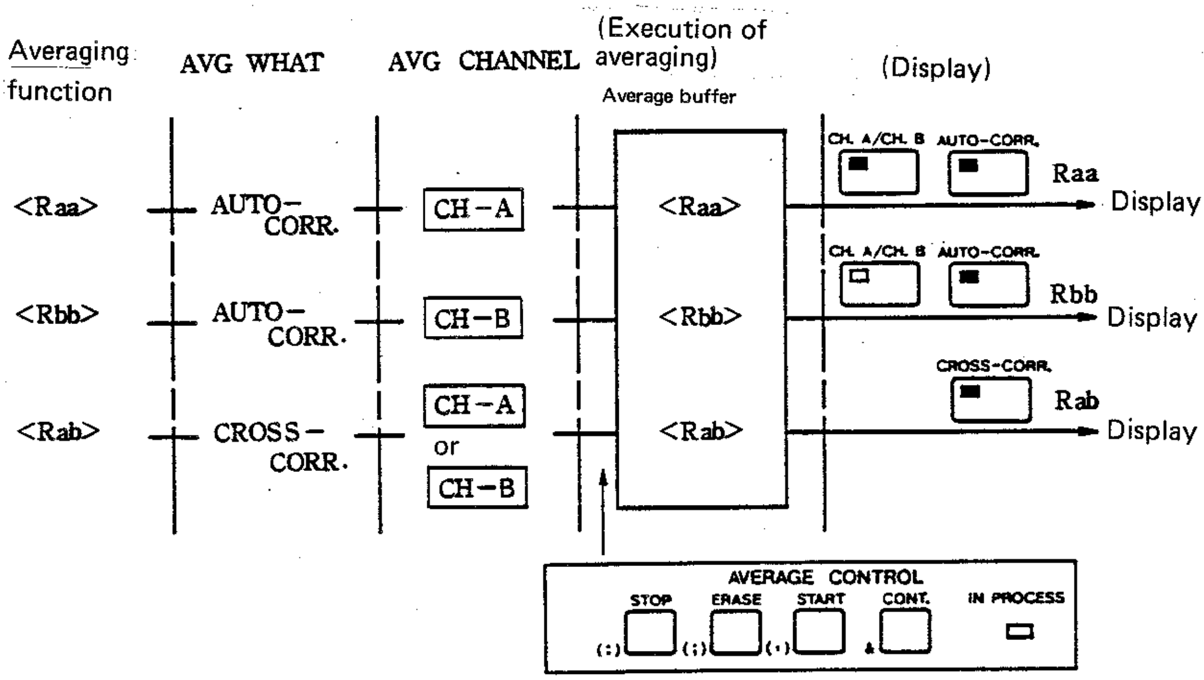


Fig. 4-28 Usage of average buffer (for correlation function averaging)

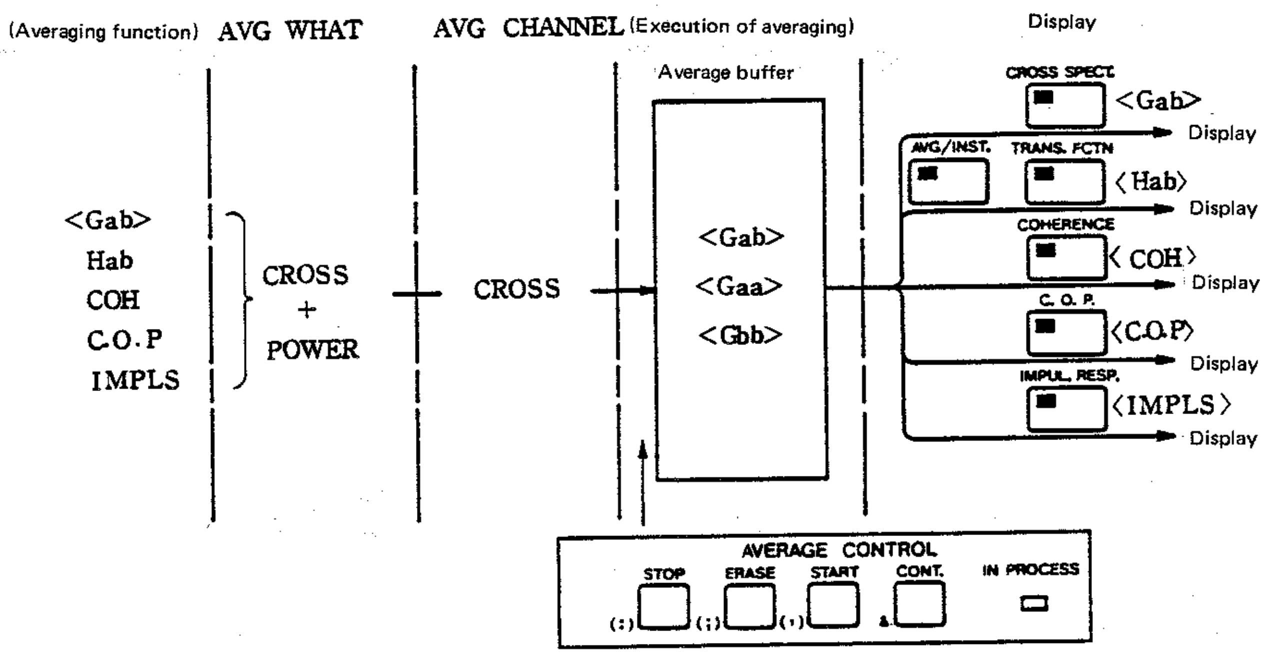


Fig. 4-29 Usage of average buffer (for CROSS function data averaging)

Execution of averaging is initiated by key operation for the AVERAGE CONTROL section. When averaging is started, the following message will flash in the bottom left display area on the CRT for a few seconds if the "COMPLEX SPECT" is selected out of the AVG WHAT? menu:

START AVG : COMPLEX SPECT

The IN PROCESS lamp in the AVERAGE CONTROL section illuminates until execution of averaging is completed.

Upon the end of averaging, the IN PROCESS lamp goes off and audible "pip" tone sounds several times to alert the operator for the end of averaging execution.

⑥ TIME

Operation of the TIME key displays any of the following data on the CRT:

- Instantaneous time series data on each channel (Xa, Xb)
- Averaged time series data on each channel (<Xa>, <Xb>)

A TIME data display example is shown in Figure 4-30. This example shows single mode display for TIME data (not the BOTH mode). The horizontal axis represents the frame time determined from the frequency range selected out of the FREQUENCY menu; the vertical axis represents amplitude determined from the sensitivity range selected from the SENSITIVITY menu for SENS. A or SENS. B. The signal shown in this example is a time series input signal (1024 data points) after being subject to A/D conversion.

Instanteneous time-series data includes the modes of

FREE RUN: Time-varying data

HOLD : Data intake in prohibited

ARM : When the incoming data meets the trigger condition, the data is held on the CRT and another data intake is prohibited

AUTO ARM: Each time incoming data meets the trigger condition the data is newly displayed on the CRT. Data intake and its display is automatically repeated

Note that averaged TIME data is displayed by operating the TIME and AVG/INST. keys.

Operation of the control keys in the DISPLAY and ZOOM (TIME & SPECT.) sections can expand the displayed signal response trace along the time and/or amplitude axis or move the trace in the vertical direction. Also Δt or ΔV can be determined by using the cursor and SET X key in the GENERAL CURSOR section.

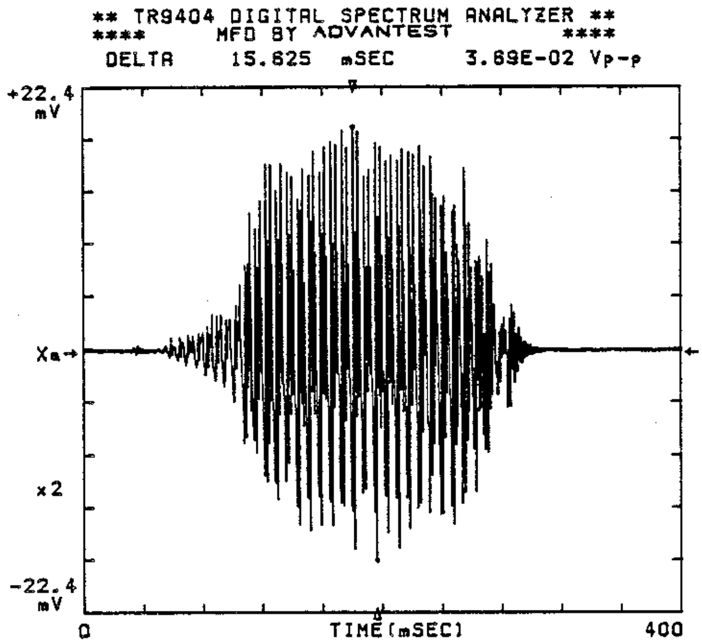


Fig. 4-30 TIME data display example

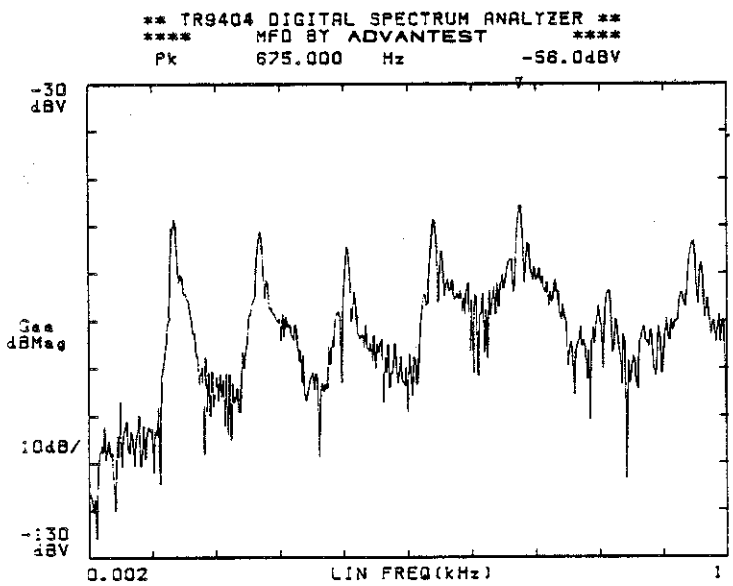


Fig. 4-31 SPECTRUM data display example

⑦ SPECTRUM

Operation of the SPECTRUM key displays one of the following spectral responses on the CRT:

- Instantaneous auto power spectrum on each channel   Gaa, Gbb
- Instantaneous complex spectrum on each channel

    Sa Phase Sa Real Sa Imag.

    Sb Phase Sb Real Sb Imag.

- Averaged auto power spectrum on each channel   <Gaa> <Gbb>
- Averaged complex spectrum on each channel

    <Sa> Mag., <Sa> Phase, <Sa> Real, <Sa> Imag.

    <Sb> Mag., <Sb> Phase, <Sb> Real, <Sb> Imag.

A display example is shown in Figure 4-32. The horizontal axis represents the frequency range selected from the FREQUENCY menu. If the input coupling is in the DC mode, "0" is shown at the bottom of the leftmost graticule; if it is AC coupled, the maximum resolution frequency in that frequency range is shown at the same point. In the ZOOM mode, horizontal axis represents START frequency on its leftmost point and STOP frequency on its rightmost.

The vertical axis represents the fullscale sensitivity range selected from the SENSITIVITY menu for SENS. A or SENS. B (if 0 dBV is selected, the top graticule on the CRT indicates 0 dBV). Display dynamic range and resolution can be controlled with the REF./GAIN, ⇧ and ⇩ keys in the DISPLAY section. In addition to the dBV logarithmic scale, the linear scale of V or V^2 is also available.

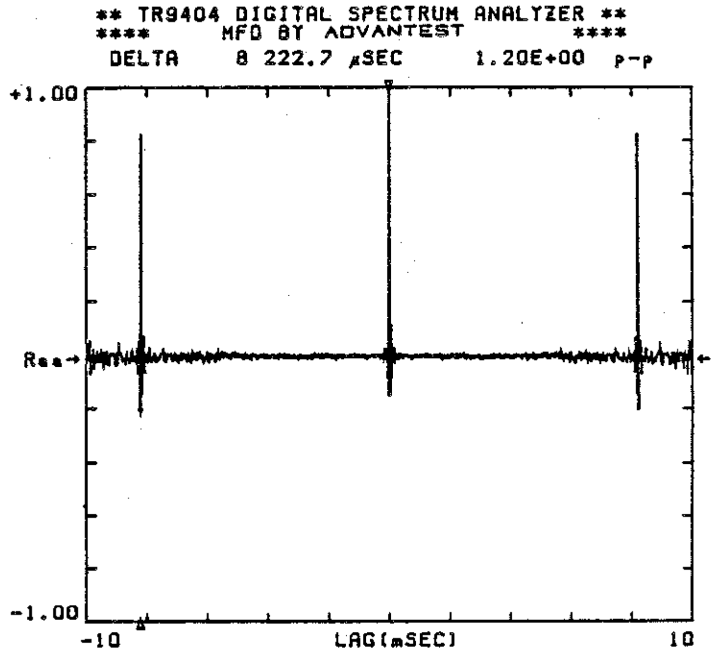


Fig. 4-32 AUTO-CORR data display example

(8) AUTO-CORR

Operation of the AUTO-CORR key displays one of the following function data on the CRT:

- Instantaneous autocorrelation function on each channel Raa, Rbb
- Averaged autocorrelation function on channel <Raa>, <Rbb>

Figure 4-32 shows a display example. The horizontal axis gives a delay time, for which one half of the frame time (selected from the FREQUENCY menu) is shown in terms of advance time ($-\tau$) and delay time ($+\tau$). The vertical axis has no dimension, with its full span between +1.0 and -1.0. An autocorrelation function is always +1.0 at $\tau = 0$.

The ZOOM section function can magnify or move displayed information in the horizontal direction. The DISPLAY section function can magnify or move displayed information in the vertical direction.

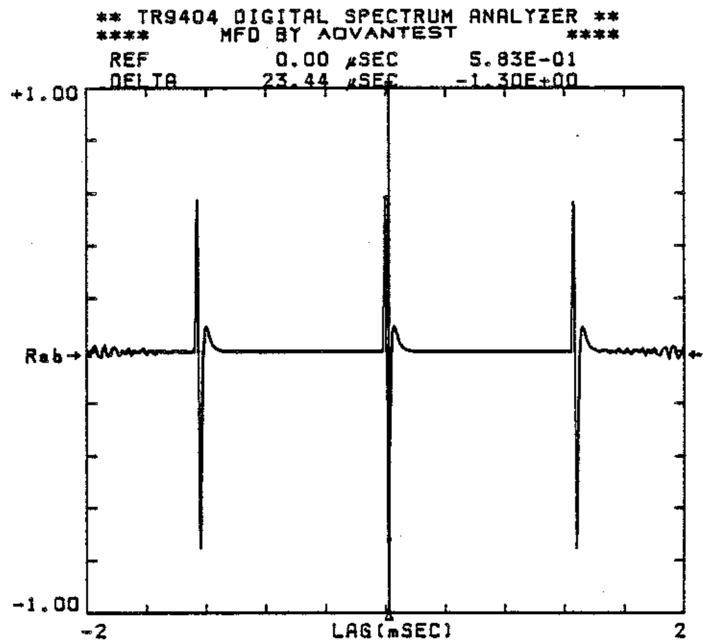


Fig. 4-33 CROSS-CORR data display example

⑨ CROSS-CORR

Operation of the CROSS-CORR. key displays one of the following data on the CRT:

- Instantaneous crosscorrelation function Rab
- Averaged crosscorrelation function <Rab>

Figure 4-34 shows a CROSS-CORR data display example. The horizontal axis gives a lag time, for which one half of the frame time (selected from the FREQUENCY menu) is shown in terms of advance time ($-\tau$) and delay time ($+\tau$). The vertical axis has no dimension, with its fullscale span between +1.0 and -1.0. The ZOOM section function can magnify or move displayed information in the horizontal direction. The DISPLAY section function can magnify or move displayed information in the vertical direction.

NOTE: For the measurement of cross correlation function, it is preferable to set the coupling mode to AC coupling.

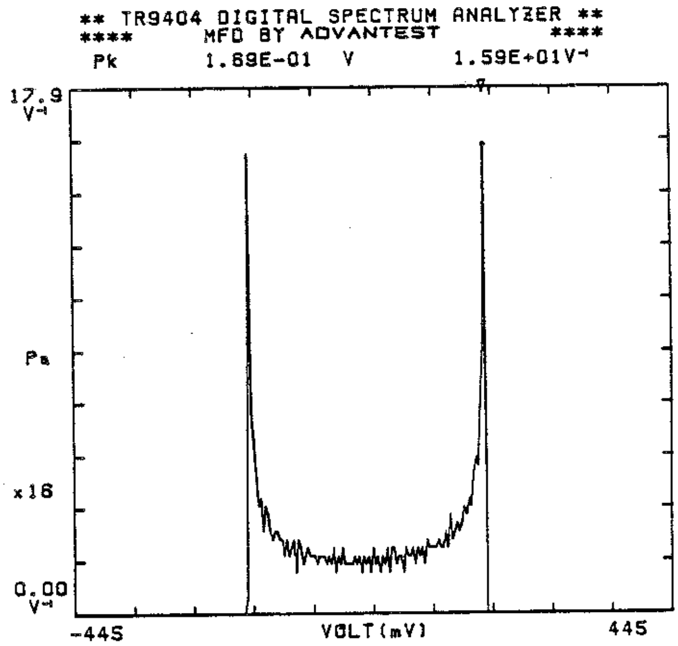


Fig. 4-34 HIST data display example

⑩ HIST (Histogram)

Operation of the HIST. key displays one of the following data on the CRT:

- Instantaneous histogram on each channel Pa, Pb
- Averaged histogram on each channel <Pa>, <Pb>

Figure 4-34 shows a HIST data display example. The horizontal axis gives positive and negative scales for the sensitivity range selected from the SENSITIVITY menu for SENS. A or SENS. B, its resolution being 256 data points. The vertical axis gives a probability (P) at ΔV (Probability Density Function), with time axis data points of 1024 defined as 1. As a result, the readout unit is V^{-1}.

The vertical scale can be magnified up to 32 magnification in binary steps with the REF./GAIN key and ⇧ or ⇩ key in the DISPLAY section, so that smaller probability values can be read out.

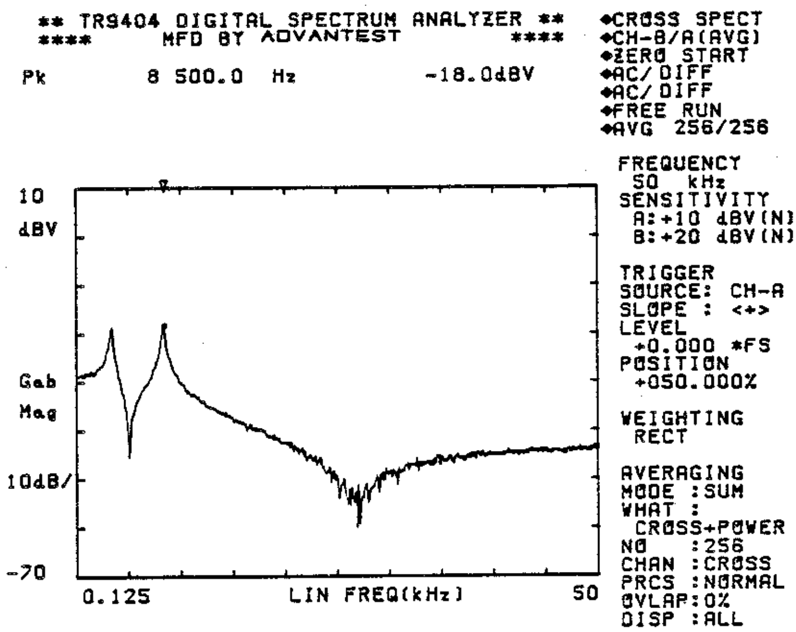


Fig. 4-35 CROSS SPECT data display example

(11) CROSS SPECT.

Operation of the CROSS SPECT key displays either of the following data on the CRT:

- Instantaneous cross spectrum

  Gab Mag., GabPhase, GabReal, GabImag.

- Averaged cross spectrum

  <Gab> Mag., <Gab>Phase, <Gab>Real, <Gab>Imag.

Figure 4-35 shows a cross spectrum data display example. The horizontal axis gives a frequency range selected from the "FREQUENCY" menu. The vertical axis can be assigned to a logarithmic scale (dBV) or linear scale (V^2 or V^4).

Display dynamic range and resolution can be controlled with the REF./GAIN, ⇧, and ⇩ keys in the DISPLAY section.

⑫ TRANS. FCTN (Transfer Function)

Operation of the TRANS. FCTN key displays the following data on the CRT:

- Transfer function <Hab> Mag., <Hab> Phase, <Hab> Real, <Hab> Imag.

Figure 4-36 shows a transfer function display example.

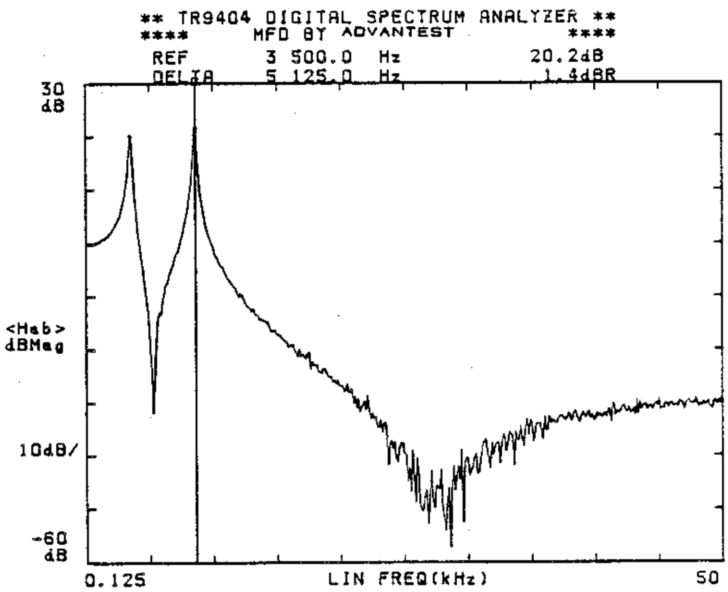


Fig. 4-36 TRANS. FCTN data display example

On a Bode diagram, the horizontal axis gives a frequency range selected from the FREQUENCY menu; if both channels A and B are DC coupled, the leftmost graticule indicates frequency 0; if either or both of channels A and B are AC coupled, the leftmost graticule represents the minimum resolution in the selected frequency range. The vertical axis gives a ratio of output to input of the DUT and has no dimension. Either a logarithmic scale (dB) or linear scale (1.0 to 0) is applicable to the vertical axis.

Display dynamic range or resolution can be magnified with the DISPLAY section keys. Phase information (<Hab> Phase), real part (<Hab> Real) or imaginary part (<Hab> Imag.) can be shown on the display also with the DISPLAY section keys.
A Nyquist diagram gives real part on the horizontal axis and imaginary part on the vertical axis to help grasp phase relationships at a glance.
Note that the coherence function should also be observed when the transfer function is measured. The coherence function should be close to 1.0 as much as possible for the best result.

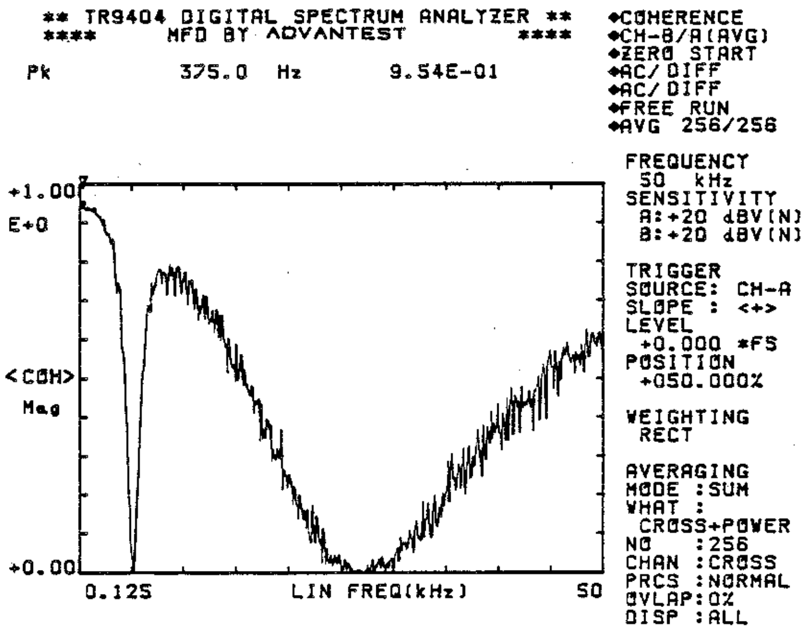


Fig. 4-37 COHERENCE data display example

(13) COHERENCE

Operation of the COHERENCE key displays the following data on the CRT:

- Coherence function < COH >

Figure 4-37 shows a coherence data display example. The horizontal axis gives a frequency range selected from the "FREQUENCY" menu. The vertical axis has no dimension, and its scale span is between 1.0 and 0.

Close to 1.0: Precise measurement least liable to noise

Close to 0 : Measurement interfered with noise

Displayed information can be magnified or moved in the vertical direction with the DISPLAY section keys. Also by using the "COH BLANK" (coherence blanking) function in the "FUNCTION" menu and the GENERAL CURSOR section function, the portions of a transfer function or C.O.P. data having less coherence can be blanked out. The coherence function measurement should be accompanied with the transfer function measurement.

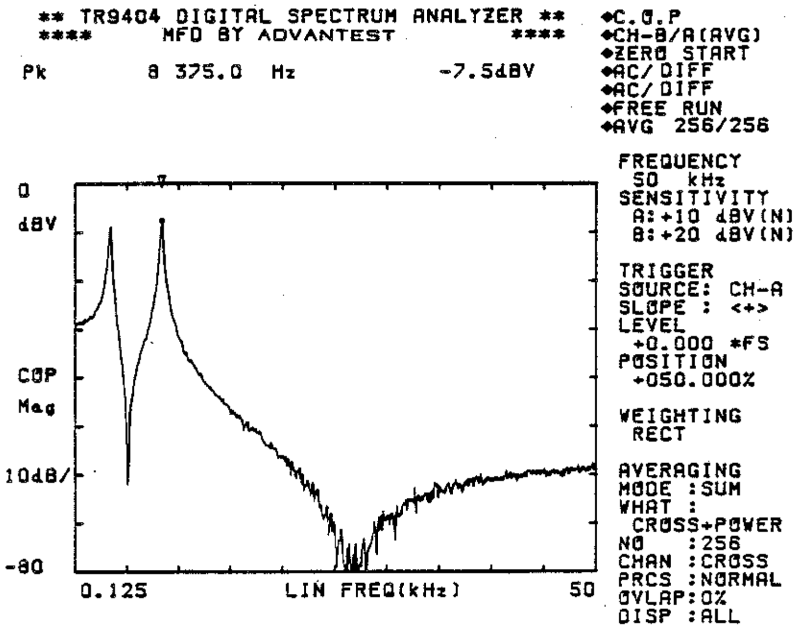


Fig. 4-38 C.O.P. data display example

⑭ C.O.P.

• Coherent output power < COP >

A C.O.P. data display example is shown in Figure 4-38. The horizontal axis gives a frequency range selected from the "FREQUENCY" menu. The vertical axis can be selected from a logarithmic scale (dBV) and linear scale (V or V^2) as C.O.P. is a product of a coherence function (no dimension) and auto power spectrum output (<Gbb>) of the system in question. Display dynamic range and resolution can be controlled with the DISPLAY section keys.

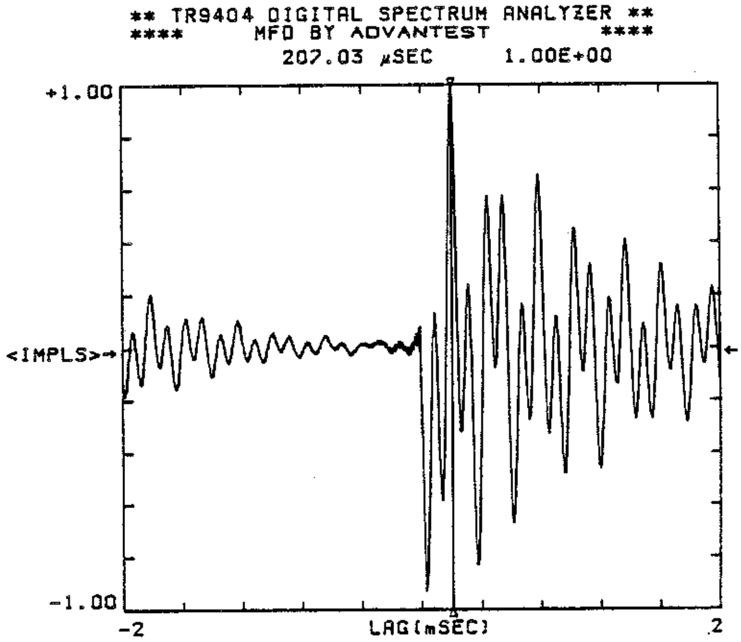


Fig. 4-39 IMPUL RESP. data display example

(15) IMPUL. RESP. (Impulse Response)

Operation of the IMPUL. RESP. key displays the following data on the CRT:

- Impulse response < IMPLS >

Figure 4-39 shows an impulse response display example. The horizontal axis gives lag time, for which a half of the frame time is shown in terms of advance time ($-\tau$) and delay time ($+\tau$). The vertical axis gives an inverse Fourier transform of transfer function (<Hab>) and has no dimension, with its fullscale span between +1.0 and -1.0.

Displayed information can be magnified or moved in the horizontal direction with the ZOOM section keys, and in the vertical direction with the DISPLAY section keys.

⑯ STORE

⑰ RECALL

The STORE key is used to temporarily store measurement information, measurement condition, and label into the internal buffer. The RECALL key is used to retrieve stored measurement information or condition to the display.

STORE

- "SINGLE" function data can be stored in individual buffer spaces for each channel.
- Only a single "CROSS" function data can be stored in the buffer at a time. Therefore, it is not possible to store "SINGLE" and "CROSS" function data at a time.
- Data shown at the moment of the STORE key depression is stored in the buffer (in BOTH mode, the data shown in the lower display area), whether the data is varying with time or in the middle of averaging execution.
- All pertinent information including measurement condition and label, as well as measurement information, is stored.

RECALL

- For "SINGLE" function data, operation of the RECALL key recalls the data selected with the CH. A/CH. B key in the VIEW section.
- For "CROSS" channel data, operation of the RECALL key recalls the CROSS data irrespective of the CH. A/CH. B key status.
- In the BOTH display mode, the data selected with the UPPER/LOWER key in the DISPLAY section is recalled.

- All pertinent information including measurement condition and label is recalled as well as measurement information.
- After stored data is recalled, the DISPLAY, GENERAL CURSOR and LIST section functions and the vertical axis control functions such as V, V^2, dBV, 2 dB/div, 5 dB/div, and 10 dB/div selected from the "DISPLAY CTL" menu are available for the recalled data.

See also (3) MEMORY.

(18) BOTH

This key is used to select between the SINGLE and DUAL display modes. When the DUAL display mode is selected, the lamp within the key comes on. Figure 4-40 shows a dual display example in which a time series signal (time domain) and its frequency spectrum (frequency domain) are displayed at a time.

In the SINGLE display mode, only one of either instantaneous or averaged data of TIME, SPECTRUM, HIST, CROSS-CORR, AUTO-CORR, IMPUL RESP, TRANS FCTN, CROSS SPECT, COHERENCE and C.O.P. or a recalled data from storage is shown on the display. In the BOTH display mode, arbitrary two data (same data allowed) out of the above data are shown in the upper and lower display areas on the display (see Figure 4-40).

If the upper data is selected with the UPPER/LOWER key in the DISPLAY section (lamp in the key comes on), the VIEW section functions are valid to the upper data. If the lower data is selected (lamp in the key goes off), the VIEW section functions are valid to the lower data.

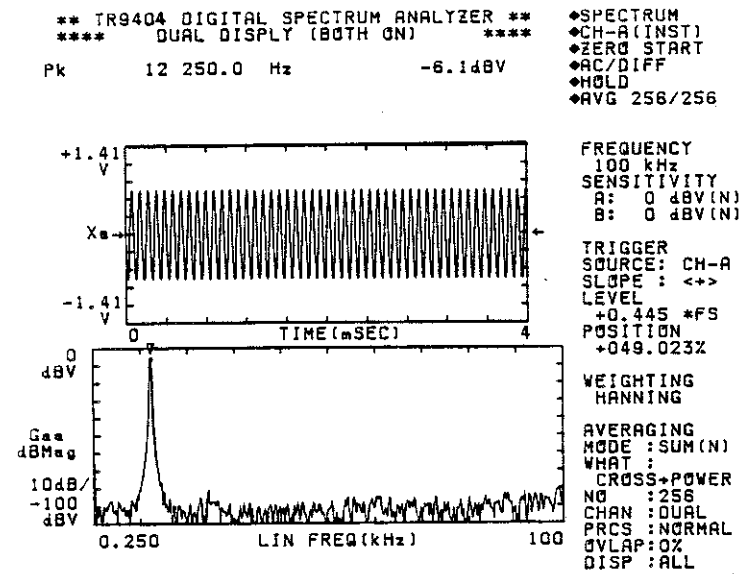


Fig. 4-40 Dual display example for time series data and its frequency spectrum

However, if the same key for the data analysis (TIME, SPECTRUM, etc.) in the VIEW section is operated consecutively two times, the same mode is selected for both upper and lower data without operating the UPPER/LOWER key.

Readout is available for both upper and lower data. When readout for the upper data is desired, set the UPPER/LOWER key in the GENERAL CURSOR section to the UPPER mode (lamp within the key turned on) and use the ⇦ or ⇨ key in the GENERAL CURSOR section to position the cursor to the desired point on the trace. The data at the point identified by the cursor is directly read out.

When readout for the lower data is desired, set the UPPER/LOWER key to the LOWER mode (lamp turned off), then perform similar cursor operation.

If two signals have the same domain and X-coordinate information are displayed in the BOTH mode, they can be superimposed on each other. To do this, press the SUPERIMPOSE key in the DISPLAY section. For more details see the description for the DISPLAY section.

To clear the BOTH mode into the SINGLE mode, press the BOTH key a second time. The lamp within the key goes off and the data which was in the lower display area is displayed in the SINGLE mode.

However, it is not possible to obtain BOTH-mode display of TIME data obtained in SINGLE mode as it will exceed the display buffer capacity. If this is attempted, the following message will flash at the bottom left display area on the CRT:

INSUFFICIENT MEMORY: GDP

There are also some combinations whose dual display is possible only in the UPSCALING mode, such as the display of TIME and SPECTRUM data each obtained in SINGLE mode.

(19) LIST

Operation of the LIST key provides a numerical listing of frequencies and levels of up to 20 spectra on the display (see Figure 4-41). The LIST mode is valid when frequency domain data (SPECTRUM, TRANS. FCTN, CROSS SPECT., COHERENCE, or C.O.P. data) is selected by the VIEW section function. Whether the data is instantaneous, averaged, or recalled from internal buffer is irrelevant, so far as it is a frequency domain data. The LIST mode is disabled for any data other than frequency domain data.

If the HARM./SINGLE key in the GENERAL CURSOR section is set to the HARM. (Harmonic line) mode (lamp comes on), harmonic frequencies up to 20th order and their levels are listed, with the data identified by the cursor defined as the fundamental frequency.

If the HARM./SINGLE key is set to the SINGLE (single line) mode (lamp goes off), up to 20 data identified by the cursor are sequentially stored in internal buffer by the SET/REF. function and are listed along with their levels.

In the LIST mode as well, frequencies and levels of spectra can be newly listed by operating the SET REF. key while controlling the cursor with the ⇦ or ⇨ key.

To clear the LIST mode, press the LIST key a second time, or operate any of the keys in the VIEW section.

The LIST mode includes the following listing modes:

- Single List mode (lists arbitrary spectra.)
- Harmonic List mode (lists harmonic spectra.)
- Harmonic Distortion List mode (lists harmonic distortion.)
- Dual List mode (lists superimposed spectra.)
- Nyquist List mode (lists Nyquist data.)

Setup procedures for each of these list modes are described in the following:

a. Single List mode

   The Single List mode is valid when frequency domain data is displayed in the SINGLE display mode or when frequency domain data is displayed in the lower display area in the DUAL display mode.

First activate the C (↔) key in the GENERAL CURSOR section (lamp comes on), then set the HARM. /SINGLE key to the SINGLE mode (lamp goes off), and activate the SET REF. ON/OFF key (lamp comes on). Then use the ⇦ or ⇨ key to position the cursor to the desired frequency, and then press the SET REF. key. This will save the frequency at the cursor. Use the ⇦ or ⇨ key again to position the cursor to the next frequency, then press the SET REF. key. Up to 20 frequencies can be sequentially saved by repeating the operations described just above. If more than 20 frequencies are specified, new one is sequentially saved while the oldest one is discarded.

To list the data at saved frequencies, press the LIST key. The data type currently listed is indicated at the top of the listing column as follows:

- SPECTRUM ---- Spectrum on channel A or B
- CROSS SPECT ---- Cross spectrum
- TRANS. FCTN ---- Transfer function
- COHERENCE ---- Coherence function
- C.O.P. ---- Coherent output power spectrum

Below this data type indicator are any of the following annunciators indicating whether the data is real, imaginary, magnitude or phase:

- Re V ---- Real part of complex data
- Im V ---- Imaginary part of complex data
- MAG V ---- Magnitude
- MAG V^2 ---- Squared magnitude
- MAG dB(V) ---- Logarithmic magnitude
- PHASE deg ---- Phase of complex data

b. Harmonic List mode

Like the Single List mode, the Harmonic List mode is also valid to frequency domain data. The Harmonic List mode is entered if any of the [REAL], [IMAG.], or [PHASE] key in the DISPLAY section is activated. If the [MAG.] key is activated, the Harmonic Distortion List mode (to be described later) will be entered.

First, activate the [C (↔)] key in the GENERAL CURSOR section (lamp comes on), and use the [⇦] or [⇨] key to position the cursor on the fundamental frequency. Set the [HARM./SINGLE] key to the HARM. mode (lamp comes on) to search for harmonics up to the 20th number.

Listable upper limit of harmonic order depends on the fundamental frequency and selected frequency range. For example, if the selected frequency range is 10 kHz and the fundamental frequency 1.25 kHz, the listable harmonic order is determined by:

10000/1250 = 8

That is, harmonics up to the 8th order can be listed.

Press the [LIST] key to list the numbers, frequencies and data (REAL, IMAG or PHASE) of the fundamental and harmonics. Each harmonic is listed as the absolute value; each one is not relative to the fundamental.

The data type of the list is indicated at the top of the listing column. See the preceding item a. Signal List mode.

c. Harmonic Distortion List mode

Like other listing modes, the Harmonic Distortion List mode is also valid to frequency domain data. To select this mode, activate the MAG. key in the DISPLAY section (lamp comes on). Note that the Harmonic Distortion List mode is not selected if the REAL, IMAG, or PHASE key in the DISPLAY section is activated.

When the LIST key is pressed, such items are listed as the orders, frequencies, relative levels to the fundamental and distortion ratios of each harmonic.

If the C (↔) key is not activated, the cursor is positioned at the top graticuale for the maximum signal and that frequency is defined as the fundamental frequency, and all harmonics are determined with respect to this fundamental frequency.

The unit for level listing should be selected from Mag, Mag^2, or dBMag in the DISP CTRL menu with the DISPLAY CTL key in the SETUP section.

The bottom two lines of a harmonic listing indicate the weighting function currently used, total rms distortion voltage of harmonic responses, and total harmonic distortion.

- Weighting function:

  RECT (Rectangular)

  HANNING

  MINIMUM

  FLAT-PASS

- TOTAL HARMONIC RMS

$$\mathrm{RMS(V)} = \sqrt{E_2^2 + E_3^2 + E_4^2 + \ldots\ldots + En^2}$$

$$\mathrm{RMS(V^2)} = E_2^2 + E_3^2 + E_4^2 + \ldots\ldots + En^2$$

$$\mathrm{RMS(dB)} = 10 \log (E_2^2 + E_3^2 + E_4^2 + \ldots\ldots + En^2)$$

- TOTAL HARMONIC DISTORTION (THD)

$$\mathrm{THD(\%)} = \frac{\sqrt{E_2^2 + E_3^2 + E_4^2 + \ldots\ldots En^2}}{E_1} \times 100$$

E_1: rms voltage of fundamental signal

E_2-E_n: rms voltages of 2nd to the nth harmonic

(n: up to 20)

Total rms voltage of harmonics and total harmonic distortion ratio for up to the nth harmonic being listed are determined by the above formulas.

d. Dual List mode

If the List mode is specified in the SUPERIMPOSE mode, in which two data with the same domain and frequency range are shown in the same display area, information of the two data can be simultaneously listed for the same frequency. This Dual List mode can list up to 20 signals with the SET REF. or the harmonics up to the 20th order in the HARMONIC mode. For instance, if a transfer function and coherence are superimposed in the same display area with the [HARM./SINGLE] key set in the SINGLE mode, the frequencies specified with the [SET REF.] key and the transfer function and coherence values at each of those frequencies can be listed by specifying n signal responses with the [SET REF. ON/OFF]-[SET REF.] keys and then selecting the List mode.

If the HARM./SINGLE key is set to the HARM. mode (lamp within the key turned on), harmonic orders, frequencies, transfer functions and coherences up to the 20th number are listed, with the frequency identified by the cursor defined as the fundamental frequency.

The Dual List mode is applicable to any combination of data so far as the data are both in the frequency domain.

Harmonic levels listed in the HARM. mode are not relative to that of the fundamental response, but are absolute levels.

e. Nyquist List mode

If the LIST key is pressed in the Nyquist display mode, the Nyquist List mode is entered. If the Nyquist display is in the REAL-IMAG. mode with the HARM./SINGLE key set to the SINGLE mode, up to 20 spectra set up with the SET REF. key, REAL values (displayed as "Re") and IMAG. values (displayed as "Im") are enumerated. If the HARM./SINGLE key is set to the HARM. mode, up to the 20 harmonics are sought out and the orders, frequencies, real part values and imaginary part values of the fundamental and harmonics are listed, with the frequency identified by the cursor defined as the fundamental frequency.

If the MAG.-PHASE display mode for transfer function is selected in the Nyquist display mode with the HARM./SINGLE key set to the SINGLE mode, the frequencies, MAG. values (dB) and PHASE values (DEG) of up to the 20 data (spectra) specified with the SET REF. key are listed. If the HARM. mode is selected, harmonics of up to the 20th order are sought out with the fundamental frequency identified by the cursor, and their harmonic orders, frequencies, MAG values (dB), and PHASE values (DEG) are listed up. MAG values (dB) of harmonics listed in the HARM. mode are not relative to that of the fundamental, but are absolute values.

```
** TR9404 DIGITAL SPECTRUM ANALYZER **

****       SINGLE LIST MODE          ****
                            SPECTRUM
               FREQUENCY     Mag
                        Hz             V
SET NO.   1    19 250.0       2.29E-05
          2    18 500.0       2.81E-05
          3    17 750.0       1.15E-05
          4    17 000.0       3.24E-05
          5    16 250.0       5.12E-05
          6    15 500.0       3.73E-05
          7    14 750.0       3.47E-05
          8    14 000.0       1.82E-04
          9    13 250.0       1.10E-03
         10    12 500.0       1.97E-01
         11    11 750.0       1.80E-02
         12    11 000.0       6.66E-04
         13    10 250.0       1.52E-04
         14     9 500.0       4.97E-05
         15     8 750.0       3.50E-05
         16     8 000.0       4.66E-05
         17     7 250.0       1.72E-05
         18     6 500.0       3.04E-05
         19     5 750.0       3.11E-05
         20     5 000.0       1.02E-05
```

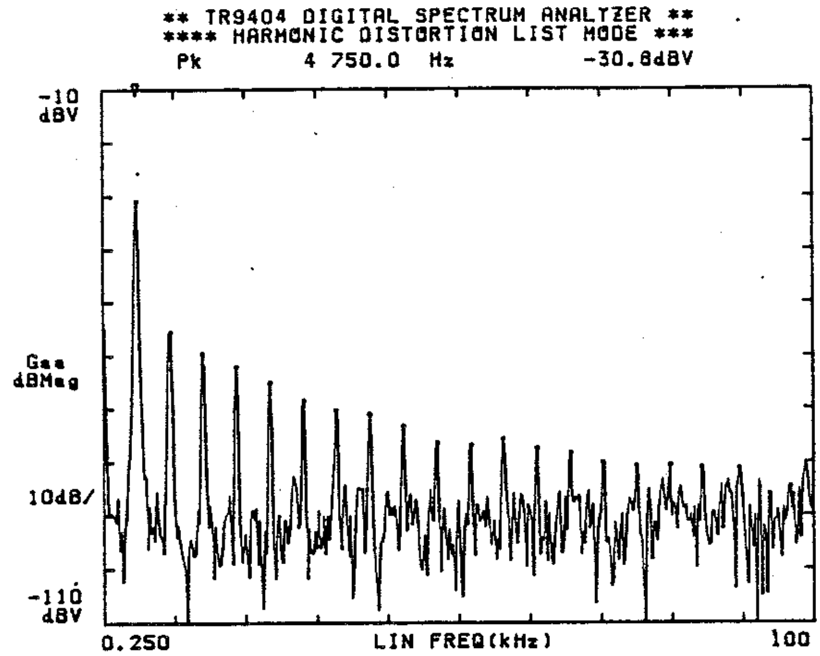
20 data are selected with the SET REF switch and their frequencies and levels are listed.

Fig. 4-41 Single List mode display example

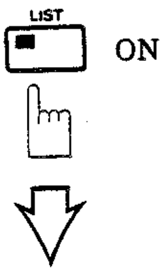
```
** TR9404 DIGITAL SPECTRUM ANALYZER **

****     HARMONIC LIST MODE          ****
                            SPECTRUM
               FREQUENCY     Phase
                        Hz            deg
FUNDAMENTAL     5 000.0          -40.1
HARMONICS  2    9 750.0          -17.8
           3   15 250.0          -70.8
           4   20 500.0          -43.2
           5   25 250.0          159.0
           6   30 000.0           90.0
           7   34 250.0         -128.0
           8   39 500.0         -155.9
           9   46 250.0          -90.0
          10   48 750.0          129.1
          11   53 750.0          -93.8
          12   58 750.0         -153.8
          13   63 500.0          -98.4
          14   71 750.0          -99.7
          15   76 750.0           11.7
          16   82 000.0           43.1
          17   83 750.0          -53.1
          18   89 500.0          107.4
          19   94 500.0          132.6
          20   98 000.0       UNDEFINED
```

Harmonics are determined with the fundamental wave of 5 kHz and phase information for each harmonic is listed.

Fig. 4-42 Harmonic List mode display example



With the spectrum at 4.75 kHz defined as the fundamental, harmonics up to the 20th number are searched for and intensified.



** TR9404 DIGITAL SPECTRUM ANALYZER **
**** HARMONIC DISTORTION LIST MODE ***

		Hz	dBV	
FUNDAMENTAL		4 750.0	-30.8	
HARMONICS			DELTA dBR	DIST. %
	2	9 500.0	-24.6	5.906
	3	14 000.0	-28.7	3.662
	4	18 750.0	-31.3	2.723
	5	23 500.0	-34.2	1.940
	6	28 250.0	-37.5	1.334
	7	32 750.0	-39.4	1.074
	8	37 500.0	-40.1	0.983
	9	42 250.0	-42.4	0.760
	10	47 000.0	-45.6	0.527
	11	51 750.0	-46.0	0.499
	12	56 250.0	-44.9	0.570
	13	61 000.0	-46.8	0.466
	14	65 750.0	-47.5	0.421
	15	70 250.0	-49.2	0.345
	16	75 000.0	-49.9	0.318
	17	79 750.0	-49.7	0.326
	18	84 250.0	-50.2	0.309
	19	89 500.0	-50.4	0.302
	20	96 750.0	-53.8	0.204

TOTAL HARMONIC RMS : HANNING -52.6 dBV
TOTAL HARMONIC DISTORTION 8.105 %

This example lists the fundamental frequency & its level, harmonic number & its frequency, difference of level from that of the fundamental, distortion ratios, total harmonic rms and total harmonic distortion.

Fig. 4-43 Harmonic Distortion List mode display examples

*** TR9404 DIGITAL SPECTRUM ANALYZER **

**** NYQUIST LIST MODE ****

	FREQUENCY Hz	SPECTRUM Real V	Imag V
FUNDAMENTAL	4 750.0	-2.32E-02	1.65E-02
HARMONICS 2	9 500.0	1.24E-04	8.54E-04
3	14 000.0	-2.86E-04	-1.89E-04
4	18 750.0	-1.75E-04	4.39E-05
5	23 500.0	-5.34E-05	1.09E-04
6	28 250.0	4.77E-06	8.49E-05
7	32 750.0	-4.48E-05	-4.39E-05
8	37 250.0	5.63E-05	1.43E-05
9	42 250.0	-5.25E-05	5.05E-05
10	47 750.0	-2.96E-05	4.20E-05
11	50 750.0	2.29E-05	5.63E-05
12	58 250.0	-0.00E+00	5.53E-05
13	63 000.0	-2.77E-05	-5.34E-05
14	66 500.0	-4.39E-05	-1.62E-05
15	73 250.0	-4.20E-05	-4.39E-05
16	74 000.0	-4.20E-05	6.01E-05
17	82 250.0	5.91E-05	0.00E+00
18	87 750.0	-6.01E-05	1.72E-05
19	91 750.0	6.48E-05	-4.67E-05
20	93 750.0	-8.58E-05	1.72E-05

Listing of the spectra specified with the SET REF key, in which real and imaginary parts of spectra are coupled.

*** TR9404 DIGITAL SPECTRUM ANALYZER **

NYQUIST LIST MODE(TRANS.FCTN MAG-PHASE)

	FREQUENCY Hz	TRANS FCTN dBMag dB	Phase deg
FUNDAMENTAL	4 750.0	-72.0	-164.9
HARMONICS 2	9 500.0	-38.9	-156.2
3	14 750.0	-7.4	60.0
4	19 250.0	2.8	45.1
5	24 250.0	-1.3	-68.9
6	28 500.0	-4.1	42.5
7	34 000.0	-2.2	134.9
8	38 500.0	-8.5	-22.5
9	44 000.0	-1.8	151.0
10	48 750.0	-2.5	-52.2
11	51 250.0	-6.8	-6.5
12	57 750.0	1.6	55.7
13	61 750.0	-0.0	114.9
14	67 500.0	-1.2	-53.8
15	69 750.0	4.7	-18.8
16	77 500.0	-4.5	45.0
17	81 250.0	-2.3	21.7
18	84 250.0	-0.7	92.3
19	88 250.0	-3.9	-79.1
20	97 250.0	-1.7	161.8

"MAG.-PHASE" Nyquist list mode obtained in transfer function. Magnitudes and phases of the harmonics up to the 20th number are listed based on the 4.75 kHz fundamental frequency.

Fig. 4-44 Nyquist List mode display examples

4-4-5. SETUP Section

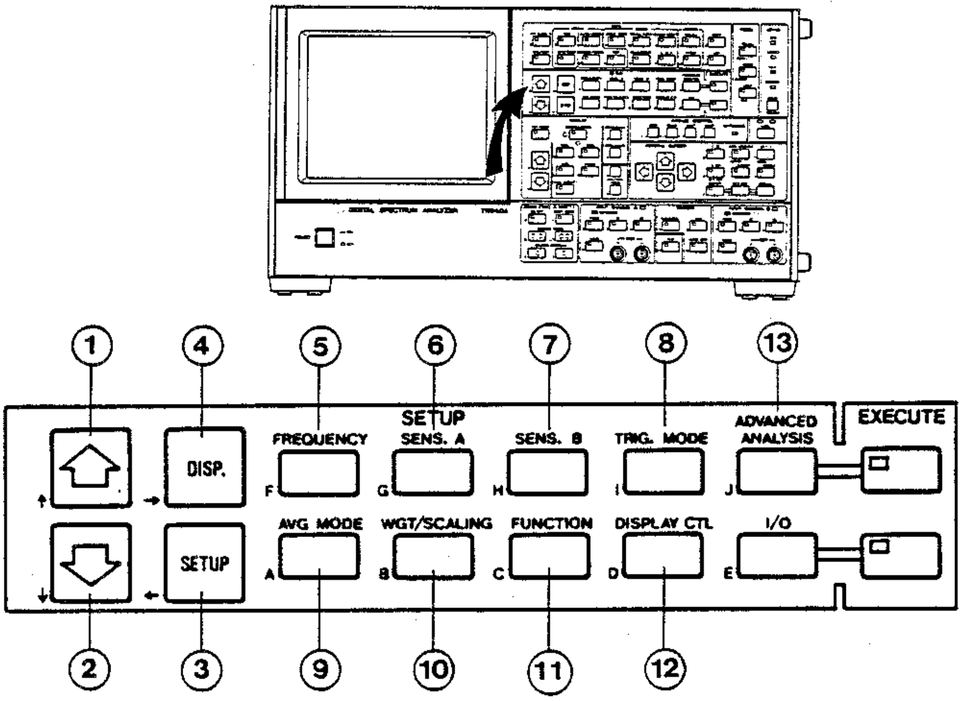


Fig. 4-45 SETUP section panel

Control keys in the SETUP section are used to set up the following ten functions with the ⇧ or ⇩ key, DISP. (Display) key, and SETUP key while referring to the menu shown in the right display area in dialogue manner:

- FREQUENCY (Frequency range for analysis)
- SENS. A (Input sensitivity range for channel A)
- SENS. B (Input sensitivity range for channel B)
- TRIG. MODE (Trigger mode)
- ADVANCED ANALYSIS (Octave analysis and 3-D display; See SECTION 7)
- AVG MODE (Average mode)
- WGT/SCALING (Weighting & Scaling)
- FUNCTION (Function setup)
- DISPLAY CTL (Display Control condition)
- I/O (I/O device attachment setup; See SECTION 6)

Setup Procedure:

Press the desired function key out of the above ten keys to show the pertinent function menu in the right display area on the CRT. If, at this time, the [LIST] key in the VIEW section has been activated for the LIST mode, the LIST mode is cleared and the signal shown before the LIST mode was entered is again displayed along with the selected function menu.

If the Upscaling mode is selected with the [UPSCALING] key in the DISPLAY section, operation of any of the SETUP section will clear the Upscaling mode.

When the desired menu is displayed, use the [⇧] or [⇩] key to position the pointer (⇨) to the desired setup item in the menu. The pointer can be moved one step with each press of the [⇧] or [⇩] key; if the key remains being pressed, the pointer moves continuously.

After the pointer is positioned to the desired item, press the [SETUP] key. This will cause a setup mark (#) to appear on the right hand side of the selected item to indicate that the pertinent function has been set up. However, some menus require only pointer movement operation to complete setup (require no operation of the [SETUP] key) (e.g. frequency range menu, input sensitivity menu, etc.), or some other menus have a pointer which blinks before setup (averaging repetitions, average mode, trigger level, trigger position, and some other menus). The latter type of menus requires operation of the [DISP.] or [SETUP] key for cyclic setup of parameters. For more details see the descriptions for each menu.

① ② $\boxed{\Uparrow}$ and $\boxed{\Downarrow}$ keys

These keys are used to move the pointer (⇨) shown on the left hand side of each menu. The pointer moves one step at a time; it moves continuously while the key is being pressed. If the $\boxed{\Downarrow}$ key is pressed when the pointer is at the bottom of a menu, it is repositioned to the top of the menu; if the $\boxed{\Uparrow}$ key is pressed when the pointer is at the top of a menu, it is repositioned to the bottom of the menu. For the frequency and input sensitivity menus, however, the pointer won't move from the bottom of the menu if the $\boxed{\Downarrow}$ key is operated.

③ SETUP key

This key is used to effectuate the conditional item selected with the pointer (⇨). When this key is pressed, a setup mark (#) appears at the selected item. If the pointer is flashing at an item, operation of $\boxed{\text{SETUP}}$ key cyclically exhibits the subitems for the selected item.

④ DISP. (Display) key

Operation of this key lists the setup conditions in the right annotation area on the display (see Figure 4-46). When in the Dual Display mode, conditions selected (from the menu) for upper and lower display information are listed in this area. In this case, the condition items for lower display information are identified by "◆" preceding each items, and those for upper display information are identified by "◇" also preceding each item. Each time $\boxed{\text{DISP.}}$ key is pressed, the conditional items listed in Figure 4-47 (a) and those listed in Figure 4-47 (b) are displayed alternately.

Figure 4-47 (a) shows a listing of conditions selected from different menus for the current display. For instantaneous data, the contents of this listing are automatically modified when setup conditions for individual menus are changed. For averaged data or data held in the buffer memory, the listing shows the conditions at the start of averaging or conditions before data is stored into the buffer.

The listing shown in Figure 4-47 (b) provides conditions selected from each menu, with coherence blanking level, data window step span, and time delay (τ) setups. Out of those features, the INTERCHANNEL DELAY, INTEGRAL & DIFFERENTIAL, and FUNCTION represent the setup conditions and values currently shown on the display. For averaged data or data held in the buffer memory, the listing shows the conditions at the start of averaging or data being stored into the buffer. The STEP (D. WINDOW), COH BLANK, and OVERLAP items in the listing represent currently setup values and the result of overlapped averaging. The pointer (⇨), if placed to such items as number of averages, averaging modes, trigger level and trigger position, begins to blink, demonstrating that the DISP. or SETUP keys can be used to change setup conditions. So when listing the setup conditions, be sure to position the pointer to an item where the pointer does not blink, before pressing DISP. key.

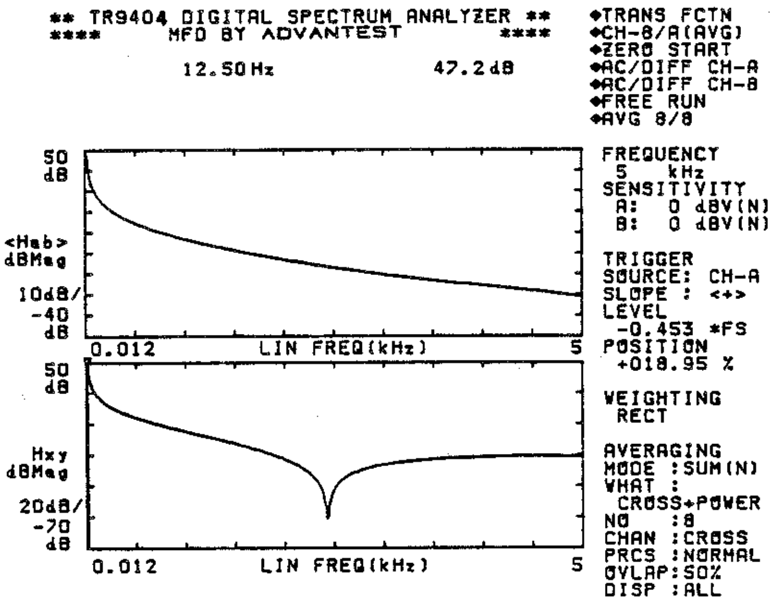


Fig. 4-46 DISP mode condition listing example

◇ Upper display

◆ Lower display

◆TRANS FCTN ◆CH-B/A <AVG>	VIEW mode
◆ZERO START	Zero start mode or zooming mode
◆AC/-GND CH-A ◆AC/-GND CH-B	Input coupling (for CH.A and CH.B in CROSS mode)
◆FREE RUN	Trigger mode
◆AVG 16/16	Averaging times (present number/set number)
FREQUENCY 20 kHz	Frequency analysis range
SENSITIVITY	Input sensitivity range
A: +10dBV <MAN>	CH.A input sensitivity range
B: -10dBV <AUTO>	CH.B input sensitivity range
TRIGGER	Trigger condition
SOURCE: CH-A	Trigger source
SLOPE : <+>	Trigger slope
LEVEL +0.250 %FS	Trigger level (in % with respect to fullscale)
POSITION +603.32 %	Trigger position
WEIGHTING RECT	Weighting function
	A-WGT: ON → OFF is displayed on 1/1- and 1/3-octave analysis on this blank line.
AVERAGING MODE : SUM <N>	Averaging mode
WHAT : CROSS+POWER	Averaging type
NO : 16	Averaging number
CHAN : CROSS	Averaging channel
PRCS : SWEEP	Averaging process
OVLAP: 0 %	Average overlap
SIGNAL: SWEPT SINE	Type of signals generated by TR98201 Signal Generator (Option 05)

Fig. 4-47 (a) Menu displayed when the DISP. key is pressed (1)

◆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	Time delay between channel A & channel B
INTEGRAL & DIFFERENTIAL	(Integral & differential mode)
A: NORMAL	In Channel A
B: NORMAL	In Channel B
FUNCTION	Math operation mode
NO-OPERATION	
STEP <D. WINDOW> 42/1024	Data window step factor
COH BLANK 0.82	Coherence blank level
OVERLAP	Average overlap
0%: 0/0	0% overlap rate for averaging number
50%: 0/0	50% overlap rate for averaging number

Fig. 4-47 (b) Menu displayed when the DISP. key is pressed (2)

⑤ FREQUENCY key

Operation of this key shows a frequency range menu (see Figure 4-48) in the right display area on the CRT.

Items "INT" and "EXT" under "SAMP CLK" in the menu allow sampling clock either to be internally set according to the selected frequency range or to be fed from an external clock source (through the rear EXT. SAMPLE connector). Selection between INT and EXT is accomplished with the SETUP key alternately regardless of the pointer (⇨) location.

When an internal ("INT") sampling clock is used, the setup mark (#) on the right hand side of a menu moves with the pointer while the ⇧ or ⇩ key is operated. This means that condition setup is completed only by pointer movement operations using the ⇧ or ⇩ key.

Note that operation of the SETUP key reverses the INT/EXT selection state.

Once a frequency range is set up, an antialiasing filter is automatically selected according to the selected frequency range, together with an internal sampling clock.

When the EXT clock mode is selected, the frequency range (fullscale frequency of the display) is 1/2.56 times the external sampling clock frequency. For example, if an external sampling clock frequency is 256 kHz, then the fullscale frequency range of the display is 100 kHz. At this time, frequency axis and readout on the display have the percent (%) unit with the fullscale frequency range defined as 100 %.

The cutoff frequency of the internal antialiasing filters can be selected as the frequency range is set up with the ⇧ or ⇩ key in the EXT mode. Select the most appropriate cutoff frequency for the antialiasing filters while taking into account the external sampling clock frequency or input signal's frequency distribution. For frequency ranges of 1 Hz to 10 Hz, the antialiasing filters have a cutoff frequency of 20 Hz.

A typical antialiasing filter response on the TR9404 is shown in Figure 4-49.

Fig. 4-48 FREQUENCY range menu

```
FREQ  RANGE
SAMP  CLK
  INT           #
  EXT

⇨ 100    kHz    #
  50
  20
  10
  5
  2
  1
  500     Hz
  200
  100
  50
  20
  10
  5
  2
  1

FRAME  TIME
   4   mSEC
```

Select this to sample data using an internal clock (this is the normal mode of operation).

Select this to apply an external sampling clock via the EXT. SAMPLE terminal on the rear panel. (Used for order analysis or sampling data in synchronism with rotation of external object)

Setting marks, ⇨ and #, move together. Note that, if the SETUP switch is used for range setting, setup of INT and EXT for SAMP CLK is reversed.

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.

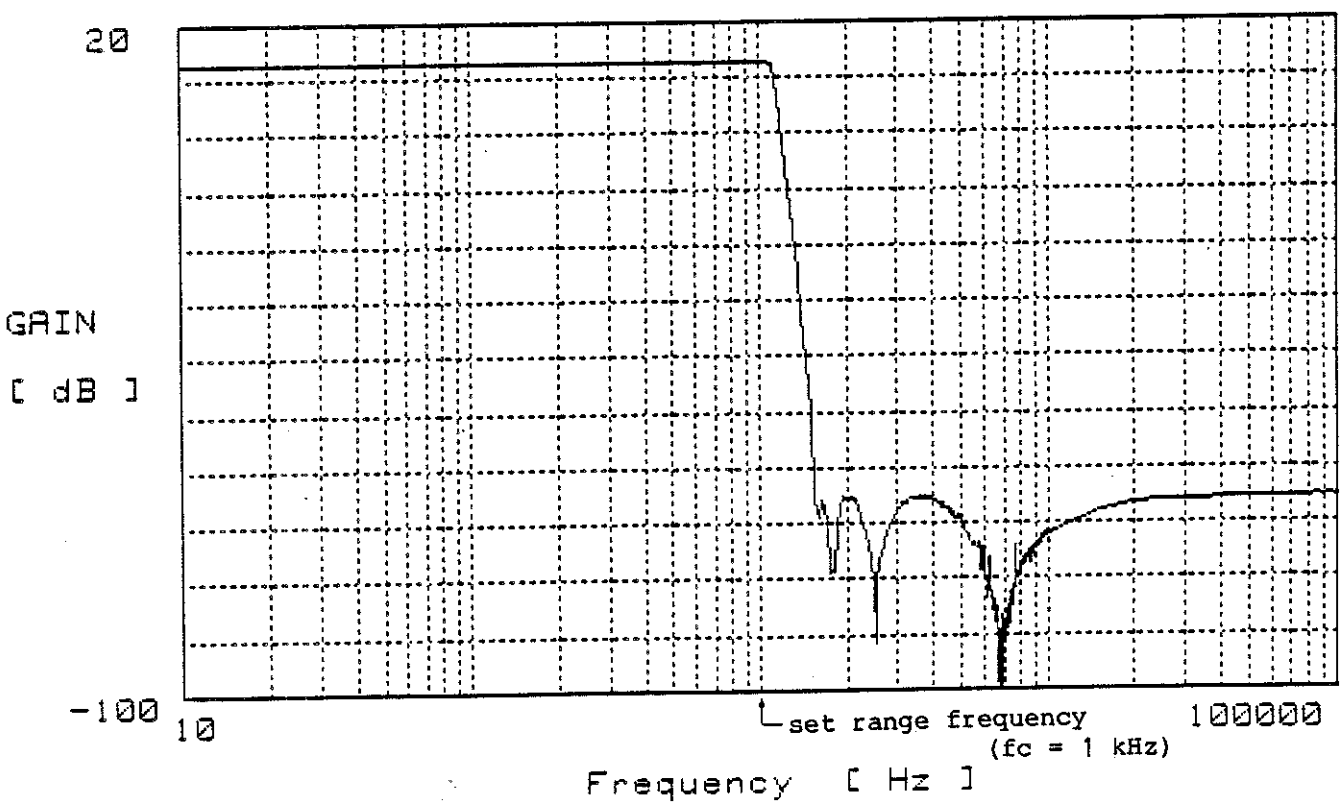


Fig. 4-49 Typical antialiasing filter response on the TR9404

⑥, ⑦ SENS. A and SENS. B keys (input sensitivity setup keys)

Operation of these keys display an input sensitivity range menu as shown in Figure 4-50 in the right display area on the CRT. The menu covers a sensitivity range from +30 dBV (+44.7 V peak) to -60 dBV (±1.41 mV peak) in ten steps, with 1 Vrms defined as 0 dBV.

SENS. A $\boxed{}$ is for channel A, and SENS. B $\boxed{}$ is for channel B. Handling of the menus is identical for both channels. If SENS. A $\boxed{}$ is pressed when data on channel B is shown on the display (lower data in the DUAL display mode), the data is replaced with that on channel A (lamp within CH. A/CH. B $\boxed{\square}$ key comes on). Similarly, if SENS. B $\boxed{}$ is pressed when data on channel A is displayed, the data is replaced with that on channel B (lamp within CH. A/CH. B $\boxed{\blacksquare}$ key goes off).

```
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
```

Maximum input to each channel

If INVERT is set using the SETUP switch, the input signal polarity is inverted. (Ordinarily, NORMAL is selected.)

If ACTIVATE is turned to DEACTIVATE using the pointer and the SETUP switch, only one channel is placed in operation; as a result, the frequency resolution in the channel is doubled. 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.

# indicates the value set for channel B.

Fig. 4-50 SENS. A (SENS. B) menu

Selection between items NORMAL and INVERT is accomplished alternately by operation of SETUP key, without the need for pointer movement operations. If setup is made to the SENS. A menu, character "A" appears on the right hand side of a selected item. If setup is made to the SENS. B menu, mark " " appears on the right hand side of a selected item.

The NORMAL mode maintains the polarity of an input signal as it is during processing, whereas the INVERT mode inverts the polarity of an input signal for later processing.

If the pointer is positioned to item "ACTIVATE" in the menu with ⇧ or ⇩ key and then SETUP key is pressed, the DEACTIVATE mode is entered for the pertinent channel. However, if channel B is already placed in DEACTIVATE mode, this mode is disabled for channel A.

If DEACTIVATE mode is entered on SENS. A menu, all operation to channel A is inhibited, with only channel B left active. At this time, frequency resolution on channel B is doubled (400 lines into 800 lines) and time series data points are increased from 1024 into 2048 points as compared with those for dual channel mode.

Similarly, if DEACTIVATE mode is entered on SENS. B menu, all operation to channel B is inhibited, with only channel A left active and frequency resolution on channel A doubled.

When a cross correlation function is being measured, DEACTIVATE mode setup is inhibited, so both channels remain always active.

To clear the DEACTIVATE mode into ACTIVATE mode, reposition the pointer to item AUTO or any of the sensitivity range items of +30 dBV to -60 dBV.

If either or both of channels A and B is placed in the ACTIVATE mode, the corresponding lamp in the INPUT CHANNEL A and/or INPUT CHANNEL B section comes on. If either of the channels is placed in DEACTIVATE mode, the corresponding lamp goes off and all operation on that channel is inhibited.

Input sensitivity range is automatically selected as the pointer is positioned to the desired sensitivity item in the menu. It should be noted that operation of [SETUP] key reverses the NORMAL/INVERT selection state.

On the SENS. A menu, character "A" appears on the right hand side of a selected range; on the SENS. B menu, mark "#" appears instead of character "A".

If the pointer is positioned to AUTO, the most appropriate range is selected according to input signal level. To clear the AUTO mode, reposition the pointer to any of the range items between +30 dBV and -60 dBV.

The maximum input voltage ranges applicable to channels A and B are indicated at the top of each sensitivity menu. The permissible input voltage ranges for each input sensitivity range are listed in Table 4-3.

Table 4-3 Permissible input voltage ranges vs. sensitivity

Input sensitivity range dBV	rms	Maximum input voltage range V_{p-p}
+30	31.6	±44.7
+20	10	±14.7
+10	3.16	±4.47
0	1	±1.41
-10	316×10^{-3}	$\pm 447 \times 10^{-3}$
-20	100×10^{-3}	$\pm 141 \times 10^{-3}$
-30	31.6×10^{-3}	$\pm 44.7 \times 10^{-3}$
-40	10×10^{-3}	$\pm 14.1 \times 10^{-3}$
-50	3.16×10^{-3}	$\pm 4.47 \times 10^{-3}$
-60	1×10^{-3}	$\pm 1.41 \times 10^{-3}$

8 TRIG. MODE key

Operation of this key shows a trigger mode menu (shown in Figure 4-51) on the right side of the CRT. The ARM and AUTO ARM functions in the TRIGGER section are enabled under the trigger conditions set up in this trigger mode menu. If FREE RUN mode is selected, all trigger mode setup is ignored.

i) Selecting a "TRIGGER SOURCE"

The CH-A, CH-B, and EXT under item SOURCE in the trigger mode menu allows you to select a trigger source from channel A signal, channel B signal, and external trigger signal coupled to the rear EXT. TRIGGER connector. Use the ⇧ or ⇩ key to position the pointer to the desired item (CH-A, CH-B or EXT), then press SETUP key.

```
◆TIME
◆CH-A(INST)
◆ZERO START
◆AC/DIFF
◆FREE RUN
◆AVG 0/0

 TRIGGER
 SOURCE
 ⇒ CH-A      #
   CH-B
   EXT
 SLOPE
   <+>       #
   <->
 LEVEL
   +0.000 *FS
 POSITION
   +300.00 %

 TRIG OUT
   OFF
 MARKER
   OFF

 ARM MODE
   NORMAL    #
   ADVANCE
 ARM LENGTH
   1K
 BLOCK NO.
   0
```

TRIGGER SOURCE: Trigger signal selection (Channel A or B, or the external trigger signal applied to the EXT. TRIGGER terminal on the rear panel.)

SLOPE: Trigger on the leading edge or trailing edge

LEVEL: The trigger level can also be set 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.

TRIG OUT: Setting TRIG OUT to ON gives an audible alarm when triggering is made.

MARKER: Setting MARKER to ON causes the trigger point, if included in the signal, 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 32K word data memory for each channel. For single-channel operation, up to a maximum of 64K words may be set. (If the ARM LENGTH is set to 64K words, the data memory consists of block 0 only.)

BLOCK NO.:

ARM MODE	TRIGGER	Blocks used
NORMAL	ARM	BLOCK 0 only.
	AUTO ARM	Only BLOCK 0 is continuously used.
ADVANCE	ARM	Block set by BLOCK NO.
	AUTO ARM	Blocks are sequentially used from BLOCK 0 to the maximum block number, then the HOLD state is set.

Fig. 4-51 TRIG. MODE menu

ii) Selecting a "TRIGGER SLOPE"

"SLOPE" in the trigger mode menu allows you to select trigger slope with <+> and <->. When positive-going trigger slope is desired, position the pointer to <+>, then press SETUP key. When negative-going trigger slope is desired, reposition the pointer to subitem <->, then press SETUP key.

iii) Selecting "TRIGGER LEVEL"

To select a trigger level, first position the pointer to "LEVEL" in the menu with ⇧ or ⇩ key. The pointer (⇨) will start flashing, indicating that DISP. and SETUP can be used to set up a trigger level. DISP. is used to increment trigger level setup, whereas SETUP is used to decrement trigger level setup. Trigger level can be set up in $\pm 1/128$ resolution. It is directly read out under item LEVEL in the menu in the form of a ratio to the fullscale of the selected input sensitivity range defined as +1.

For example, if the input sensitivity range is selected at 30 dBV ($\pm$44.7 V) and the trigger level readout is +0.516*FS, the actual trigger level is determined as follows:

$$+0.516 \times 44.7 \text{ [V]} \cong +23.1 \text{ V}$$

Both DISP. and SETUP keys have repeating capability: that is, while the key is pressed and held, trigger level setup is incremented or decremented continuously. If trigger level setup reaches the positive fullscale while DISP. key is held down, it goes to the negative fullscale; if trigger level setup reaches the negative fullscale while SETUP key is held down, it goes to the positive fullscale.

iv) Setting "TRIGGER POSITION"

a. General

A trigger position is set to observe the pretrigger waveform. The extent of trigger position that can be set depends on the "ARM LENGTH" value in the "TRIG.MODE" menu.

Data can be written into or read from the specified block if the "ARM LENGTH" and "BLOCK NO." are set and the ARM or AUTO ARM function is executed; execution of the ARM or AUTO ARM function requires the "TRIGGER POSITION" setup. The position is indicated by %. 0% corresponds to delay time 0. When the position is 0%, all the data are post-trigger signals. 100% corresponds to 1K words for dual channel operation and 2K words for a single channel operation. If 32K-word data memory of channel A is divided into four 8K-word blocks as shown in Figure 4-58, the maximum trigger position that can be set for one block is 799.71%, which corresponds (8K - 1) words.

Figure 4-52 shows an example of the trigger position in block 0.

In this figure, data is sequentially written from point A. When data is written to point B, the succeeding data is written at point A again. Thus, a ring buffer is formed as if point B and point A are continuous.

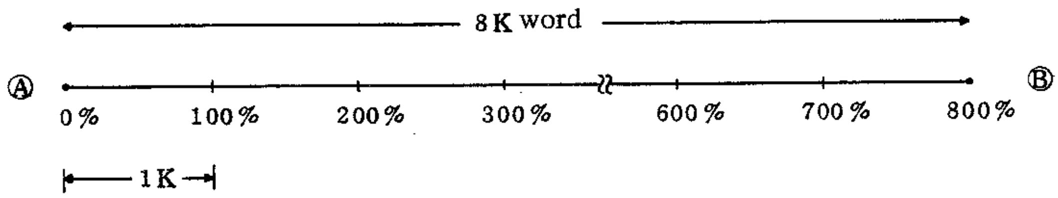


Fig. 4-52 Trigger position of block 0

Table 4-4 lists maximum values of trigger position (%) for each "ARM LENGTH".

Table 4-4 Maximum values of trigger position for each ARM LENGTH

ARM LENGTH	Single channel operation (100% = 2K)	Dual channel operation (100% = 1K)
1K	——	99.71%
2K	99.85%	199.71%
4K	199.85%	399.71%
8K	399.85%	799.71%
16K	799.85%	1599.71%
32K	1599.85%	3199.71%
64K	3199.85%	——

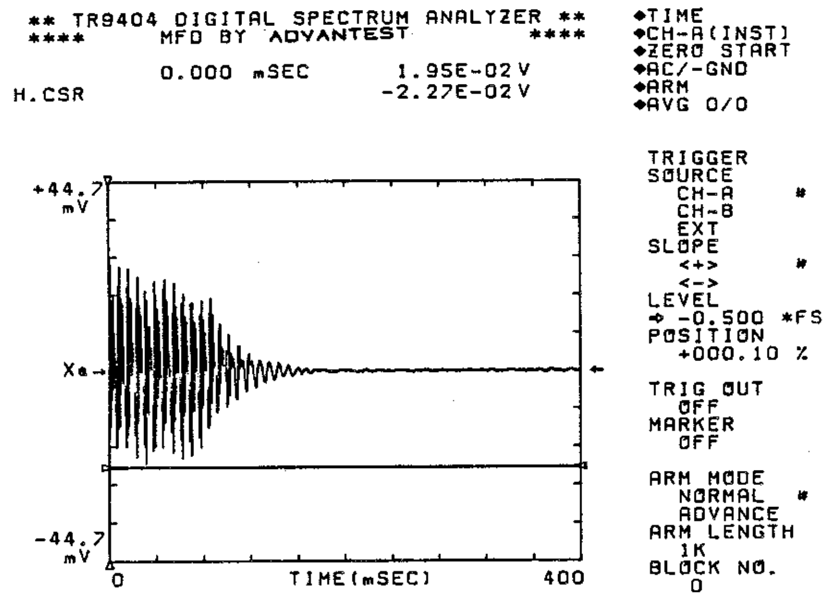
b. Setting trigger position

Move the pointer (⇨) to the "POSITION" with the ⇧ or ⇩ key. The pointer will start flashing, indicating that the DISP. or SETUP key can be used for the trigger position setting. When the "POSITION" is set, the DISP. key is used to increment trigger position value and the SETUP key is used to decrement it. Moreover, a cursor can be used for the trigger position setting (See the explanation of cursor trigger function.)

When averaging in the "AUTO ARM" mode, set the "ARM LENGTH" as follows to reduce the averaging time:

"ARM LENGTH" = 1K (Dual channel operation)

"ARM LENGTH" = 2K (Single channel operation)



Trigger condition

Trigger level: -0.5 x 44.7 mV

$\cong$ -22.4 mV

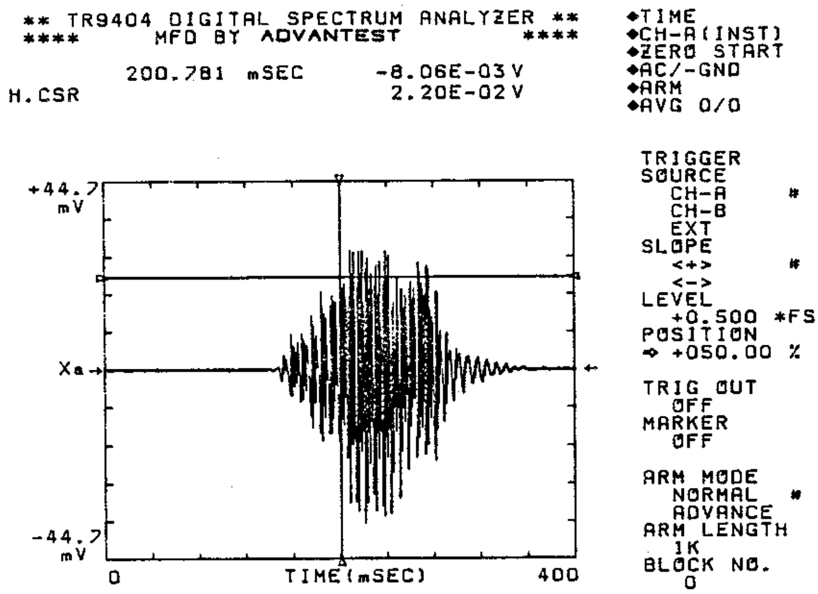
Trigger position: 0%

All data comes past the trigger point

Trigger slope: <+>

On the positive-going edge

(a) Burst sound captured in the AUTO ARM mode under the above trigger condition --- pretrigger information is not known from this data.



Trigger condition

Trigger level: +0.5 x 44.7 mV

$\cong$ +22.4 mV

Trigger position: 50%

Trigger slope: <+>

(b) Burst sound captured under the above trigger condition --- the left half of the data is the post-trigger information.

Fig. 4-53 Examples of trigger level, position, and slope

v) Trigger level and trigger position setup using cursors:

In addition to the techniques described just above, there is another technique for trigger level and trigger position setup. This technique uses the cursor trigger function, in which a trigger level and trigger position are identified by the intersection of two cursor lines (horizontal and vertical cursors) (see Figure 4-54).

Use the following procedure to determine the trigger condition with the cursor lines.

① Display the TIME data by pressing [TIME] in the VIEW section.

② Press [C (↕)] and [C (↔)] in the GENERAL CURSOR section (light on)

③ Move the horizontal cursor with [⇧] [⇩] to the desired trigger level.

④ Move the vertical cursor with [⇦] [⇨] to the desired trigger position.

⑤ Press [SET X] to set up the trigger point at the intersection of cursors.

The following message will blink for a few seconds at the bottom left of the display area:

SET: TRIGGER

If, at this time, the DATA WINDOW key is activated (lamp within the key goes on), the setup trigger position is given by the following formula:

Setup trigger position = data window position + vertical cursor position

When data window is active, the data window automatically moves to the block in which the trigger point is contained, immediately after setup condition data reading is completed. When the vertical cursor is active, the vertical cursor moves to the trigger point. As a result, it is possible to determine what type of input signal is captured by observing time domain data. While the example shown in Figure 4-54 gives 32K words of data (64K words for single channel operation) shown over an absolute time, the time on the display gives relative time within the frame time.

SET X key has many functions depending on the menu currently displayed or on the selected VIEW mode. When setting up a cursor trigger value, the TIME mode must be selected for the VIEW selection and a trigger mode menu must be shown on the display. Once condition setup with SET X key is completed, the VIEW mode and menu may be changed; the trigger level and position being set up remains effective.

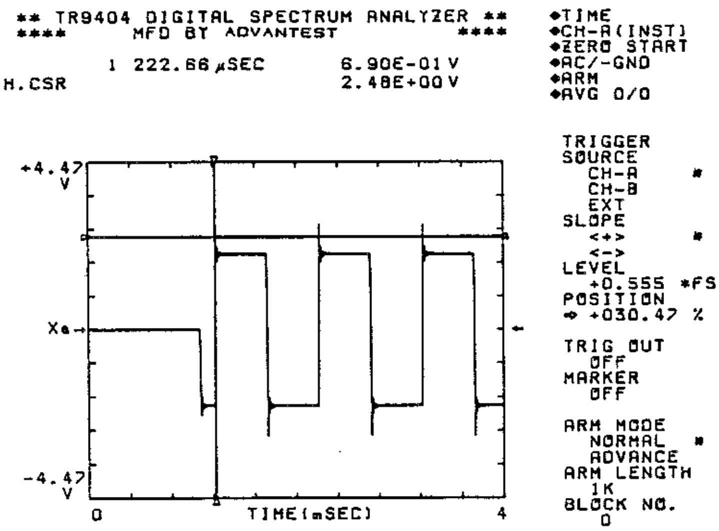
vi) Selection of TRIG OUT

When you wish to observe an event whose occurence is not frequent nor expectable, activate the TRIG OUT item in the trigger menu. Once TRIG OUT is activated, an audible "pip" alarm of one second is issued several times continuously when necessary data reading is completed. If TRIG OUT is deactivated, the audible alarm will not sound even when data reading is completed.

If the TRIG OUT mode is used for transfer function measurement using the impulse as a signal source, you need not constantly observe the signal on the display. You can proceed with averaging with "+1 AVG" after being alerted by the audible "pip" alarm and check the signal on the screen.

vii) Selection of TRIG-MARKER

If the MARKER in the trigger menu is turned ON, the trigger point on the display is intensified if the time signal on the display contains that trigger point. If a block not containing a trigger point is displayed with the Data Window feature, the marker point will not be intensified even when the MARKER item in the menu is activated.



The intersection of the vertical and horizontal cursors is defined as a trigger point. In this example, the trigger slope is positive.

Fig. 4-54 Cursor trigger mode

viii) Selecting the "ARM MODE"

The "ARM MODE" is classified into the "NORMAL MODE" and the "ADVANCE MODE" as shown in the TRIG MODE menu of Figure 4-51. Move the pointer (⇨) to the "NORMAL" or the "ADVANCE" with the ⇧ or ⇩ key, then press the SETUP key.

a. Use of the ARM in the ADVANCE ARM MODE

Simultaneous use of the "ADVANCE ARM MODE" and ARM key allows writing data in the specified blocks (see x) BLOCK NO.). If the data memory is divided into four blocks as shown in Figure 4-58, data is written into the desired block as follows:

① Set the "ARM MODE" to the "ADVANCE".

② Set the "ARM LENGTH" (described later) to 8K.

③ Set the "BLOCK NO." to the number of block to write data. When the "ARM LENGTH" is 8K words, only four blocks are available and settable "BLOCK NO." is limited to 0 through 3.

④ Set the "TRIGGER POSITION".

⑤ Press the ARM key in the TRIGGER section to execute the ARM function.

The HOLD/REL lamp turned on (the HOLD state is on) indicates that data is captured onto the specified block. Thus, data can be written in assigned blocks by repeating the above steps ③, ④, and ⑤. (Step ④ may be omitted if the trigger position need not be changed.)

b. Use of the ARM in the "NORMAL ARM MODE"

When the "NORMAL ARM MODE" is used along with ARM, data is always written in block 0 irrespective of the "BLOCK NO." When the data memory is divided as shown in Figure 4-58, for example, other blocks (blocks 1-3) are not used.

c. Use of the AUTO ARM in the "ADVANCE ARM MODE"

When the "ADVANCE ARM MODE" is used along with the AUTO ARM, adata is always written from block 0 irrespective of "BLOCK NO." up to the maximum block number. When writting data into the maximum block is completed, the AUTO ARM is reset into the HOLD state. Accordingly, if the data memory is divided as shown in Figure 4-58, data such as consecutive transient phenomena can be written in four blocks. (See Figure 4-55.)

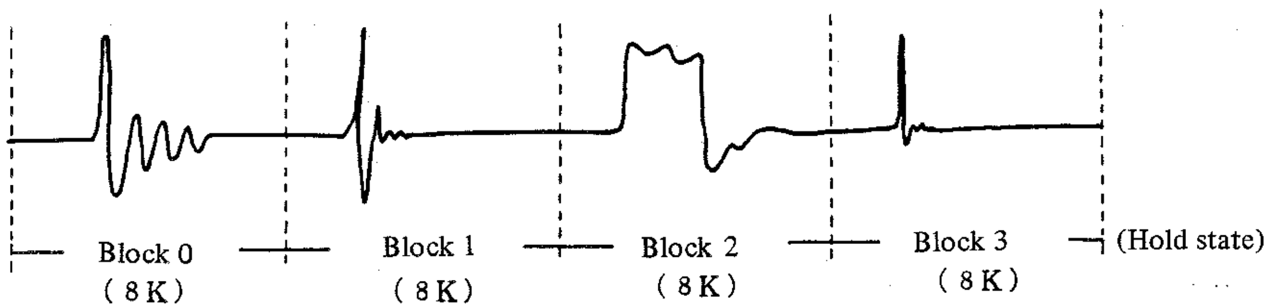


Fig. 4-55 Data when both "ADVANCE ARM MODE" and AUTO ARM are used

d. Use of the AUTO ARM in the "NORMAL ARM MODE"

When the "NORMAL ARM MODE" is used along with the AUTO ARM, data is always written in block 0 irrespective of the "BLOCK NO." When the data memory is divided as shown in Figure 4-58, the other blocks (blocks 1-3) are not used.

Table 4-5 lists the blocks used when the NORMAL (ADVANCE) ARM MODE is used along with the ARM (AUTO ARM).

Table 4-5 Blocks used when the NORMAL (ADVANCE) ARM MODE is used along with the ARM (AUTO ARM)

ARM MODE	TRIGGER	Blocks used
NORMAL	ARM	BLOCK 0 only
	AUTO ARM	Only BLOCK 0 is continuously used.
ADVANCE	ARM	Block set by BLOCK NO.
	AUTO ARM	Blocks are sequentially used from BLOCK 0 to the maximum block number, then the HOLD state is set.

NOTE

Division of data memory by ARM LENGTH and the block designation by BLOCK NO. are invalid in the free-run mode.

In the free-run state, the data memory of all 32K words is used for dual channel operation; the data memory of all 64K words is used for single channel operation.

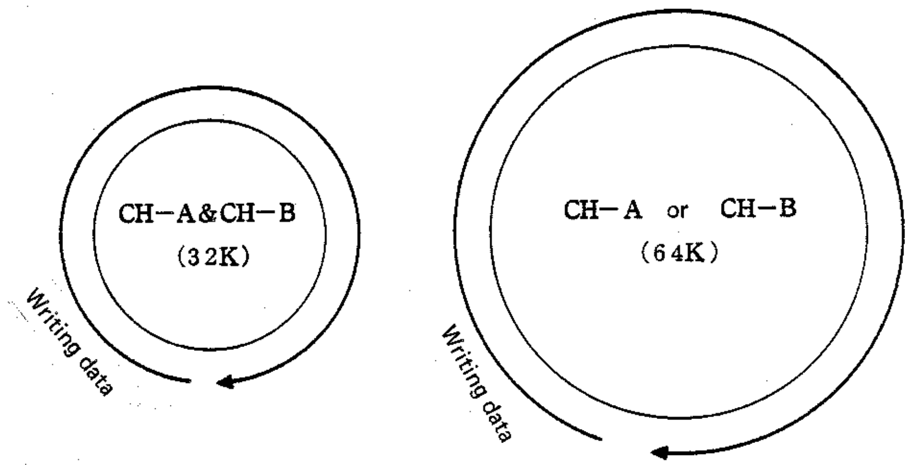


Fig. 4-56 Writing data in free run state

e. Recalling data from the assigned block

Data (1K-word data for dual channel and 2K word for single channel operation) in the assigned block by executing ARM or the AUTO ARM can be recalled and displayed in the time domain. The data read out can be displayed in the frequency or amplitude domain. Data is read from the assigned block as follows:

① Pressing the TRIG. MODE key in the SETUP section will display the trigger mode menu shown in Figure 4-51.

② Move the pointer (⇨) to "ARM MODE" ADVANCE by the ⇧ or ⇩ key, then press the SETUP key.

③ Set the "ARM LENGTH" to the value used when data is captured in the block. If another value is set, data cannot be read properly. For example, when the data memory is divided as shown in Figure 4-58 and data is read, the "ARM LENGTH" must be set to 8K.

Move the pointer (⇨) to the "ARM LENGTH" by the ⇧ or ⇩ key; the pointer will start flashing. Set the "ARM LENGTH" value by the DISP. (or SETUP) key.

4) Set "BLOCK NO." to the number of the block to be read.

Move the pointer (⇨) to the "BLOCK NO." setting position by the ⇧ or ⇩ key; the pointer will start flashing. Press the DISP. (or SETUP) key to set the block number by incrementing (or decrementing) the block number by 1.

5) Press the RECALL key in the PANEL section to recall the data from the specified block. Display of Xa or Xb data (time domain data of channel A or B) on the CRT screen would demonstrate how the data is changing. To read data from another block, execute step 4) and change "BLOCK NO."; the RECALL key need not be pressed. When reading data is completed, a message

"DATA BLK IS RECALLED: 3"

is displayed on the CRT screen to indicate that data was read from specified block No. 3.

NOTE

- Data can be read from the assigned block by executing the above steps (1) to (5) only in the HOLD state. (The status is always in the HOLD mode after the ARM or AUTO ARM function is executed in the ADVANCE ARM mode.) Therefore, in the free-run state, data cannot be read from the specified block.
- Data is written into the desired block using the ARM or AUTO ARM in the ADVANCE ARM MODE. Cancellation of HOLD state to accomplish the free-run mode would destroy all the captured data, and the data cannot be read even if "BLOCK NO." is specified.

f. Reading data from assigned position in block using the DATA WINDOW

To read data from the assigned position in the block, set the "ADVANCE ARM MODE" and "BLOCK NO." in the HOLD state and press the RECALL key in the PANEL section, then use the DATA WINDOW feature. Figure 4-57 shows the example in which the data memory is divided as shown in Figure 4-58 and data is read from block 1.

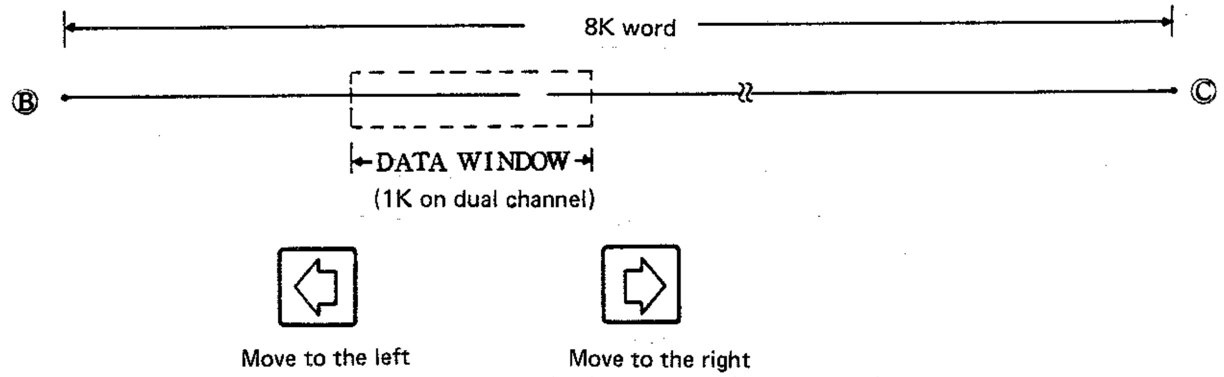


Fig. 4-57 Data window movement in block 1

If data is written by setting "ARM LENGTH" to 8K as shown in Figure 4-57, 1K-word data can be read from the assigned position by moving the data window in the block of 8K-word. See Section 4-4-7 ② and ③, b. "Data Shift in Data Window ON mode" for details using the data window.

ix) "ARM LENGTH"

a. General Description

"ARM LENGTH" designates a unit length by which the data memory is divided. The TR9404 preserves the maximum of 32K word of data memory for each channel in the dual channel mode. In the single channel mode in which either channel A or channel B is DEACTIVATED, the data memory is 64K word length.

The 32K word memory (or 64K word for single channel) can be divided by ARM LENGTH value for use. If the "ARM LENGTH" is set to 2K, for example, the 32K word of memory is divided by 2K word unit into the 16 blocks for each channel (32 blocks for the single channel mode).

b. Setup of "ARM LENGTH"

① Press [TRIG. MODE] in the SETUP section to display the TRIG MODE menu as shown in Figure 5-51.

② Move the pointer (⇨) to the "ARM LENGTH" with [⇧] [⇩] switches in the SETUP section and press [DISP.] (or [SETUP]) switch to set up the value.

The settable values include

1K, 2K, 4K, 8K, 16K, 32K for dual channel mode and

2K, 4K, 8K, 16, 32K, 64K for single channel mode.

x) "BLOCK NO."

a. General Description

The unit length as determined by the above procedure divides the data memory in blocks. "ARM LENGTH" and the available "BLOCK NO." are tabulated in Table 4-6.

Table 4-6 Relation of "ARM LENGTH" and "BLOCK NO."

	Dual channel mode		Single channel mode
Data memory / Arm Length	CH-A (32K)	CH-B (32K)	CH-A or CH-B (64K)
1K	Blocks 0-31	Blocks 0-31	
2K	0-15	0-15	Blocks 0-31
4K	0-7	0-7	0-15
8K	0-3	0-3	0-7
16K	0,1	0,1	0-3
32K	0	0	0,1
64K			0

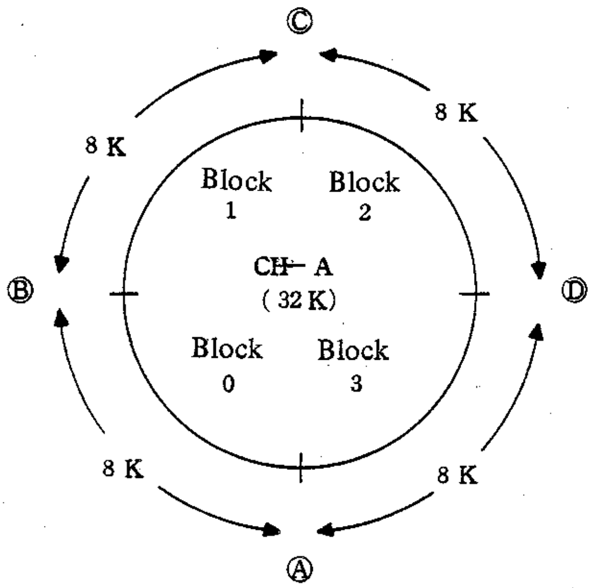


Fig. 4-58 Blocks of 32K word data memory divided by 8K word

Figure 4-58 shows how the 32K data memory of channel A is divided into 4 blocks by the ARM LENGTH of 8K.

b. Setup of BLOCK NO.

Use ⇧ ⇩ switches in the SETUP section to move the pointer (⇨) to the "BLOCK NO." and press DISP. (or SETUP) to increment (or decrement) the BLOCK NO. by one.

⑨ AVG MODE key (averaging condition setup key)

Operation of this key shows an average mode menu (shown in Figure 4-59) on the display. Averaging is executed with the control keys in the AVERAGE CONTROL section under the conditions set up on this menu.

i) Setting up the "AVG MODE"

Averaging mode is selectable from the following six modes. To select one of these modes, position the pointer (⇨) to the desired mode item in the menu, then press SETUP key.

"SUM(N)" (Normalized sum)

"SUM(L)" (Linear sum)

"DIFF" (Differential)

"EXP" (Exponential)

"PEAK" (Maximum peak search)

"SUM(T)" (Correlation data mode)

AVG MODE	
⇨ SUM <N> #	Most commonly used mode. With normalized averaging, accurate data can be read even during averaging.
SUM <L>	Linear summation. An accurate average value cannot be obtained until the preset number of averaging is reached.
DIFF	Difference averaging is used to remove the effects of given spectra (esp. background noise) from the measurements obtained in the SUM mode.
EXP	Exponential averaging. The latest data contributes most and the oldest data least to the average.
PEAK	Peak detection
SUM <T>	Normalized summation of time-domain data; used for correlation data.
AVG WHAT ?	What is to be averaged is selected from 7 categories by DISP or SETUP keys.
CROSS+POWER	
AVG NUMBER	DISP. Key increases the number; SETUP key decreases the number.
2	
AVG CHANNEL	Select the channel in which averaging is to be made.
CH-A	
CH-B	
DUAL	
CROSS #	
AVG PROCESS	
NORMAL #	
+1 AVG	Averaging by monitoring one event at a time with CONT. key.
SWEEP	Sweep averaging allows precise measurement of transmissibility (resonances).
OVERLAP	On a low-frequency band, averaging time can be reduced by setting OVERLAP to 50%.
0 % #	
50%	
DISPLAY	
ALL #	
1/2	
END	

Fig. 4-59 AVG MODE menu

a. "SUM(N)"

This mode allows for averaging in sum mode by the number of repetitions specified under the AVG NUMBER in the menu. The setup number of averaging repetitions and the current averaging repetition count are shown at the top of the AVG MODE menu in the form of a denominator and a numerator respectively. During averaging execution, the IN PROCESS lamp in the AVERAGE CONTROL section illuminates.

Since the SUM mode includes normalizing process in its averaging operation, correct averaged spectrum levels can be read out even in the middle of averaging execution. The total time duration required for averaging is the sum of a frame time and averaging time. For example, if averaging is executed on CROSS + POWER 256 times repeatedly in a frequency range of 100 kHz (frame time: 4 ms), the following duration is needed for averaging:

(4 ms + 290 ms) x 256 = approx. 76 sec. or less

If averaging is executed on CROSS + POWER 256 times in a frequency range of 200 Hz (frame time: 2 sec.), the following duration is required:

(2 sec + 0.29 sec) x 256 = 587 sec. or less

b. "SUM(L)"

Sum mode for spectral information. Unlike the normalized sum in the SUM(N) mode, the SUM(L) mode does not normalize data, so that the accurate averaged data will not be obtained until the setup number of averagings is completed. SUM (L) is 10% faster in its averaging execution than SUM(N) mode, allowing a larger number of averaging executions in unit time.

c. "PEAK"

This mode stores and displays only the peak spectum at each frequency under averaging.

In this mode, averaging is executed up to 8192 times repeatedly regardless of the setup averaging number.

d. "DIFF"

The difference averaging mode substracts a newly averaged spectrum from a stored averaged spectrum (obtained in "SUM" mode).

For example, if it is desired to subtract a certain spectrum from a stored spectrum averaged in "SUM" mode so as to observe the difference signal, switch the averaging mode from "SUM" into "DIFF" under the same averaging number setup, then press the START key in the AVG CONTROL section. At this time, do not press ERASE key.

Subtraction is started immediately and the resulting spectra are sequentially shown on the display, with the current subtraction count and setup number indicated at the top of the menu in the form of a numerator and a denominator respectively.

e. "EXP"

The EXP mode averages spectral data by weighting it in terms of time. In actual operation, weighted new spectral data is added to weighted averaged data according to the setup averaging number. (SUM(N) is executed up to the setup number.)

If the "AVG NUMBER" is set to 64 or more and the START switch in the AVERAGE CONTROL section is pressed in the "EXP" mode, "AVG NUMBER" is automatically set to 32 and then executed.

$$\frac{K-1}{K}\underbrace{\langle D(N-1)\rangle}_{\text{Averaged data}} + \frac{1}{K}\underbrace{D(N)}_{\text{New data}}$$

where K = AVG number

If K = 2, AVG : NEW = 1 : 1

If K = 4, AVG : NEW = 3 : 1

If K = 8, AVG : NEW = 7 : 1

As a result, the latest 400-point data is weighted most heavily, and as the data is older, the weight becomes lighter in an exponential manner. The setup AVG NUMBER is equivalent to the RC constant, indicating the averaging number at which the data value reaches 63% of the final value.

f. SUM(T)"

The SUM(T) mode performs normalized sum on cross correlation function data in the time domain. It is automatically set up if the AUTO-CORR or CROSS CORR is selected from the AVG WHAT? menu.

Table 4-7 Relationship between "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: Usable x: Not usable

ii) Averaging type selection using "AVG WHAT?"

As mentioned in Section 3, the averaging function has a significant role in signal analysis. Different analyzing functions require different data domains and averaging types. The "AVG WHAT?" in the AVG MODE menu allows you to select a specific averaging type from the menu.

First, use [⇧] or [⇩] key to position the pointer to "AVG WHAT?" in the menu. The pointer will start blinking, indicating that [DISP.] and [SETUP] keys can be used to select a subitem under the "AVG WHAT?" in the menu.

Each time [DISP.] key is pressed, averaging type subitems "CROSS+POWER", "TIME", "AUTO-CORR", "CROSS-CORR", "HIST", "POWER SPECT", and "COMPLEX SPECT" are sequentially selected. [SETUP] key selects these subitems in the reverse order.

Explanation of these averaging types follows:

a. "CROSS + POWER" averaging < Gab >< Gaa > and < Gbb >

The CROSS + POWER averaging should be selected when measurement is to be performed on any of the following data types which are included within the CROSS demarcation in the VIEW section on the front panel:

TRANS. FCTN: Transfer Function

CROSS SPECT: Cross Spectrum

COHERENCE: Coherent Function

C.O.P.: Coherent Output Power

IMPUL RESP: Impulse Response

The CROSS+POWER averaging can simultaneously provide averaging over cross spectrum and power spectrum on channels A and B.

NOTE

Averaging will be automatically executed in the CROSS+POWER averaging mode if averaging is started when "CROSS" is selected from item AVG CHANNEL in the menu. In the "AVG WHAT?" items other than CROSS + POWER, the item "CROSS", if selected from "AVG CHANNEL", is automatically changed to "DUAL" and the "SWEEP", if selected in the "AVG PROCESS", is automatically changed to "NORMAL".

b. "POWER SPECT" averaging <Gaa><Gbb>

The POWER SPECT averaging should be selected when averaged power spectrum of the input signals on channels A and B is to be measured. Spectra with random frequency components applied to each input are averaged and smoothed.
The result of POWER SPECT averaging has nothing to do with the signal analysis corresponding to the CROSS functions in the VIEW section.

c. "COMPLEX SPECT" averaging <Sa><Sb>

The COMPLEX SPECT averaging is used to average complex spectra of the input signals applied to channels A and B. It allows observation of averaged real and imaginary parts of the spectra. For this reason, they require synchronization in the time domain.
The result of "COMPLEX SPECT" averaging is not related to the CROSS functions in the VIEW section.

d. "TIME" averaging <Xa><Xb>

The TIME averaging averages data in the time domain. It may be useful for improving signal-to-noise ratio of signals buried in noise or extracting one of the two or more signals by taking synchronization with the signal of interest while rejecting the nonsynchronized components.
It should be noted that the spectrum resulting from TIME averaging cannot be viewed in the frequency domain by using the VIEW section functions; use, in this case, COMPLEX SPECT averaging capability.
Automatic synchronization is achieved with the [AUTO ARM] key based on the trigger condition set up by the [TRIG. MODE] and [SET X] keys.

e. "HIST" averaging <Pa><Pb>

The HIST averaging may be used for averaging in the amplitude domain. It can be executed in either the FREE RUN or AUTO ARM mode.

f. "CROSS-CORR" averaging <Rab>

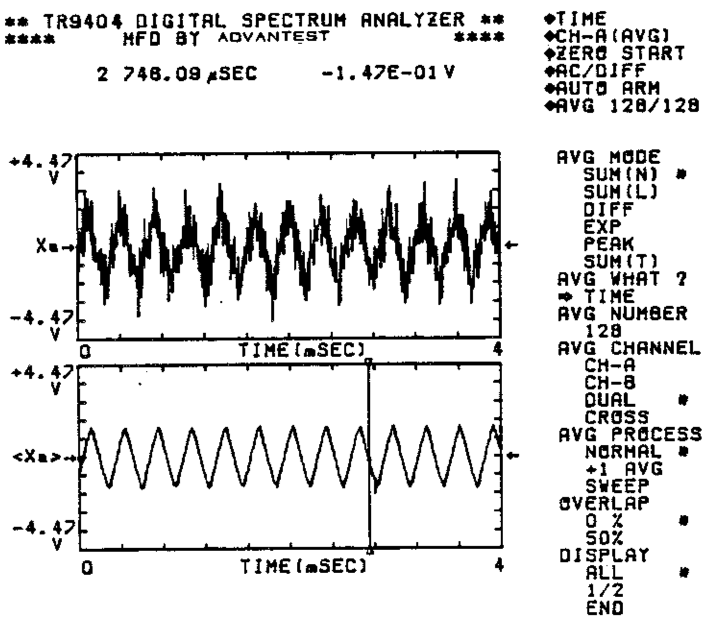
This averaging is used to average cross correlation information.

Set "AVG CHANNEL" to DUAL, CH-A or CH-B.

g. "AUTO-CORR" averaging <Raa><Rbb>

The AUTO-CORR averaging may be selected when auto correlation data is to be averaged.

Autocorrelation data on channels A and B cannot be averaged simultaneously. Set "AVG CHANNEL" to CH-A or CH-B.



Periodical signal component can be extracted from background noise.

Top: Signal is buried in noise

Bottom: Noise is eliminated by 128-time averagings

Fig. 4-60 TIME averaging effect

iii) "AVG NUMBER" selection

The AVG NUMBER item in the menu allows you to select the number of averaging repetitions for the SUM and DIFF modes, and time constant K for the EXP mode. Although the EXP and PEAK modes continuously perform averaging and theoretically have no end to it, the TR9404 automatically stops execution at 8192nd repetition.

To set up an averaging number, first position the pointer (⇨) to AVG NUMBER in the menu. The pointer will start blinking. Each depression of [DISP.] key increments the number of averaging in binary steps (2, 4, 8, 16, and so forth) up to 8192. Each depression of [SETUP] key decrements it in binary steps.

The averaging number setup is shown in the form of a denominator for "AVG (current count)/(setup number)" which is presented at the top of the menu.

When execution of averaging is started by operating START [ ] key in the AVERAGE CONTROL section, the current averaging count is shown as the numerator for the indicator.

For the EXP and PEAK modes, the denominator of the indicator is always 8192.

iv) "AVG CHANNEL" selection

AVG CHANNEL in the menu permits selection of the channel on which averaging is to be made. If "CROSS+POWER" is selected for item "AVG WHAT?", subitem "CROSS" must be selected for AVG CHANNEL. In other words, if averaging is specified for any of the CROSS functions in the VIEW section, AVG CHANNEL selection must always be "CROSS". Actually, if "CROSS+POWER" is selected for "AVG WHAT?", "CROSS" is automatically selected for AVG CHANNEL upon averaging start (mark # is shown beside the CROSS) even if AVG channel selection has been "CH-A", "CH-B" or "DUAL".

For averaging modes other than CROSS+POWER and AUTO-CORR., AVG CHANNEL may be set up for CH-A, CH-B or DUAL.

When averaging is desired for both channels A and B, select DUAL for AVG CHANNEL. When averaging is desired only for channel A or B, select CH-A or CH-B respectively. The "DUAL" mode averaging will take longer time than "CH-A" or "CH-B" mode.

v) AVG PROCESS selection

a. Averaging operation in the NORMAL mode

Usually, is executed in the NORMAL mode. Operation of START key in the AVERAGING CONTROL section starts averaging. Once started, averaging is continued until STOP key is pressed or the preset number of averages is reached.

b. Averaging operation in the "+1 AVG" mode

Averaging in the +1 AVG mode is useful for averaging a single event (impulse, etc.) such as a burst.

Operation of START key in the AVERAGING CONTROL section makes execution of averaging ready (IN PROCESS lamp turns on). Averaging is executed each time you press CONT. key.

c. Averaging operation in the SWEEP mode

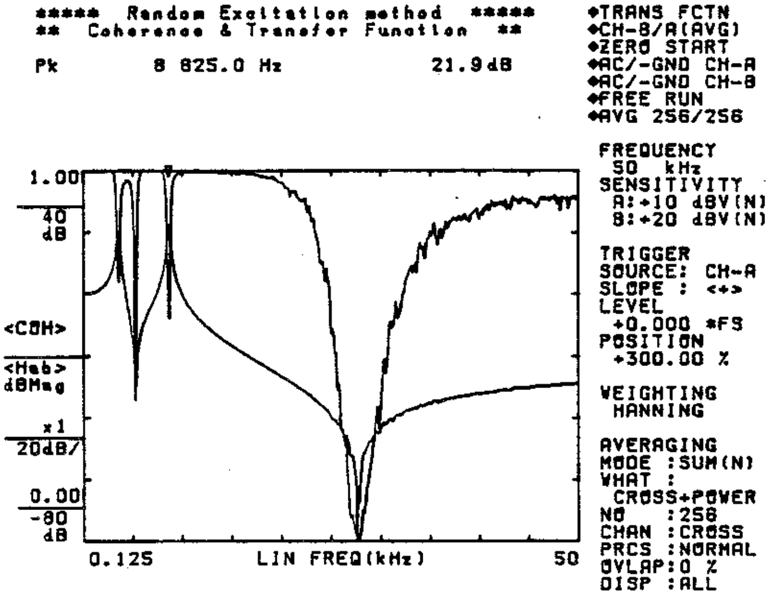
Averaging in the SWEEP mode is useful for precision measurement of transfer functions (resonance, etc.). Since this mode takes a long measurement time, it is recommended that the sweep mode be used only for a particular portion after overall averaging has been performed in the NORMAL mode. If TR98201 Signal Generator (with optional interface 005) is used, it is possible to achieve a relatively fast measurement with precision.

Operation of START key in the AVERAGING CONTROL section automatically selects the CROSS mode for "AVG CHANNEL" and starts averaging in the "CROSS + POWER" mode. Averaging is executed each time peak frequency changes, until STOP key is pressed.

In this mode, the number of averages in progress, indicated by "No. in progress/preset No." at the top right annotation area, is different from the number of averages which have been actually executed. Note that No. in progress indicates the number of executions at a current peak frequency.

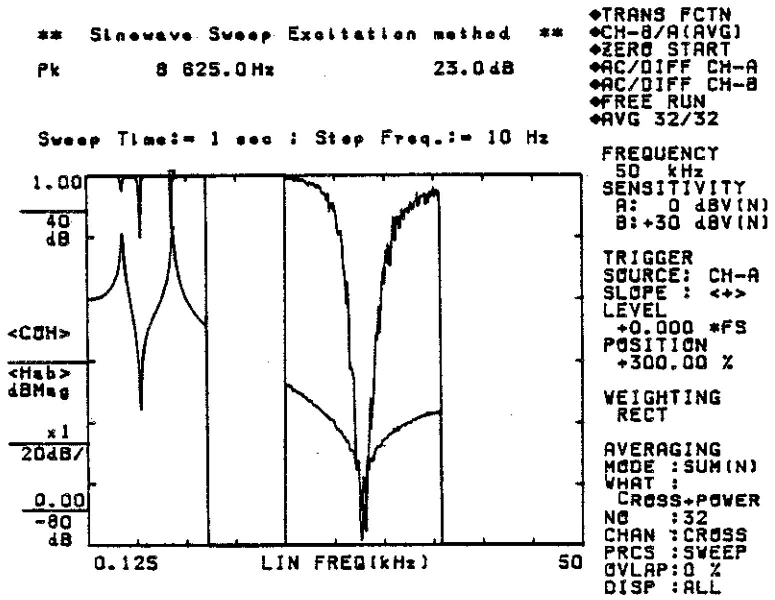
With the GPIB, averaging can be continued by moving to the next peak frequency after the setup number of averages have been executed (see the GPIB application examples). In this case, the readout of the number of averaging is identical to the number of averaging which have actually been executed.

> **NOTE**
>
> In the SWEEP mode of averaging process, use the weighting function of either "RECT" or "HANNING". Use of "FLAT-PASS" will not yield accurate measurement for the signals in the neighborhood of dc.



This example shows a coherence and transfer function obtained as a result of 256 repetitions of averaging, executed in the NORMAL mode.

Fig. 4-61 (a) Transfer function measurement using the random noise method



This example shows a more precise measurement of the coherence and transfer function obtained through 32 repetitions of averaging, made in the SWEEP mode for the section in the vicinity of the resonant point of the above data.

Fig. 4-61 (b) Transfer function measurement example using the sine wave sweep method

vi) Selection of OVERLAP

When a signal with a low frequency is averaged N times in the frequency domain (see Figure 4-62 (a)), the required time for averaging is more than N times the frame time (T) if data is not overlapped (0%) in the time domain. However, if a data overlap of 50% is executed in the time domain ("50%"), the time required for averaging is reduced to approximately one half that with 0% overlap. This means that averaging for low-frequency signal response can be done twice as much with 50% overlap in a fixed time, and hence more precise measurements with smaller dispersion or deviation is possible.

Figure 4-63 (a) shows a transfer function measurement example obtained by averaging, with the overlap set up at 50% at 2 kHz. When DISP. key is pressed twice, the annotation shown on the right-hand side of the same figure appears on the display. The readouts under "OVERLAP" indicate that 57 data have been taken with 50% overlap as a result of 64 repetitions of averaging, but the remaining 7 data have not be read with 50% overlap and taken with 0% overlap.

Figure 4-63 (b) shows a transfer function measurement example obtained by averaging, performed at a high frequency of 50 kHz with "OVERLAP-50%" setup. In this example, 32 out of 64 averagings are failed (data reading with 0% overlap immediately after failure is added to 50% overlapped data). From this information, it can be determined whether the 50% overlap should be used or not in the current analysis range. In the "SWEEP" mode of "AVG PROCESS", execution of averaging in the "50% OVERLAP" yields the peak averaging (asynchronous signals are also averaged) instead of 50% overlapped averaging.

In the following cases, the "OVERLAP-50%" setup is automatically changed into the "OVERLAP-0%" setup:

(1) Averaging performed in the other domains than the frequency's.

(2) Averaging using the ARM or AUTO ARM.

(3) Averaging with the Data Window activated.

(4) AVG PROCESS is set up for +1 AVG.

If data input with 50% overlap has failed more than 7 times consecutively, the following message will flash for a few seconds, at the bottom left on the display:

50% OVERLAP IS NOT AVAILABLE

vii) "DISPLAY" selection

This menu item controls display for signal under averaging and its readout.

If "ALL" is selected, display will be updated upon each execution of averaging.

If "1/2" is selected, display will be updated upon every two repetitions of averaging. If "END" is selected, display will not be updated until all averaging is completed. In any of these cases, the " AVG(avg No.)/(setup No.)" in the top display area is updated upon each averaging execution. When the "CROSS + POWER" averaging type selected, the combination of SUM(L) and END allows for an execution time approximately 20% shorter than combination of SUM(N) and ALL. This means that a larger number of averaging repetitions is possible in a given time with the former combination.

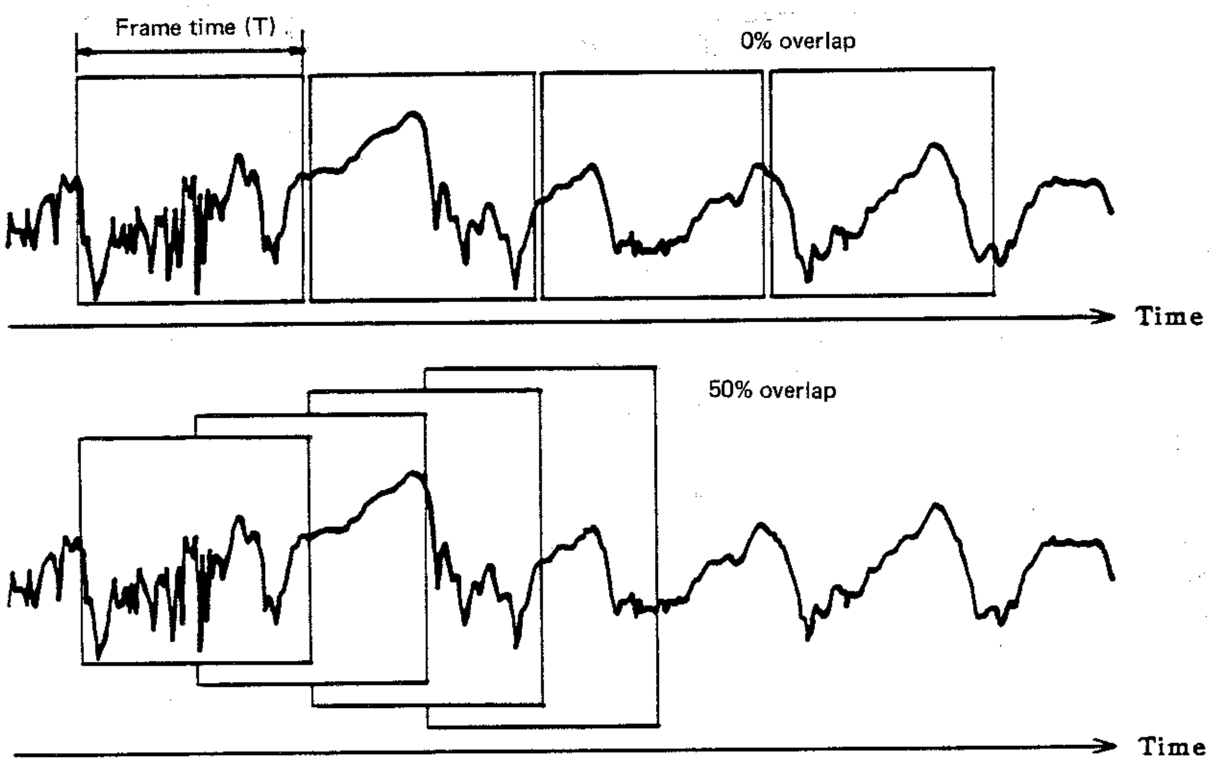


Fig. 4-62 Description of overlap

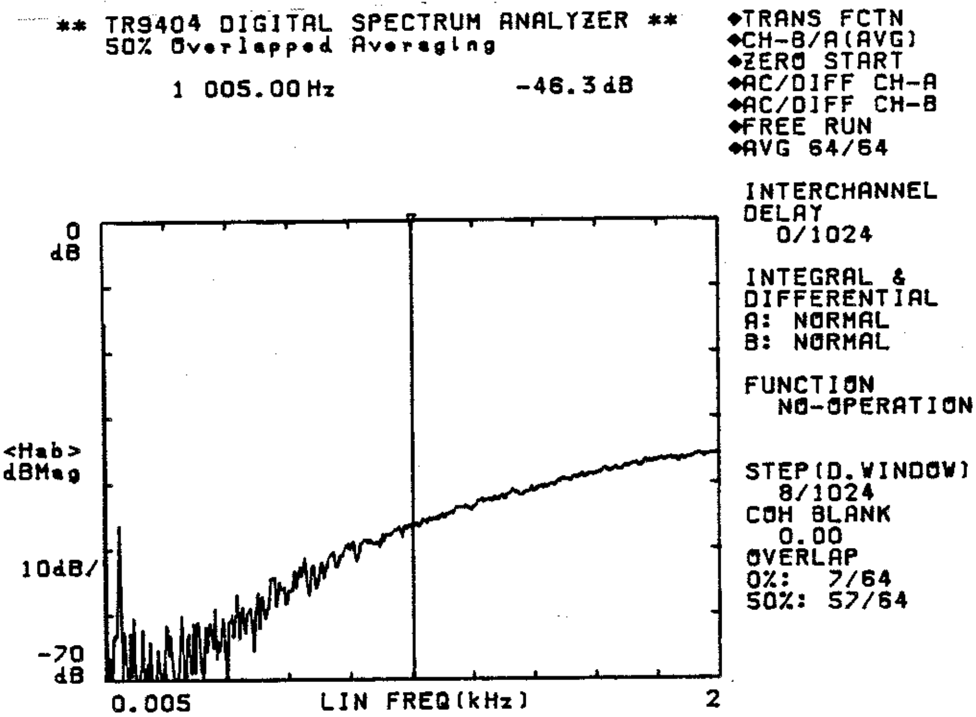


Fig. 4-63 (a) Result of 50% overlapped averaging executed in a lower frequency range

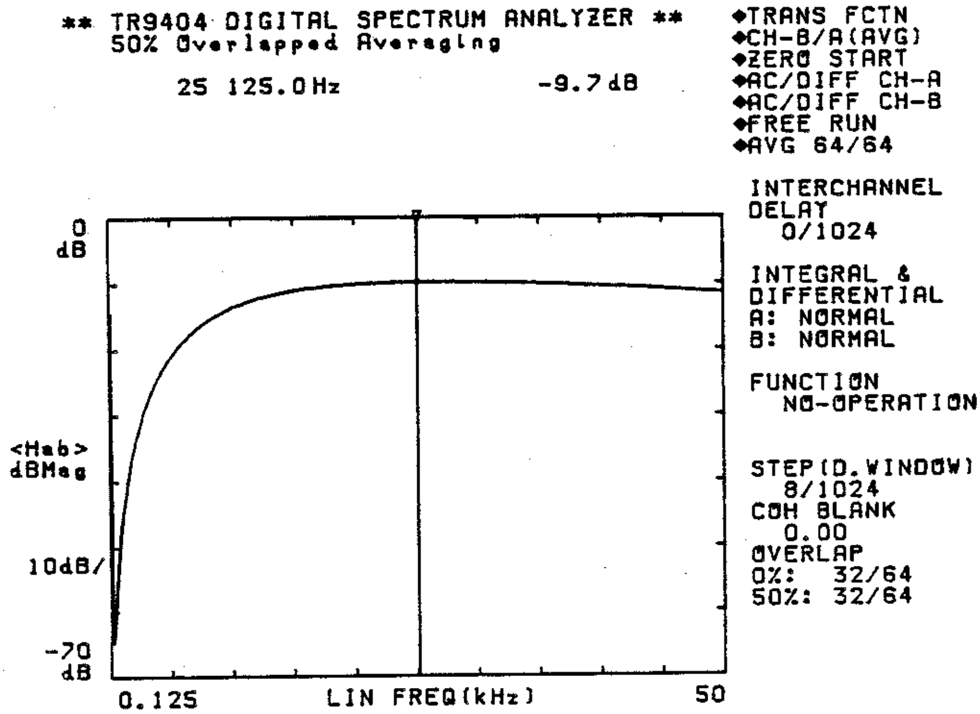


Fig. 4-63 (b) Result of 50% overlapped averaging executed in a higher frequency range

⑩ WGT/SCALING

Operation of this key shows a WGT/SCALING menu (shown in Figure 4-64) on the display. This menu allows to set up a weighting function, frequency scale unit (Hz or CPM), vertical scale unit (voltage or power spectrum density), scaling on/off, and scaling factor.

WEIGHTING
  RECT #
  HANNING
  MINIMUM
  FLAT-PASS
	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.
	RECTANGULAR is mainly used for impulse signal analysis; HANNING is most commonly used for continuous wave analysis; MINIMUM is used to observe a small spectrum adjacent to a continuous wave; FLAT-PASS having the highest amplitude accuracy among all weighting modes is suitable for harmonic analysis.

READ ØUT	

FREQ UNIT
  Hz #
  CPM
	Select either Hz or CPM (cycle per minute) as the frequency axis unit.

VERT UNIT
  NØRMAL #
  PER Hz
	Select either NORMAL for power spectrum or PER Hz for PSD (power spectrum density; power per Hz) as the amplitude unit.

SCALING
⇒ KEY #
  CURSØR
  ØFF
	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.

0 dBEU= 000.0 dBV EU =EU	

Fig. 4-64 WGT/SCALING menu

i) Selection of "WEIGHTING" function

Position the pointer to the pertinent item in the menu with [⇧] or [⇩] key in the SETUP section and press [SETUP] key. While description of weighting function requires mathematical discussion, this paragraph deals only with its basic selecting procedure.

a. "RECT" (Rectangular)

The rectangular function causes no energy loss to sampled data captured in a frame time, and hence is useful for spectral analysis in the cases where the frame time is integral multiple of the time-series data period in question or an impulsive time-series data has the same amplitude at its first and last data points. The rectangular function is, however, not suited to continuous signals which do not meet the condition of this periodicity. This is because discontinuity occurs in signal waveform being truncated by frame time boundaries and the resulting spectra may have extreme side lobes (skirt-like spread of spectrum).

b. "HANNING" (Hanning function)

The Hanning function is most commonly used for observation of continuous waves. Since this function has a high frequency resolution, it is suited for observation of events over the broad spectral ranges. Keep in mind, esp. at high amplitude accuracy measurement, that the amplitude accuracy will be slightly degraded (max. 1.4 dB of error) when the spectrum of interest is off the center of frequency resolution.

c. "MINIMUM" (Minimum function)

The Minimum function is situated in between the Hanning and Flat-Pass functions in terms of its characteristic, and may be used for observation of continuous waves. Its frequency resolution is inferior to the Hanning function but superior to the Flat-Pass function, whereas its amplitude accuracy is superior to the Hanning function but inferior to the Flat-Pass function. The worst-case level error is 0.9 dB.

The Minimum function provides the best sideband shape. It would, therefore, be useful for measurement of correlation between mutually adjacent signal responses (e.g. notch) whose amplitudes differ greatly.

d. "FLAT-PASS" (Flat-Pass function)

The Flat-Pass function is most suited for observation of continuous waves with high amplitude accuracy. The maximum amplitude accuracy is 0.1 dB. This value is, however, concerned only with the weighting function, and in practice, the accuracy is affected with the frequency flatness error generated in the analog system.

Because of its high amplitude accuracy, the Flat-Pass function is especially useful for harmonic analysis.

The drawback of the Flat-Pass function is its relatively poor frequency resolution.

ii) Selection of "FREQ UNIT" (Frequency Unit)

The FREQ UNIT menu allows you to select the frequency scale unit between Hz and CPM.

To select the CPM unit, position the pointer to CPM in the menu with [⇩] or [⇧] key, then press [SETUP] key. This will place the frequency axis annotation in CPM (cycle per minute) and provide frequency readout also in CPM. In the CPM mode as well, the frequency axis can be switched between linear and logarithmic scales with the [LIN./LOG. FREQ.] key in the DISPLAY section.

To return the frequency readout unit into Hz, position the pointer to Hz in the menu, then press [SETUP] key.

iii) Selection of "VERT UNIT" (Vertical Unit)

This arranges the power spectrum display unit for NORMAL (power spectrum) or PER Hz (power spectrum density).

Posititon the pointer to item "PER Hz" in the menu with [⇧] or [⇩] key in the SETUP section, then press [SETUP] key. The amplitude display unit is now switched from NORMAL into PER Hz (power per 1 Hz). The annotation concerning the amplitude axis is also switched into PER Hz including the readout unit.

While the "FREQ UNIT" in the WGT-SCALING menu is set to the CPM mode, selection of PER Hz is inhibited.

To return the amplitude axis readout unit to "NORMAL", position the pointer to item NORMAL, then press [SETUP] key.

iv) Selection of "SCALING"

If [WGT/SCALING] key in the SETUP section is pressed, the display will show either of the two menus depending on whether the display mode of "dBMag" or "Mag, Mag^2" is selected through the DISP CTL menu for the VIEW section function (SPECTRUM, C.O.P., or CROSS SPECT.):

dBMag display mode		Mag, Mag^2 display mode
WEIGHTING		WEIGHTING
RECT #		RECT #
HANNING		HANNING
MINIMUM		MINIMUM
FLAT-PASS		FLAT-PASS
READ ØUT		READ ØUT
FREQ UNIT		FREQ UNIT
Hz #		Hz #
CPM		CPM
VERT UNIT		VERT UNIT
NØRMAL #		NØRMAL #
PER Hz		PER Hz
SCALING		SCALING
⇨ KEY #		⇨ KEY #
CURSØR		CURSØR
ØFF		ØFF
0 dBEU=		1 EU=
000.0 dBV	⇔	0.00E 00Vrms
EU =EU		EU =EU

Fig. 4-65 SCALING selection menu

As shown by Figure 4-65, the SCALING mode includes:

1 "KEY" mode and

2 "CURSOR" mode.

a. KEY mode

The KEY mode may be used for scaling display with 0 [dBEU] (or 1 EU) set up for X [dBV] (or X [Vrms]). However, when specifying the value X, it is restricted as follows:

When setting up 1 EU = X [Vrms]:

$$10^{-12} \leqq X \leqq 10^{12},\ X \neq 0 \text{ ----- } (1)$$

When setting up 0 dBEU = X [dBV]:

$-240 \leqq X \leqq +240$ ------------ (2)

If scaling display is attempted out of the above ranges of X value, the scaling display will not be executed, with the following message shown at the bottom left area on the CRT:

INVALID SCALING FACTOR

b. CURSOR mode

The CURSOR mode may be used for scaling display with the data currently identified by the cursor set up as X [dBEU] (or X [EU]). When specifying the value X, it is restricted as follows:

When setting up CURSOR = X [EU]:

$10^{-12} \leqq 1EU \leqq 10^{12}$, $1EU \neq 0$ ----- (1)

When setting up CURSOR = X [dBEU]:

$-240 \leqq 0dBEU \leqq +240$ ------------ (2)

If scaling display is attempted out of the above value ranges, the scaling display will not be executed, with the following message shown at the bottom left area on the CRT:

INVALID SCALING FACTOR

The scaling is effective only when the SPECTRUM, C.O.P., or CROSS SPECT. is displayed.

NOTE

In the CURSOR mode, use of Flat-Pass is preferable in the WEIGHTING mode for the best amplitude accuracy.

c. Setting up the KEY mode

① Press [WGT/SCALING] key to obtain the SCALING menu on the display. Position the pointer (⇨) to item "KEY" in the menu with ⇩ or ⇧ key in the SETUP section, then press [SETUP] key. The KEY mode is now selected.

② When setting up a 0 dBEU (or 1 EU) value, use ⇩ or ⇧ key to position the pointer to item "0dBEU" in the menu (refer to Figure 4-66), then operate any of the +, -, 0, ..., 9 keys on the front panel. The example in the Figure shows a setup for 0 dBEU= +123.4 dBV. Select the display mode "dBMag" when setting up a "0 dBEU=" value while "Mag" or "Mag^2" should be selected for setting up "1 EU=" value through the DISP CTRL menu with [DISPLAY CTL] key.

```
WEIGHTING
  RECT          #
  HANNING
  MINIMUM
  FLAT-PASS

READ OUT
FREQ UNIT
  Hz            #
  CPM
VERT UNIT
  NORMAL        #
  PER Hz

SCALING
  KEY           #
  CURSOR
  OFF

⇨ 0 dBEU=
 +123.4 dBV
  EU =EU
```

Fig. 4-66 0 dBEU setup

```
WEIGHTING
  RECT          #
  HANNING
  MINIMUM
  FLAT-PASS

READ OUT
FREQ UNIT
  Hz            #
  CPM
VERT UNIT
  NORMAL        #
  PER Hz

SCALING
  KEY           #
  CURSOR
  OFF

  0 dBEU=
 +123.4 dBV
⇨ EU =kg
```

Fig. 4-67 EU setup

③ When setting up an engineering unit EU, position the pointer to item "EU=" in the menu (refer to Figure 4-67), key in the desired engineering unit using front panel keys. Up to two characters out of the following characters are usable for engineering unit setup:

Alphabetic characters (both uppercase and lowercase)

Greek characters (α , β , λ , μ , π , Θ , Ω)

Space

④ Next, position the pointer to item "OFF" in the menu, then press [SETUP] key to switch the item into "ON" mode.

The scaling display in the KEY mode is now executed through the above operations. Figure 4-69 shows a scaling display example, in which "0 dBEU=+123.4 dBEU" and "EU=kg" are set up for the display data shown in Figure 4-68.

d. Setup in the CURSOR mode

① Use [⇧] or [⇩] key in the SETUP section to position the pointer to item "CURSOR" in the menu, then press [SETUP] key to select the CURSOR mode. At this time, mark "#" is positioned at item "CURSOR".

② The menu will show "CURSOR= ____ [dBEU]" or "CURSOR = _ [EU]". Use [⇩] key to position the pointer to "CURSOR=" in the menu, then determine the readout value of the data identified by the cursor by using the numeric data keys (including signs) on the front panel (in the example shown in Figure 4-68, the cursor readout is 10.0 dBV).

③ Key in the appropriate engineering unit for "EU" in the same way as step ③ in KEY mode setup.

④ Enable the scaling mode in the same manner as in the KEY mode setup. Figure 4-70 shows a scaling display example in the CURSOR mode, in which "CURSOR=+123.4 dBEU" and "EU=kg" are set up for the display data shown in Figure 4-68.

PRECAUTIONS FOR SCALING DISPLAY

(1) When changing setup values for "0dBEU=" or "1EU=" or "CURSOR=" after the scaling mode is turned ON, temporarily turn it OFF before keying in new values.
(2) While it is possible to obtain P.S.D. (power spectrum density) display for scaling display, it is not possible to obtain scaling mode display for P.S.D. display.

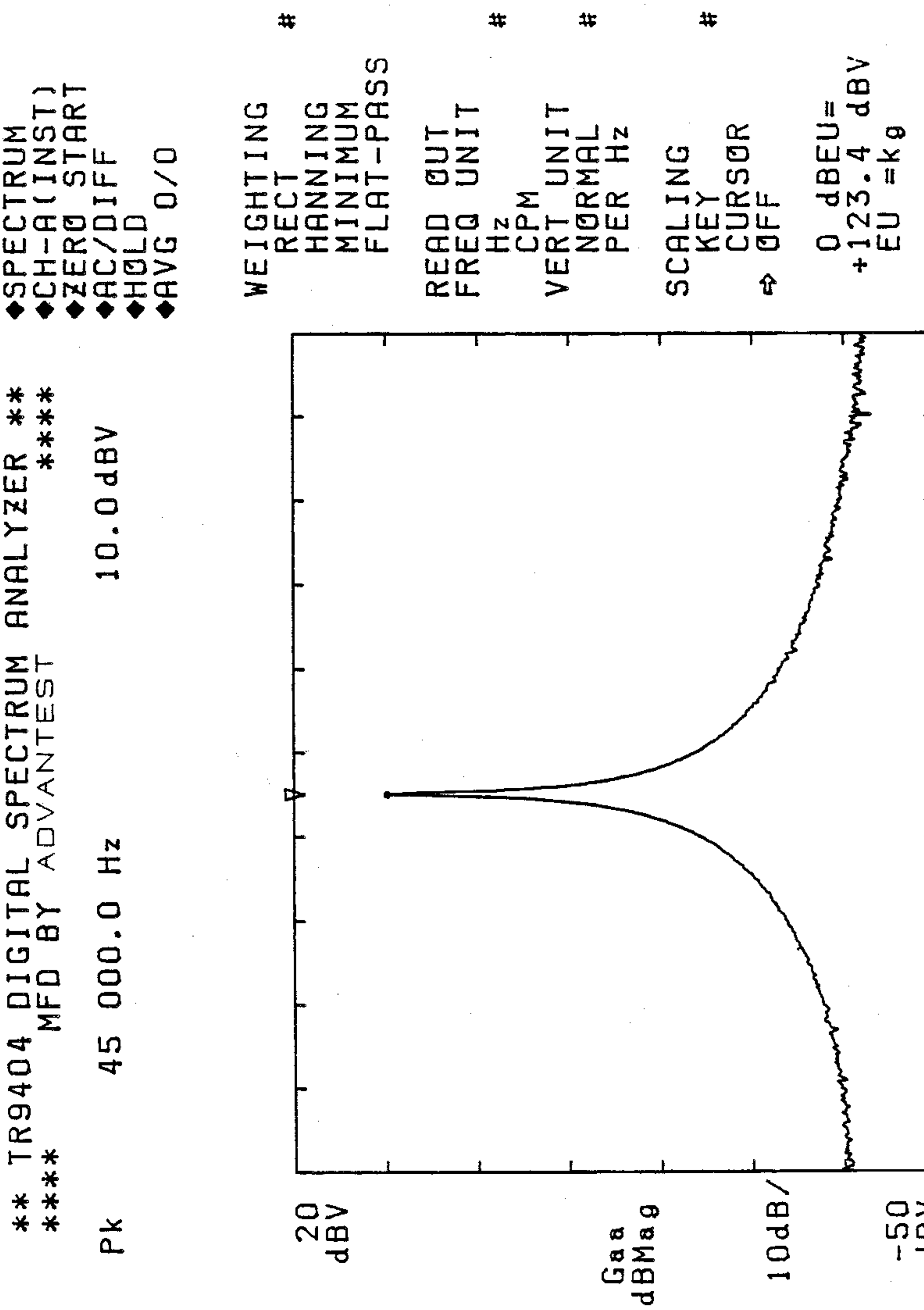


Fig. 4-68 Spectrum display with no scaling mode

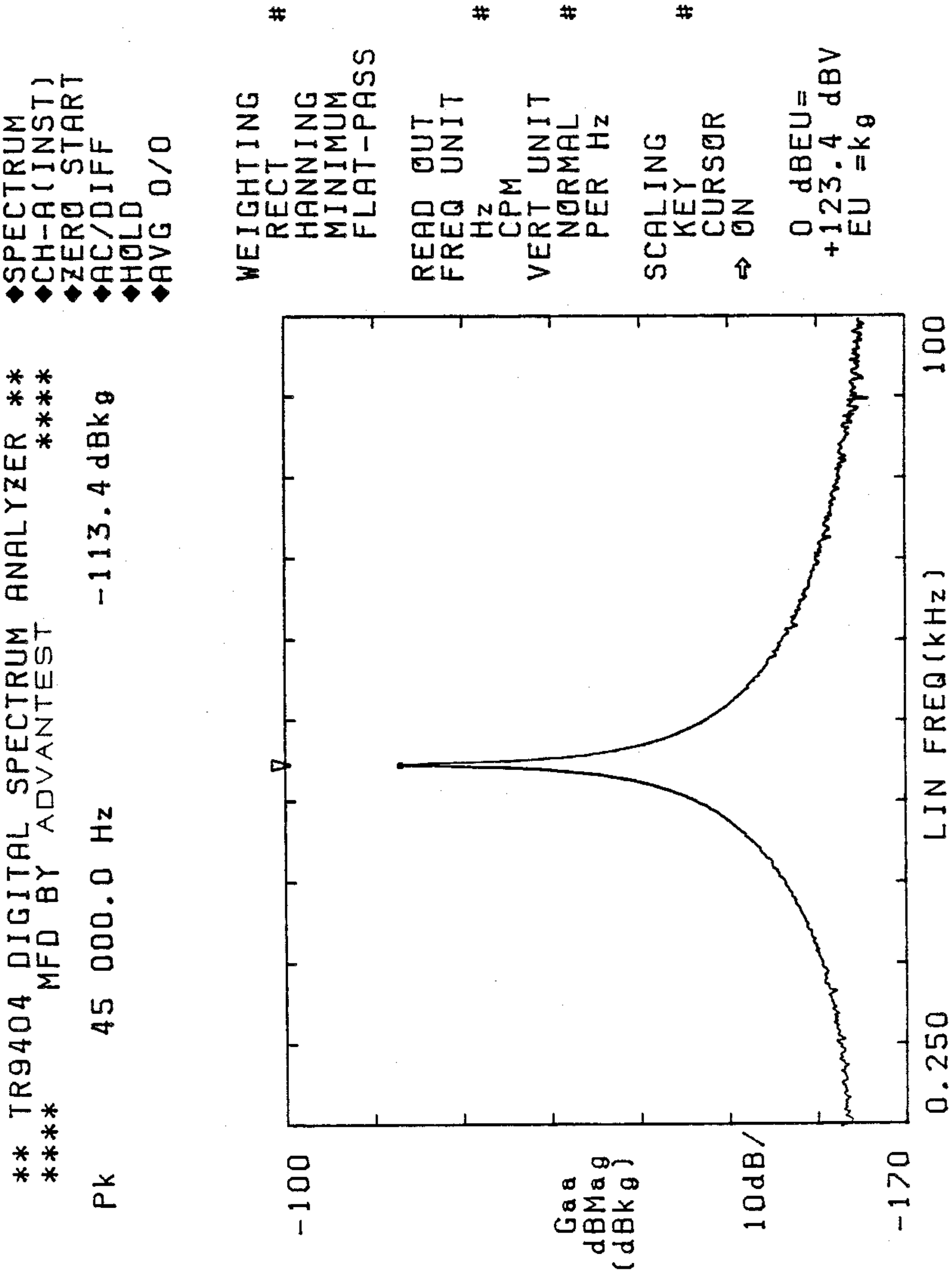


Fig. 4-69 Scaling display in the KEY mode

(0 dBEU=+123.4 [dBV], EU=kg)

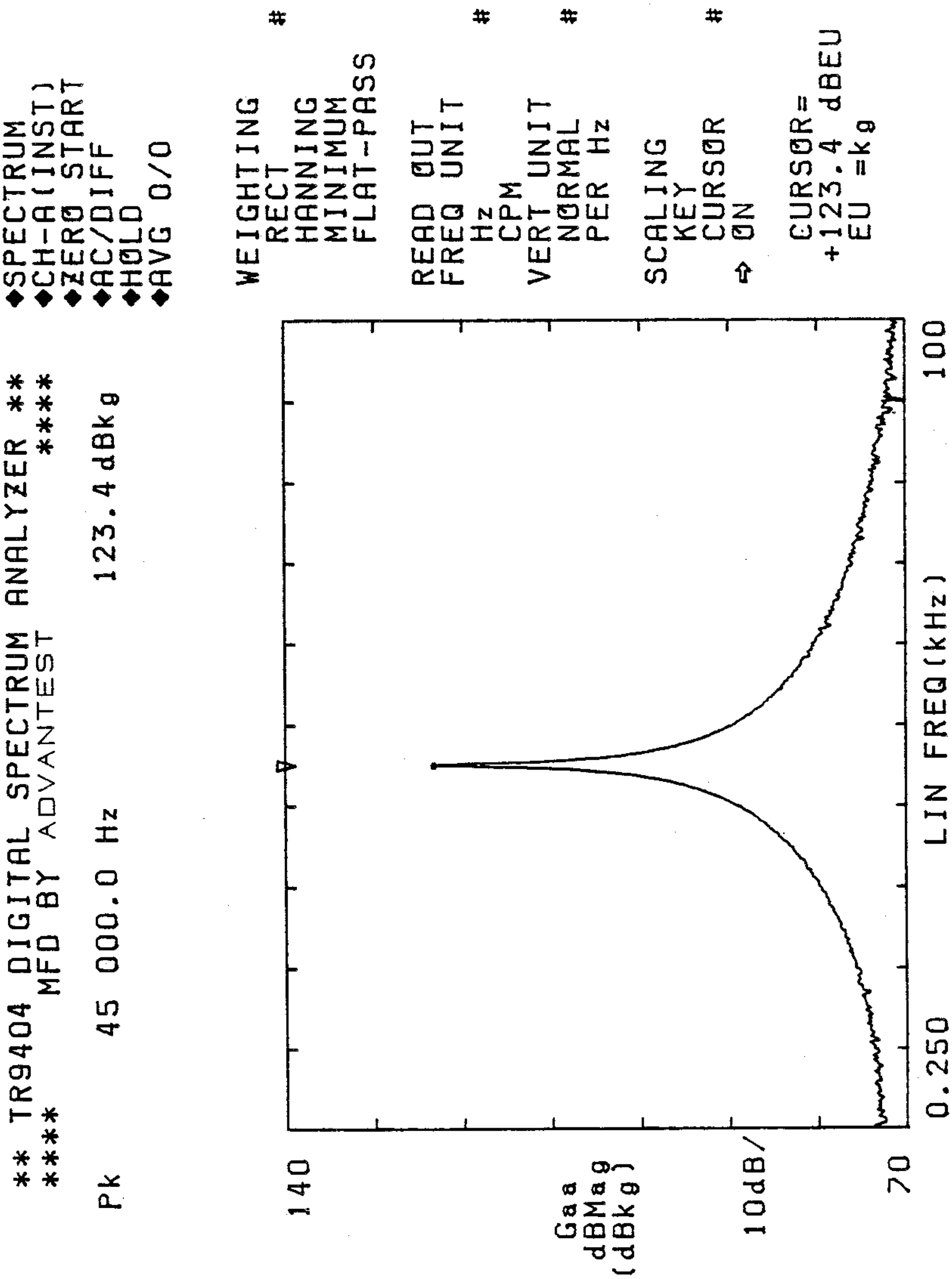


Fig. 4-70 Scaling display in the CURSOR mode

(CURSOR=+123.4 [dBEU], EU=kg)

⑪ FUNCTION key

Operation of this key shows a FUNCTION menu (shown in Figure 4-71) on the display.

FUNCTION ØFF <+> # <-> <*> </>	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.
INTEGRAL & DIFFERENTIAL *∫Xadt* ØFF *dXa/dt* ØFF *∫Xbdt* ØFF *dXb/dt* ØFF	Differentiation or integration for channel A or B.
VIEW ⇨ (jw)	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.
EQUALIZE ØFF	Removes the effects of the frequency characteristic of the sensor itself.
CØH BLANK ØFF	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.
ØVERALL ØFF	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).

Fig. 4-71 "FUNCTION" menu

i) "FUNCTION"

The FUNCTION feature provides arithmetic operations between data shown in the upper and lower display areas in the Dual Display mode, provided that each data is in the same domain (frequency, time, amplitude, or delay domain) and in the same frequency range.

Press [FUNCTION] key in the SETUP section to obtain the FUNCTION menu on the display. Use [⇧] or [⇩] key to position the pointer (⇨) to the arithmetic item (<+>, <->, <*>, or </>) to be executed, then press [SETUP] key. The pointer will start blinking. Press [DISP.] key or [SETUP] key to set the FUNCTION mode to "ON". The data shown in the upper and lower display areas are now operated by each other, and the result is shown in the bottom area.

When the FUNCTION feature is to be used, the sampling clock (SAMP CLK) setups (in the FREQUENCY menu) for the upper and lower display areas must be the same. In other words, operation between "INT" and "EXT" samplings is not executable.

The FUNCTION features executable between the same data are identified by "o" in Table 4-8. Executable FUNCTIONS between different data are listed in Tables 4-9 and 4-10.

For subtraction, (upper display) - (lower display) is executed. For division, (upper display)/(lower display) is executed.

Table 4-8 FUNCTION features executable between the same data

FUNCTION / DATA	<+>	<->	<*>	</>
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: Executable
x: Not executable

Table 4-9 FUNCTION features executable between different data (No. 1)

Upper data / Lower data	AUTO-CORR	CROSS-CORR	IMPUL. RESP.
AUTO-CORR.		<+>, <->	<+>, <->
CROSS-CORR.	<+>, <->		<+>, <->
IMPUL. RESP.	<+>, <->	<+>, <->	

Table 4-10 FUNCTION features executable between different data (No. 2)

Upper data / Lower data	COMPLEX SPECT.	TRANS. FCTN
TRANS. FCTN	<*>, </>	
COMPLEX SPECT.		Operation impossible

Note: "*" denotes multiplication, and "/" denotes division.

(1) Operations between data in the time domain

- (TIME) + (TIME)
- (TIME) - (TIME)

When these operations are executed, the Xa or Xb on the vertical axis in the lower display area is replaced by Xx, to indicate that the operation has been executed. The engineering unit for the vertical axis is mV or V, which is the same as those used before operation. Figure 4-72 shows a (TIME) + (TIME) operation example.

- (TIME)*(TIME)

When this operation is executed, the Xa or Xb on the vertical axis is replaced by Xxy, to indicate that the operation has been executed. The engineering units for the vertical axis, V and mV, are replaced by V^2 and mV^2 respectively.

- (TIME)/(TIME)

Not executable.

(2) Operation between data in the amplitude domain

- (HIST) + (HIST)
- (HIST) - (HIST)

When these operations are executed, the Pa or Pb on the vertical axis in the lower display area is replaced with Px, to indicate that the operation has been executed. The engineering unit for the vertical axis is V^{-1}, which is the same as that used before operation. Message "UNCAL" will be displayed since the vertical scale is not calibrated. Figure 4-73 shows a (HIST) + (HIST) operation example.

If the result of a (HIST) - (HIST) operation is negative, the readout will be "0".

- Operations of (HIST.)*(HIST.) or (HIST.)/(HIST.) are not executable.

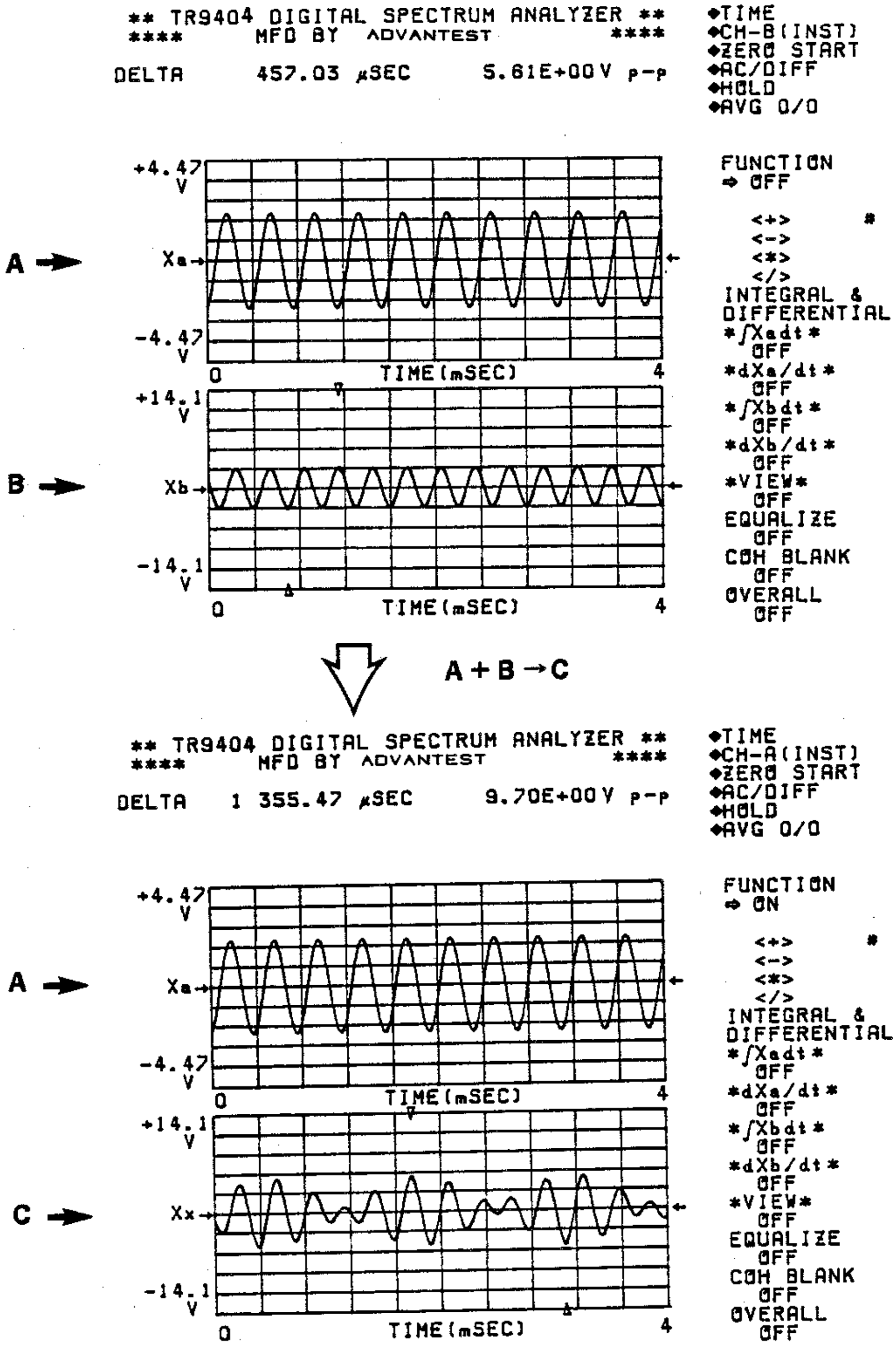


Fig. 4-72 Operation mode (addition) display example in the time domain

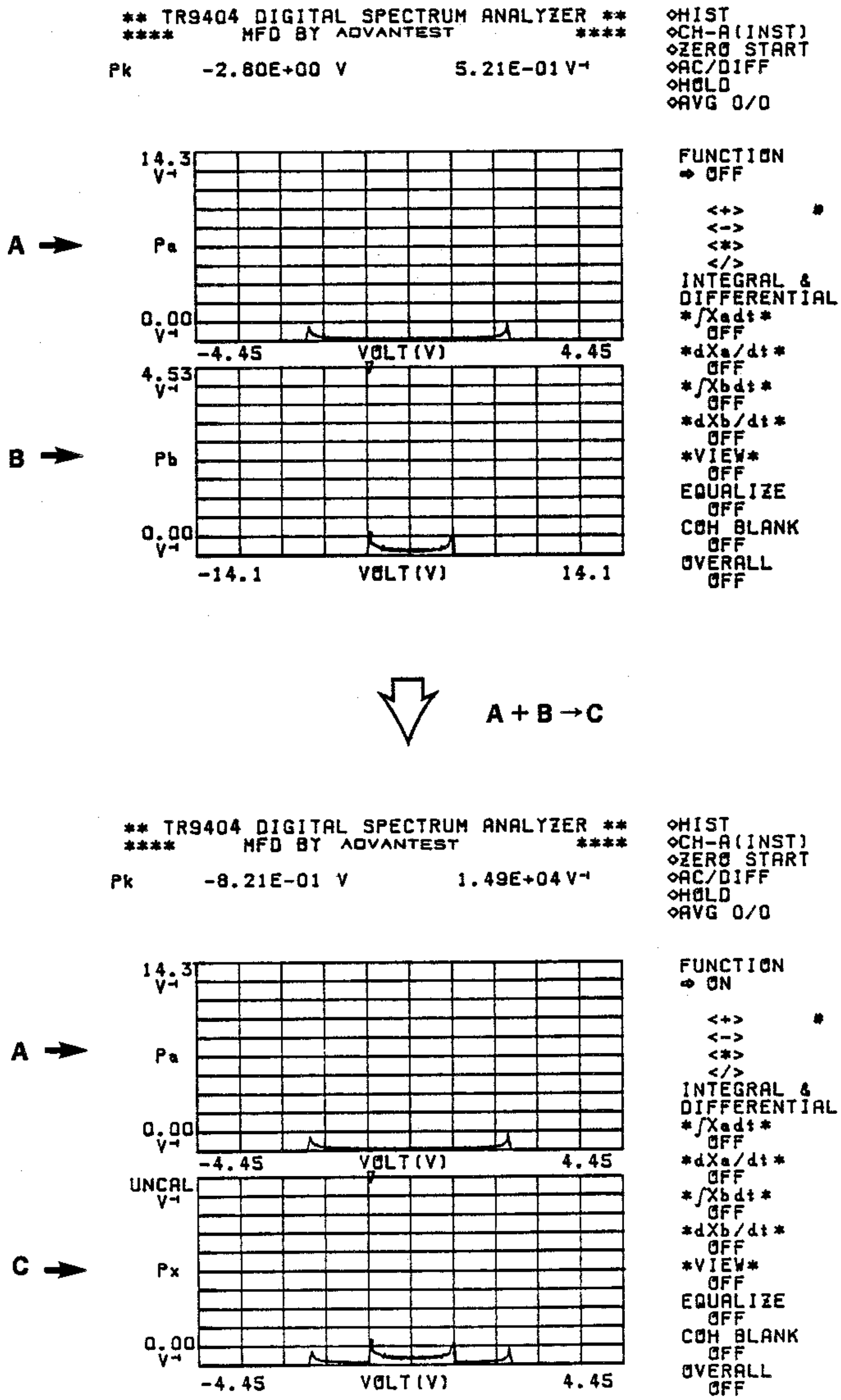


Fig. 4-73 Operation mode (addition) display example in the amplitude domain

(3) Interdata operation in the delay domain

Data in the delay domain includes impulse response (IMPUL. RESP.), auto correlation (AUTO CORR.), and cross correlation (CROSS CORR.). Interdata operation in the delay domain is possible between the same or different data (such as between impulse response and cross correlation data).

- (DELAY) + (DELAY)
- (DELAY) - (DELAY)

  When these operations are executed, the Raa, Rbb, Rab, or <IMPLS> on the vertical axis in the lower display is replaced with Rxy, to indicate that the value of operation has been executed. Note, however, that the value of displayed operation result is one half the actual operation result. The vertical axis in the lower display data has no engineering unit.

- Operations of (DELAY)*(DELAY) or (DELAY)/(DELAY) are not executable.

  Figure 4-74 shows an (IMPUL. RESP.) + (IMPUL. RESP.) operation example.

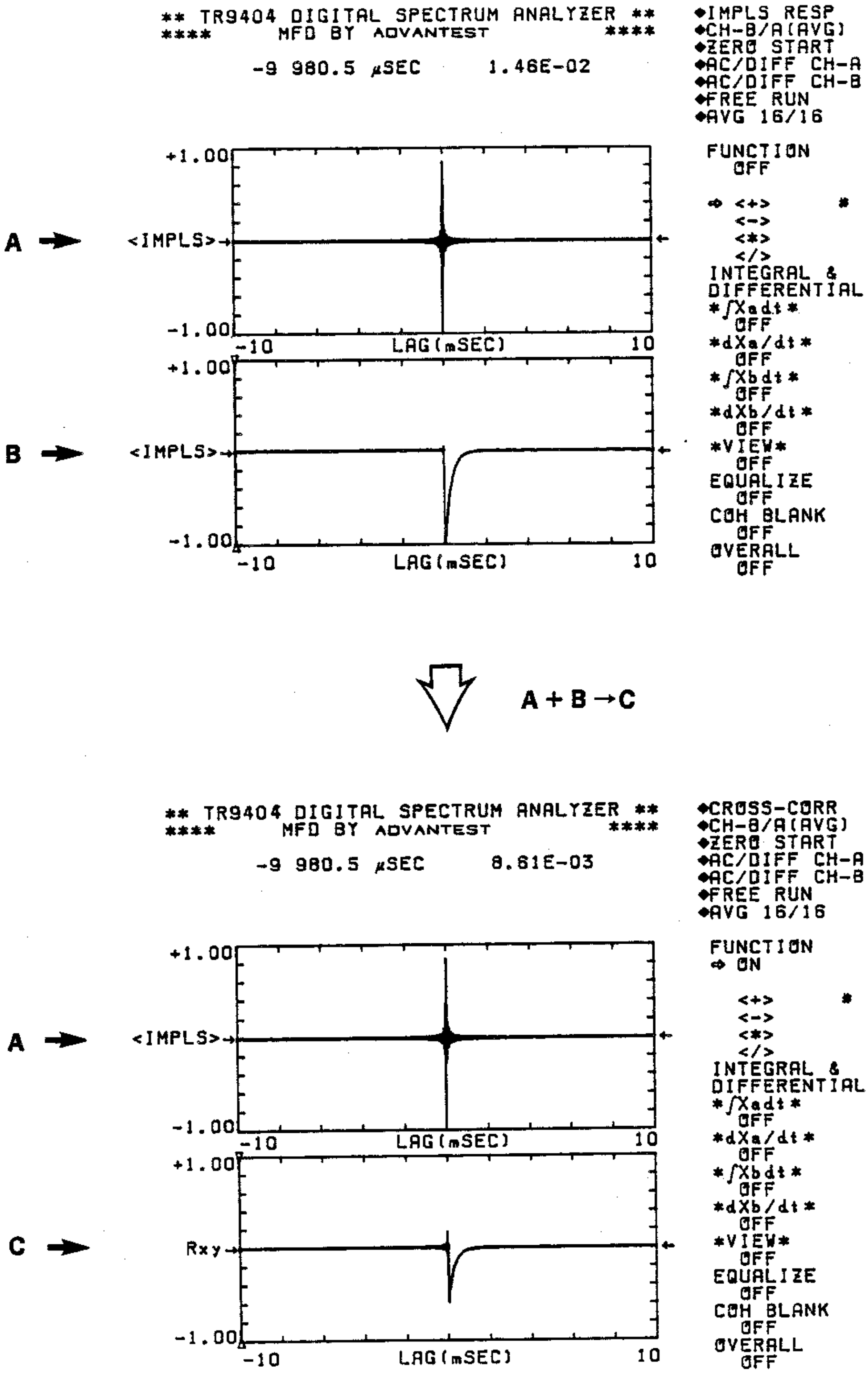


Fig. 4-74 Operation mode (addition) display example in the delay domain

(4) Interdata operation in the frequency domain

Interdata operation in the frequency domain provides the same result in either the Zero Start mode or Zoom mode. Arithmetic operation between cross spectra (Gab) is not available in this domain.

- (POWER SPECT.) + (POWER SPECT.)
- (POWER SPECT.) - (POWER SPECT.)

  When the above operations are executed, the Gaa, Gbb, <Gaa>, <Gbb>, or <C.O.P.> on the vertical axis in the lower display is replaced with Gxx, indicating that the operation has been executed.

  The engineering unit for the vertical scale in the lower display area can be selected from V, V^2, and dBV by selecting Mag, Mag^2, or dBMag for the DISP MODE item in the DISL CTRL menu (which is obtained on the display by operating DISPLAY CTL key in the SETUP section).

  If the result of the (POWER SPECT.) - (POWER SPECT.) operation is negative, the readout will be 0.

- (POWER SPECT.)/(POWER SPECT.)

  When the above operation is executed, the Gaa, Gbb, <Gaa>, <Gbb>, or <C.O.P.> on the vertical axis in the lower display area is replaced with H'xy, indicating that the operation has been executed. The operational result indicates the Transmissibility Function.

- Operation of (POWER SPECT.)*(POWER SPECT.) is not executable.

Figure 4-75 shows a (POWER SPECT.) + (POWER SPECT.) operation example.

- (OCTAVE) + (OCTAVE)
- (OCTAVE) - (OCTAVE)

When the above operations are executed, the OCTa or OCTb on the vertical axis in the lower display area is replaced with OCTx, indicating that the operation has been executed. Unlike power spectrum, the engineering unit for the vertical scale (in the lower display area) is always dBV.

- Operation of (OCTAVE)*(OCTAVE) is not available.
- (COMPLEX SPECT.) + (COMPLEX SPECT.)
- (COMPLEX SPECT.) - (COMPLEX SPECT.)

When either of the above operation is executed, the Sa or Sb on the vertical axis in the lower display area is replaced with Sx, indicating that the operation has been executed. The result of the operation can be selected from real and imaginary parts of a complex spectrum, or from the phase and amplitude value, with REAL, IMAG., MAG. and PHASE keys in the DISPLAY section.

The engineering unit for the vertical scale in the lower display area can be selected from V, V^2 and dBV by selecting from Mag, Mag^2, and dBMag for the DISP MODE item in the DISP CTRL menu (which is obtained on the display by operating DISPLAY CTL key in the SETUP section).

● (COMPLEX SPECT.)*(COMPLEX SPECT.)

When this operation is executed, the Sa or Sb on the vertical axis in the lower display area is replaced with Sxy to indicate that the operation has been executed.

Unlike cross spectrum (Gab), the product of two complex spectrum data corresponds to the convolution function between two time series in the time domain as shown in equation.(1).

$$Sa(f) \cdot Sb(f) \Longleftrightarrow Xa(t) \circledast Xb(t) \quad \text{-----} \quad (1)$$

The result of operation can be shown in the desired display mode selected with REAL, IMAG., MAG. or PHASE in the DISPLAY section.

The unit for the vertical scale in the lower display can be selected from V, V^2 and DBV by selecting from Mag, Mag^2 and dBMag in the DISP CTRL menu available via DISPLAY CTL key.

● (COMPLEX SPECT.)/(COMPLEX SPECT.)

When this operation is executed, the Sa or Sb on the vertical axis in the lower display area is replaced with Hxy to indicate that the operation has been executed.

If the operation is executed when Sb and Sa are displayed in the upper and lower display areas respectively, the transfer function is obtained.

The result of operation can be shown in the desired display mode selected with REAL IMAG. MAG. or PHASE in the DISPLAY section. The vertical scale in the lower display section has no engineering unit.

Figure 4-77 shows a (COMPLEX SPECT.)/(COMPLEX SPECT.) operation example.

- (TRANS. FCTN) + (TRANS. FCTN)

When this operation is executed, the <Hab> on the vertical axis in the lower display area is replaced with Hxy, to indicate that the operation has been executed. This result of operation gives the transfer function of the two systems connected in parallel. The result can be displayed in the desired display mode selected with REAL IMAG. MAG. or PHASE key in the DISPLAY section. The vertical scale in the lower display area has no engineering unit.

Operation example of (TRANS. FCTN) + (TRANS. FCTN) is shown in Figure 4-77.

- (TRANS. FCTN) - (TRANS. FCTN)

When this operation is executed, the <Hab> on the vertical axis in the lower display portion is replaced with Hxy to indicate that the operation has been executed. With this operation you can get the transfer function of the constituent system of the two systems connected in parallel. The result of operation can be displayed in the desired display mode selected with REAL IMAG. MAG. or PHASE. The vertical scale in the lower display area has no engineering unit.

- (TRANS. FCTN)*(TRANS. FCTN)

  When this operation is executed, the <Hab> on the vertical axis in the lower display area is replaced with Hxy, to indicate that the operation has been executed. This result of operation gives the transfer function of the two systems connected in cascade. The result can be displayed in the desired display mode selected with [REAL] [IMAG.] [MAG.] or [PHASE] key in the DISPLAY section.

  The vertical scale in the lower display area has no engineering unit.

- (TRANS. FCTN)/(TRANS. FCTN)

  When this operation is executed, the <Hab> on the vertical axis in the lower display area is replaced with H^{e}_{xy}, to indicate that the operation has been executed. This operation is also called equalization. With this operation you can get the transfer function of the constituent system of the two systems connected in cascade.

  The result of operation can be displayed in the desired display mode selected with [REAL] [IMAG.] [MAG.] or [PHASE] key in the DISPLAY section.

  The vertical scale in the lower display area has no engineering unit.

- (COMPLEX SPECT.)*(TRANS. FCTN)

This operation is available only when a complex spectrum is shown in the upper display and a transfer function in the lower display. When this operation is executed, the <Hab> on the vertical axis in the lower display area is replaced with Sy, to indicate that the operation has been executed. As shown by Equation (2), the product of complex spectrum and transfer function corresponds to convolution function between two time-series in the time domain. If operation is executed with Sa and <Hab> shown in the upper and lower display areas respectively, the output complex spectrum Sb is obtained.

$$Sb(f) = Hab(f) \cdot Sa(f) \Longleftrightarrow Xb(t) = Hab \circledast Xa(t) \quad \text{---} \quad (2)$$

The result of operation can be displayed in the desired display mode selected with REAL, IMAG., MAG. or PHASE key in the DISPLAY section. The engineering unit of V or mV is provided for the vertical scale. Figure 4-78 shows a (COMPLEX SPECT.)*(TRANS. FCTN) operation example.

• (COMPLEX SPECT.)/(TRANS. FCTN)

This operation is available only when a complex spectrum is shown in the upper display and a transfer function in the lower display. When this operation is executed, the <Hab> on the vertical axis in the lower display is replaced with Sx, to indicate that the operation has been executed. As shown by Equation (3), the division of a complex spectrum with transfer function corresponds to deconvolution function of two time-series domain. If the operation is executed with Sb and <Hab> shown in the upper and lower display areas respectively, the input complex spectrum Sa can be obtained in the lower display area.

$$Sa(f) = Sb(f)/Hab(f) \Leftrightarrow Xa(t) \text{------------------} (3)$$

The result of operation can be displayed in the desired display mode selected with [REAL] [IMAG.] [MAG.] or [PHASE] in the DISPLAY section. The engineering unit of V or mV is provided for the vertical scale in the lower display area.

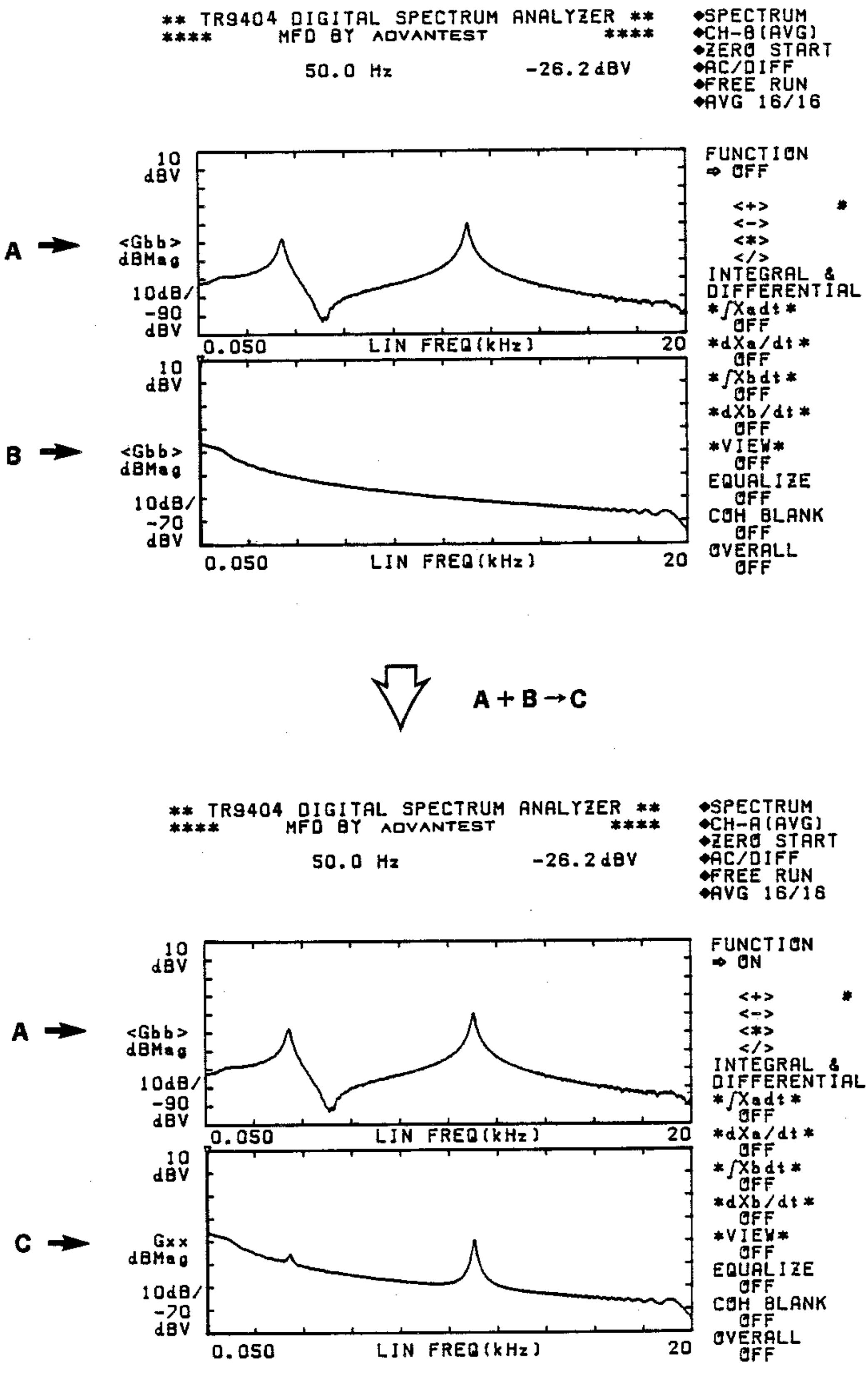


Fig. 4-75 Operation mode (addition) display example in the frequency domain

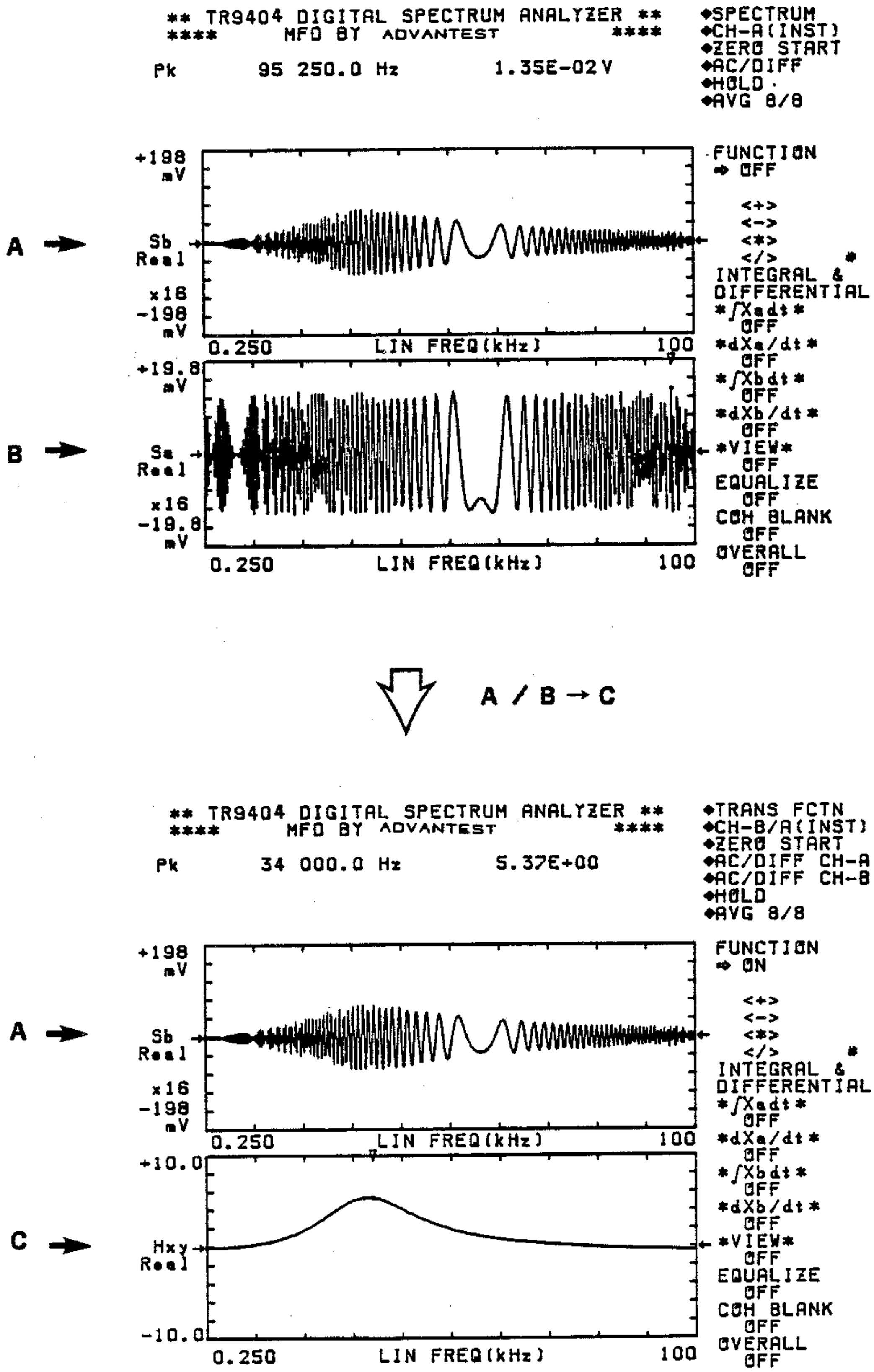


Fig. 4-76 (COMPLEX SPECT.)/(COMPLEX SPECT.) operation result display example

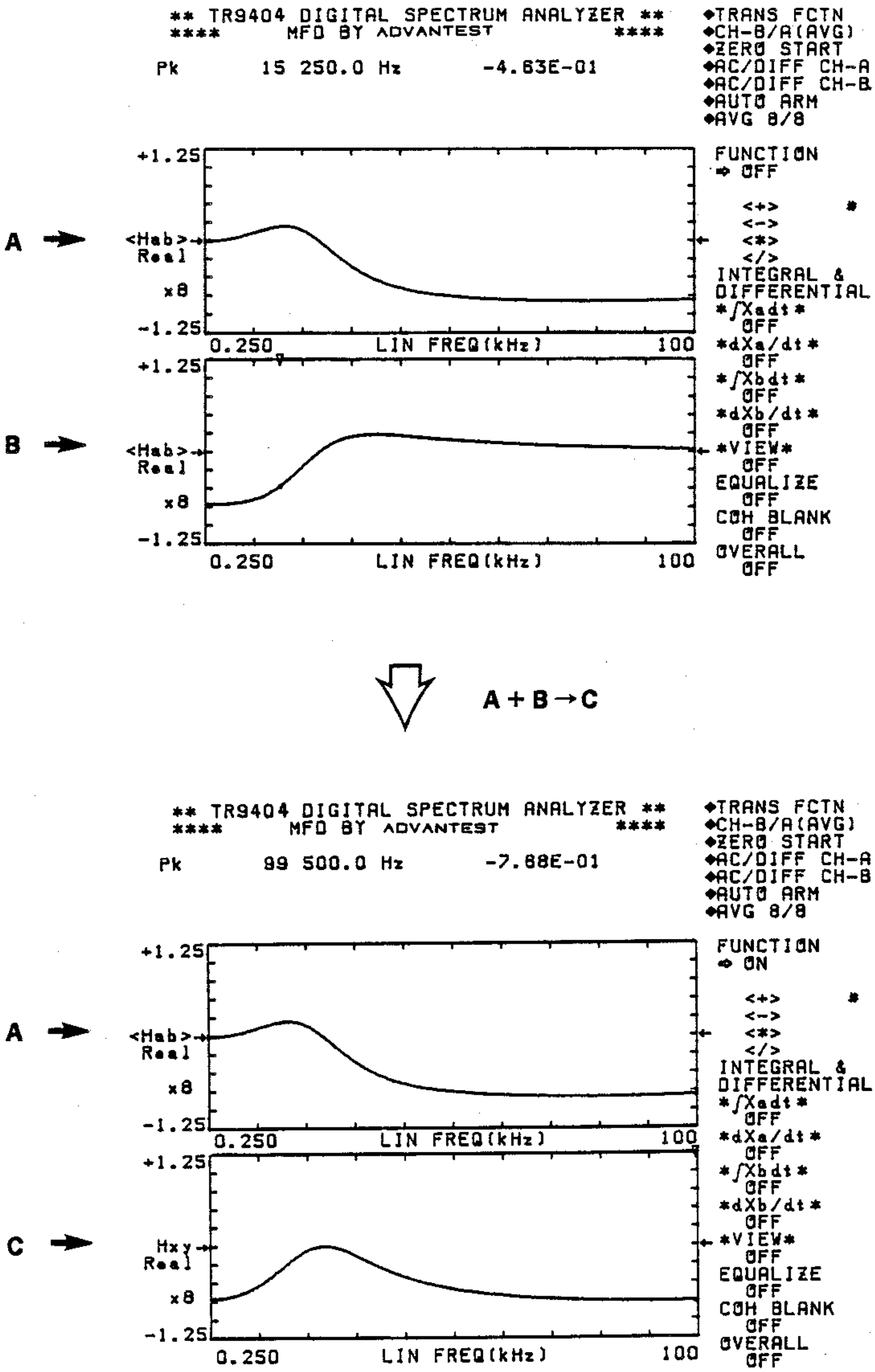


Fig. 4-77 (TRANS. FCTN) + (TRANS. FCTN) operation result display example

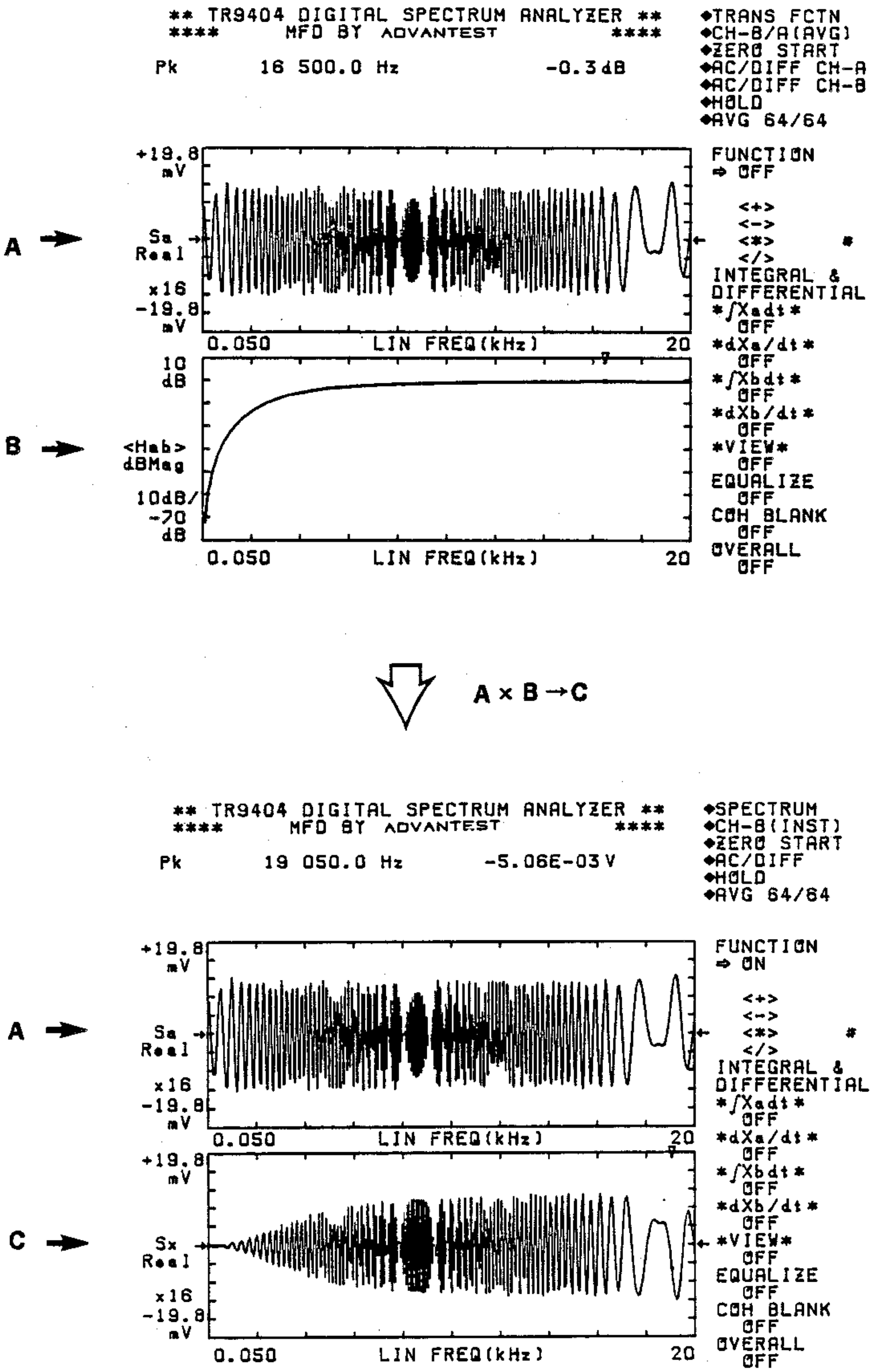


Fig. 4-78 (COMPLEX SPECT.)*(TRANS. FCTN) operation result display example

ii) "INTEGRAL & DIFFERENTIAL"

The integration and differentiation features include operation in the time domain indicated by "INTEGRAL & DIFFERENTIAL" and operation in the frequency domain indicated by "VIEW".

In the time domain, differentiation, double differentiation, integration, and double integration are available.

NOTE

The result of integration or differentiation is displayed in the frequency domain, but is not displayed in the time domain.

In the frequency domain, the display data is multiplied by $j\omega$, $(j\omega)^2$, $1/(j\omega)$, or $1/(j\omega)^2$.

This multiplication is a good approximation of differentiation or integration.

(1) INTEGRAL & DIFFERENTIAL

When the pointer (⇨) is positioned to $\overset{*\int Xadt*}{OFF}$ (or $\overset{*\int Xbdt*}{OFF}$) with [⇧] or [⇩] key in the SETUP section and [SETUP] key is pressed, the "OFF" indicator is replaced with "DOUBLE", and a double integration is executed in the time domain. If [SETUP] key is subsequently pressed, the "DOUBLE" indicator is replaced with "SINGLE", and integration is executed in the time domain.

Subsequent operation of [DISP.] key replaces the "SINGLE" indicator with "OFF". Thus, each operation of [SETUP] key sequentially selects the operation mode from OFF, DOUBLE, SINGLE, OFF, and so on. Each operation of [DISP.] key selects the operation modes in the reverse order of OFF, SINGLE, DOUBLE, OFF, and so on.

When executing differentiation, posititon the pointer to *dXa/dt* OFF or *dXb/dt* OFF, then use [SETUP] or [DISP.] key to select the operation mode from OFF, SINGLE, or DOUBLE. If the SINGLE mode is selected, differentiation is executed in the time domain. If the DOUBLE mode is selected, double differentiation is executed in the same domain.

NOTE

- When executing (double) integration, the input coupling mode should be set to AC. DC offset riding on the the input signal largely affects the results of operation of (double) integration, so the setup of the AC coupling on the TR9404 would automatically calculate and eliminate the offset before the operation.
- When the integration or differentiation is applied during ARM or AUTO ARM mode, be sure to set the ARM LENGTH to 64K for single channel or 32K for dual channel.

- If the ZOOM, AUTO CORR., or CROSS CORR. mode is selected in the frequency domain, differentiation or integration will not be executed.
- The VIEW feature and the INTEGRAL & DIFFERENTIAL feature are not executed at the same time. When either of these features are activated, the other is always deactivated.

(2) VIEW

Selecting this mode allows multiplication of the frequency domain data by $(j\omega)$, $(j\omega)^2$, $1/(j\omega)$, $1/(j\omega)^2$, whose result is a good approximation of differentiation or integration.

If the pointer is positioned to *VIEW* OFF with [⇧] key in the SETUP section and then [SETUP] key is pressed while a power spectrum, coherence output power (C.O.P.), transfer function (TRANS. FCTN), or cross spectrum (CROSS SPECT.) is shown on the display (in the lower display when in the Dual Display mode), "OFF" is replaced with $1/(j\omega)$, and the displayed data is multiplied by $1/(j\omega)$. Each time [SETUP] key is pressed, the parameter is sequentially selected in the order of OFF, $1/(j\omega)$, $1/(j\omega)^2$, $(j\omega)^2$, $(j\omega)$, and OFF. This means that the displayed data can be multiplied by $1/(j\omega)^2$, $(j\omega)^2$, or $(j\omega)$ as well. Each time [DISP.] key is pressed, the item is selected in the reverse order of OFF, $(j\omega)$, $(j\omega)^2$, $1/(j\omega)^2$, $1/(j\omega)$, and OFF.

The relation between ($j\omega$) and the integration or differentiation is shown in Table 4-11.

Results of integration and differentiation operations are shown in Figures 4-79 through 4-87.

Table 4-11 Differentiation and integration corresponding to ($j\omega$) operations

	$1/(j\omega)$	$1/(j\omega)^2$	$(j\omega)^2$	$(j\omega)$
Gaa (Gbb)	Integration on CH-A (CH-B)	Double integration on CH-A (CH-B)	Double differentiation on CH-A (CH-B)	Differentiation on CH-A (CH-B)
C.O.P.	Integration on CH-B	Double integration on CH-B	Double differentiation on CH-B	Differentiation on CH-B
Hab	Integration on CH-B or differentiation on CH-A	Double integration on CH-B or double differentiation on CH-A	Double differentiation on CH-B or double integration on CH-A	Differentiation on CH-B or integration on CH-A
Gab	Integration on CH-B orCH-A	Double integration on CH-B or CH-A	Double differentiation on CH-B or CH-A	Differentiation on CH-B or CH-A

NOTES

- When averaging, differentiation, or integration features are simultaneously required, application of (jω) upon completing averaging is more effective than the INTEGRAL & DIFFERENTIAL.
- Operation with the VIEW feature is not usable simultaneously with integration or differentiation, using the INTEGRAL & DIFFERENTIAL feature. If selection of the VIEW feature is attempted when it is inhibited, the following message will flash for a few seconds in the bottom left information area on the display:

  (jω) IS NOT AVAILABLE
- When using an arithmetic operation feature (FUNCTION "ON") with the VIEW mode, the VIEW or arithmetic operation should be executed after the result of the arithmetic operation or (jω) operation is stored into and then recalled from memory.

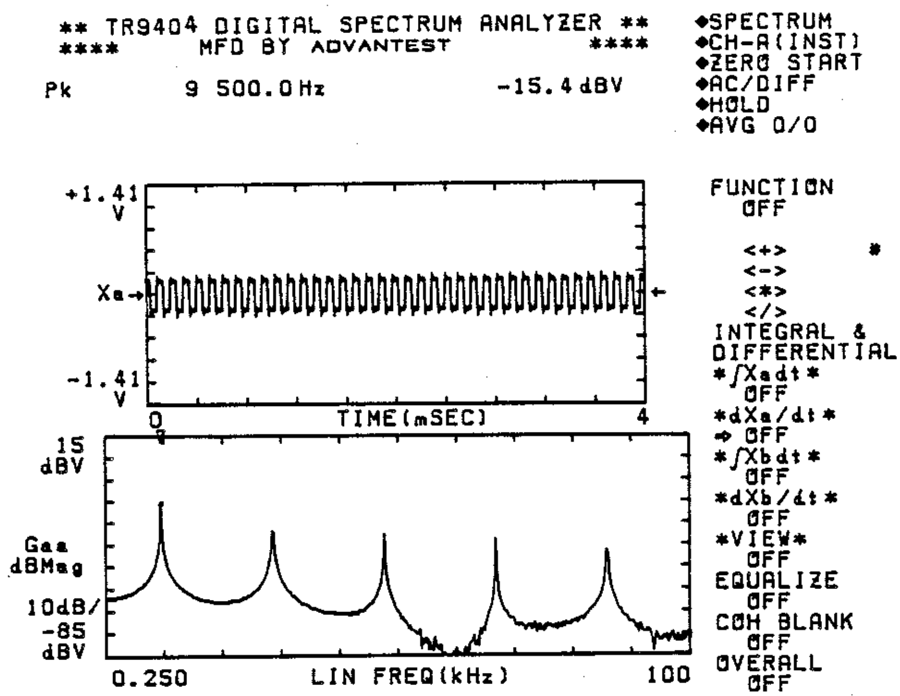


Fig. 4-79 Input square wave signal and its power spectrum (INTEGRAL & DIFFERENTIAL feature OFF)

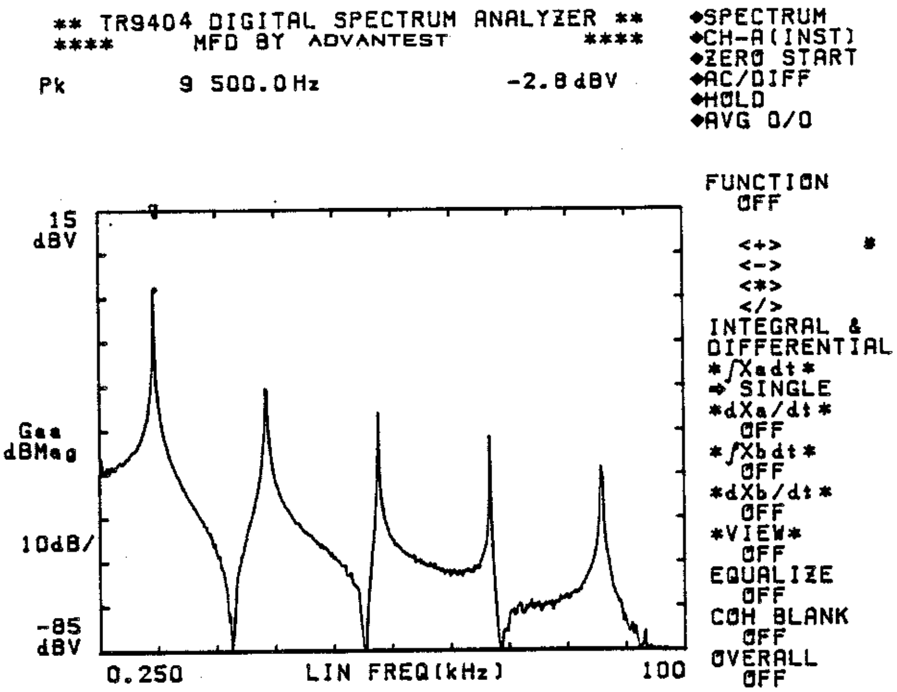


Fig. 4-80 Power spectrum after being subject to dual integration

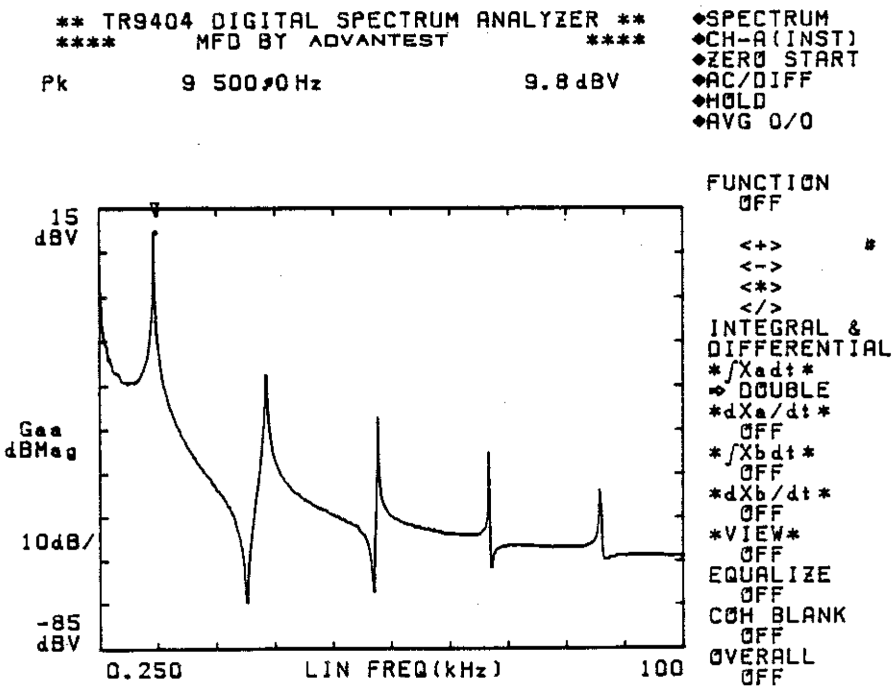


Fig. 4-81 Power spectrum after being subject to integration

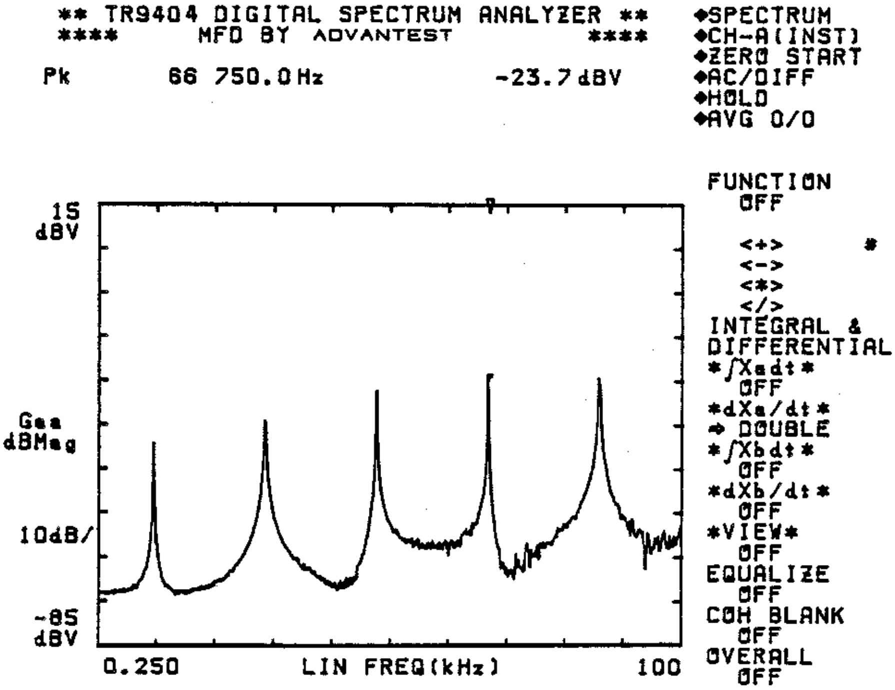


Fig. 4-82 Power spectrum after being subject to double differentiation

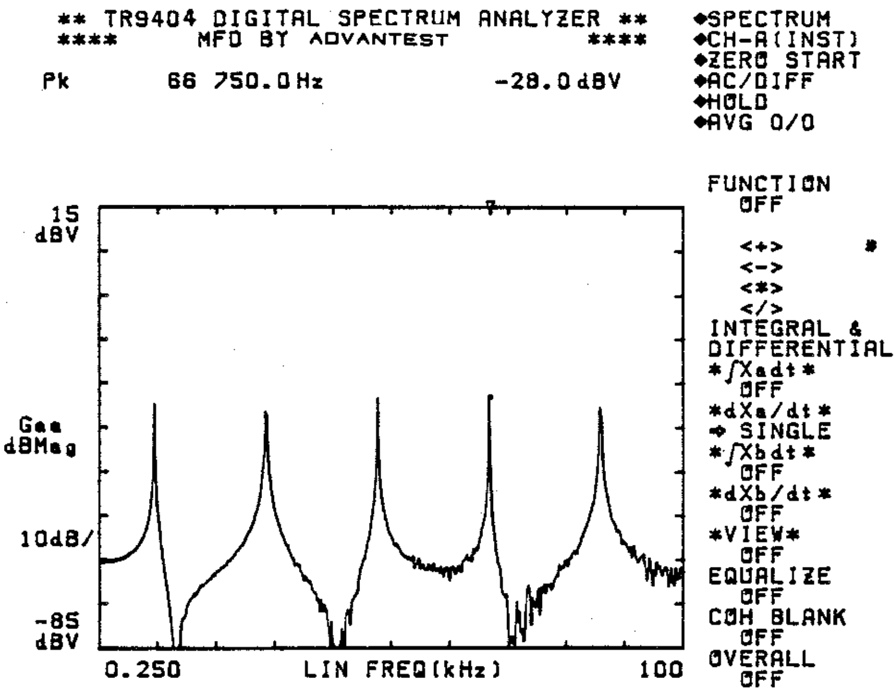


Fig. 4-83 Power spectrum after being subject to differentiation

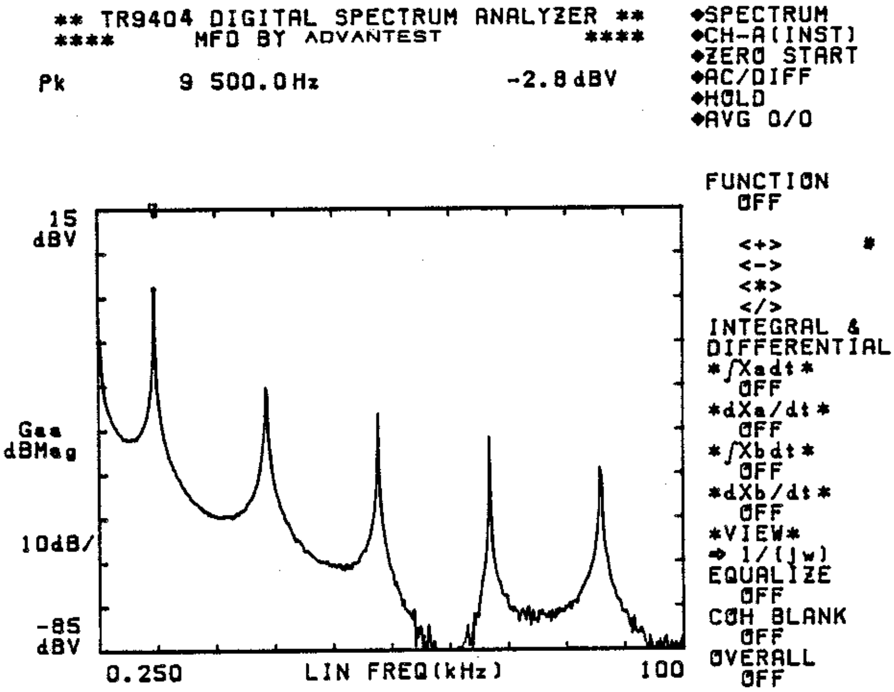


Fig. 4-84 Power spectrum multiplied by $1/(j\omega)$

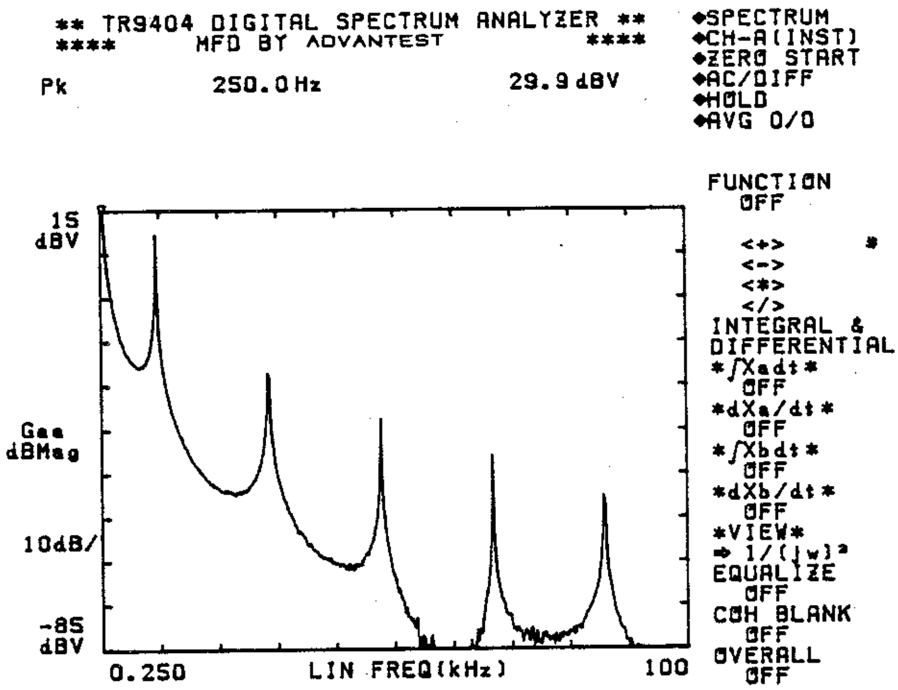


Fig. 4-85 Power spectrum multiplied by $1/(j\omega)^2$

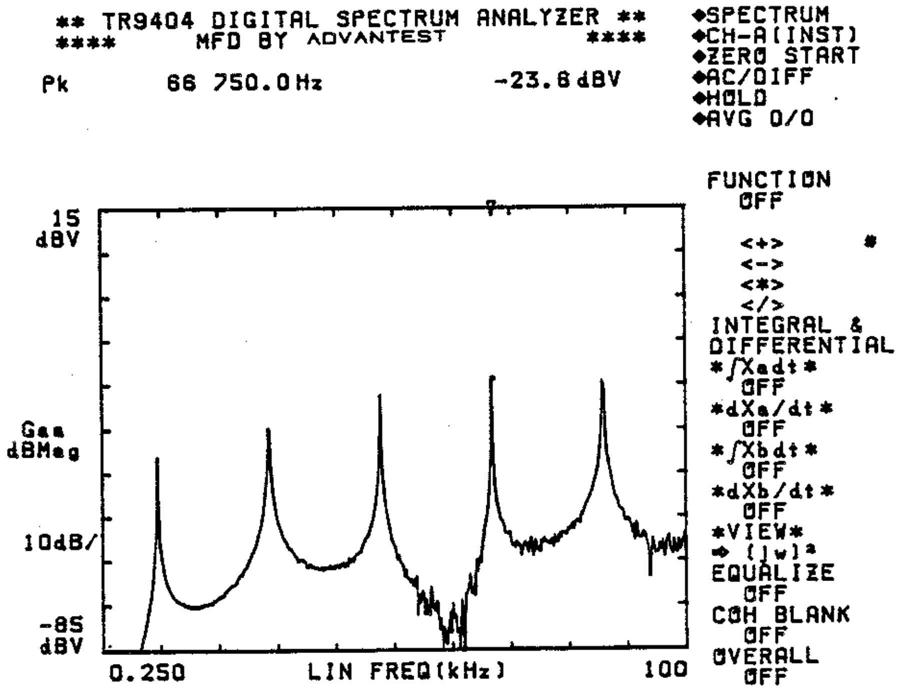


Fig. 4-86 Power spectrum multiplied by $(j\omega)^2$

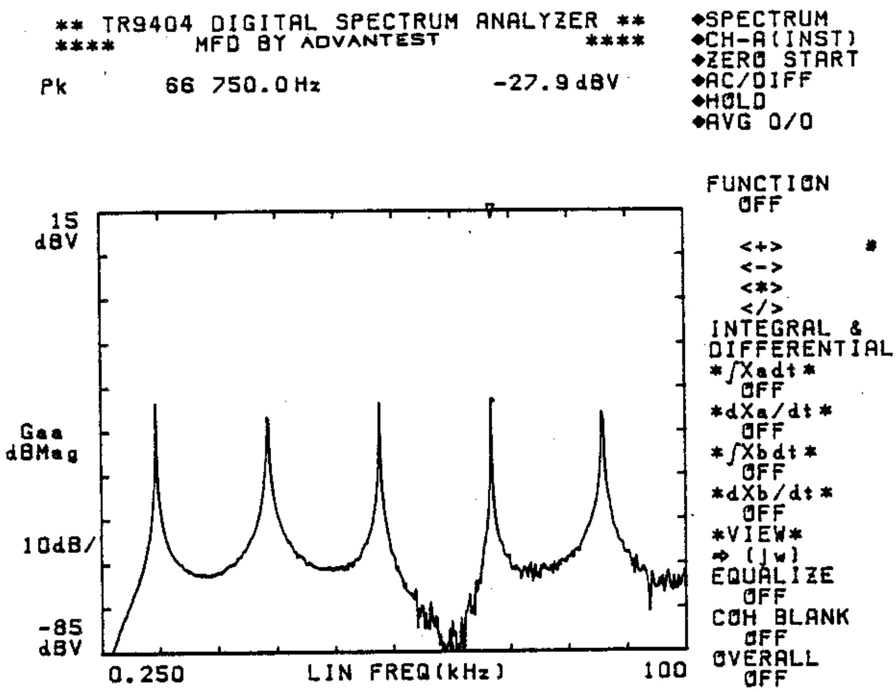


Fig. 4-87 Power spectrum multiplied by $(j\omega)$

iii) EQUALIZE

When measuring the transfer function of a given system, influence from the measuring system (which may contain an accelerometer) can cause an error. The Equalize feature is intended to eliminate errors caused by the measuring system and to provide the true transfer function of the system. To activate the Equalize feature, follow the steps below:

① Measure the transfer function of the measuring system itself (including an accelerometer), and press STORE key in the VIEW section to store the transfer function into the memory buffer.

② Measure the transfer function of the total system and display it on the CRT.

③ Press FUNCTION key in the SETUP section to obtain the FUNCTION menu on the display. When the pointer (⇨) is positioned to the item "EQUALIZE" in the menu, it will start flashing. Press DISP. or SETUP key to activate the EQUALIZE mode.

The true transfer function after being subject to equalization is now shown on the display. The equalized transfer function is identified by "$\overset{e}{\mathrm{Hxy}}$" annotated on the vertical axis.

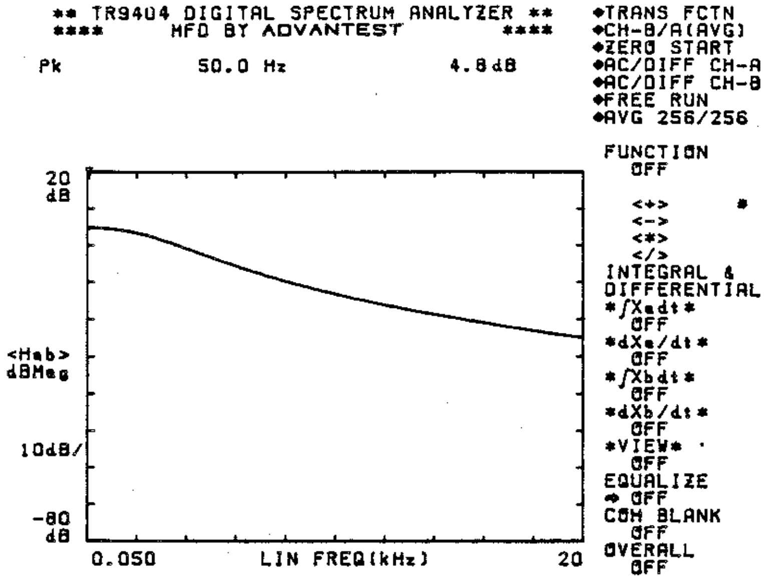
Figure 4-88 shows the result of equalization (c) executed on data (b) by (a).

If the Equalize feature is activated with no transfer function data stored in the memory buffer, equalization will not be executed. In this case, the following message will flash for a few seconds at the bottom left display area on the CRT:

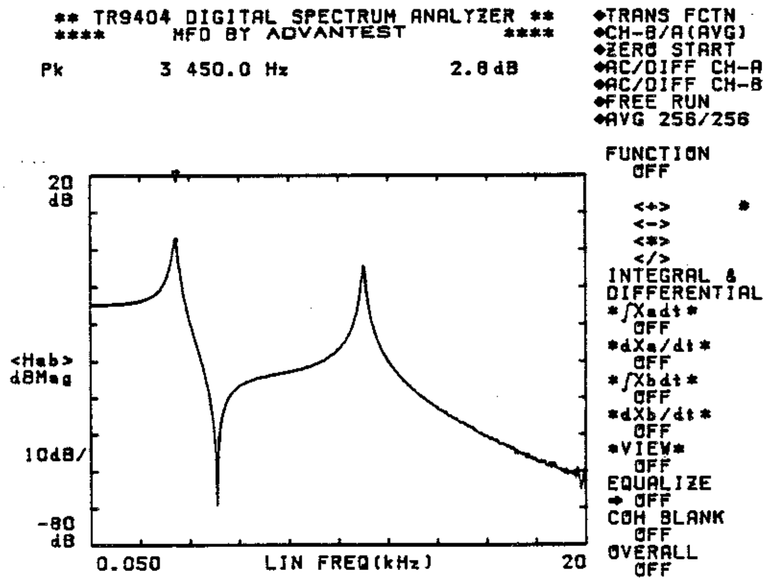
NO TRANS FCTN IS STORED IN MEMORY

Even though the transfer function is stored in the buffer, equalization will not be executed if displayed information is other than the transfer function. In this case, the following message will flash for a few seconds in the bottom left display area on the display:

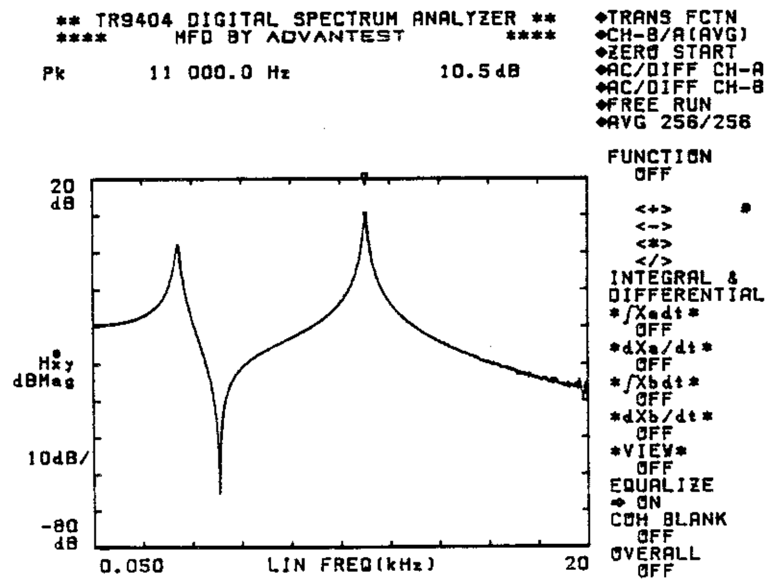
EQUALIZE IS NOT AVAILABLE



(a) Transfer function of the measuring system itself



(b) Transfer function of the total system



(c) Equalized transfer function

Fig. 4-88 Description for the Equalize feature

iv) "COH BLANK" (Coherence Blanking)

Once the regions of high coherence have been identified, they can be made prominent on the "CROSS" data display. This feature removes "CROSS" data below a certain coherence level from the display. The coherence blanking function provides a more understandable display for the correlation between input and output signals.

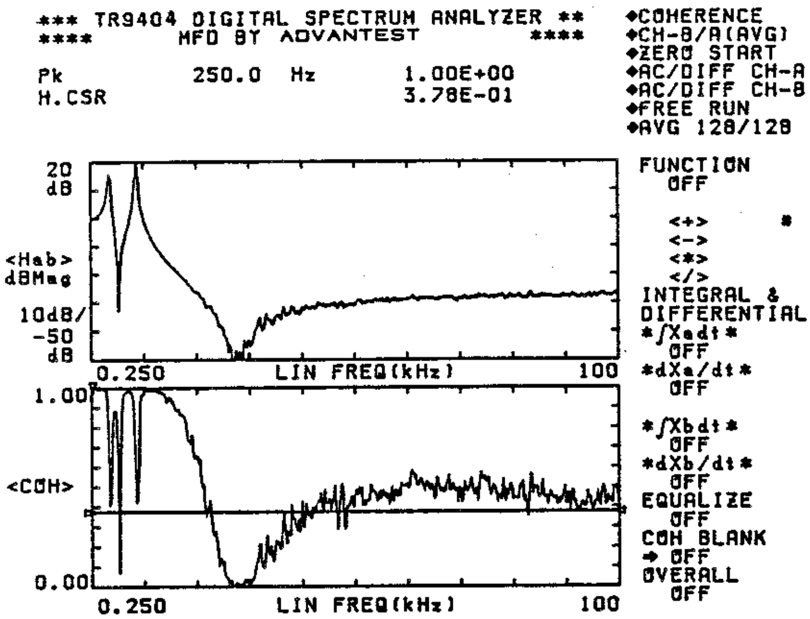
1. Press COHERENCE key in the VIEW section to display the coherence function.
2. Press FUNCTION key in the SETUP section to obtain the FUNCTION menu on the display. When the pointer (⇨) is positioned to the item "COH BLANK", the pointer will start flashing. Now press SETUP or DISP. key to activate the COH BLANK mode.
3. Activate C (‡) key in the CURSOR section; a horizontal cursor appears on the display and the value identified by the cursor is read out as "H. CSR" (horizontal cursor) above the signal trace.
4. Use ⇧ or ⇩ key in the GENERAL CURSOR section to position the horizontal cursor to the coherence value below which the coherence function is to be blanked out.
5. Press SET X key. (At this time, message "SET COHERENCE" will flash for a few seconds in the bottom left display area for confirmation.) This will define the coherence value identified by the cursor as a coherence blanking threshold, and the coherence function below this threshold is blanked out.

If any of the "CROSS" data (TRANS. FCTN, COHERENCE, and C.O.P.) or averaged power spectrum or cross spectrum is selected with the VIEW section key after the coherence blanking threshold is set up, the signal trace below the threshold will be removed (see Figure 4-89).

To change the coherence blanking threshold, first position the pointer to the top item "FUNCTION" in the menu, then press [COHERENCE] key in the VIEW section. Next, use [⇧] or [⇩] key in the GENERAL CURSOR section to position the horizontal cursor to the desired coherence value, then press [SET X] key.

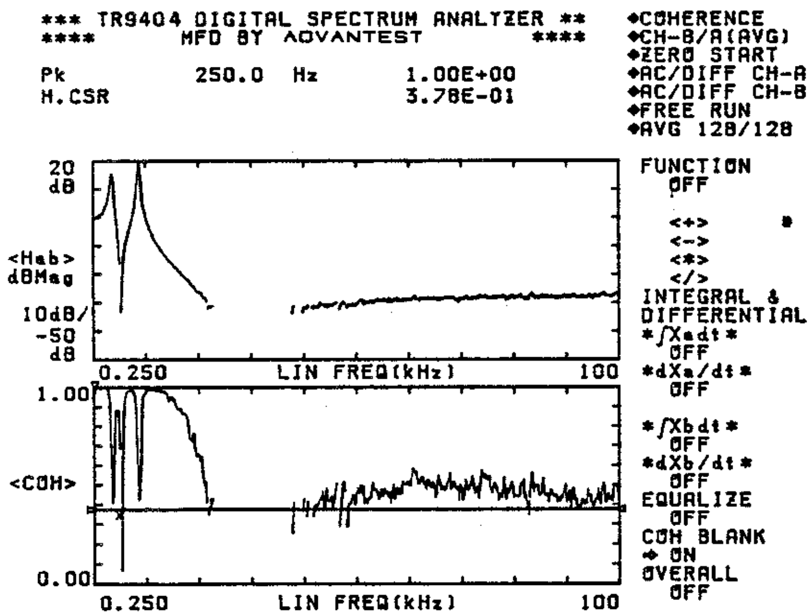
The [SET X] key provides several different functions depending on setups in the menus for the VIEW and SETUP sections. When setting up a coherence blanking threshold, therefore, be sure to set up the VIEW section for COHERENCE.

To reset the COH BLANK mode, first position the pointer to item "COH BLANK" in the FUNCTION menu, then press [DISP.] or [SETUP] key to set COH BLANK to OFF. Each operation of [DISP.] or [SETUP] key will reverse the ON and OFF states alternately. COH BLANK value being set up will be displayed on the right hand side of the CRT by depressing [DISP.] twice (See Figure 4-47 (b)).



(a) Coherence Blanking: OFF
Transfer function of a system is shown above and the coherence function below

Set "COH BLANK" in the FUNCTION menu to ON, then activate [C ($)] and use [⇩] [⇧] keys to position the horizontal cursor line to the desired position for coherence blanking. Then press [SET X] key.



(b) Coherence Blanking: ON
Transfer function below a coherence level of 0.378 is removed (top)

Coherence function being removed below 0.378 (bottom)

Fig. 4-89 Illustration for coherence blanking function

v) "OVERALL" ("PARTIAL")

This mode in the FUNCTION menu allows you to determine the total rms power of the overall or partial spectrum shown on the display and provide their readouts.

To activate this mode, press FUNCTION key in the SETUP section to show the FUNCTION menu. Position the pointer to "OVERALL"; the pointer will start flashing. Press SETUP or DISP. key to set the OVERALL mode to ON.

Once the OVERALL mode is set up, the rms power of the overall spectrum is determined and read out in the top display area on the CRT (see Figure 4-90). The readout unit is selectable from Mag, Mag^2, and dBMag in the "DISP CTRL" menu which is obtained by pressing DISPLAY CTL key in the SETUP section.

To reset the OVERALL mode, position the pointer to item "OVERALL" in the FUNCTION menu, then press SETUP or DISP. key; the OVERALL readout will disappear from the display.

Total rms power of a partial spectrum in a certain frequency range can be determined as follows:

Select the FUNCTION menu, then activate SET REF. ON/OFF key in the GENERAL CURSOR section (lamp within the switch comes on). If the lamp flashes, it indicates no REF. is set up. Press SET REF. key to set up REF. After positioning the pointer to "OVERALL" in the menu, press SETUP key to select the OVERALL mode, then press the same key again to select the PARTIAL mode.

Use ⇦ or ⇨ key in the GENERAL CURSOR section to position the cursor to the lowest frequency of the region in question. Press the SET REF. key to define this frequency as the start frequency. If the cursor is subsequently moved, the total rms power of the region specified by the defined start frequency and the frequency identified by the cursor is calculated and read out in the top display area of the CRT under the title "PARTIAL" (see Figure 4-91). In this case as well, the readout unit is selectable from Mag, Mag^2, and dBMag.

To reset the PARTIAL rms mode, position the pointer to "OVERALL" in the FUNCTION menu, then press SETUP or DISP. key to set the mode to OFF.

CAUTION

The OVERALL and PARTIAL in the frequency domain are determined as the sum of $[V^2]$ for auto power spectrum (Gaa, Gbb), as the sum of $[V^4]$ for cross spectrum (Gab), and as the sum of $[Mag^2]$ for transfer function. For example, when the DISP MODE is set up for Mag in an auto power spectrum display, the overall and partial values are simply the square root of the sum in $[V^2]$ and are not the overall and partial values in [V].

If the OVERALL mode is selected with the time data being displayed, the total absolute voltage of the overall time data is determined and read out in the top display area on the CRT under the title "OVERALL Σ ABS" (see Figure 4-92).

If the PARTIAL mode is selected when SET REF. key is activated, the absolute voltage summation of the time data existing in between the time set up with SET REF. key and the time identified by the cursor is determined and read out as "PARTIAL Σ ABS" (see Figure 4-93).

Table 4-12 OVERALL/PARTIAL modes vs message

Domain	VIEW	OVERALL/PARTIAL	MESSAGE
TIME	TIME	o	1
	AUTO-CORR	x	2
	CROSS-CORR	x	2
	IMPUL RESP.	x	2
FREQUENCY	REAL/IMAGE.	x	3, 4
	PHASE	x	3, 4
	MAG.	o	1
	COHERENCE	o	1
AMPLITUDE	HIST	o	1

o: enable x: disable

MESSAGES: 1 PARTIAL: SET REF.
2 OVERALL (TIME, HIST, MAG.)
3 PARTIAL: POWER SPECT.
4 OVERALL: POWER SPECT.

As shown in Table 4-12, the OVERALL/PARTIAL modes are disabled when the VIEW section is set up for the AUTO-CORR. or CROSS-CORR. or IMPUL.RESP. mode or when the display mode is set up for REAL, IMAG., or PHASE for spectral information.

Meaning of the messages (1) through (4) is as follows:

(1) The reference is not set up. Set up the reference.

(2) The OVERALL and PARTIAL modes are selectable only when the VIEW section is set up for the TIME or HIST mode or spectrum display is in the MAG. mode.

(3) The PARTIAL mode is valid only in the MAG. display mode.

(4) The OVERALL mode is valid only in the MAG. display mode.

Total power of the spectra is indicated as "OVERALL" in the top readout area.

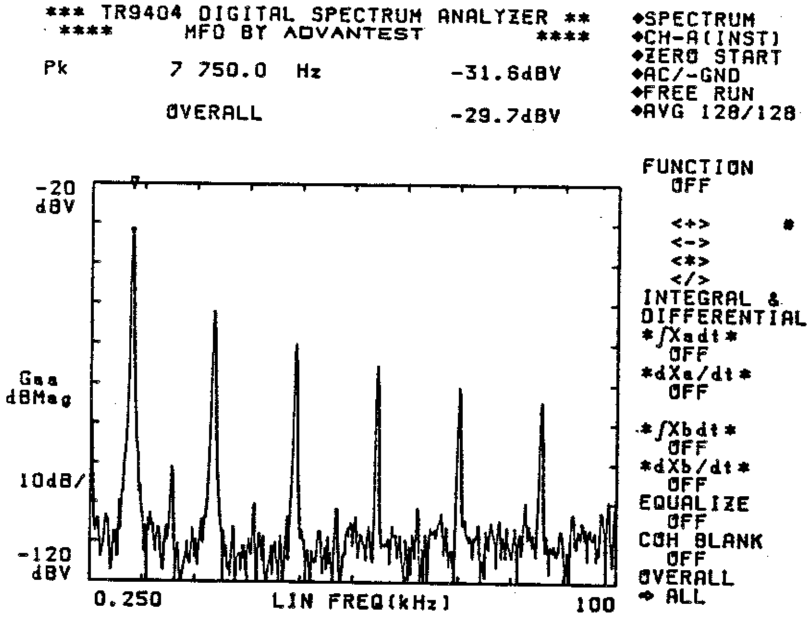


Fig. 4-90 RMS power of overall spectrum

Total power of the spectra between the frequency set up with the SET/REF key and the frequency identified by the cursor is displayed as "PARTIAL".

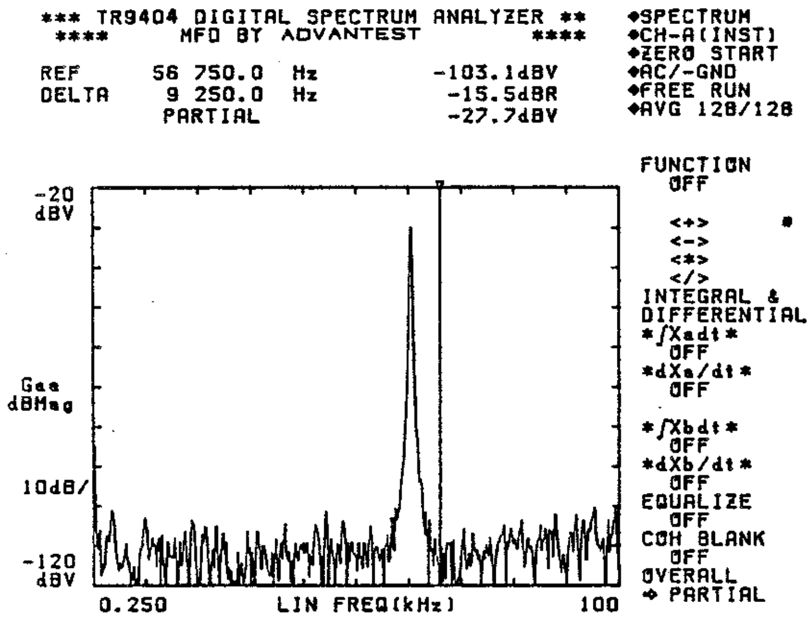


Fig. 4-91 RMS power of partial spectrum

Sum of absolute voltage of overall time data in the frame time

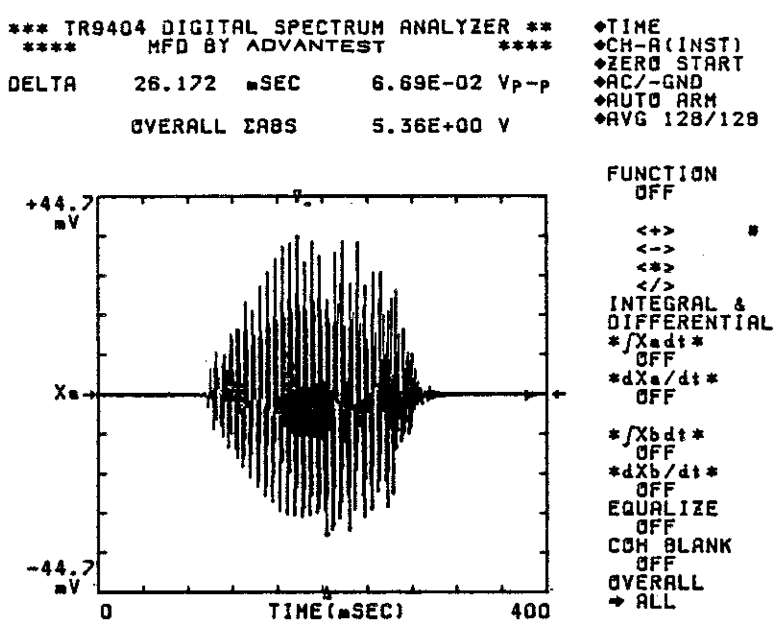


Fig. 4-92 Absolute voltage summation of overall time data

Sum of absolute voltage of the time data existing between the time set up with the SET/REF key and the time identified by the cursor.

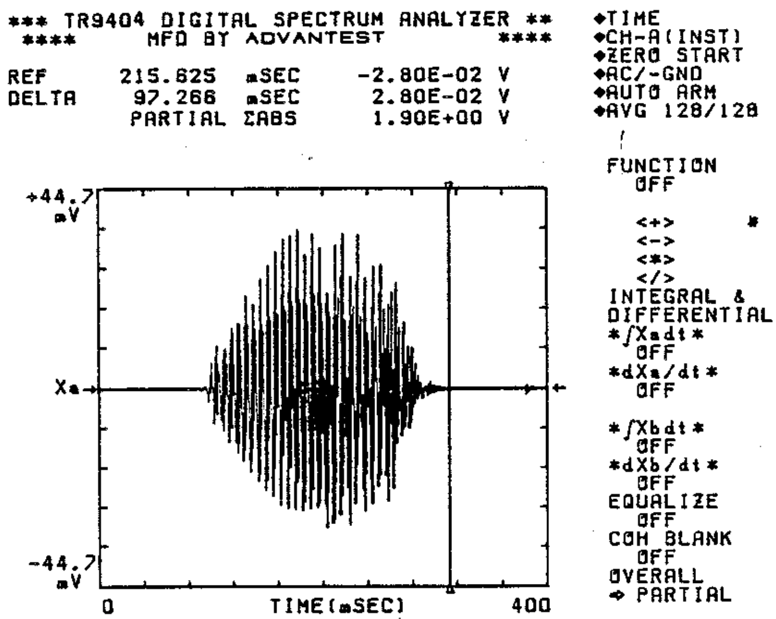


Fig. 4-93 Absolute voltage summation of partial time data

⑫ DISPLAY CTL key

Operation of this key shows a "DISP CTRL" menu (shown in Figure 4-94) on the display.

Setup of the "DISP CTRL" menu in the dual display mode is with respect to the display designated by the UPPER/LOWER [□] key in the DISPLAY section. The currently selected mode is indicated either as *LOWER* or *UPPER* in the menu.

Menu	Description
DISP CTRL *LOWER*	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.
DISP MODE TIME HIST	
Mag Mag^2 ⇨ dBMag L#	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.
DISP GAIN (dB/DIV)	Set 10 dB, 5 dB, or 2 dB as the value of each division on a dB display.
2 5 10 L#	In this example, L indicates a setting for the lower display and # for the upper display.
DATA WINDOW AUTO # MANUAL	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 width each time either key is pressed.

Fig. 4-94 DISP CTRL menu

Items Mag, Mag^2 and dBMag in the DISP CTRL menu are used to select the unit of power spectrum and readout shown on the display when MAG. key in the DISPLAY section is activated. To select one of these units, first use ⇧ or ⇩ key in the SETUP section to position the pointer (⇨) to the desired unit (Mag, Mag^2 or dBMag), then press SETUP key. If the lower display area is selected as the objective of the menu, setup mark "L" will appear beside the selected item. If the upper display area is selected, setup mark "U" will appear alongside the selected item. Mark "#", if appeared with "U", indicates the setup mode for the lower display area on the screen.

When the display shows a Nyquist diagram with TRANS. FCTN key activated, items Mag, Mag^2 and dBMag in the menu are used to specify the Nyquist diagram display modes. The Real-Imag. Nyquist display mode is selected by selecting Mag or Mag^2. The dBMag.-Phase Nyquist display mode is selected by setting up dBMag. See the paragraph pertaining to NYQ (ORBIT) in the DISPLAY section description.

i) "DISP GAIN (dB/DIV)"

The DISP GAIN setup to the DISP CTRL menu is valid to the MAG. (dBMag.) display mode for spectral data. When a spectrum is shown in dBMag, the DISP GAIN setup allows you to select display gain per division from 2, 5, and 10 dB/div. To select one of these gains, first use ⇧ or ⇩ key in the SETUP section to position the pointer to the desired gain item (2, 5 or 10) in the menu, then press SETUP key.

ii) "DATA WINDOW"

The DATA WINDOW setup is associated with the DATA WINDOW key in the GENERAL CURSOR section. See the paragraph pertaining to the DATA WINDOW in the GENERAL CURSOR section descriptions.

The DATA WINDOW setup to the DISP CTRL menu is valid when DATA WINDOW [□] key in the GENERAL CURSOR section is activated. If "AUTO" is selected for DATA WINDOW, momentary operation of [⇦] or [⇨] key continuously moves the data window until either of the keys is pressed again. If "MANUAL" is selected for DATA WINDOW, the data window moves only while [⇦] or [⇨] key is depressed and held.

(13) ADVANCED ANALYSIS

As for the use of this key, refer to section 7: ADVANCED ANALYSIS.

4-4-6. DISPLAY Section

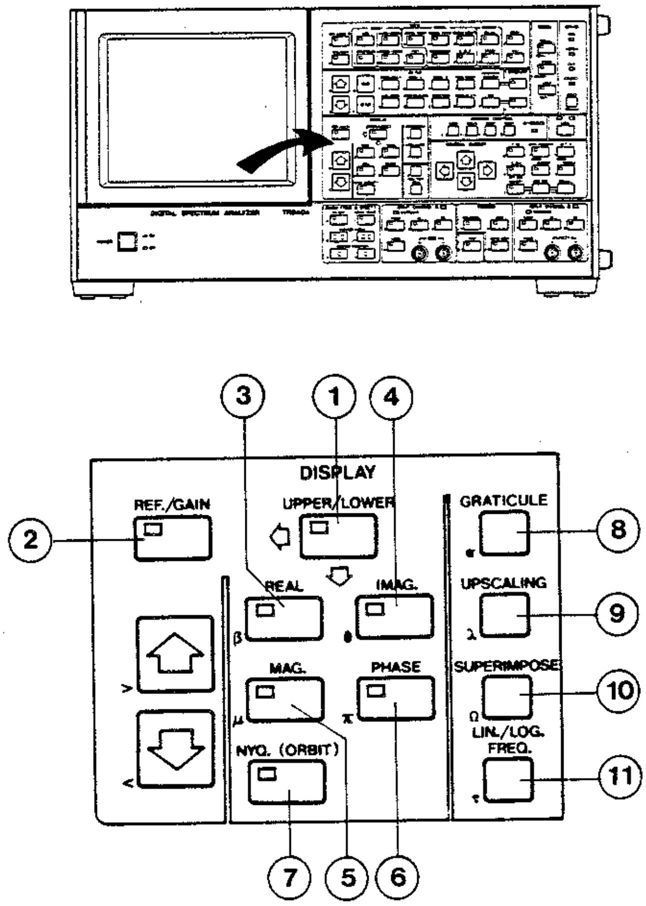


Fig. 4-95 DISPLAY section panel

(1) UPPER/LOWER key

This key is used in the BOTH display mode to select either the upper or lower display area on the display to be affected by the VIEW section keys and the REF/GAIN, REAL, IMAG., MAG., and PHASE keys in the DISPLAY section.

In the SINGLE display mode, the UPPER/LOWER key is inoperative and is always placed in the LOWER mode (lamp remains off).

If UPPER/LOWER key is placed in the UPPER mode in the BOTH display mode, data in the upper display area on the screen is affected by the VIEW section functions and the REF./GAIN ⇧ ⇩ REAL IMAG. MAG. and PHASE keys in the DISPLAY section. If UPPER/LOWER key is placed in the LOWER mode, the VIEW and DISPLAY section functions are eligible for the data in the lower display area. However, the upper/lower switching function is not valid for GRATICULE UPSCALING SUPERIMPOSE and LIN./LOG. FREQ. keys.

② REF./GAIN (Reference/Gain) key

If the REF./GAIN key is placed in the REF. mode (lamp comes on), the signal trace on the display can be moved in the vertical direction with ⇧ and ⇩ keys.

The trace on the display is moved continuously upward while ⇧ key is depressed and held, and is moved continuously downward while ⇩ key is depressed and held. The REF is initialized when any of the keys in the VIEW section is operated; the signal trace returns to its original position.

If the REF./GAIN key is placed in the GAIN mode (light remains off), Y axis gain on the display can be varied with ⇧ and ⇩ keys. The signal on the display is magnified with ⇧ key and is reduced with ⇩ key.

The signal response, once magnified or reduced by the GAIN mode function, won't be initialized into the original position even when any of the keys in the VIEW section is operated.

In the Dual display mode, keys REF./GAIN ⇧ and ⇩ are effective for data in either the upper or lower display area on the CRT depending on whether UPPER/LOWER key is placed in the UPPER (light on) or LOWER mode.

It should be noted that the REF mode simply moves the reference level for the data on the display and does not apply a DC offset to the input signal. Also note that the GAIN mode does not control input sensitivity on the analyzer, but simply controls the display gain.

a. REF./GAIN functions in the linear display mode

Data in the linear display mode has both positive (+) and negative (-) polarities, and includes TIME, AUTO-CORR, CROSS-CORR, and IMPUL. RESP. data, plus the real, imaginary and phase information of spectral data.

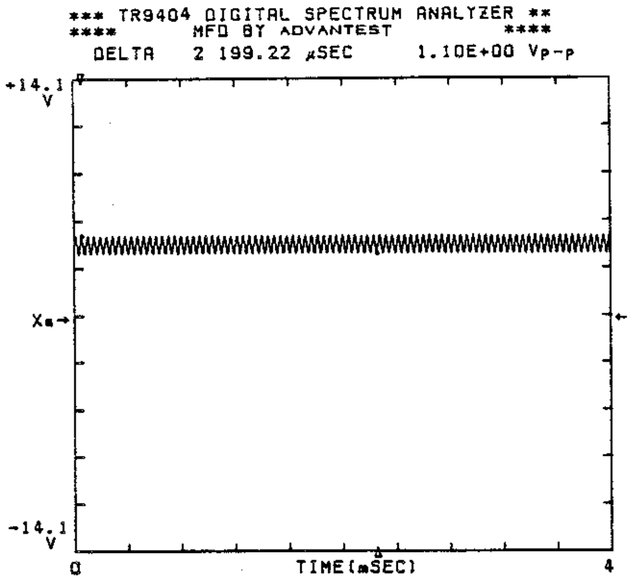
If [REF./GAIN] key is placed in the REF. mode (lamp is lit) and then [⇧] key in the DISPLAY section is pressed, the signal response trace on the display moves upward. Operation of [⇩] key moves the trace downward. Since [⇧] and [⇩] keys have alternate action capability, the trace moves continuously upward or downward while these keys are depressed and held.

The REF mode allows for a reference level movable range of +2 times the selected fullscale range. For example, if the +30 dBV range is selected for TIME data, the fullscale is ±44.7 V, and hence the variable reference range is between -89.4 V and +89.4 V. It should be noted here that the maximum voltage applicable to the inputs of the analyzer is still +30 dBV (±44.7 V) although the sensitivity range appears to be broadened to ±89.4 V by the REF mode function.

If ⇧ or ⇩ key is operated when the reference level is at the maximum limit (either positive or negative) of the variable range, it is alerted by a "beep" tone, instead of a "pip" tone, and further movement of the level is disabled.
As the reference level is moved with ⇧ or ⇩ key, mark "—►" (indicating the zero level) shown on the left margin of the graticule also moves with the level.
When you wish to enlarge the display signal on the display, first use the REF mode function to position the response to the center of the display, then set REF./GAIN key to the GAIN mode. The ⇧ and ⇩ keys in the DISPLAY section now provide gain magnification and reduction functions respectively.
Each operation of ⇧ key enlarges the signal response around the center of the display in binary steps (x2, x4, and so forth). The maximum available magnification is x16 for TIME, AUTO-CORR., CROSS-CORR., and IMPUL. RESP. data, x512 for REAL and IMAG. parts of spectral data, and x8 for PHASE information of spectral data.
When the maximum magnification is reached by the operation of ⇧ key, it is alerted by a "beep" sound, and further enlargement of the signal response is disabled. To reduce the enlarged signal response to its original scale, use ⇩ key.
The ⇧ and ⇩ keys have alternate action capability in the GAIN mode as well, allowing continuous enlargement and reduction of signal response while they are depressed and held.

While a signal response is enlarged by the GAIN mode function, the magnification is read out as "x n" (n: a factor of magnification in binary steps).

If the REF./GAIN and ZOOM functions are combined for TIME data, the TR9404 can be used as a powerful digital oscilloscope.



DC component is superimposed on the signal.

① 

Set in the REF mode.

②  Move the trace to the center of the CRT.

③ 

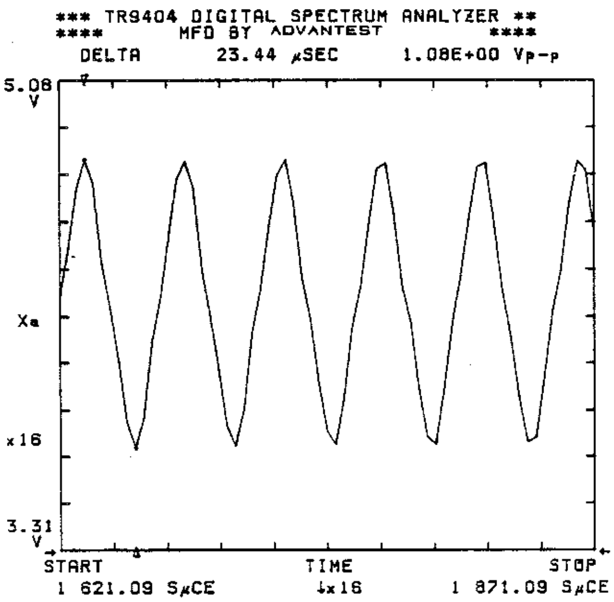
Set to the GAIN mode.

④  Expand the Y axis (x 16 in this example).

⑤ 

ZOOM-ON

⑥  Expand the X axis with EXPAND WIDTH (x16 in this example).



Time signal is clearly observed.

Fig. 4-96 Effective use of the REF./GAIN and ZOOM functions for TIME data

b. REF./GAIN functions in the linear power display mode

Data in the linear power display mode always has a positive (+) polarity, and includes HIST and COHERENCE data plus Mag and Mag^2 spectral data. The REF. mode is not available for HIST data, however.

If [REF./GAIN] key is set in the REF. mode (light comes on), operation of [⇧] key in the DISPLAY section moves the signal response trace on the display upward. Operation of [⇩] key moves it downward. The reference level variable range available in the linear power display mode is between zero and 1.5 times the fullscale. When the maximum limit of the variable range is reached with [⇧] key or the original level is restored with [⇩] key, it is alerted by a "beep" sound and further operation of these keys is disabled.

When you wish to obtain an enlarged signal in the linear power display mode, set [REF./GAIN] key in the GAIN mode (lamp goes off). The displayed response can now be enlarged in binary steps (x2, x4, and so forth) each time [⇧] key is pressed. The maximum magnification available is x32 for HIST data and x512 for COHERENCE and power spectrum (Mag, Mag^2) data. Unlike the linear display mode, the linear power display mode places the reference for signal enlargement at the bottom graticule of the display. To restore the original size, use [⇩] key until magnification is returned to x1. The current magnification is read out in the left display area on the CRT, except for x1.

c. REF./GAIN functions in the dB display mode

Usage of the REF./GAIN functions for SPECTRUM, TRANS. FCTN., CROSS SPECT., and C.O.P. data in the dBMag. (dB) display mode is as follows:

If REF./GAIN key is set in the REF. mode, operation of ⇧ and ⇩ keys moves the signal on the display upward and downward respectively. The movable range is between +250 dB and -250 dB irrelevant to the input sensitivity setup. In the reduction of transfer function data, REF. mode is inhibited at such factors as X1/2, X1/4, X1/8, X1/16 and X1/32.

The step span for reference level movement depends on the DISP GAIN setup (2, 5, or 10 dB/div.) with the DISP CTRL switch. For instance, if "10 dB/DIV." is selected for DISP GAIN, each operation of ⇧ or ⇩ key moves the reference level in 10 dB steps. If the maximum limit of variable range is reached, it is alerted by an audible tone, and further movement of the reference level is disabled.

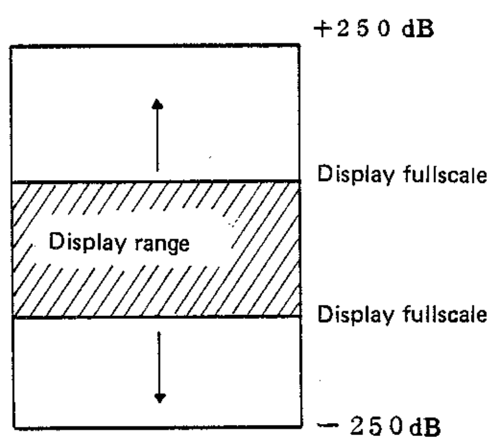


Fig. 4-97 REF. variable range for spectrum (dB)

Unlike other linear display modes, the dB display mode for spectral data allows the GAIN function to provide enlargement of display dynamic range.

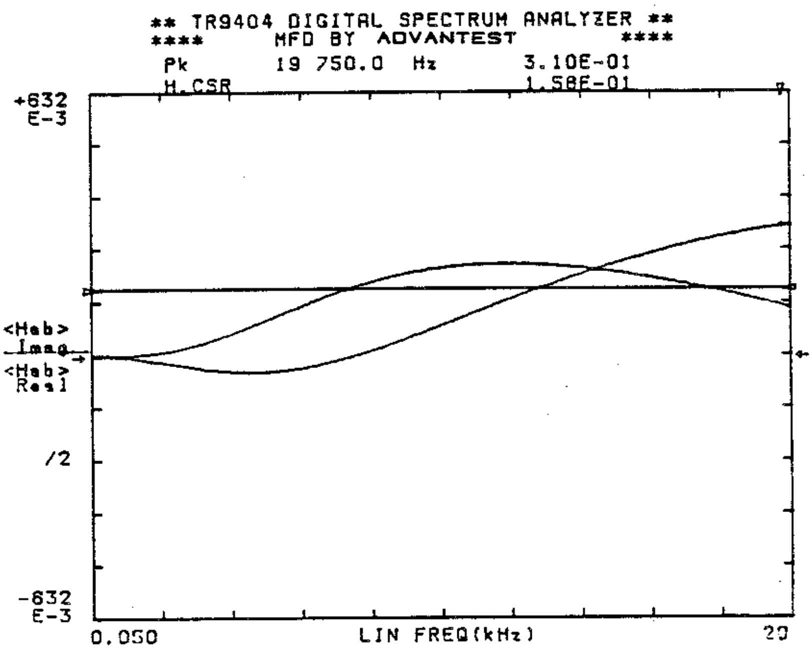
When REF./GAIN key is set in the GAIN Mode and DISP GAIN menu is set up at "10 dB/DIV." with DISPLAY CTL key in the SETUP section, each operation of ⇧ key increases display dynamic range in 10 dB steps starting from 60 dB. The maximum available dynamic range is 100 dB when 10 dB step is selected. As for transfer function, cross spectrum, or C.O.P. shown within the front-panel frame of CROSS in the VIEW section, dynamic range is 200 dB. When the maximum dynamic range is reached by the operation of ⇧ key, a "beep" alarm sounds and further operation of ⇩ key is disabled. To reduce display dynamic range from the maximum setup, use ⇩ key.

If DISP GAIN menu is set up at "5 dB/DIV.", the initial display dynamic range is 30 dB. In this case, each operation of ⇧ key increases dynamic range in 5 dB steps. Beyond 50 dB, ⇧ key increases it in 10 dB steps up to 100 dB.

If DISP GAIN menu is set up at "2 dB/DIV.", the initial display dynamic range is 14 dB. In this case, each operation of ⇧ key increases dynamic range in 2 dB steps up to 20 dB, and in 4 dBs steps up to 40 dB.

d. REF./GAIN setup using a horizontal cursor

When a horizontal cursor is on the display in the Linear, Linear Power, or dB display mode, operation of the key (in the DISPLAY section) after selecting the GAIN mode with the REF./GAIN key expands the displayed signal in binary steps. The level which was identified by the horizontal cursor is repositioned in the center level on the screen for the expanded signal. This feature may thus be useful to relocate a signal trace from the top or bottom display area to the center area.



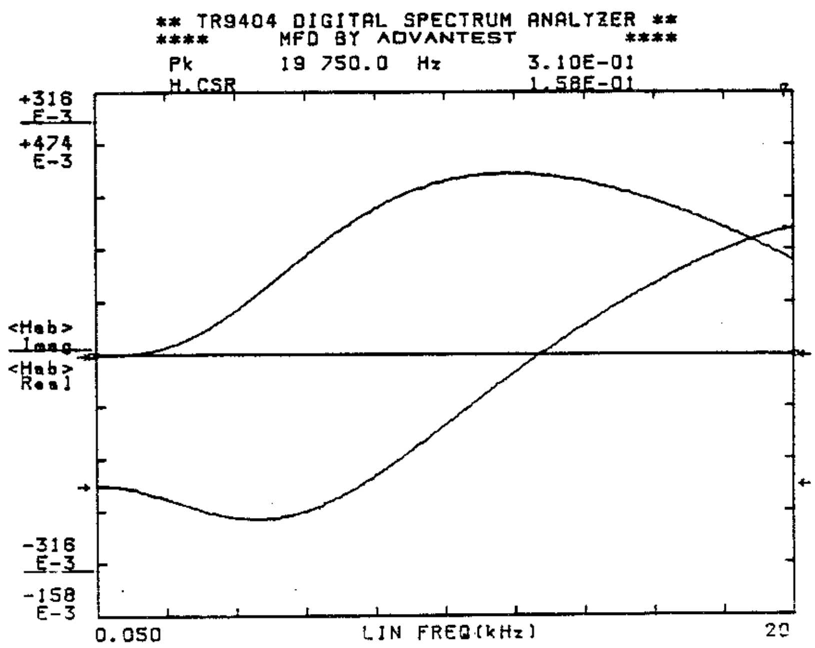


Fig. 4-98 REF./GAIN setup using the horizontal cursor (linear display)

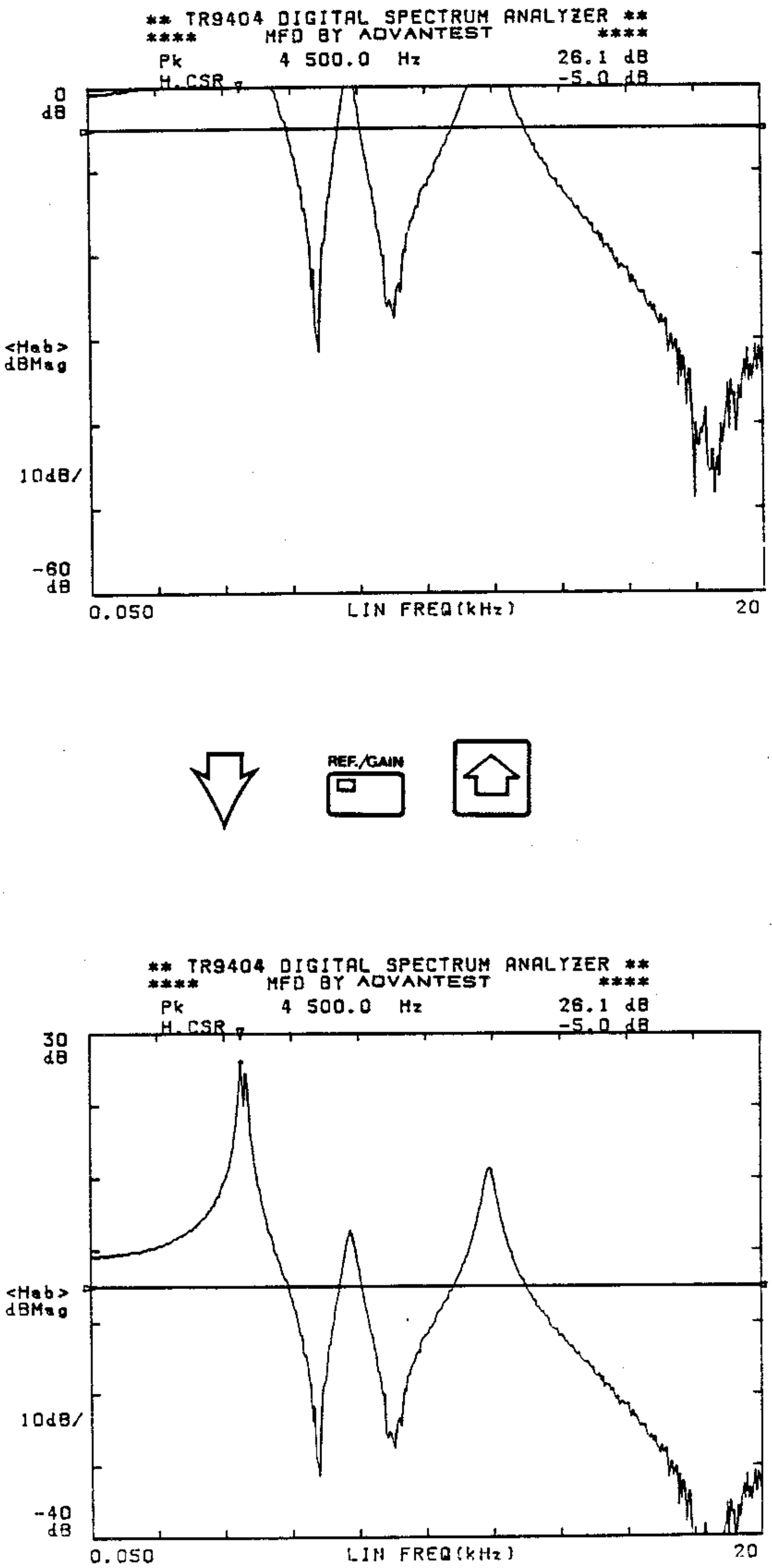
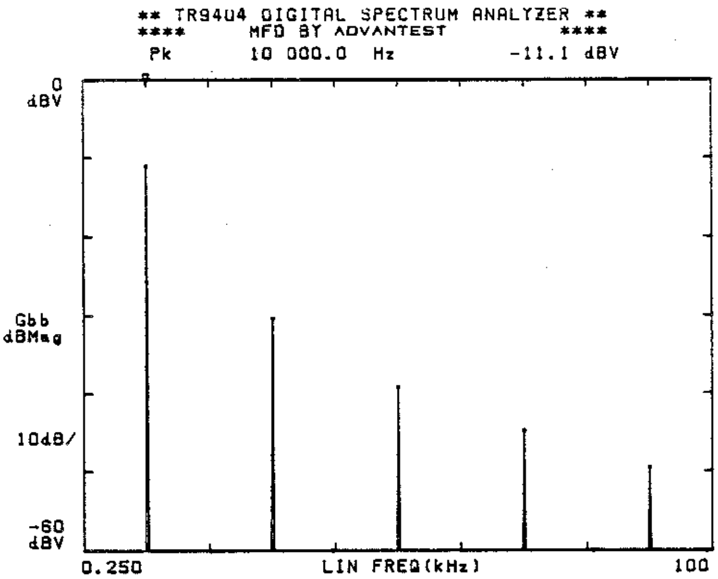
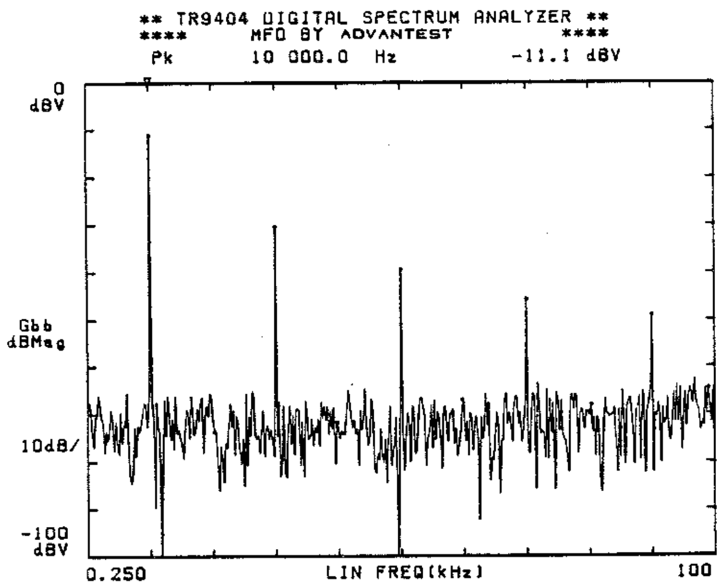


Fig. 4-99 REF./GAIN setup using the horizontal cursor (dB display)



Display dynamic range

60 dB



Display dynamic range

100 dB

When the display dynamic range is 60 dB, the fundamental and odd-number harmonics of the 3rd and 5th can be read on the display. If the display dynamic range is increased to 100 dB by setting the REF/GAIN key to the GAIN mode and then using the  key, even-number harmonics of 2nd, 4th and 6th plus background noise can be observed.

Fig. 4-100 GAIN mode for spectral data (dBMag)

Table 4-13 REF./GAIN variable range for each VIEW section function

VIEW		REF.		GAIN	
		(+) Maximum	(-) Minimum	Magnification (binary steps)	Reference position for magnification
TIME		(+)fullscale range x 2	(-)fullscale range x 2	x2 - x16	Center level on the display
AUTO-CORR. CROSS-CORR.		+2.0	-2.0	x2 - x16	Center level on the display
HIST.		REF. unavailable	REF. unavailable	x2 - x32	Bottom fullscale level on the display
IMPUL. RESP.		+2.0	-2.0	x2 - x16	Center level on the display
COHERENCE		+1.5	0.0	x2 - x512	Bottom fullscale level on display
SPECTRUM TRANS.FCTN CROSS SPECT.	REAL IMAG.	(+)fullscale range x 2	(-)fullscale range x 2	x2 - x512 (/32 - x512: Transfer function only)	Center level on the display
	MAG. V MAG. V^2	Fullscale range x 1.5	0.0	x2 - x512 (/32 - x512: Transfer function only)	Bottom fullscale level on the display
	MAG. dB	+250 dB	-250 dB	Display dynamic range expansion *	Top fullscale level on display
	PHASE	+400 deg.	-400 deg.	x2 - x8	Center level on the display
C.O.P.	MAG. V MAG. V^2	Fullscale range range x 1.5	0.0	x2 - x512	Bottom fullscale level on the display
	MAG. dB	+250 dB	-310 dB	Display dynamic range expansion *	Top fullscale level on display

* 10 dB steps 60 dB - 200 dB (20-dB steps from 100 dB to 200 dB) (Up to 100 dB as to the parameters outside the CROSS frame in VIEW section)

5 dB steps 30 dB - 50 dB (10-dB steps from 50 dB to 100 dB)

2 dB steps 14 dB - 20 dB (4-dB steps from 20 dB to 40 dB)

These figures, dynamic range on display, correspond to the "DISPLAY GAIN" selected in the "DISP CTRL" menu.

③ REAL key (Real Part)

④ IMAG. key (Imaginary Part)

⑤ MAG. key

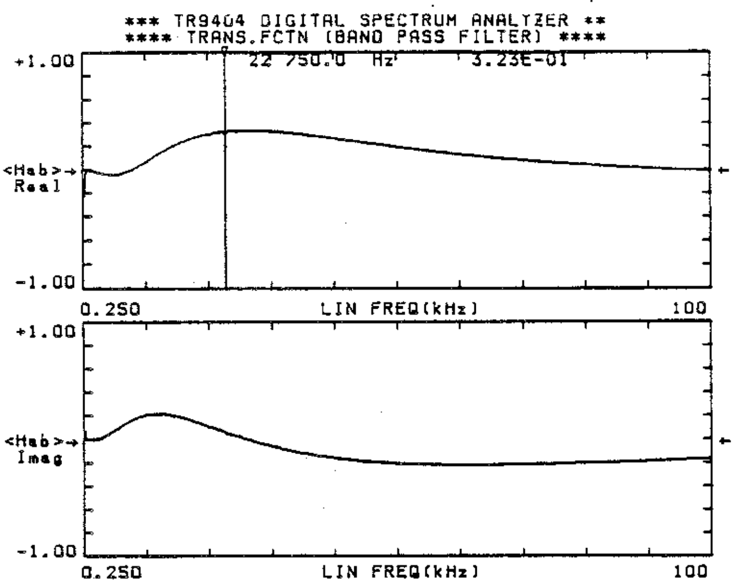
⑥ PHASE key

The REAL, IMAG., MAG., and PHASE keys allow to display the real part, imaginary part, phase, and magnitude of a complex spectrum selected with the VIEW section, respectively.

These keys are effective to SPECTRUM, TRANS. FCTN, or CROSS SPECT data selected with the VIEW section functions, whereas they are not effective to TIME, AUTO-CORR., HIST., CROSS-CORR., IMPUL. RESP., COHERENCE, or C.O.P. data.

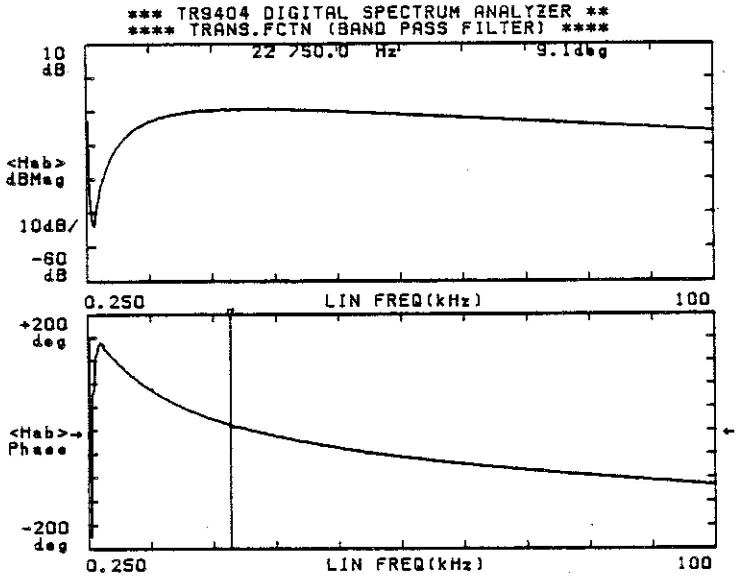
In the Dual display mode, display modes of REAL, IMAG, MAG, PHASE can be assigned using UPPER/LOWER key.

If MAG. display is specified for power spectrum, its magnitude can be displayed in Mag, Mag^2, or dBMag depending on the setup in the DISP MODE menu by using DISPLAY CTL key.



"REAL" and "IMAG" of a filter obtained with TRANS.FCTN
Top: "REAL"
Bottom: "IMAG"

Fig. 4-101 REAL and IMAG. display examples for bandpass filter response



"MAG" and "PHASE" display

Top: "MAG" (dBMag)

Bottom "PHASE" (deg)

Fig. 4-102 MAG. and PHASE display examples for bandpass filter response

7 NYQ (ORBIT) key

This key enables REAL-IMAGE Nyquist display for complex spectrum. For TIME data, it allows for orbital (Lissajous) diagram.

- Nyquist display for complex spectrum

  If SPECTRUM in the VIEW section and REAL, IMAG. or PHASE in the DISPLAY section are activated for the data in the single display mode or lower data in the dual display mode, operation of NYQ. (ORBIT) key selects the Nyquist display mode, with the X and Y axes giving the real and imaginary parts of a complex spectrum respectively (see Figures 4-104 and 105).

  Operation of NYQ. (ORBIT) key won't activate the Nyquist display mode if MAG. key in the VIEW section is activated.

In the Nyquist display mode, a cursor mark "+" is shown on the signal trace on the display and moves with frequency. The real and imaginary parts at the frequency identified by the cursor are read out on the display as "Re" and "Im".
Since the Nyquist mode defines the frequency axis as vertical to the CRT (see Figure 4-103), no frequency information is shown on the display.

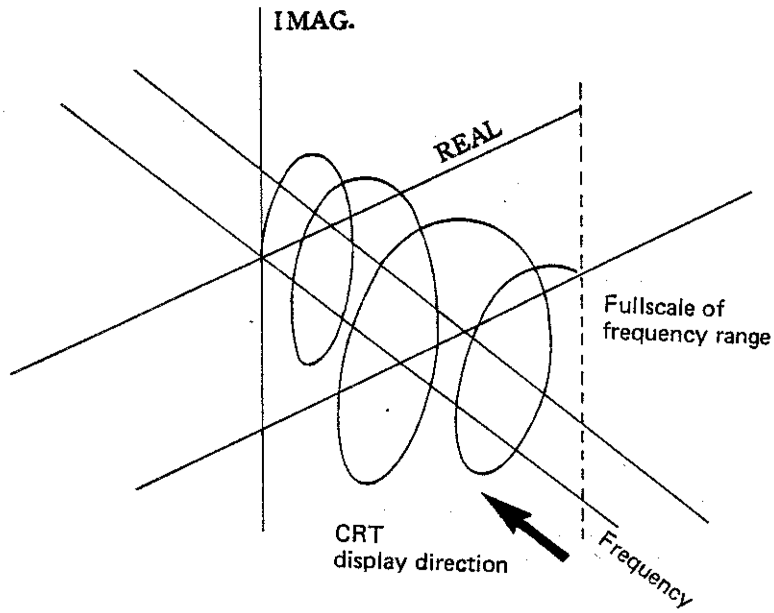


Fig. 4-103 Nyquist display mode

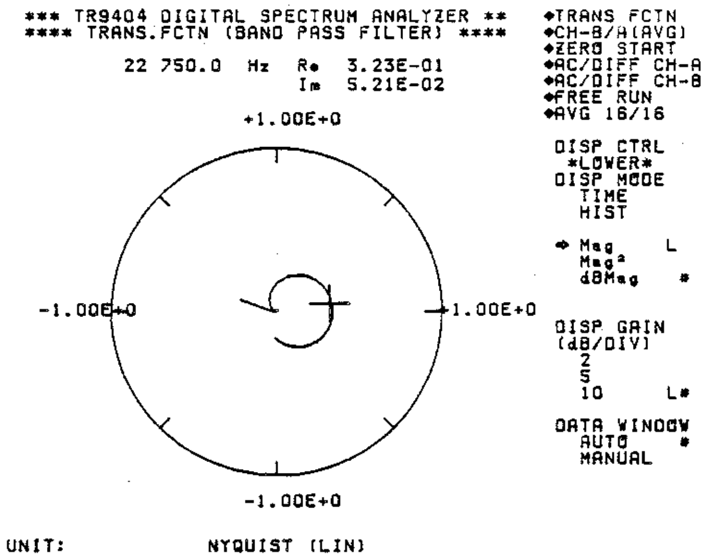
- Nyquist display for TRANS. FCTN data

  In addition to the REAL-IMAGE. display mode there is another Nyquist display for TRANS. FCTN data (dBMag-Phase display) in which the equivalent magnitude (dBMag.) is represented on the concentric circle and the angle gives phase information (see Figure 4-105).

To select the REAL-IMAG. Nyquist display mode for TRANS. FCTN data, activate [NYQ. (ORBIT)] key after specifying "Mag" or "Mag^2" for the DISP MODE menu by using [DISPLAY CTL] key. The X and Y axes give the real and imaginary parts of a TRANS. FCTN data respectively. The real and imaginary parts at the frequency identified by the cursor are read out on the display while the cursor moves with frequency.

To select the dBMag-PHASE Nyquist display mode for TRANS. FCTN data, activate [NYQ. (ORBIT)] key after specifying "dBMag" for the DISP MODE menu by using [DISPLAY CTL] key. In the dBMAG.-PHASE display mode, the radial axis gives magnitude (dB) information and the angle from the X axis gives phase information. In this case as well, the cursor moves with frequency, and the magnitude and phase at the frequency identified by the cursor are directly read out on the display.

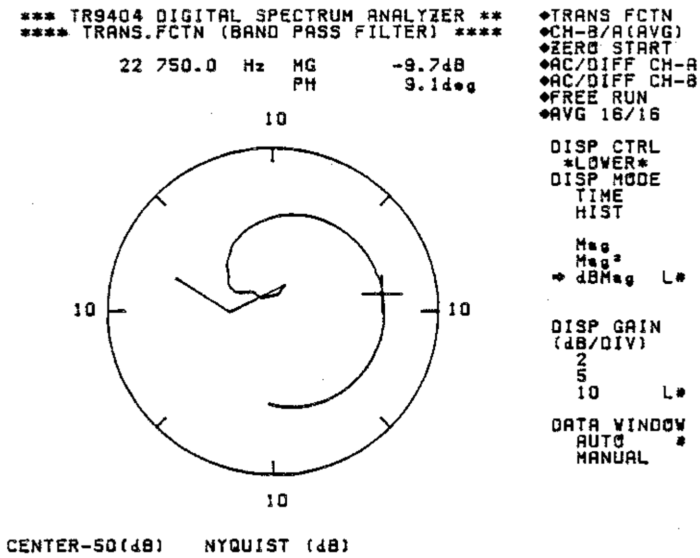
	Data to be analyzed	Form	DISP MODE
NYQ.	Complex spectrum Sa, Sa	Real - Imag	-
	Cross spectrum Gab, Gab	Real - Imag	-
	Transfer function Hab	Real - Imag	Mag, Mag^2
		dBMag - Phase	dBMag
ORBIT	Time data Xa, Xb	X-axis data: lower display Y-axis data: upper display	-



REAL-IMAG. Nyquist display for a bandpass filter analyzed by the TRANS FCTN.

DISP MODE : Mag or Mag^2

Fig. 4-104 Nyquist display example (REAL-IMAG.)



DISP MODE : dBMag

Fig. 4-105 Nyquist display example (MAG.-PHASE)

● Orbit diagram mode

If, in the Dual display mode, the data in both the upper and lower display areas are TIME data with equivalent frame time, operation of NYQ. (ORBIT) key activates the orbit (Lissajous) diagram mode (see Figure 4-106). Once this mode is entered, the data which has been shown in the upper display area is assigned to the Y (vertical) axis data, while the data which has been shown in the lower display area is assigned to the X (horizontal) axis data. A cursor "+" appears on the signal trace and continuously moves on it. The time identified by the cursor and the X and Y voltage values at the time are directly read out in the top display area on the CRT.

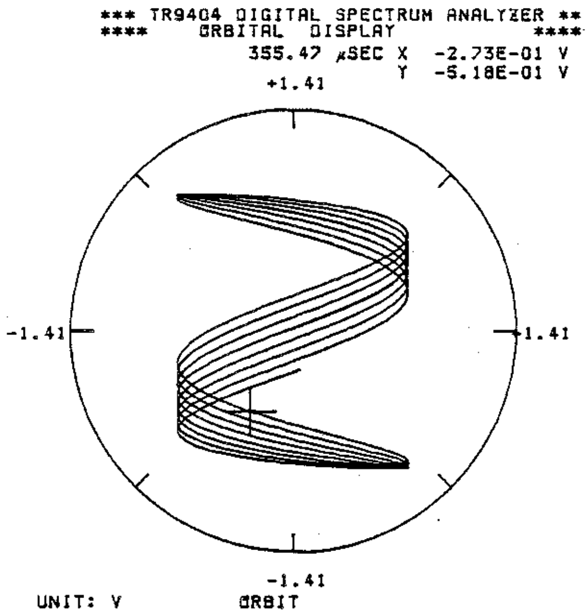
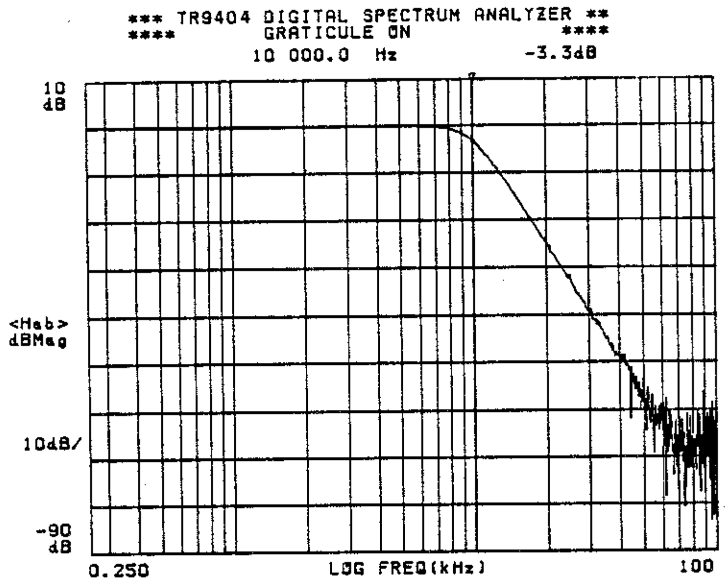


Fig. 4-106 Orbit (Lissajous) diagram example

8 GRATICULE

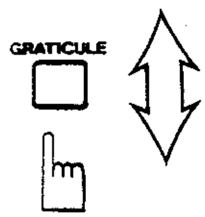
This key is used to erase the electronic graticule from the display screen (see Figure 4-107). It gives a clearer view of the signal trace on the display.

A second operation of the GRATICULE key will restore the graticule on the display. The GRATICULE key is also effective to the Nyquist or orbital display to erase the graticule from the diagram.

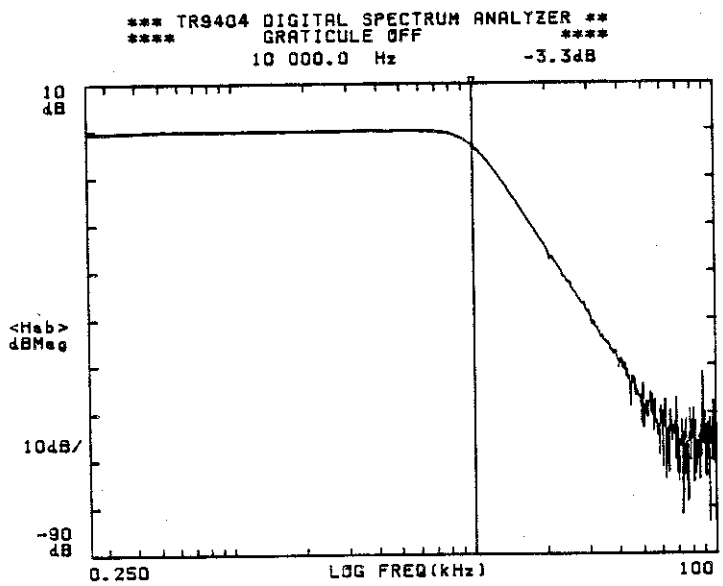


GRATICULE: ON

Graticules are displayed.



Alternates with each press of this key.



GRATICULE: OFF

Scales are displayed and the inner graticule lines disappear.

Fig. 4-107 Effect of the GRATICULE key

⑨ UPSCALING key

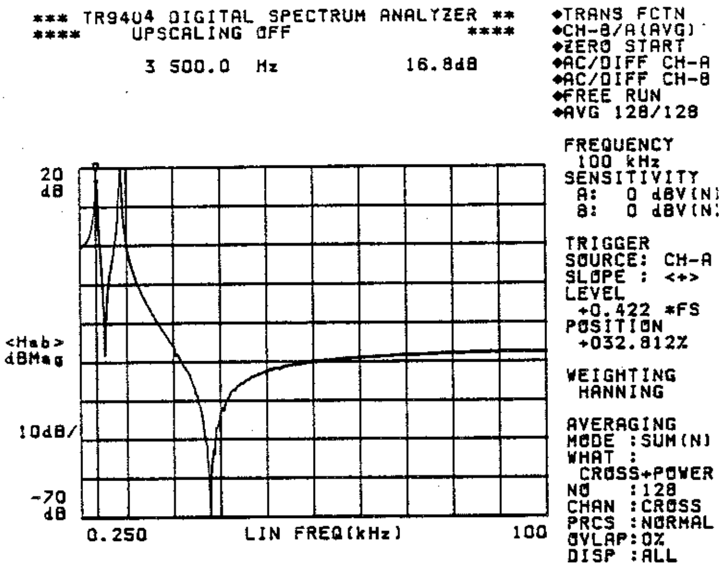
This key is used to expand the display area for signal trace. Operation of UPSCALING key erases the setup menu from the right display area on the CRT and broadens the display area for signal trace by approximately 40% (see Figure 4-108). This key is particularly useful for data observation under the same measurement condition, without changing menu setup. The GRATICULE key (to erase graticule) is effective also while the UPSCALING function is used.

Information shown during the UPSCALING mode includes the X and Y axis annotations, readouts at the cursor, and two lines of label information, as well as signal trace.

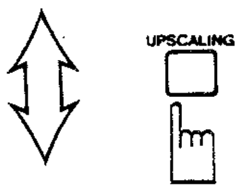
The UPSCALING function is effective also to the Nyquist or orbital display mode.

Also there are some combinations of data displays which are possible only in the UPSCALING mode, such as the BOTH display for TIME and SPECTRUM in single channel mode.

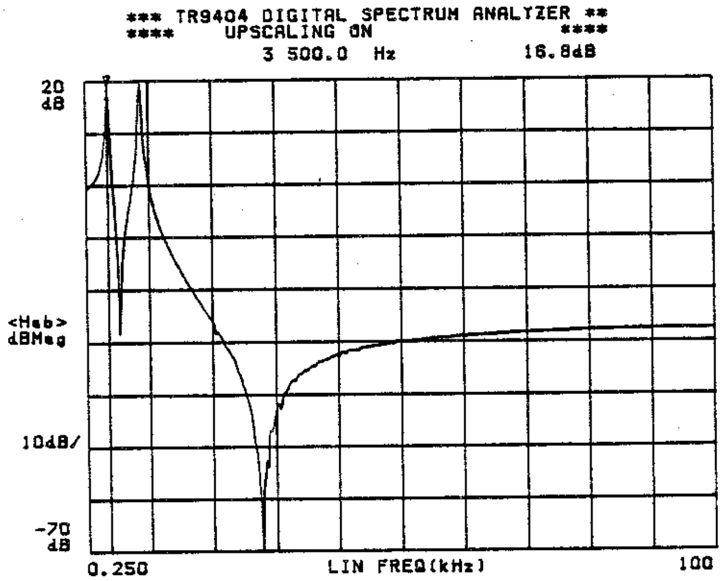
To clear the UPSCALING mode, either press the UPSCALING key again or operate any of the keys in the SETUP section; the setup menu will be restored in the right display area on the CRT.



Setup menu is displayed on the right side



Alternates with each press of the key



The setup menu disappears and the signal trace area is expanded by about 40%

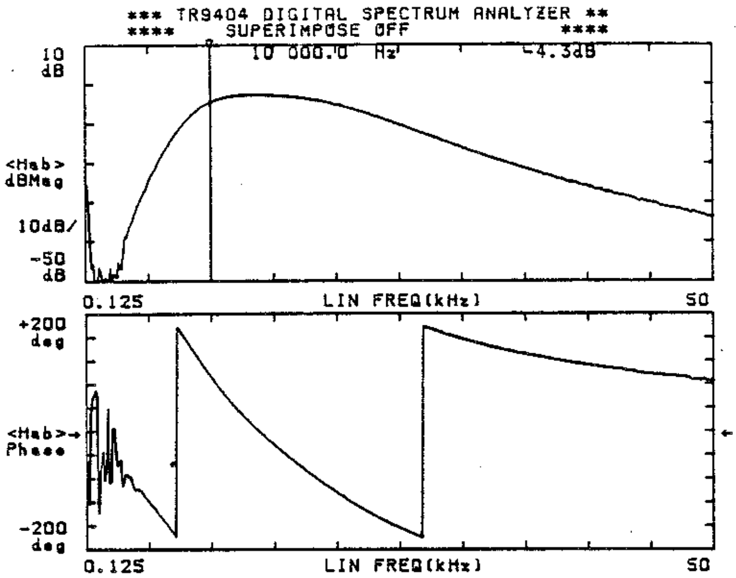
Fig. 4-108 UPSCALING key function

(10) SUPERIMPOSE key

This key is used to superimpose one signal trace on another. If two signal traces having identical domain (frequency, time, delay, amplitude domain) and analysis range are shown in the upper and lower display areas each in the Dual display mode, operation of [SUPERIMPOSE] key superimposes these traces each other in one display area. It may be useful for comparison of two signals or for superposition of magnitude plus phase information of complex spectrum or transfer function plus coherence information.

The [GRATICULE] and [UPSCALING] keys are effective in the SUPERIMPOSE mode as well.

To reset the SUPERIMPOSE mode, press the SUPERIMPOSE key again; the Dual display mode will be restored. See Figure 4-109.

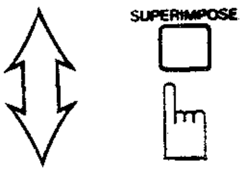


SUPERIMPOSE OFF:

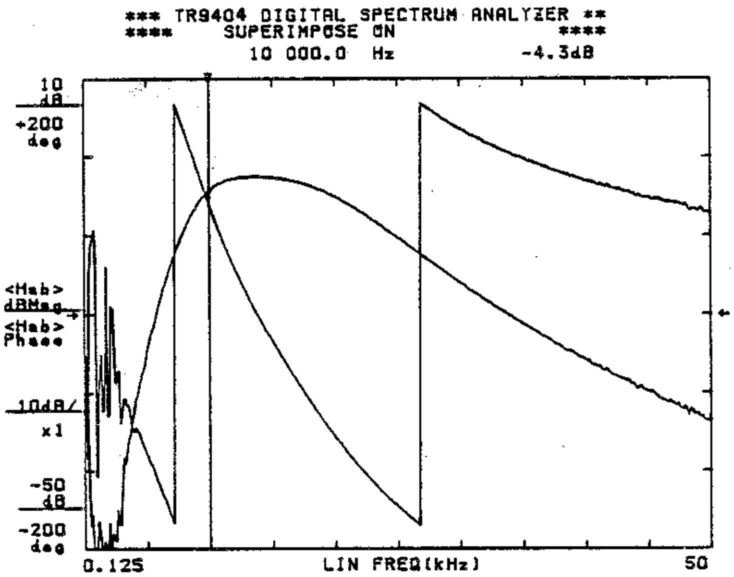
Normal dual display mode

Top: dBMag of a transfer function

Bottom: Phase of Transfer function



Alternates with each press of the key



SUPERIMPOSE ON:

Signal traces in the upper and lower displays are superimposed within a single graticule border

Fig. 4-109 SUPERIMPOSE key function

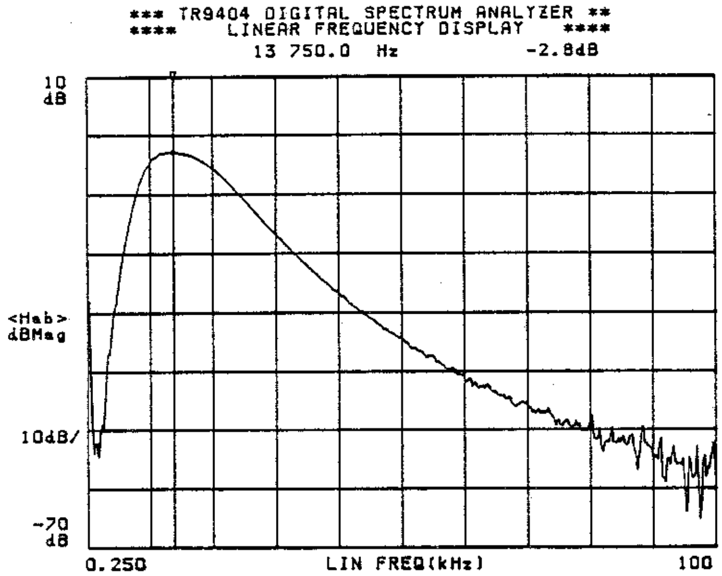
(13) LIN./LOG. FREQ. key

This key is used to switch between linear frequency and log frequency modes in the frequency domain. When the displayed data is in the frequency domain, operation of LIN./LOG. FREQ. key places the frequency axis in the logarithmic mode. A second operation of this key replaces the frequency axis in the linear scale of ten divisions.

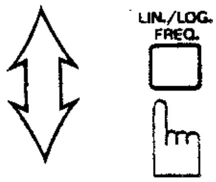
The LIN./LOG. switching function is effective also to the GRATICULE, UPSCALING, and SUPERIMPOSE modes. The logarithmic scale is available for CPM (Cycle per minute, see WGT/SCALING menu) representation of the frequency axis as well.

However, the LIN./LOG. FREQ. key is not operative for time series data, delay data or histogram data.

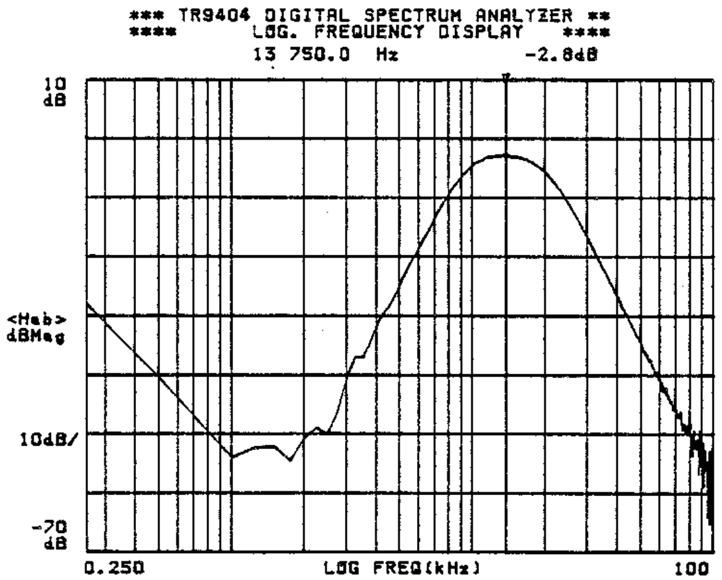
In the Dual display mode, if the signals in both the upper and lower display areas are in the frequency domain, LIN./LOG. switching is performed simultaneously for the both data. The linear and logarithmic modes are not specifiable independently for the information in the upper and lower display areas.



Linear frequency scale mode:
The frequency axis is equally divided into 10 divisions.



Alternates with each press of the key.



Log frequency scale mode:
The frequency axis is logarithmically displayed.

Fig. 4-110 LIN./LOG. key function

4-4-7. GENERAL CURSOR Section

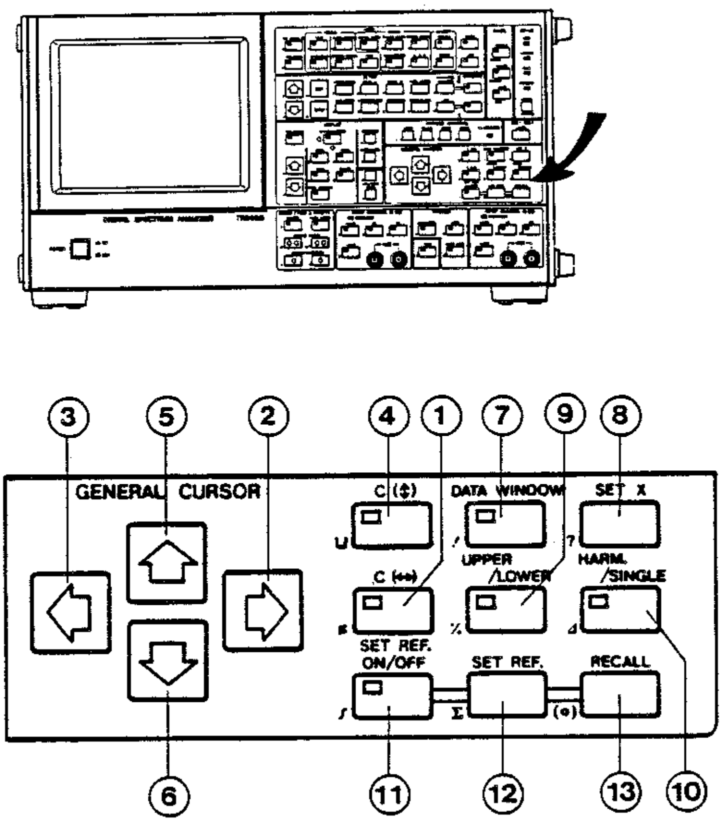


Fig. 4-111 GENERAL CURSOR section panel

Control keys in this section are used to provide further information of data points identified by one or more cursors or to read more precisely the difference between two data points with the aid of a cursor.

(1) C (↔) vertical cursor ON/OFF key

This key is used to control vertical cursor display on the screen: a cursor appears when the key is activated (light comes on).

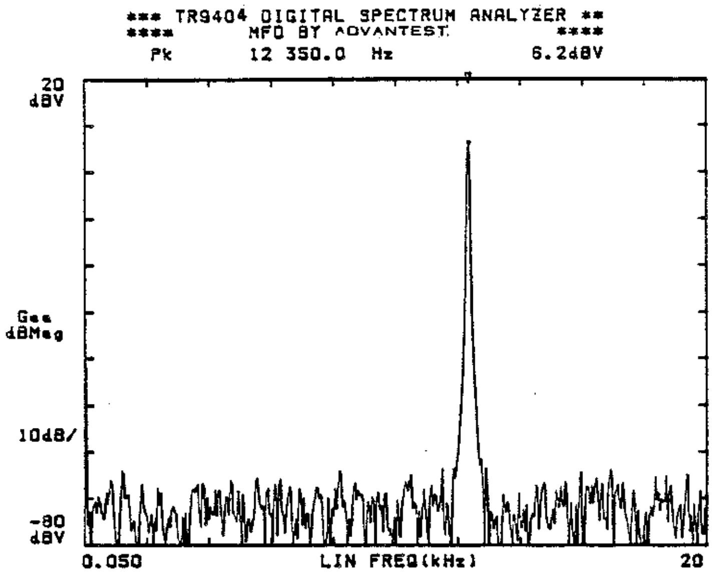
If the vertical cursor is turned off, auto peak search mode is entered. When a signal in the frequency domain is shown on the display (when, in the BOTH display mode, signal in either the upper or lower display area (specified by UPPER/LOWER key) is in the frequency domain) with the vertical cursor off, the maximum peak is automatically sought out and its frequency and level readouts are shown on the display. At the same time, the maximum peak is indicated by mark " ▽ " on the scale for quick identification. See Figure 4-112(a). As the frequency and/or level of the input signal changes, the Auto peak Search feature automatically follows it up to provide the readouts and " ▽ " mark changing accordingly.

If any of the REAL, IMAG, MAG, PHASE and NYQ. (ORBIT) keys in the DISPLAY section is activated when a frequency-domain data is shown on the display, the maximum peak is automatically sought out and its frequency and the pertinent information selected with the key are directly read out in the top information area. The example shown in Figure 4-112(d) indicates that the maximum peak is at a frequency of 32000 Hz and its phase value is 133.4 deg.

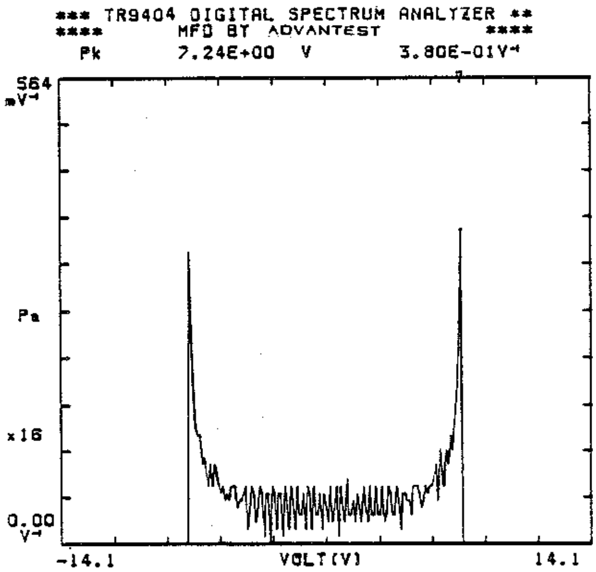
For data in the amplitude domain, the vertical cursor OFF mode similarly provides mark " ▽ " at the maximum peak and the readouts of its amplitude and probability density (see Figure 4-112(b)).

For time domain data, the vertical cursor OFF mode automatically detects the maximum and minimum points (with polarity taken into account) of the signal and provides direct readouts of the time and amplitude differences between the two points. Marks " ▽ " and " △ " appear at the maximum and minimum points respectively. (See Figure 4-112(c))

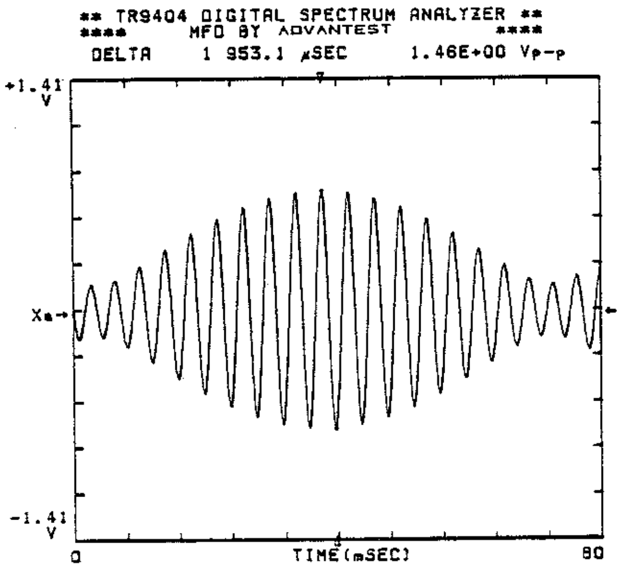
If the vertical cursor is turned on, it is automatically positioned to the maximum peak point. When the cursor readout is designated for the upper display in the dual display mode with UPPER/LOWER (the lamp within the key is turned on), the cursor is antomatically positioned to the minimum point in the time or delay domain. As shown in Figure 4-112(e), mark " ▽ " and a vertical cursor appear at the maximum peak and the amplitude (frequency domain) and probability density (amplitude domain) of the peak response are directly read out in the top area. For time domain data, marks " ▽ " and " △ " and a vertical cursor appear on the display, and the time and voltage information measured with reference to the leftmost graticule is directly read out in the top information area.



(a) Auto peak search mode (frequency domain)
Identified by " ∇ "
Pk 12350.0 Hz, 6.2 dBV

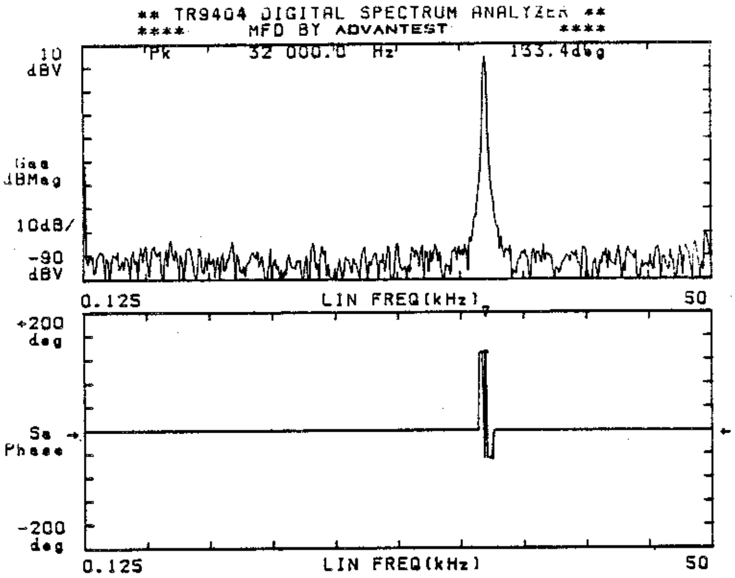


(b) Auto peak search mode (amplitude domain)
Identified by " ∇ "
Pk 7.24E + 00V, 3.80E-01V[1]



(c) Auto peak search mode (time domain)
Maximum and minimum points are identified by " ∇ " and " Δ " respectively and time and amplitude differences are also annotated
DELTA 1953.1 μsec
1.46E+00 V_{p-p}

Fig. 4-112 Vertical cursor ON/OFF mode functions (1)

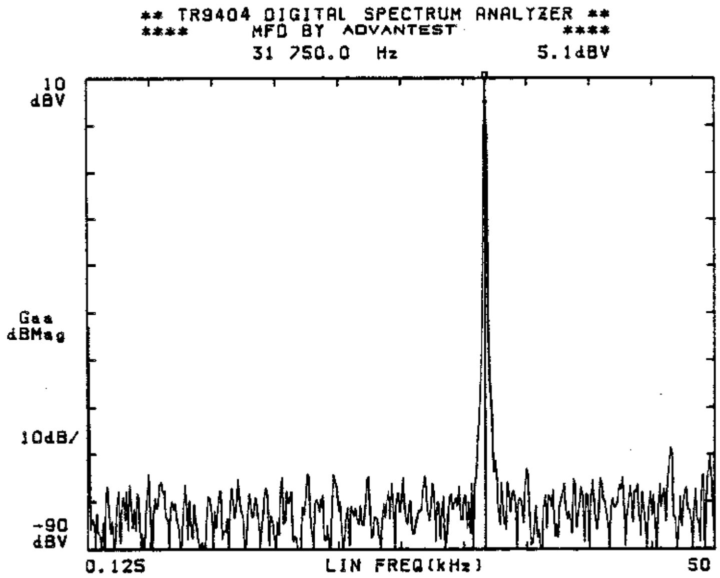


(d) Auto peak search mode

(frequency domain)

If PHASE key in the DISPLAY section is activated, the frequency and phase at the maximum peak is displayed.

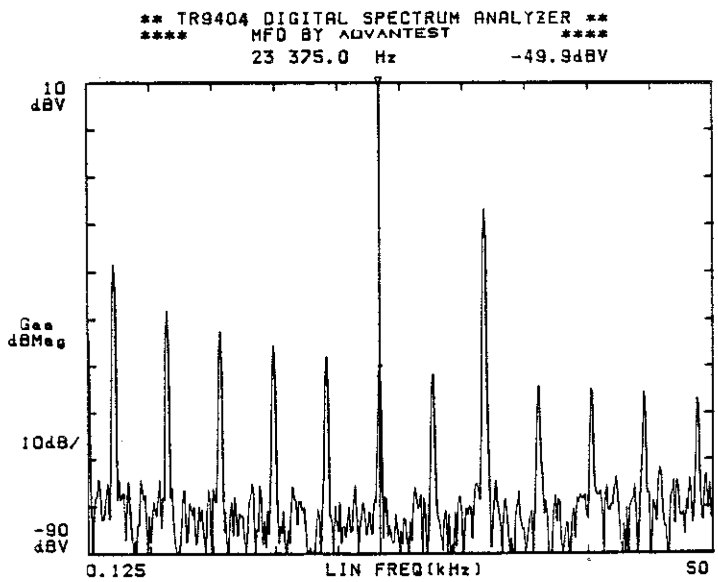
32000.0 Hz, 133.4 deg



(e) Vertical cursor: ON

Maximum peak is identified by mark " ▽ " and vertical cursor. Intersection of the cursor with the signal:

31750.0 Hz, 5.1 dBV



(f) The vertical cursor is moved to the spectrum of interest to read out its frequency and level

23375.0 Hz, -49.9 dBV

Fig. 4-112 Vertical cursor ON/OFF mode functions (2)

②③ [⇦] and [⇨] keys

These keys may be used in the following four ways:

a. Vertical cursor control

Keys [⇦] and [⇨] move the vertical cursor in the left and right directions respectively. If C (↔) [□] key is activated, a press of these keys moves the cursor one data point to the left or right. If either of the keys is depressed and held, the cursor moves continuously in the respective direction. If the cursor reaches the leftmost or rightmost graticule while the corresponding key is depressed and held, it is repositioned to the opposite end of the graticule.

b. Data shift in the Data Window ON mode

To activate data shift function in the Data Window mode, first select the SINGLE function (TIME, SPECTRUM, AUTO-CORR., CROSS-CORR., or HIST function) in the VIEW section and hold the data (with either manual hold or ARM hold), then activate DATA WINDOW [□] key ⑦. Next, press DISPLAY CTL [ ] key in the SETUP section and select "AUTO" or "MANUAL" from the DATA WINDOW menu. If the AUTO mode is selected, operation of [⇦] key moves the data window to the left, and hence the displayed time-domain data continuously moves to the right. To stop data movement, press [⇦] or [⇨] key again. Operation of [⇨] key moves the data window to the right, and hence the displayed data continuously moves to the left. To stop data movement, press [⇦] or [⇨] key again.

If the MANUAL mode is selected from the DATA WINDOW menu, each press of key moves data by the setup step span to the right; holding the depressed key activates continuous movement of the window. The data movement stops when the key is released. key similarly causes the movement of displayed data to the left. The step span of data movement is determined by vertical cursor position and SET X key. The setup procedure is described in item (8) SET X key. Time annotation at the bottom of the display in Figure 4-113 indicates the absolute time in the 32K data (64K data in a single channel) while time displayed on the top indicates relative time within a frame time.

When DATA WINDOW is set to ON, "/D.W./" is displayed in the left bottom of the CRT.

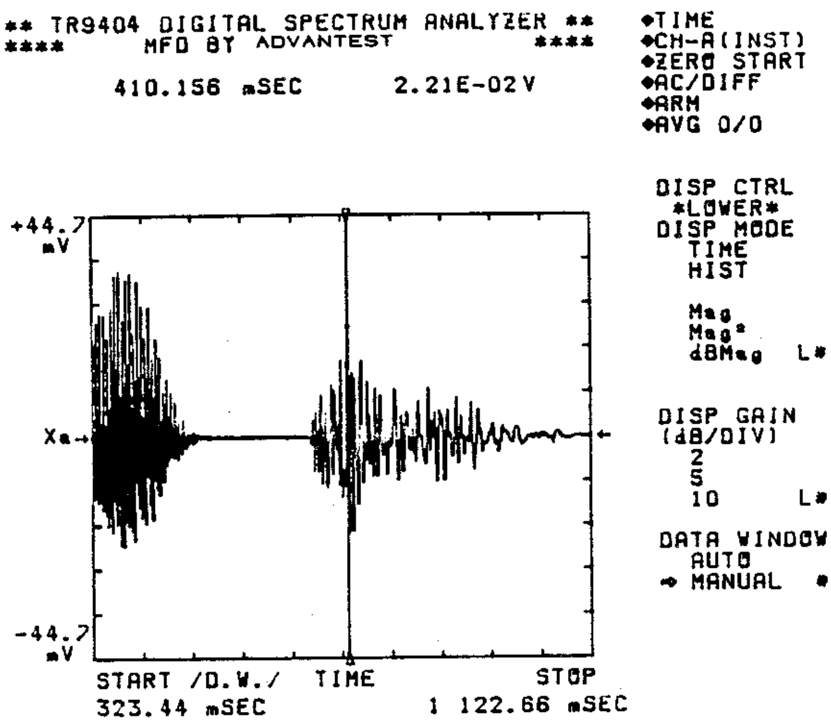


Fig. 4-113 Display example of DATA WINDOW set to ON

DATA WINDOW

(i) Vertical cursor control for DATA WINDOW

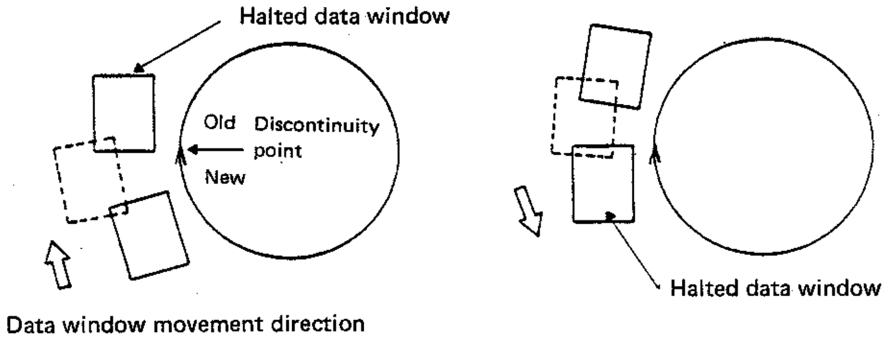
When the DATA WINDOW □ key in the GENERAL CURSOR section is activated, the vertical cursor is automatically turned OFF. If, at this time, ⇦ or ⇨ key is pressed, the data window will move in the horizontal direction. If the vertical cursor key C (↔) □ is activated, operation of ⇦ or ⇨ key will now move the vertical cursor instead of the data window. In other words, when the DATA WINDOW key is activated, operation of ⇦ or ⇨ key moves the vertical cursor if the vertical cursor key is activated, and moves the data window if the vertical cursor key is left deactivated.

(ii) Data discontinuity point

In dual channel mode, for example, there are time data of maximum 32K words per channel. Since these data are stored in a circular memory, the newest 32K-th word data is followed by the oldest 0th data word, and between the two data words exists a discontinuity point.

If the specified data-window area includes this discontinuity point, the data window will stop past the discontinuity point, so that this point will not be included in the data window area. By utilizing this feature, it is possible to shift the data window at the oldest or newest data location.

To set up the data window stepping span of 1K word, position the vertical cursor to the rightmost graticule on the CRT in the TIME display mode and press [SET X].



Data window stopping past the discontinuity point

c. Horizontal control of pointer in LABEL mode

Keys [⇦] and [⇨] are also used to control horizontal movement of pointer when setting up Label 1 or 2. Each press of [⇦] or [⇨] key moves the label setup pointer (flashing mark) one character location to the left or right; continuous depression of these keys allows continuous movement of the pointer in the respective directions. If the pointer reaches the first or last character location of a line while either of the keys is depressed and held, it is repositioned to the opposite end of the line and continues to move.

d. Trigger position setup for ARM or AUTO ARM mode

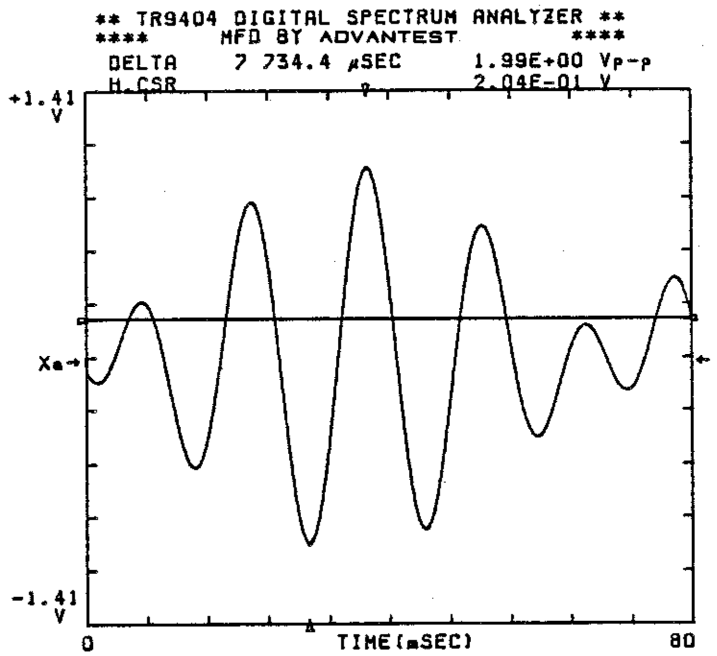
The fourth function of ⇦ and ⇨ keys is trigger position setup. First activate TIME key in the VIEW section, and while data is shown on the display, press TRIG. MODE key in the SETUP section to show the TRIG. MODE menu on the display. Next, activate C (↔) key and use ⇦ or ⇨ key to position the vertical cursor to the desired trigger position. Finally press SET X key (8). This will define the data point identified by the vertical cursor as the trigger position, and the trigger position data is automatically determined and read out under "POSITION" in the TRIG. MODE menu. (When the vertical cursor is OFF, the signal peak becomes the trigger position)

Message "SET: TRIGGER" will flash for a few seconds in the bottom left display area for confirmation.

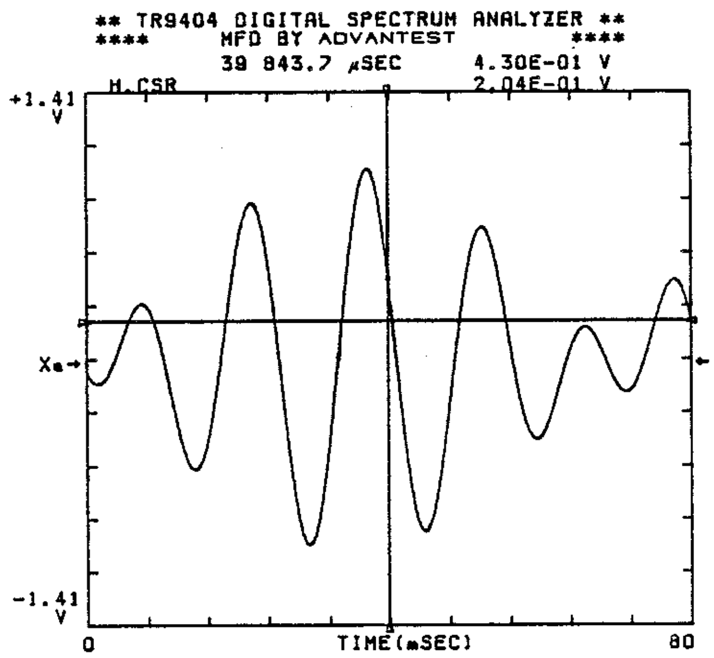
④ C (⇕) [▭] horizontal cursor ON/OFF key

This key is used for horizontal cursor display control: when activated (light within the key comes on), a horizontal cursor appears on the display.

If this key is activated, mark "▷", horizontal cursor, and mark "◁" appear on the display, and the level identified by the horizontal cursor is directly read out in the top information area on the screen (see Figure 4-114(a)). If the Auto Peak Search feature is activated in the vertical cursor OFF mode, the first two intersection points with the horizontal cursor which are on the right-hand side of and nearest to the maximum peak (the vertical cursor position if the vertical cursor is ON) are automatically detected and intensified in brightness. If the vertical cursor is turned on and moved, the intersections automatically follow it up.

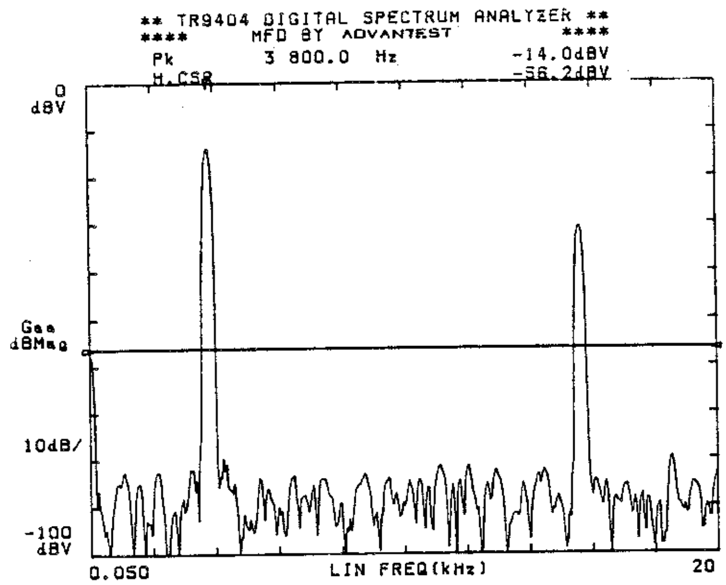


(a) When the horizontal cursor switch is turned on, "▷", horizontal cursor and "◁" are shown on the display. The level of the horizontal cursor is identified as H. CSR 2.04E-01V. In the Auto Peak Search mode, the first two intersection points to the right of the maximum "▽" are intensified in brightness.

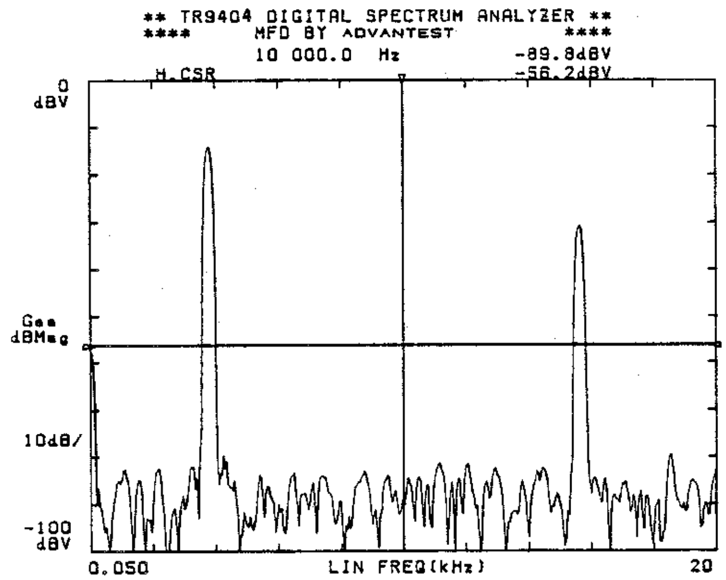


(b) The same is true with the vertical cursor ON: the first two points intersected with the horizontal cursor line to the right of the cursor point are intensified.

Fig. 4-114 Horizontal cursor functions (1)



(c) This example shows a trace in the frequency domain in the Auto Peak Search mode with the horizontal cursor turned on.



(d) This example shows a signal trace in the frequency domain with both vertical and horizontal cursors turned on.

Fig. 4-114 Horizontal cursor functions (2)

⑤ ⑥ $\boxed{\Uparrow}$ $\boxed{\Downarrow}$

These keys may be used in the following three ways:

a. Horizontal cursor control

Keys $\boxed{\Uparrow}$ and $\boxed{\Downarrow}$ are used to move the horizontal cursor upward and downward respectively. If C (‡) $\boxed{\square}$ key is activated, each press of these keys moves the cursor a single position upward or downward. If either of the keys is depressed and held, the cursor moves continuously in the respective direction. When the cursor reaches the top or bottom graticule while the corresponding key is depressed and held, the cursor is repositioned to the opposite end of the graticule and continues to move.

b. Label line shift control

A second function of $\boxed{\Uparrow}$ and $\boxed{\Downarrow}$ keys is to move Label 1 or Label 2 in the vertical direction. Each press of $\boxed{\Uparrow}$ or $\boxed{\Downarrow}$ key moves the label one line upward or downward. If either of the keys is depressed and held, the label moves continuously in the respective direction. If the label reaches the top or bottom graticule while the corresponding key is depressed and held, the label is repositioned to the opposite end of the graticule and continues to move.

c. Trigger level setup for ARM or AUTO AHM mode

A third function of $\boxed{\Uparrow}$ and $\boxed{\Downarrow}$ keys is trigger level setup. First activate TIME $\boxed{\square}$ key in the VIEW section, and while data is shown on the display, press TRIG. MODE $\boxed{}$ key in the SETUP section to show the TRIG. MODE menu on the display.

Next, activate [C (↕)] key, and use [⇧] or [⇩] key to position the horizontal cursor to the desired trigger level. Finally press [SET X] key ⑧. This will define the level identified by the horizontal cursor as the trigger level, and the trigger level data is automatically determined and read out under "LEVEL" in the TRIG. MODE menu. (When the horizontal cursor is OFF, no trigger level will be set up.) If both the vertical and horizontal cursors are simultaneously turned on, operation of [SET X] key will simultaneously set up a trigger position and a trigger level.

⑦ DATA WINDOW key

This key is used to activate the Data Window display mode in which 64K words of TIME data can be sequentially shown in a data window of 1K word length (dual channel mode; 2K word length for single channel mode).

When the DATA WINDOW key is activated (lamp comes on) after [HOLD/REL.] key in the TRIGGER section is pressed to hold the data, the Data Window on the display can be controlled with [⇦] and [⇨] keys to sequentially observe 64K words of time data. The DATA WINDOW shift step span can be set up with the [SET X] key to be described in the following paragraph. This feature will be useful to observe the neighborhood of a trigger point in detail after a single event is captured with the ARM function. It should be noted, however, that the vertical cursor cannot be moved while [DATA WINDOW] key is activated. The Data Window function is illustrated in Figure 4-115.

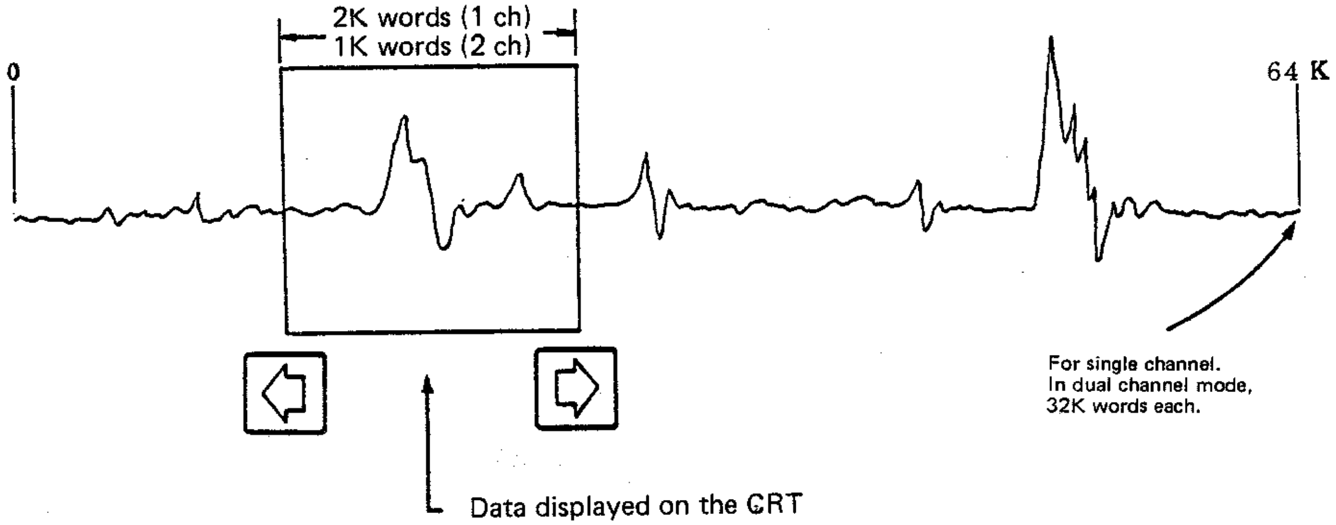


Fig. 4-115 Data Window function

(8) SET X key

This key provides the following four functions:

a. Trigger position & trigger level setup

If this key is pressed after TIME key in the VIEW section is activated while the TRIG. MODE menu is shown on the display, the position on the waveform identified by the vertical and horizontal cursors are defined as trigger position and trigger level respectively. The trigger position and level data are read out under "POSITION" and "LEVEL" in the TRIG.MODE menu.

Message "SET: TRIGGER" will flash in the bottom left display area for a few seconds for confirmation.

b. Data Window movement span setup

If this key is pressed after TIME key in the VIEW section is activated and the DISPLAY CTL menu for the SETUP section is shown on the display, the time value identified by the vertical cursor defines the step span for Data Window movement.

Message "SET: DATA WINDOW" will flash in the bottom left display area for a few seconds for confirmation.

c. Coherence blanking value setup

Activate COHERENCE key in the VIEW section, display the FUNCTION menu for the SETUP section on the screen, and activate the COH BLANK. Then turn on the horizontal cursor and position it to the desired value. Now press SET X key. This will define the level identified by the horizontal cursor as a coherence blanking threshold level.

Message "SET: COHERENCE" will flash in the bottom left display area for a few seconds for confirmation.

d. Interchannel delay setup

Where a time delay exists between input and output signals, the output signal is affected by the incoming signals other than the input signal in question. This results in a measured coherence value smaller than the true value and a larger error in the measured transfer function data.

To eliminate this type of error, the time data which has a delay of τ with respect to the input signal is to be used for data processing. This time delay can be obtained by activating AUTO-CORR., IMPUL. RESP. or CROSS-CORR. key in the VIEW section, positioning the vertical cursor to the desired delay time (since the time delay is normally a peak value, it is recommended to select the Auto Peak Search mode in which the cursor is turned OFF), and then pressing SET X key. The following message will blink for a few seconds in the bottom left to indicate the interchannel delay mode has been selected:

"SET: INTERCHANNEL DELAY"

Once a delay time is established, the analyzer acquires time data which has a time delay of with respect to the input signal, until another time delay is specified or the frequency range is changed over. If frequency range setup is changed, the following message will blink for a few seconds in the bottom left information area:

RESET: INTERCHANNEL DELAY

⑨ UPPER/LOWER key

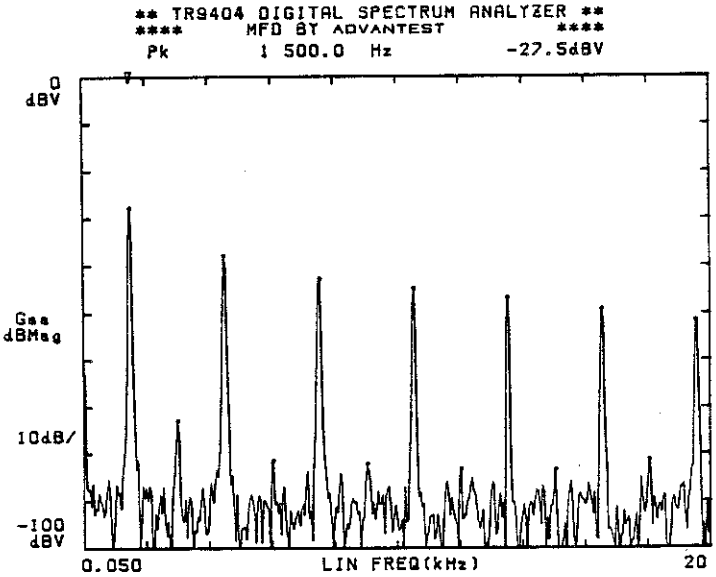
In the Dual display mode, this key is used to select data in either the upper or lower display area on the screen to read out data by using a cursor. When this key is activated, the data in the upper display area is selected; when it is deactivated, the data in the lower display area is selected. The intersections of the cursor with the signal trace being intensified in brightness are switched between upper and lower display.

(10) HARM./SINGLE (Harmonic/Single mode) key

Activating this key (light comes on) selects the HARM. mode; deactivating this key (light goes off) selects the SINGLE mode. If this key is set in the SINGLE (OFF) mode, the intersection of the vertical cursor with the signal trace (as shown in Figure 4-112(e)) is intensified in brightness. If it is set in the HARM. (ON) mode, the signal peak (in this case, the maximum peak because of the Auto Peak Search mode) identified by the vertical cursor and the peaks of its harmonics (up to 20 harmonics) are automatically detected and intensified (see Figure 4-116) . This function is, however, not available for the ZOOM mode.

If LIST key in the VIEW section is pressed in the HARM. mode, the fundamental signal and its harmonics are listed on the display in the numerical form.

If the vertical cursor is positioned to the fundamental signal when the HARM. mode is selected, the harmonics related to the fundamental response can be discriminated from those not related. If the vertical cursor is turned off when the HARM. mode is selected, the HARM. mode is combined with the Auto Peak Search mode, wherein the cursor follows up the change in the fundamental frequency and its harmonics are also automatically operated and shown by intensified dots at the peaks, provided that the fundamental has the maximum peak level.



Peak of fundamental identified by mark " ∇ " and its neighboring harmonics of integer multiples are intensified.

Fig. 4-116 Display example of HARM. mode

(11) SET REF. ON/OFF key

(12) SET REF. (Set Reference) key

(13) RECALL key

These keys are used to determine the differences between an arbitrary reference point and other data points. As an example, let us assume a case where the frequency and level differences between a reference line spectrum (A) and another line spectrum (B) of a frequency domain data are to be determined (see Figure 4-117(a)).

Set [SET REF. ON/OFF] key to ON (lamp comes on). Activate [C (↔)] key to turn on a vertical cursor and position the cursor to the desired line spectrum (A).

Next press [SET REF.] key (12). This will define the spectrum identified by the cursor as a reference line spectrum and cause a data display as shown in Figure 4-117(a). Then use [⇦] or [⇨] key to reposition the vertical cursor to another spectrum (B). This will show the frequency and level difference of line spectrum (B) with respect to line spectrum (A) at the top of the display (see Figure 4-117(b)).

If the vertical cursor is then repositioned to a third data point on the signal response trace and then [SET REF.] key is pressed, the data point is newly defined as a reference point.

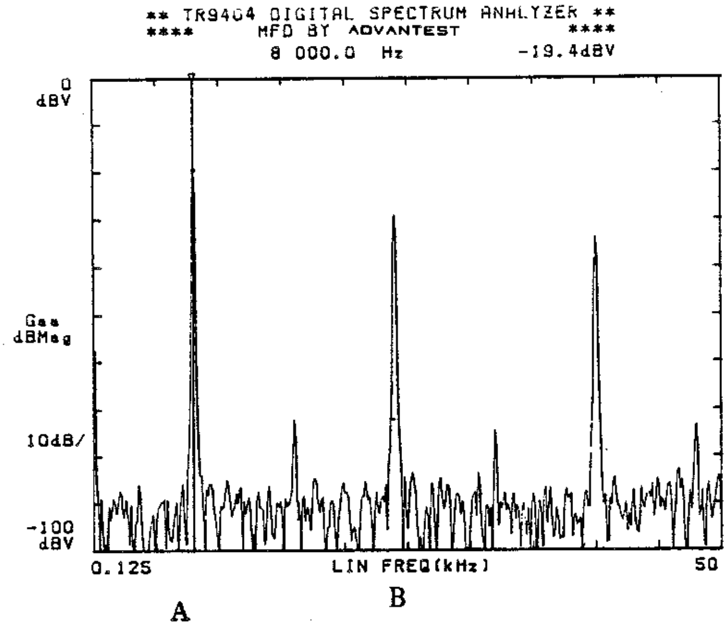
The frequencies of up to 20 data points defined as reference points with [SET REF.] key can be stored in internal buffer.

Operation of [RECALL] key recalls the preceding reference point from the buffer. Each time [RECALL] key is operated, older reference point data are sequentially recalled from the buffer.

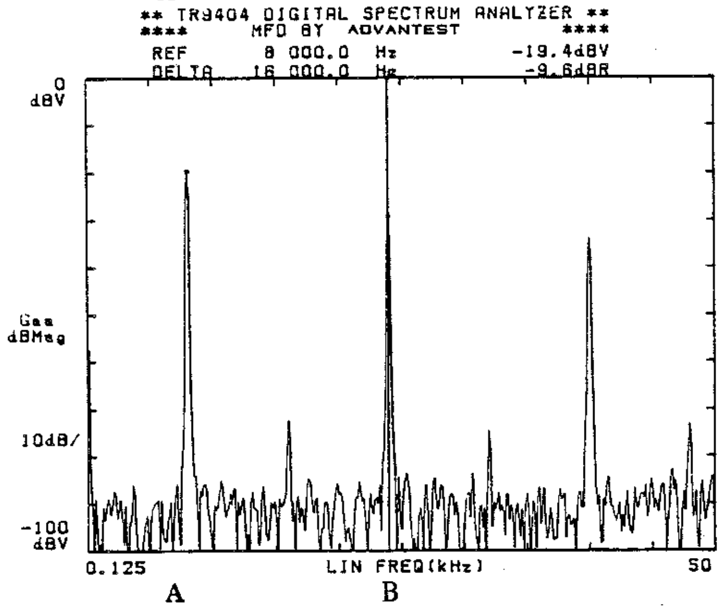
If RECALL key is operated to the point where stored reference point data no longer exists in the current area, it is alerted by flashing lamp within SET REF. ON/OFF key (e.g. 1024th reference value in the frequency domain).

The SET REF. function can be used in much the same way for time and amplitude domain data as well.

If the horizontal cursor is turned on when the SET REF. ON mode is selected, the two intersection points with the horizontal cursor which are on the right-hand side of and nearest to the vertical cursor are intensified and the frequency difference between the two points and its level are read out at the top of the display (see Figure 4-117(f)).



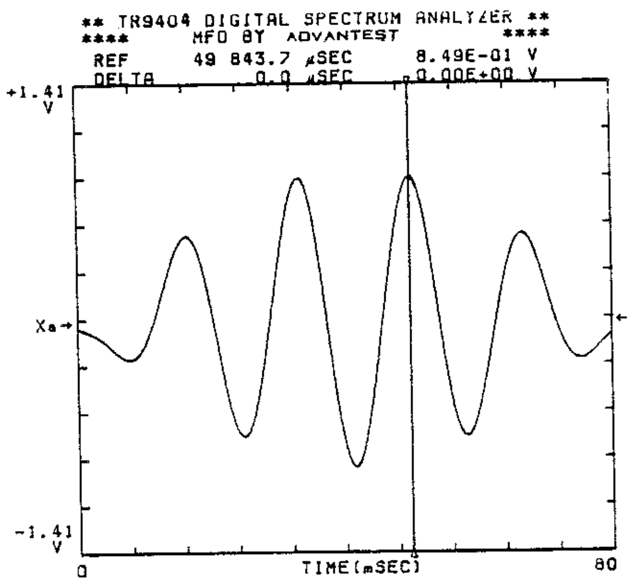
(a) The frequency and level of the spectrum (A) are defined as the reference if the activated vertical cursor is positioned to the spectrum (A) and then [SET REF.] key is pressed.



(b) If the vertical cursor line is moved to the spectrum (B), the frequency and level differences with respect to the reference line spectrum are indicated as

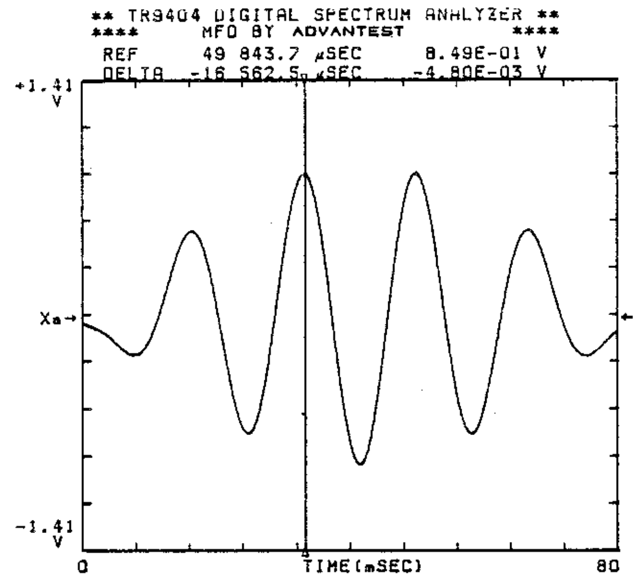
DELTA 16000.0 Hz -9.6 dBR

The reference point is intensified in brightness.



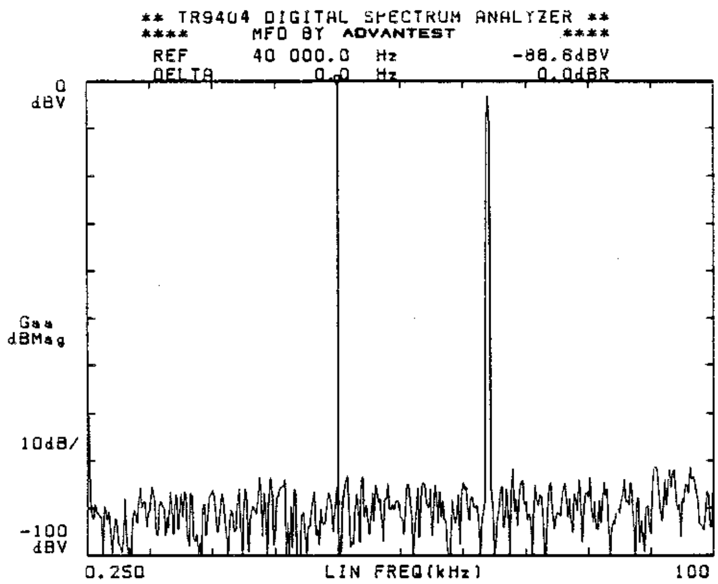
(c) This example shows the SET REF. capability being used in the time domain.

Fig. 4-117 SET REF. function example (1)



(d) The reference point is intensified.

If the vertical cursor is moved, the time and amplitude differences are displayed.



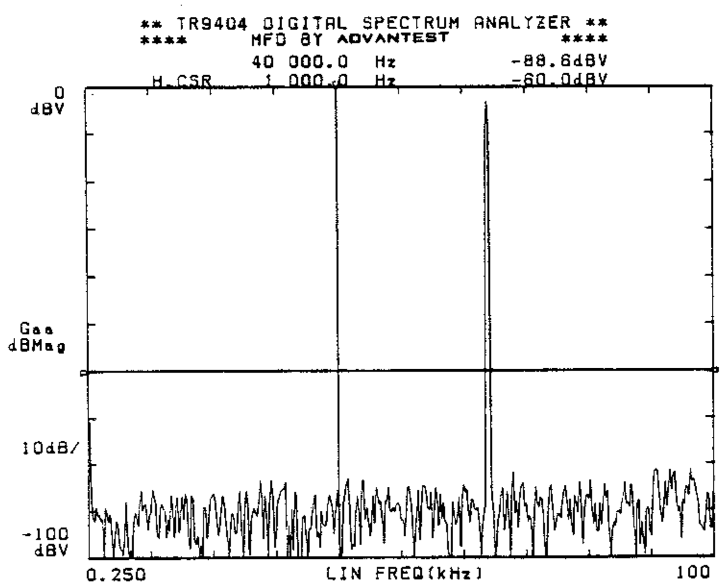
(e) Set REF. mode: ON

REF 40000.0 Hz -88.6 dBV

DELTA 0.0 Hz 0.0 dBR

C (⇕)

key ON (Horizontal cursor ON)



(f) REF data annotation disappears and the data about the vertical cursor is displayed.
DELTA data disappears and the first two points on the trace crossed with the horizontal cursor to the right of the vertical cursor point are intensified and the frequency difference between the two points and the level of the horizontal cursor are shown.
H.CSR 1000.0 Hz -60.0 dBV

Fig. 4-117 SET REF. function example (2)

4-4-8. TRIGGER Section

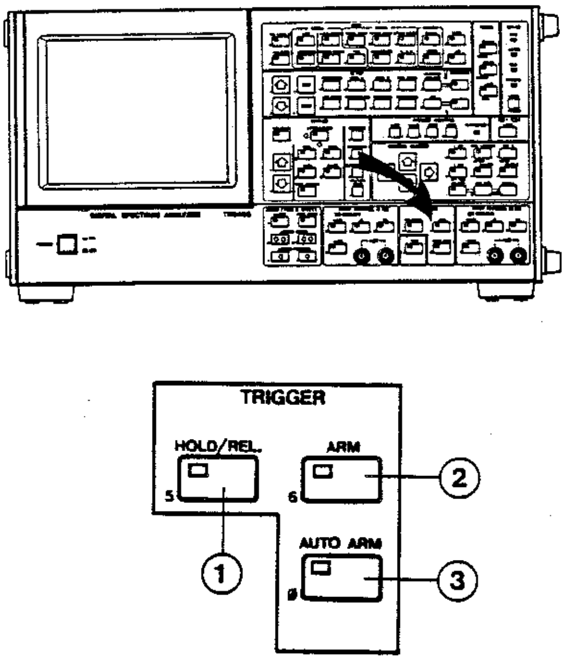


Fig. 4-118 TRIGGER section panel

1. HOLD/REL. key

When the lamps within the keys HOLD/REL. , ARM and AUTO ARM are all off, it indicates that the instrument is in the Free Run mode. The Free Run mode is indicated in the top right annotation area on the display as "FREE RUN" (see Figure 4-119).

In the Free Run mode, the trigger conditions set up in the TRIG. MODE menu (see paragraph 4-4-5 SETUP Section) are ignored, and the instrument runs at its internal timing rate. To hold a waveform or frequency spectrum, press HOLD/REL. key; the lamp within the key comes on and the data on the display is held up. At this time, the mode indicator shown in Figure 4-119 is changed from "FREE RUN" into "HOLD". To reset the HOLD mode, press HOLD/REL. key again; the FREE RUN mode will be restored.

② ARM key

Observation of a single event such as an impact waveform is facilitated with the ARM mode. To select the ARM mode, press ARM key; the light within the key comes on. Once the ARM mode is selected, data on the display will not change until a signal which meets the trigger conditions setup in the TRIG. MODE menu for the SETUP section is found out. This state is called the WAIT state.

If an input signal meeting the trigger conditions is applied, the instrument captures and automatically holds it (lamp within the HOLD/REL key comes on) and resets the ARM mode (lamp within the ARM key goes off). When the ARM mode is selected, indicator "ARM" is shown in the top right annotation area on the display (see Figure 4-119).

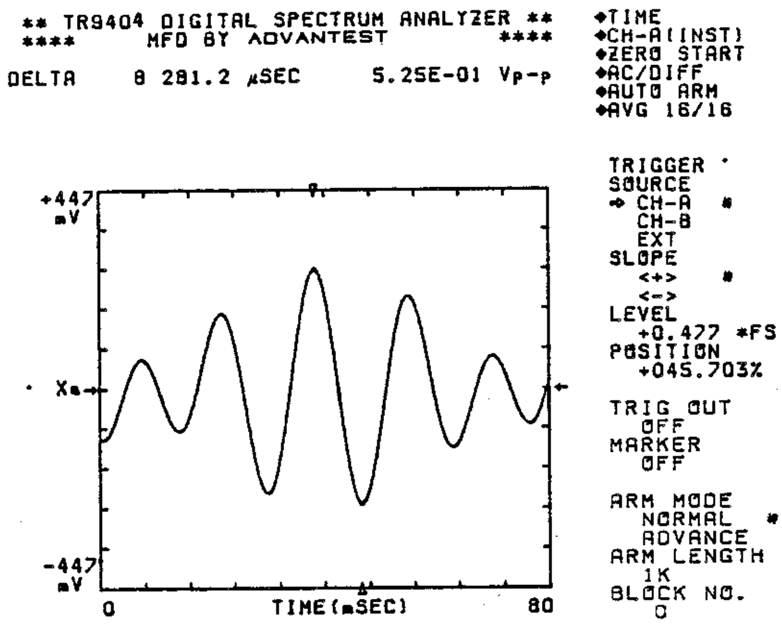
ARM key is effective in the "HOLD ZOOM" mode.

③ AUTO ARM key

The AUTO ARM mode automatically repeats the ARM mode. When AUTO ARM key is pressed, the lights of AUTO ARM and ARM keys come on and indicator "AUTO ARM" is shown in the top right area on the display (see Figure 4-119). This is the WAIT state for the AUTO ARM mode. If an input signal which meets the trigger conditions mentioned above is applied to the instrument and one frame or more of data is taken in, the lamp of HOLD/REL key comes on and that of ARM key goes off. After the data is taken in, the ARM mode is automatically entered again, with the lamp of HOLD/REL key turned off and that of ARM key turned on.

Combining the AVERAGING mode with the AUTO ARM mode allows for averaging of single event in any of the time, frequency and amplitude domains.

To reset the AUTO ARM mode, press AUTO ARM key again.



TRIGGER section includes the four modes of

"FREE RUN"

"HOLD"

"ARM"

"AUTO ARM",

one of which is selected and displayed.

Fig. 4-119 TRIGGER display example

4-4-9. ZOOM (TIME & SPECT.) Section

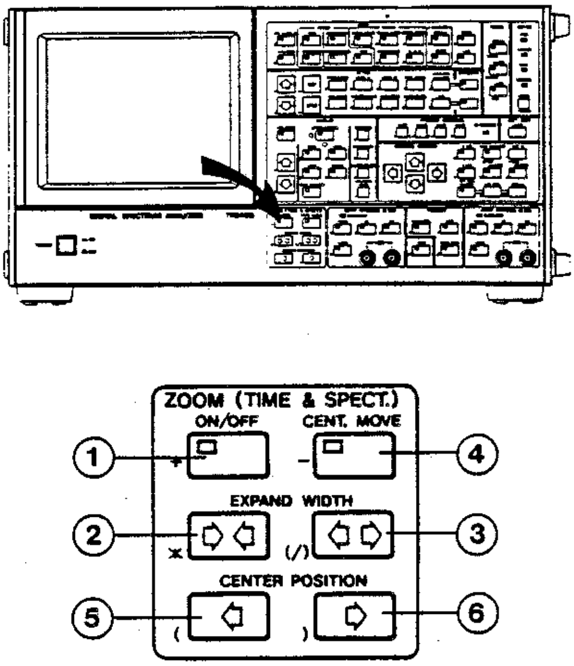


Fig. 4-120 ZOOM (TIME & SPECT.) section panel

Control keys in this section are used for high resolution analysis in the frequency domain and expanded observation in the time domain. The functions of this section are not available for data in the domains other than the time and frequency domains.

(1) Operations in the time domain (TIME)

A waveform on the display can be expanded at a magnification of 2 to 16 in binary steps within the frame time determined by the selected frequency range.

It is expanded with respect to the vertical cursor centered on the display (if the time value of interest is at the maximum amplitude within the range, press C (↔) key (light off) to automatically center the peak value in the automatic peak search mode).

If the ZOOM key is activated, the center time position can be moved at a constant step span which is irrelevant to the selected magnification.

(2) Operations in the frequency domain (SPECT.)

The ZOOM function in the frequency domain is the HOLD ZOOM mode in which input data is held for processing before being expanded. A signal response on the display can be zoomed in on at a magnification factor of 2 to 8 in the HOLD ZOOM mode in binary steps within the selected frequency range, with the center frequency identified by the vertical cursor (C (↔) key enabled) (or by the maximum peak response when in the Auto peak Search mode where C (↔) key is disabled). If the ZOOM key is activated, the center frequency can be moved in the horizontal direction at a step span which depends on the selected magnification.

(3) Description of key functions

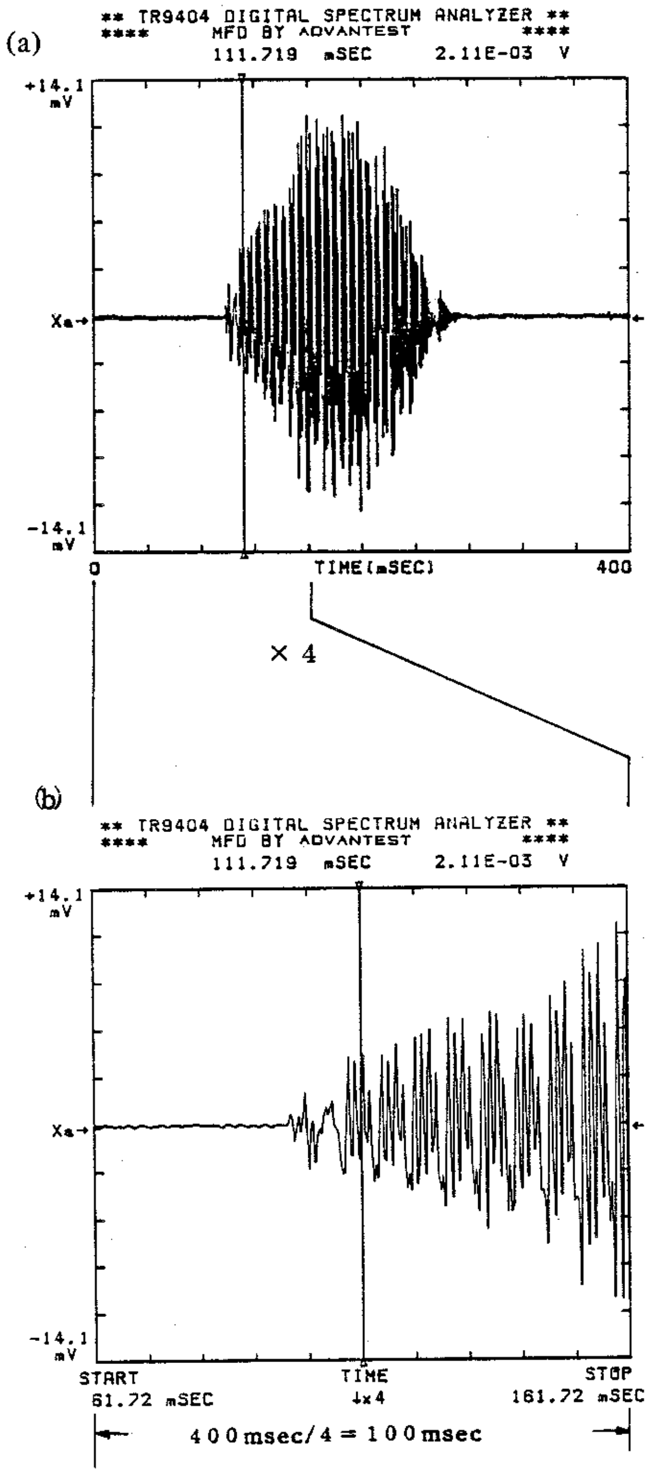
① ON/OFF key

a. Functions in the time domain (TIME)

When one of [TIME], [AUTO-CORR.], [CROSS-CORR.] or [IMPUL. RESP.] keys in the VIEW section is activated (for the waveform specified by [UPPER/LOWER] key when in the BOTH display mode), the ZOOM mode can be entered by pressing the ZOOM ON/OFF key to ON, after positioning the vertical cursor to the desired center time position or, if the maximum peak response is to be zoomed in on, after setting [C (↔)] key to OFF. Figure 4-121(a) shows a waveform in the ZOOM OFF mode; (b) in the same figure shows the same waveform which is magnified by 4 in the ZOOM ON mode, with the center position identified by the cursor. The full span of the horizontal axis in the ZOOM ON mode is determined as frame time/magnification. In the example of Figure 4-121(b), it is 400 msec/4 = 100 msec.

When in the BOTH display mode, the waveform specified by the [UPPER/LOWER] key is expanded, and mark "↑" (for upper data) or "↓" (for lower data) is shown beside the magnification readout on the display (see Figure 4-122(a) and (b)).

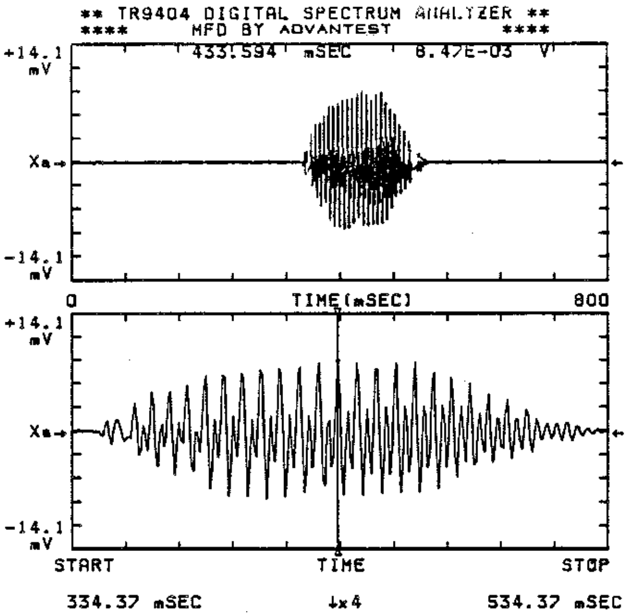
Since, in the ZOOM ON mode, the display time span changes even if the frame time is 40 msec (frequency range of 10 kHz), the display shows a START time at the bottom left corner, a STOP time at the bottom right corner, and a magnification at the bottom center. The START and STOP time depend on the selected frequency range, magnification, and center position.



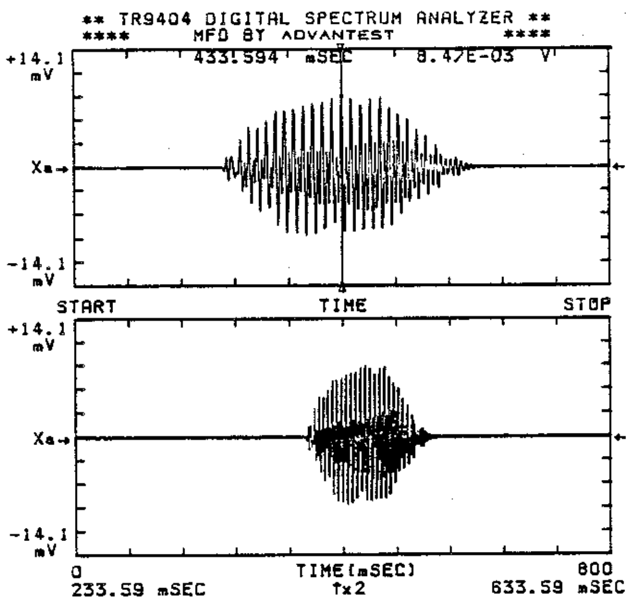
ZOOM OFF mode

ZOOM ON mode (X 4)

Fig. 4-121 ZOOM mode display example (for time domain data)



(a) "START" time, "STOP" time and magnification are displayed. If the ZOOM mode is activated for the data in the lower display section, mark "↓" will be shown.



(b) If the ZOOM mode is utilized for the upper display data, mark "↑" will be shown.

Fig. 4-122 ZOOM mode display for BOTH mode (time domain data)

b. Functions in the frequency domain (SPECT.)

If the ZOOM ON mode is selected when an instantaneous spectrum is shown on the display in the HOLD mode, message "HELD DATA IS TO BE ZOOMED" will flash in the bottom display area for a few seconds; the lamp within the ZOOM ON/OFF key will flash to indicate that the HOLD ZOOM mode is selected. When the HOLD ZOOM mode is selected, it is indicated by "/HOLD/" shown in the bottom right display area on the CRT.

In the HOLD ZOOM mode, time domain data acquired in the HOLD state is subject to Fourier transform and is expanded in the frequency domain. The available magnification factor is selectable from 2, 4, and 8, in each of which cases data of 2K, 4K, and 8K words are subject to Fourier transform respectively. At magnification factor of 4 or 8, fast Fourier transform is performed 4 and 8 times respectively.

In the zero start mode, time data of 1K words is subject to Fourier transform, in which case the frequency resolution is 400 lines. If, at this time, the HOLD ZOOM mode is activated, the frequency resolution is increased to 800, 1600, and 3200 lines depending on the selected magnifications. Since the display shows only 400 lines, the desired portion of the zoomed spectrum may be observed by selecting the center frequency.

If the display mode is set up for TIME when the HOLD ZOOM mode is selected, the display will show the first half (1K words) of time data (2K words in all) at a magnification of 2; and at a magnification of 4 or 8, the display will show 1K words of data which are resampled at every 4 and 8 data points from the time data of 4K or 8K words respectively. Therefore, the frame time is identical to that in the zero start mode when a magnification of 2 is selected, while it is 4 or 8 times as much as zero start mode when a magnification of 4 or 8 is selected.

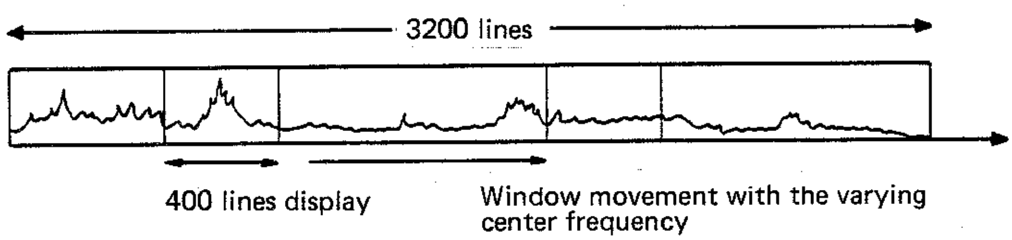
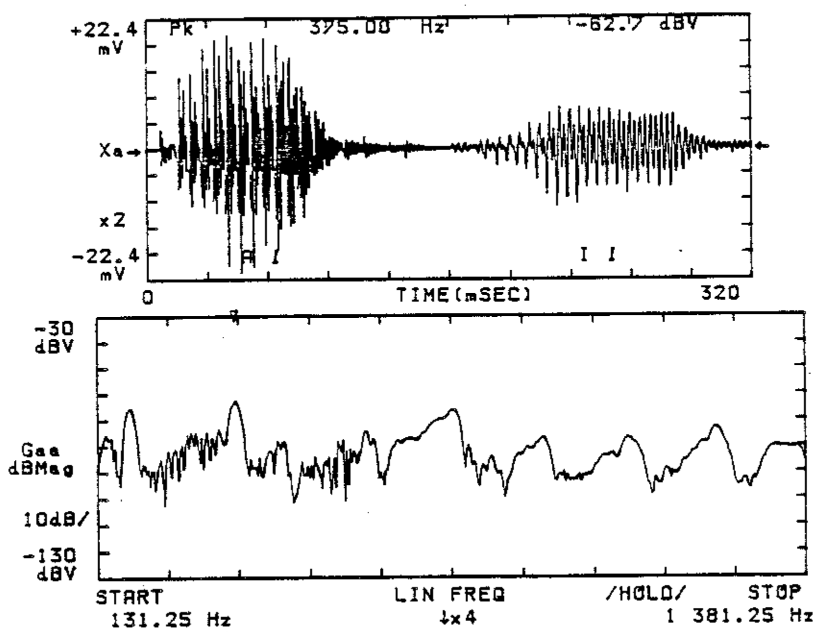


Fig. 4-123 HOLD ZOOM display with a factor of 8



Above: TIME data for vowels "a", "i" and its HOLD ZOOM spectrum at a magnification factor of 4.

Below: Time data for vowels "a", "i", "u" and "e" and its HOLD ZOOM spectrum at a magnification factor of 8.

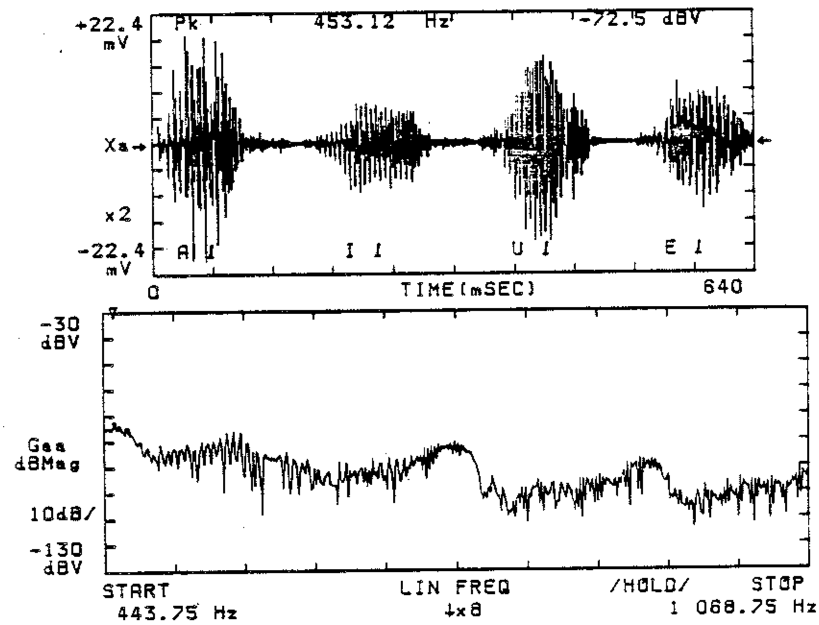


Fig. 4-124 Display examples for "HOLD ZOOM" mode

② ③ EXPAND [▷◁] (/) WIDTH [◁▷] keys (magnification or bandwidth selection)

These keys are used to control magnification. For time domain data, magnification is available in x2, x4, x8, and x16; for frequency domain data, it is available in x2, x4, x8. Keys [▷◁] and [◁▷] are used to increase and reduce magnification respectively.

a. Operations in the time domain

If the Auto Peak Search mode is selected with C (↔) [□] key set to OFF and the maximum peak is to be zoomed in on, the START and STOP time values are determined and read out so that the peak is automatically positioned to the center of the screen (see Figure 4-125(a) and (b)) after expansion.

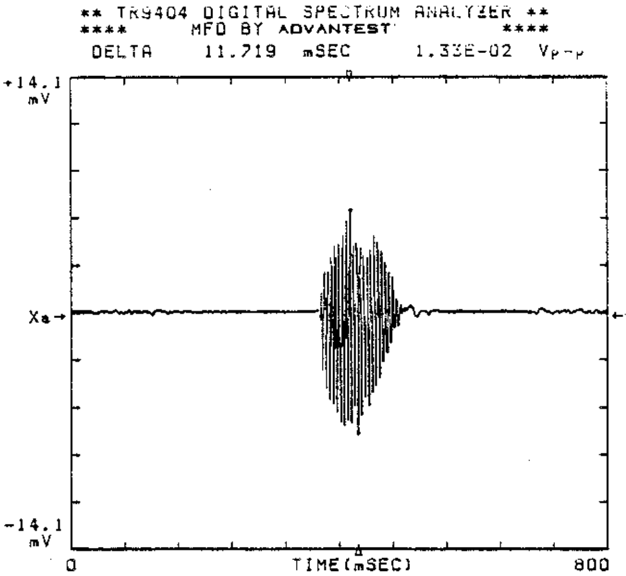
If C (↔) [□] key is set to ON, waveform can be zoomed in on, with the time value identified by the vertical cursor defined as the center. This mode will be effective for observation of waveform with relatively small magnitudes (see Figure 4-126(a) and (b)).

While C (↔) [□] key is activated, the cursor position selected before the ZOOM ON mode setup is stored in internal buffer. The cursor will automatically return to its original position when the ZOOM OFF mode is restored.

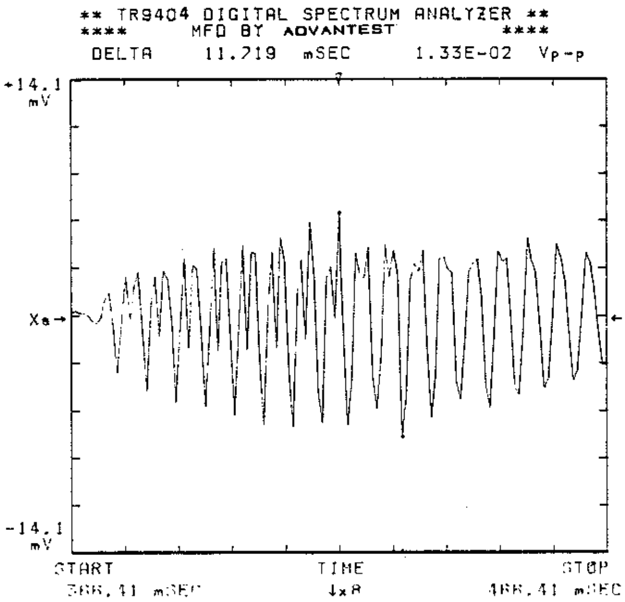
b. Operations in the frequency domain

If the Auto Peak Search mode is selected with $\overset{C(\leftrightarrow)}{\boxed{\square\quad}}$ key set to OFF and the maximum peak is to be observed, the START and STOP frequencies are determined and read out so that the peak spectrum is automatically positioned to the center of the CRT (See Figure 4-127(a) and (b)) after zoom.

If $\overset{C(\leftrightarrow)}{\boxed{\square\quad}}$ key is set to ON, spectrum can be expanded or reduced on the both sides of the frequency identified by the vertical cursor. This mode will be useful for observation of spectrum with relatively low level (see Figure 4-128(a) and (b)). While $\overset{C(\leftrightarrow)}{\boxed{\square\quad}}$ key is activated, the cursor position selected before the ZOOM ON mode setup is stored in internal buffer. The cursor will therefore automatically return to its original position when the ZOOM OFF mode is restored.

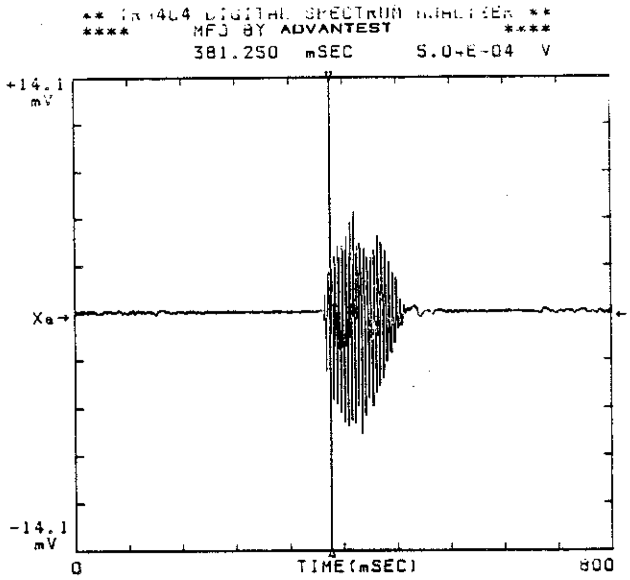


(a) With ZOOM OFF and vertical cursor OFF (Auto Peak Search mode), select ZOOM ON mode.

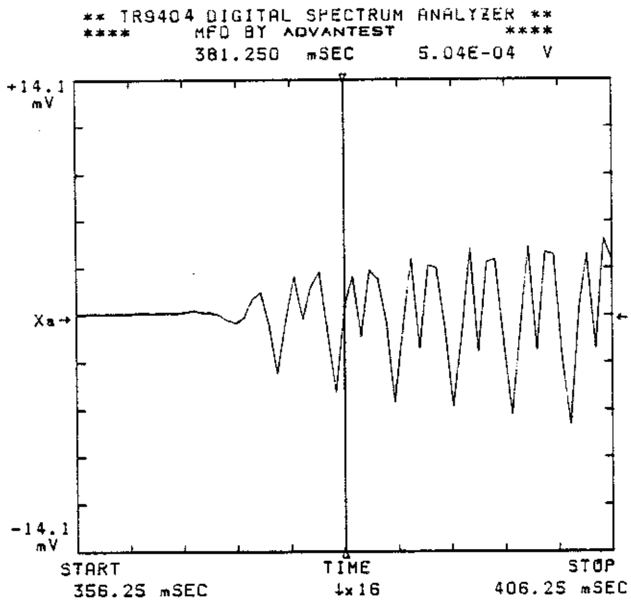


(b) Time at "START" and "STOP" is set up so that the maximum amplitude detected in the Auto Peak Search mode with x8 zooming is automatically centered on the CRT.

Fig. 4-125 Zooming in the Auto Peak Search mode (TIME)

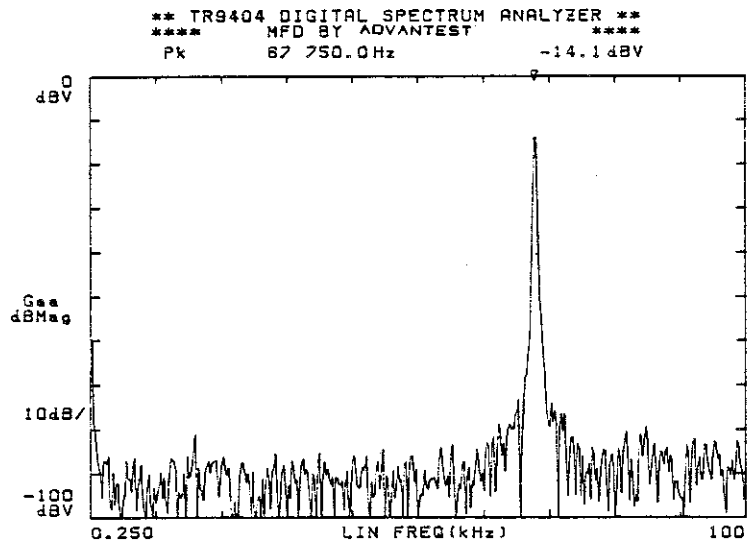


(a) With ZOOM OFF and vertical cursor line ON, move the cursor to the spectrum or time value to be observed.

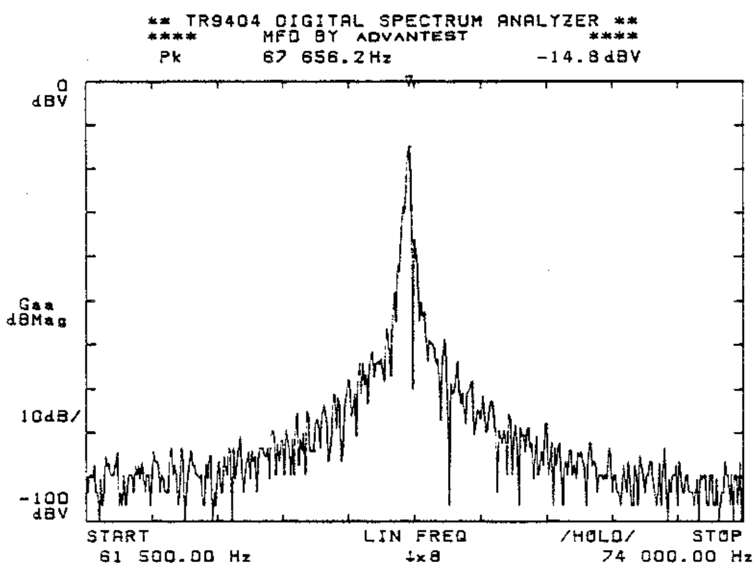


(b) If the ZOOM ON mode is selected (x16), the "START" and "STOP" times are automatically set up with the cursor in the ZOOM OFF mode being placed in the center.

Fig. 4-126 Zooming in vertical cursor ON mode (TIME)

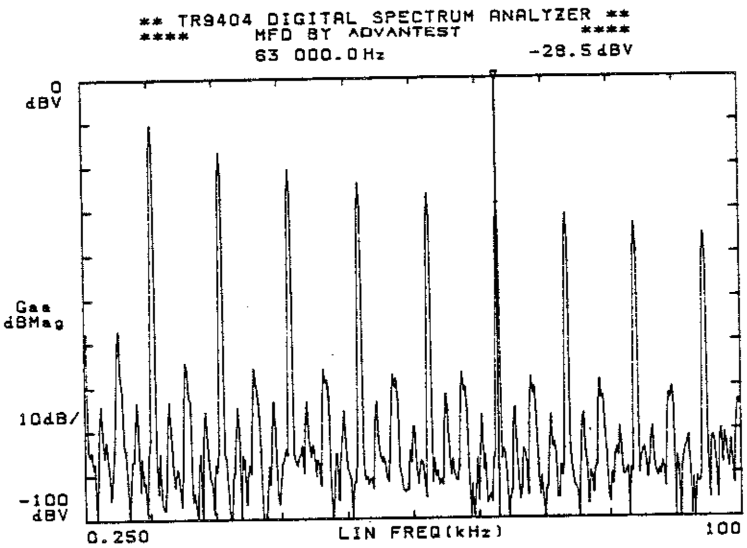


(a) First select ZOOM OFF and vertical cursor OFF mode (Auto Peak Search mode), and HOLD, then select ZOOM ON mode.

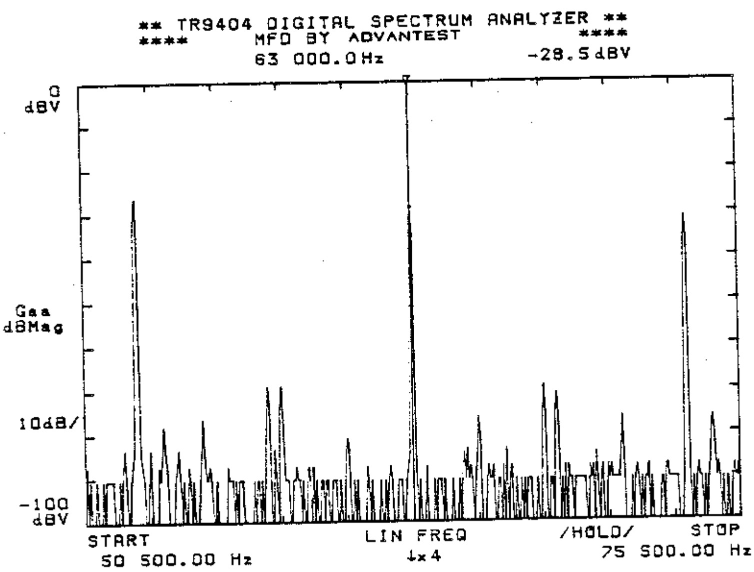


(b). The "START" and "STOP" frequencies are automatically set up so that the maximum peak spectrum captured by the Auto Peak Search mode is positioned in the center of the CRT (X8 zooming).

Fig. 4-127 Zooming in the Auto Peak Search mode (SPECT.)



(a) With ZOOM OFF, "0" start mode and vertical cursor ON, move the cursor to the spectrum or the frequency to be observed.



(b) If the HOLD and ZOOM ON mode (X4) is selected, the cursor position in the zero start mode is set to the center frequency.

Fig. 4-128 Zooming in vertical cursor ON mode (SPECT.)

④ CENT. MOVE key

This key is used to select center position (center time for time domain data; center frequency for frequency domain data) movement mode for zoomed signals. Activating this key selects the automatic movement, while deactivating it selects the manual movement. This key is used with [CENTER ⇦] [POSITION ⇨] keys described below.

⑤ ⑥ CENTER POSITION keys

These keys are used to move the center position (center time for time domain data; center frequency for frequency domain data) of a zoomed signal.

If [CENT. MOVE ▭] key is activated and [⇦] is pressed, the signal on the display continuously moves to the right as the center value is lowered. To stop center movement, press [⇦] or [⇨] key again.

If [⇨] is pressed while [CENT. MOVE ▭] key is activated, the signal on the display continuously moves to the left as the center value is enhanced. To stop center movement, press [⇦] or [⇨] key again.

If [⇦] or [⇨] key is momentarily pressed while [CENT. MOVE ▭] key is deactivated, the signal on the display moves a single step in the respective direction. If either of the keys is depressed and held, the signal continuously moves in the corresponding direction. The step span for time domain data is identical to measurement resolution, which is constant irrelevant to the selected magnification. The step span for frequency domain data is 1/magnification of the resolution in the Zero Start mode.

(4) DATA WINDOW in ZOOM mode

The DATA WINDOW key is effective also when the ZOOM mode is selected. For details of the DATA WINDOW setup procedure, see paragraph 4-4-7 GENERAL CURSOR Section.

a. Time domain

With the DATA WINDOW feature, any time data in the maximum of 64K or 32K word buffer can be expanded for observation.

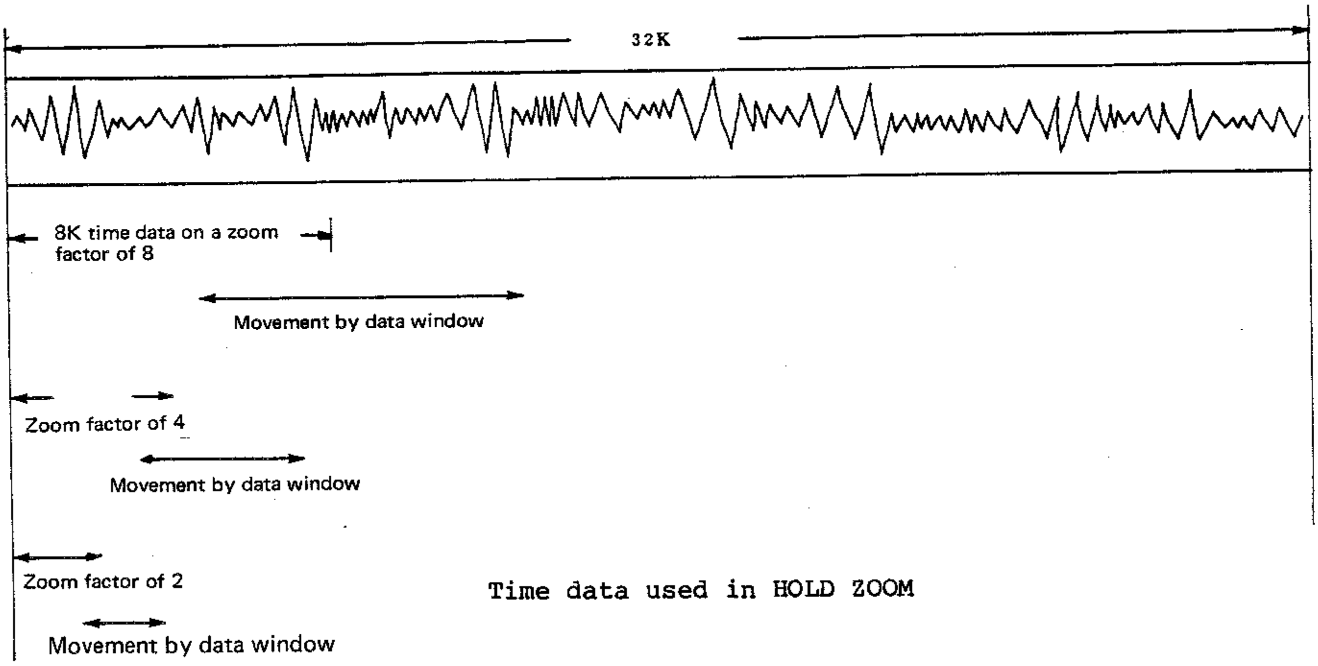
b. HOLD ZOOM

In the HOLD ZOOM mode, continuous 2K or 4K words of data are picked up from 8K words of data per channel when a magnification of 2 or 4 is selected. Therefore, it is possible with the DATA WINDOW feature to select from which portion of an 8K word buffer the data of 2K or 4K words is to be picked up. Since the HOLD ZOOM function starts Fourier transform from the oldest data in the buffer, data selection may also be started from the oldest data. If TIME and SPECTRUM data are shown simultaneously on the display in the BOTH display mode, what TIME data is now zoomed in on may be known from the display information.

(5) ARM in HOLD ZOOM mode

The ARM mode may be selected in HOLD ZOOM mode, but the AUTO ARM may not be selected.

If "4K" or less is selected for ARM LENGTH, 8K words of time data will not be read properly by ARM mode. Therefore, the correct signal may not be obtained when HOLD ZOOM operation is executed. To prevent this, the TR9404 automatically sets ARM LENGTH to "8K" if THe ARM LENGTH is 4K or less in the ARM mode being selected during HOLD ZOOM operation.



Time data used in HOLD ZOOM

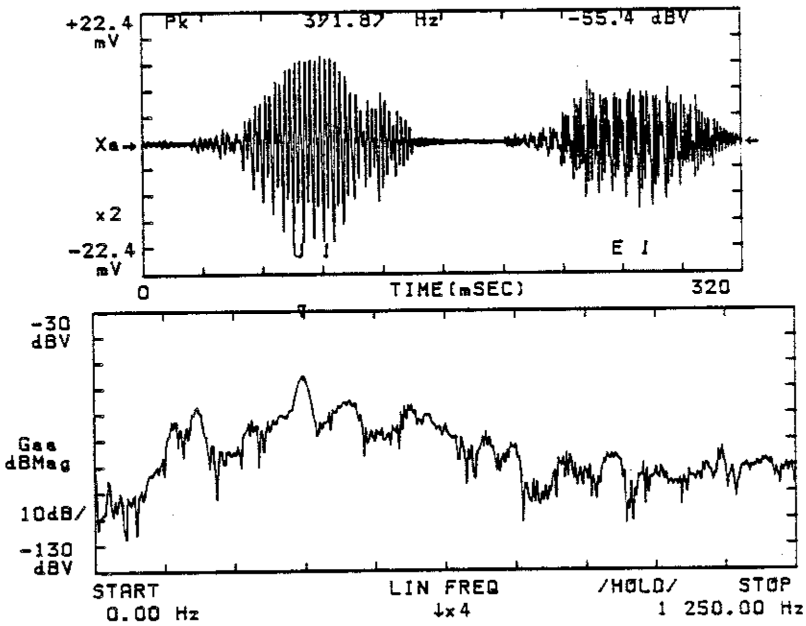


Fig. 4-129 DATA WINDOW in ZOOM mode

(6) Data averaging under HOLD ZOOM

a. AUTO ARM

① HOLD ZOOM mode

② Press AUTO ARM

③ Press START

NORMAL can be used in the AVG PROCESS.

b. ARM MODE

Use "+1 AVG" in the AVG PROCESS.

① HOLD ZOOM mode (ZOOM ON, HOLD/REL.)

② Press START

③ Press ARM

④ HOLD/REL. New data is captured and TR9404 enters automatically HOLD ZOOM mode. (light automatically on)

⑤ Press CONT.

⑥ The averaging count increments by 1.

⑦ Press ARM

Procedure ④ to ⑦ is thereafter repeated.

4-4-10. AVERAGE CONTROL Section

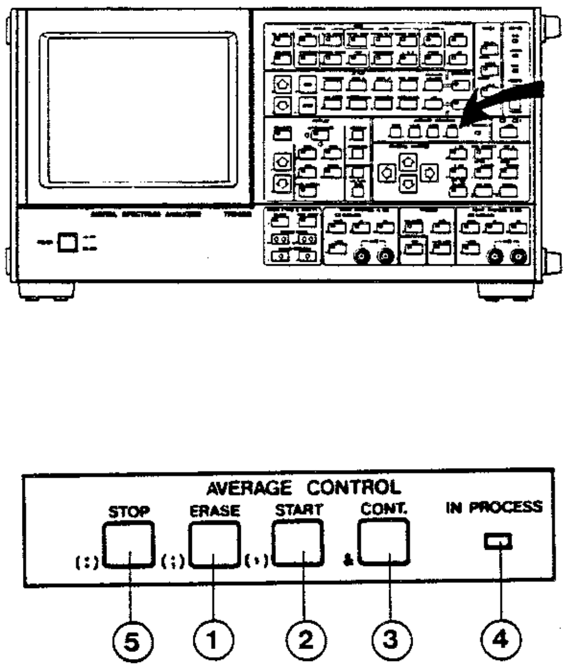


Fig. 4-130 AVERAGE CONTROL section panel

Control keys in this section are used to control and execute averaging functions selected from the AVG MODE menu activated by the SETUP section function.

① ERASE key

This key is used to erase the contents of the averaging buffer.

② START key

This key is used to start averaging execution under the averaging number set up in the AVG MODE menu. If averaging mode has been switched from one domain into another, for instance, if averaging in the time domain is selected when data averaged in the frequency domain is stored in the averaging buffer, operation of START key automatically detects this mode change.

Upon depression of START $\boxed{}$ key, the averaged data and measurement conditions for the preceding mode are erased from the buffer, and the scale and measurement condition data for the new mode is written into the buffer, then execution or averaging is initiated.

If the selected mode is the same as the preceding mode, START $\boxed{}$ key provides only the start function. Therefore, the data and measurement conditions for the preceding mode will still be shown on the display until START $\boxed{}$ key is pressed, even after the averaging mode is changed on the AVG MODE menu. It should be noted here that, if mode change has occurred from ZERO START into ZOOM mode or vice vers, the data and measurement conditions for the preceding mode are erased upon operation of START $\boxed{}$ key, although the both modes are in the same frequency domain.

When averaging is initiated, the IN PROCESS lamp on the front panel comes on. Upon each end of averaging execution, the numerator "○○" in the following indicator (♦AVG○○/xxx; xxx is the setup number of averaging) is incremented by one, and the pertinent content of "AVG WHAT?" comes on and off in the bottom left corner of the CRT for a few seconds. For example, if averaging for time series data is started, the following indicator flashes for a few seconds:

START AVG: TIME

When the setup number of averagings is reached, the averaging execution is terminated. The IN PROCESS lamp goes off and a "pip" tone continuously sounds to alert the operator for the end of averaging execution.

For PEAK and EXP averaging, the number of averagings is always set up at 8192 and the averaging counter is incremented to this value. However, averaging will be automatically disabled if an input overload has been detected (OVER lamp comes on).

The following operations are prohibited during averaging execution:

- Frequency range setting change
- Sensitivity range setting change
- Mode change from ZERO START into ZOOM or vice vers
- Mode change from FREE RUN into AUTO ARM or vice vers
- Input coupling condition change
- Trigger condition change
- Weighting function change

3 CONT. (Continue) key

4 IN PROCESS lamp

5 STOP key

STOP key is used to forcibly suspend averaging. When averaging is suspended, IN PROCESS lamp goes off, and the averaging count shown in the top right annotation area on the display stops incrementing. To restart the remaining part of averaging, press CONT. key. To restart averaging from the very beginning, operate START key.

Since averaging is executed between the averaging buffer and AVERAGING CONTROL section even if AVG/INST. key in the VIEW section is not placed in the "AVG" mode and another data is shown on the display, the result of averaging can be recalled on the display by activating AVG/INST. key (lamp is lit up) any time after averaging execution is completed.

If the result of averaging is unsatisfactory after repeated execution of the setup number, in other words, if the convergence of the objective transfer function in a certain frequency range is still not sufficient, further averaging can be resumed in the same mode just by pressing the CONT. key, without the need for restarting averaging from the very beginning after increasing the averaging number setting. For example, if the averaging number of 16 is set up and then the CONT. key is pressed after an averaging execution of 8 repetitions is completed, the final average AVG' is given by the following formula:

	Setup	Annotation
$AVG = \dfrac{D(1) + \ldots\ldots\ldots\ldots + D(8)}{8}$	8	8/8
$AVG' = \dfrac{AVG + D(10) + \ldots\ldots\ldots\ldots + D(24)}{16}$	16	24/24

4-4-11. LABEL Section

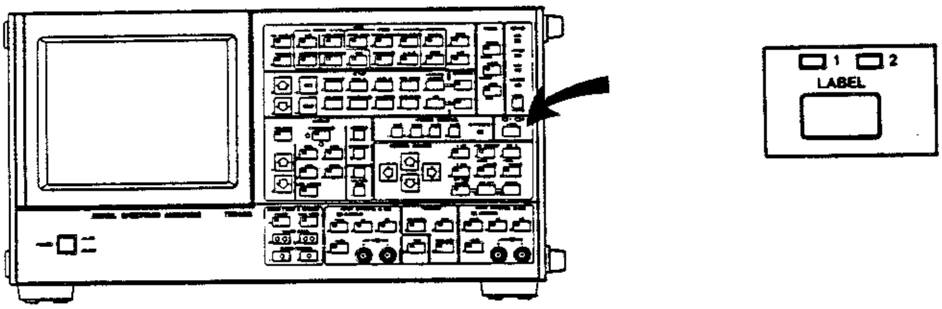


Fig. 4-131 LABEL section panel

The TR9404 provides two lines (Labels 1 and 2) of label area on its display which are available to the user for recording of pertinent data, such as date, experiment name, comments, etc.

A first operation of LABEL key selects the Label 1 write mode; LABEL lamp comes on. In this mode, all front panel keys lose their original functions and shift into the character mode, for which green letters are printed at the bottom left corner of each key. Therefore, all measurement condition setup, operations, and input mode change are disabled while either of the lable indicator lamp is on.

A second operation of LABEL key resets the Label 1 write mode and restores the original functions for all the front panel keys. A third depression of LABEL key selects the Label 2 write mode; 2 lamp comes on. A fourth operation of LABEL key resets the Label 2 write mode and restores the original functions for all the front panel keys.

The following paragraph describes label writing procedure in some detail, which is identical for both Labels 1 and 2:

Press LABEL key to activate indicator lamp ▭1 or ▭2 . A pointer will appear at the first character location of the selected label area. As you enter label characters, the pointer will move to the right one character at a time. (The pointer is a flashing mark " ■ ".) Up to 40 characters can be written into Label 1 and 2 areas each.

Available label characters include uppercase letters (A to Z), lowercase letters (a to z), numerals (0 to 9), limited Greek characters (α, β, Θ, λ, μ, π, τ, Δ, Σ, Ω), symbols (+, -, *, /, (,), =, ., °, %, #, !, ?, &, :, ;, (, ,, >, ,, <, ←, →, ↓, ↑, ∫, TR9404). To write lowercase alphabetic characters, first activate LABEL key, then press SMALL key in the PANEL section (light comes on). All alphabetic keys will be placed in the lowercase shift until SMALL key is pressed again.

Pointer movement can be controlled with ⇦ ⇨ keys in the GENERAL CURSOR section. These keys have repeating capability for pointer control.

A label character can be overwritten by first positioning the pointer to the character to be changed and then entering the desired new character. When entry of a space is desired, press U key in the GENERAL CURSOR section.

If you wish to delete a label character, move the pointer to the character to be removed and press CLR key in the PANEL section. Only one character is deleted. CLR key is repeatable in its function, you can delete the characters continuously by depressing and holding the key. If you want to remove a line of characters, place the pointer at the beginning of the line and use the CLR key. To insert one or more characters into a label, first select the label write mode, then use ⇦ , ⇨ keys to position the pointer to the character location for insertion, and finally press INSERT key in the PANEL section. Insertion of any number of characters (up to 40 characters) is now enabled. If the total number of label characters exceeds 40, overflow occurs at the last character location of the line.

A second operation of the INSERT key clears the Insert mode.

Labels 1 and 2 can be moved in the vertical direction independently. The vertical positioning of the lables can be controlled with ⇧ and ⇩ keys in the GENERAL CURSOR section when in the label write mode. These keys have repeating capability for label positioning control. This feature allows you to attach comments close to the pertinent signal responses. In the example shown in Figure 4-133, comments "FUNDAMENTAL" and "3rd HARMONIC" are written for labels 1 and 2 respectively.

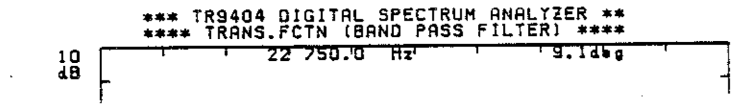


Fig. 4-132 Label entry example

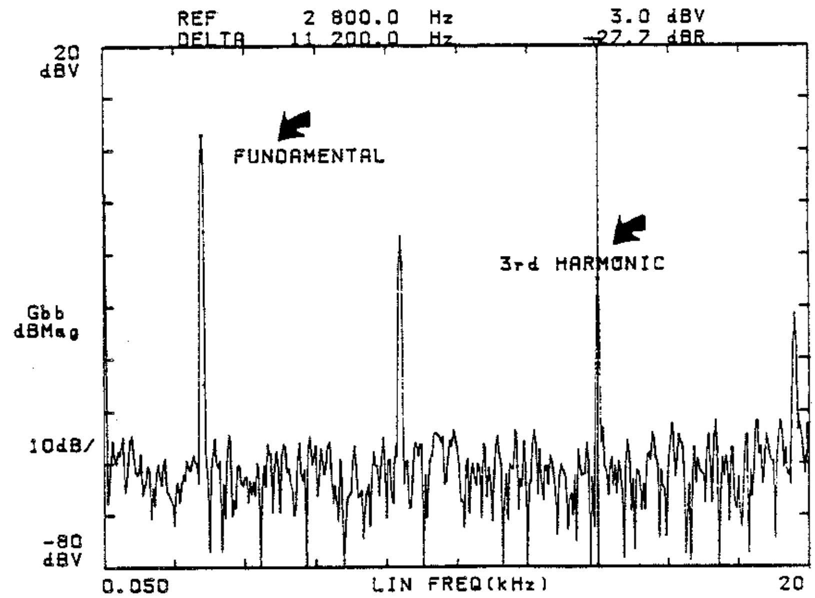


Fig. 4-133 Comment entry using label feature

The vertical label movement feature is also available for the List mode. The label mode is reset when any of the keys in the VIEW section or [UPSCALING] key is pressed, and Label 1 returns to the first line and Label 2 returns to the second line of the top label area on the CRT. Where needed, activate the label write mode again and reposition the labels to the appropriate positions with [⇧] [⇩] keys.

Labels can be specified independently for instantaneous, averaged, and stored data. For example, when a certain set of data is stored in internal memory, labels are also stored along with measurement information, setup conditions, etc., and may be recalled with the RECALL key.

"INST" data labels specified before averaging execution is started by AVERAGE CONTROL keys are defined as the labels for the averaged data.

- Initialization of setup

  Set up the VIEW section for the "LIST" mode, then press the LABEL key to select the Label 1 or 2 Write mode. If the POWER switch is set to OFF in this situation, the memory holding measurement condition will be initialized when the POWER to the instrument is restored. The display is placed in the time domain and will show the label "TR9404 DIGITAL SPECTRUM ANALYZER" if the LABEL key pressed.

  This setup initialization is useful if the contents of the measurement condition memory has been destroyed by an intense extraneous noise, etc. and the analyzer's operation is disturbed. Once the condition memory is initialized, it is ready for the re-setting of the measurement condition data such as the input mode, etc.

4-4-12. PANEL Section

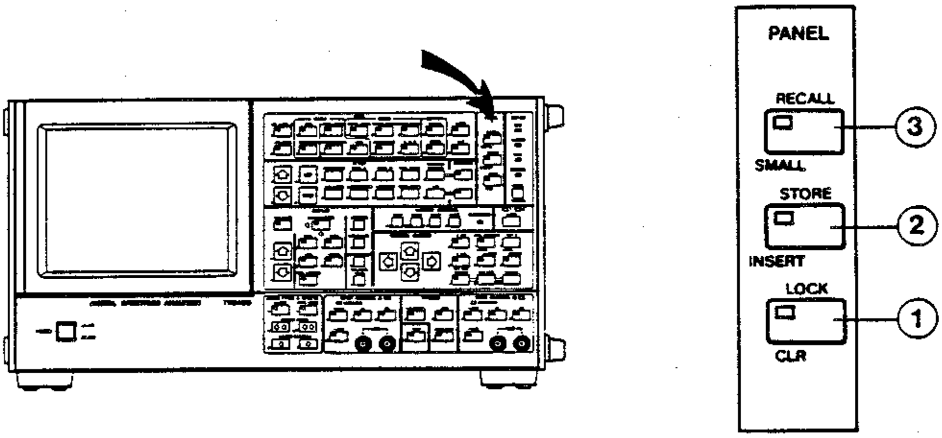


Fig. 4-134 PANEL section panel

① LOCK key

All the front panel keys on the TR9404 Analyzer are designed for light-touch operation. The LOCK key is used to lock all these front key functions to prevent undesired measurement condition changes by inadvertent key operation.

If the key is pressed and held for approximately 1 second, the lamp within the key comes on and all the front key functions are locked, except for the I/O EXECUTE keys, LOCAL and the GENERAL CURSOR section C (↕), C (↔), ⇧, ⇩, ⇦, ⇨ keys.

To unlock the panel key functions, press and hold LOCK key again for approximately 1 second. The lamp within the key will go off and all the key functions will be made accessible.

CAUTION

The LOCK key is designed to remain inoperative even if it is momentarily operated either advertently or inadvertently. To lock or unlock the panel key functions, be sure to press and hold the key for approximately 1 second and check its key lamp.

② STORE

③ RECALL

The STORE key is used to store measurement conditions in the internal non-volatile memory, and the RECALL key is used to retrieve the same information from memory to the display.

STORE

- Up to 4 sets of measurement conditions can be stored by memory.
- The C-MOS memory is divided into 4 blocks and the measurement conditions can be stored in the specified block (A to D) or automatically stored in the next block.

  a. Storing data in the specified block

     If the STORE key is pressed (the lamp within the key turns on) and the key corresponding to the specified block (for example, A key) is pressed, measurement conditions are stored in block A and the following message blinks for a few seconds in the bottom left area on the CRT display:

     PANEL IS STORED : A

b. Storing data automatically in the next block

If the STORE key is pressed twice, measurement conditions are automatically stored in the next block (the lamp in the key turns on).

NOTE

> If a key other than the key (A to D in the bottom left area) corresponding to the specified block is pressed after the STORE key is pressed, the ordinary function of the key is executed; measurement conditions are not stored.

RECALL

- If the RECALL key is pressed (the lamp in the key turns on) then the RECALL key or the key corresponding to the specified block (for example, A key) is pressed when measurement conditions are not stored in the recalling block, (STORE key lamp off), recall is inhibited and the lamp in the RECALL key goes off. The following message blinks for a few seconds in the bottom left area of the CRT display:

  NO PANEL IS STORED

- When the STORE key is set to ON (the lamp in the key turns on), the measurement conditions (except for zoom and trigger conditions) stored in the specified or preceding block are recalled.

a. Recalling specified block

To recall the measurement conditions in block A, press the [RECALL] key (the lamp within the key turns on), then press the key corresponding to the specified block (for example, [A] key). The following message indicating the recalled block blinks for a few seconds:

PANEL IS RECALLED : A

b. Recalling the preceding block automatically

If the [RECALL] key is pressed twice, the measurement conditions stored in the preceding block are automatically recalled (the lamp within the key turns on).

- If an error occurs in the nonvolatile memory (stored information changes), the information in this memory is cleared and the [STORE] and [RECALL] keys are set to OFF to disable recall of the measurement conditions in the block.

NOTES on RECALL

The measurement conditions in the block are not recalled if the following three conditions are satisfied:

(1) The "TRIG. MODE" menu is displayed (including the case where the [UPSCALING] key is set to ON).

(2) The "ARM MODE" is set to "ADVANCE".

(3) The [HOLD/REL.] key is set to ON (the lamp turns on).

(See Section 4-4-5 8 TRIG. MODE, "BLOCK NO" for details.)

4-4-13. EXT. TRIGGER Connector

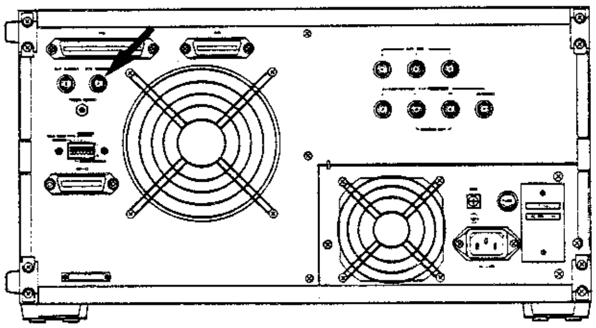


Fig. 4-135 EXT. TRIGGER connector

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 +5 V and -5 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 +5 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 "0.3 * FS" (approximately +1.5 V).

For more details of setup procedure, see the paragraph pertaining to the TRIG MODE in the SETUP section description.

4-4-14. EXT. SAMPLE Connector

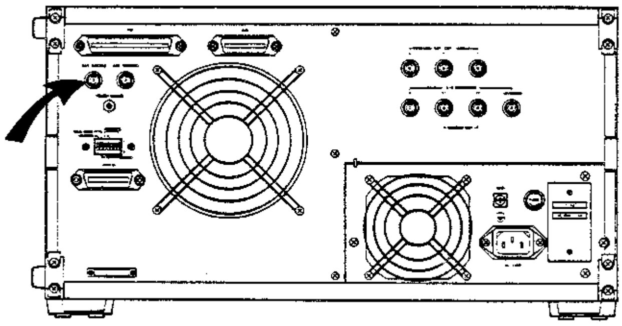


Fig. 4-136 EXT. SAMPLE connector

This connector accepts an external clock which determines the data sampling timing. It is effective when "SAMP CLK" of the FREQUENCY menu (selected with the SETUP section) 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 256 kHz and pulse width more than 1μ sec. The internal sampling signal is generated in synchronism with the leading edge of the external sampling signal.

4-4-15. TOUCH SOUND Control

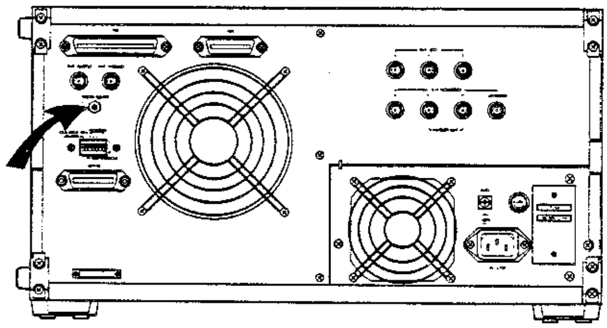


Fig. 4-137 TOUCH SOUND control

This screwdriver adjustment controls the volume level for key touch tone, input overload alarm, and other alarm buzzer sounds. Clockwise rotation of this adjustment increases the volume level. To completely diminish buzzer sound, turn this adjustment fully counterclockwise.

4-4-16. EXT. CRT Connectors

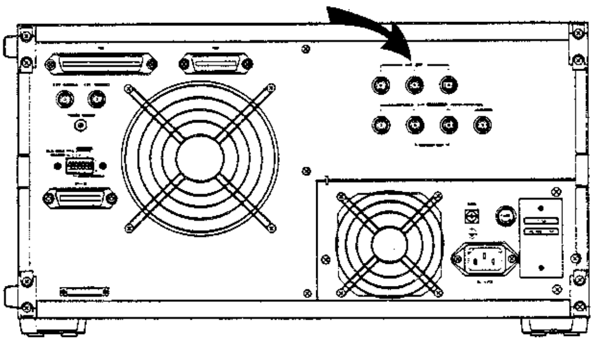


Fig. 4-138 EXT. CRT connectors

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. Peripheral circuitry for the EXT. CRT terminal is given in Figure 4-139 (a).

For the external monitoring through the EXT. CRT terminal, the noise on the signal should be eliminated (See Figure 4-139 (b))

(a)

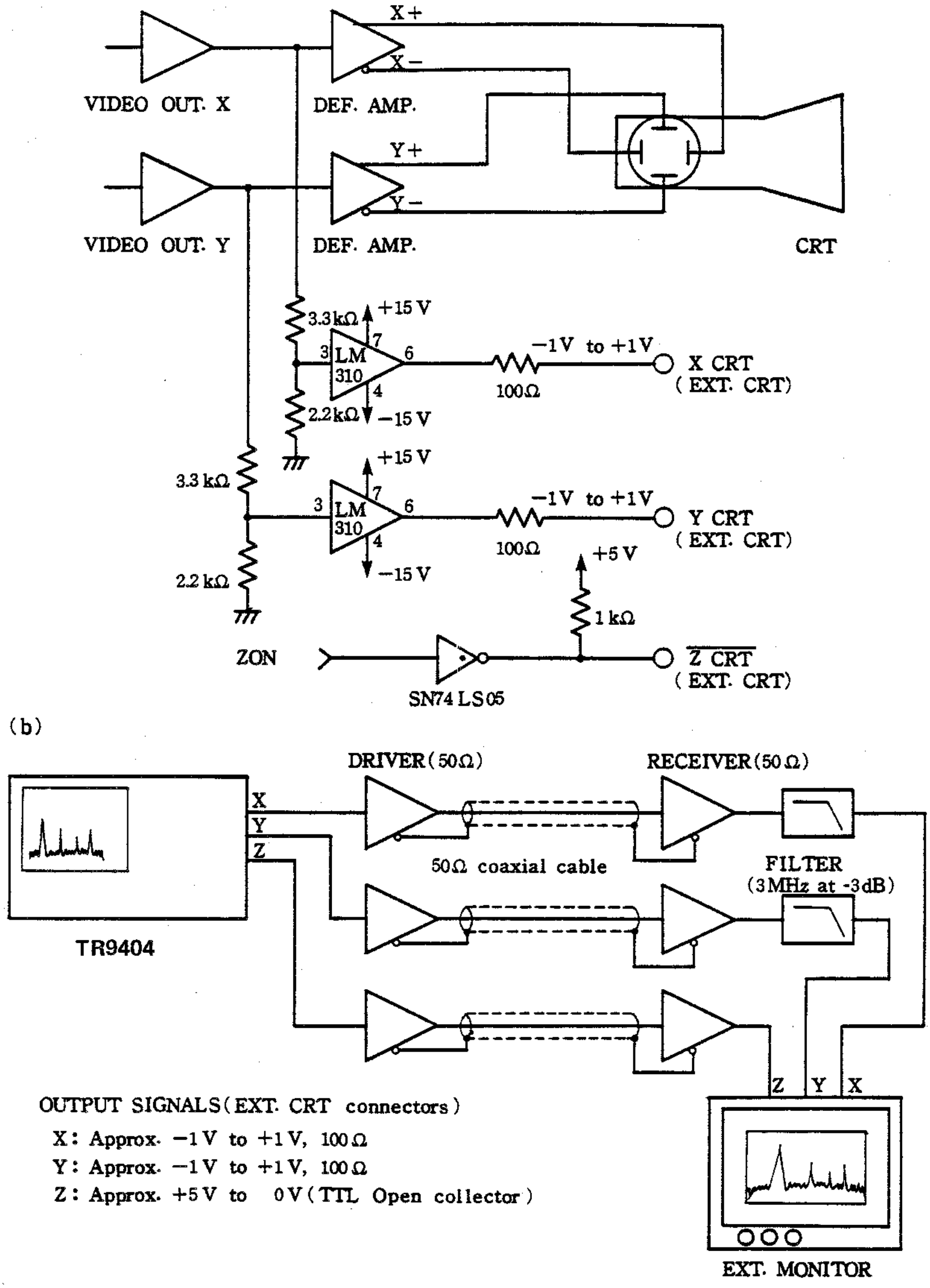


Fig. 4-139 EXT. CRT peripheral circuitry and noise rejection example

When the longer cables are required, provide the external amplifiers of large CMR for the drivers and receivers. The delay in the transmission line causes difference of timing between the blanking signal (Z axis) and the other signals; provide appropriate delay circuit for the adjustment.

Figure 4-140 shows an example of display obtained on a Tektronix monitor scope connected to the TR9404.

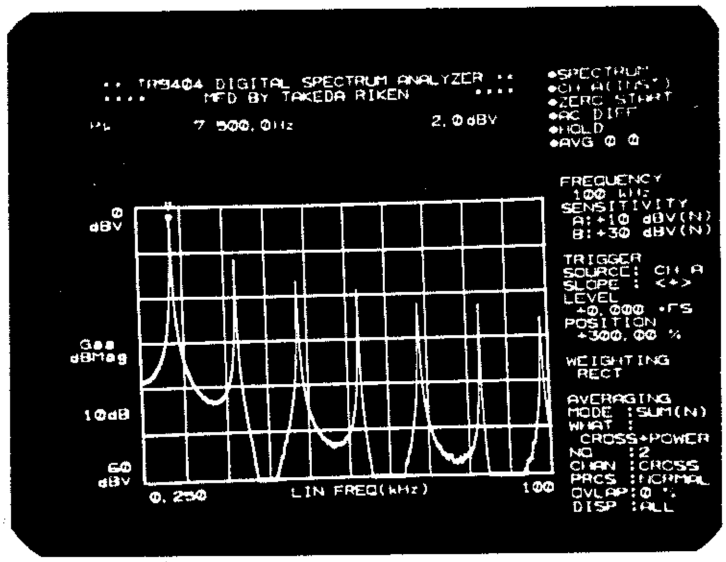


Fig. 4-140 Display obtained on an external monitor scope

SECTION 5

GPIB INTERFACE

5-1. GENERAL

TR9404 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.

TR9404'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.

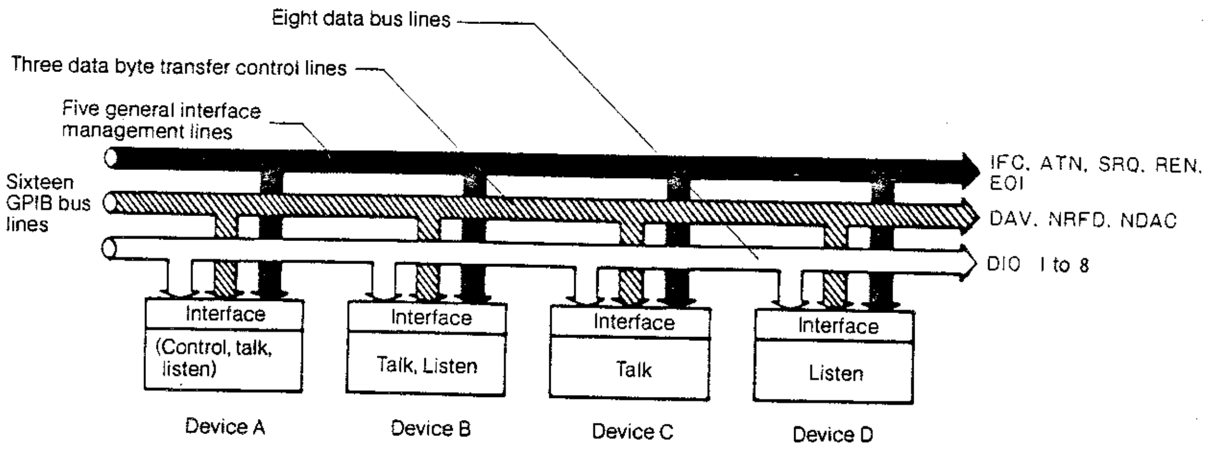


Fig. 5-1 Concept of GPIB

5-2. SPECIFICATIONS

5-2-1. 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 5-2 each.

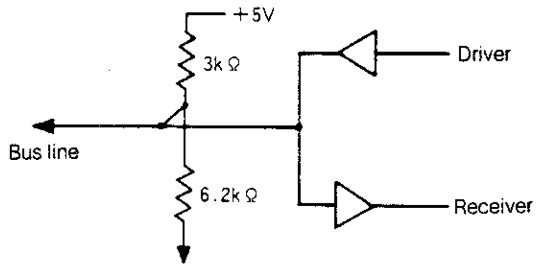


Fig. 5-2 Signal line termination

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

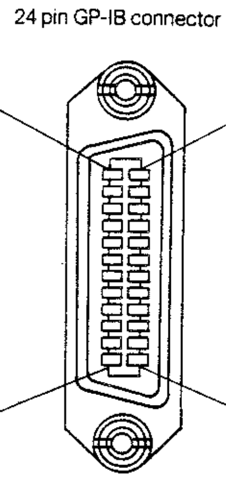
Bus cable length : The maximum length of cable that may be used to connect together a group of devices within one bus system is 2m times the number of devices, or 20m, whichever is less.

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

Fig. 5-3 GPIB connector pin configuration

5-2-2. Interface Functions

The GPIB interface functions are listed in Table 5-1.

Table 5-1 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.
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).

5-3. GPIB SYSTEM HANDLING PROCEDURE

5-3-1. 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:

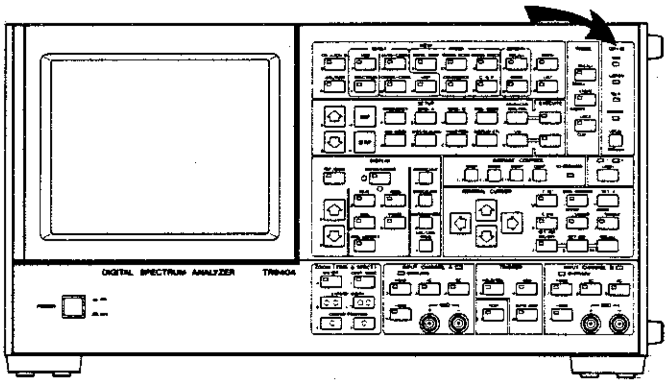
Table 5-2 Standard bus cables (optional)

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.

5-3-2. GPIB Interface Section



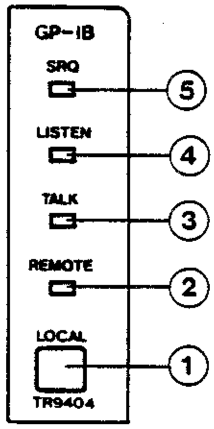


Fig. 5-4 GPIB interface panel

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 TR9404 is controlled over the GPIB. In Remote, the front panel controls are disabled.

③ TALK indicator lamp

This lamp comes on when the TR9404 is addressed to talk.

④ LISTEN indicator lamp

This lamp comes on when the TR9404 is addressed to listen.

⑤ SRQ indicator lamp

This lamp comes on when the TR9404 is in request for service to the controller.

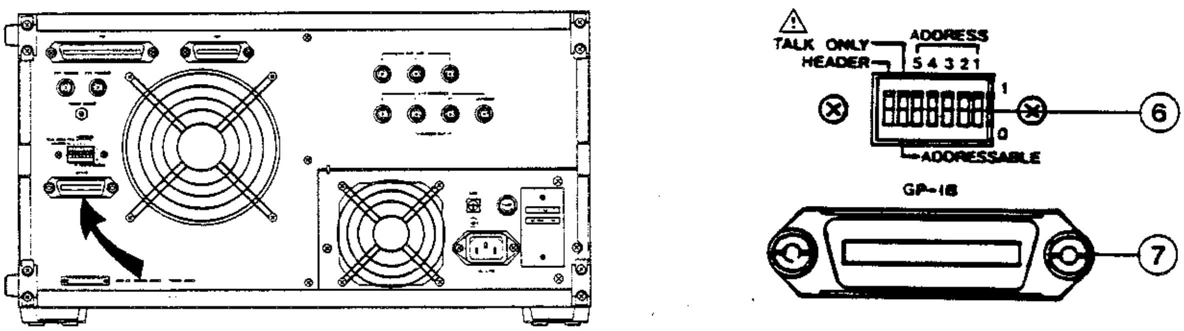


Fig. 5-5 GPIB facilities on rear panel

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 TR9404.
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 TR9404.

5-3-3. Listener Operations

The TR9404 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 TR9404, 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:

FROASOBSOCRLF & 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.

5-3-4. Talker Operations

The Talker mode of the TR9404 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 5-3.

Table 5-3 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:

a-1) When two levels are sent (CO2, CO4, CO1)

Header	Body	∇	Header	Body	Delimiter

Data length 31

a-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 5-7, 5-8, and 5-9 for code table.

d. Body

d-1) The body section consists of 10 characters. Two types of output format are selectable with Set command FX. The formats are shown below:

(i) 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

␣-5Δ 28E-02

␣␣␣␣ 383.6␣

(ii) When FX1 is specified

The body is sent out in the following format:

+ΔDDDDE ±DD

Decimal point

The fifth and lower decimal places are omitted.

d-2) If a value unable to operate is internally generated, such as the case where "INVALID" readout is shown, ASCII code "0" is sent out.

(i) When FX0 is specified

```
00 HZ  44 500.0,00 DG0000000000,00 000000000000
```

(ii) 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) SQ4 block transfer mode (binary mode)

This mode sends displayed data identified by the cursor in binary code.

a. SQ4 output format

1	2	3	4	5	6	7	8	9	- - - - - - - - - - - -			N-2	N-1	N

Data

Coefficient K for overall block

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}
Byte 1								Byte 2							

Coefficient K

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:

$A = D_A \times 2^k$

b-1) Output formats classified by precision types

Table 5-4 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 5-5 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">Byte 1</td><td colspan="8">Byte 2</td></tr>
</table>
Δ

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 5-6 Output format for code "2"

Code	Format Δ : Decimal point, FS: Fullscale or coefficient
2	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} 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} Byte 3 Byte 4 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, $D_A = D' \times FS$.

Table 5-7 Output format for code "3"

Code	Format Δ : Decimal point, FS: Fullscale or coefficient
3	2's complement MSB D_0 D_1 Δ D_2 D_3 D_4 D_5 D_6 D_7 LSB (Byte 1) MSB D_8 D_9 D_{10} D_{11} D_{12} D_{13} D_{14} D_{15} LSB (Byte 2) — Decimal places MSB D_{16} D_{17} D_{18} D_{19} D_{20} D_{21} D_{22} D_{23} LSB (Byte 3) MSB D_{24} D_{25} D_{26} D_{27} D_{28} D_{29} D_{30} D_{31} LSB (Byte 4) — exponent part 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 $E = \left\{ \sum_{n=16}^{31} Dn \times 2^{-(n-31)} \right\} - 2^{15}$ As a result, $D_A = D \times 2^E \times FS$.

c. 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.

d. 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.

e. 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,

$A1 = A$

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):

$$D_K = \left\{\sum_{n=0}^{31} D_n \times 2^{(31-n)}\right\} \Big/ 2^{16}$$

The value to be obtained is

$$A = \frac{D_K \ / \ \omega}{2 \times Fs/256}$$

where ω is the sum of 256 points of Histogram data

$$\omega = \sum_{k=1}^{256} D_K = 2048$$

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 $0.5 \geqq X \geqq -0.5$, it must be doubled after operation is completed.

$$D = \left\{(2^{-1}+2^{-2}+2^{-3}+2^{-4}+2^{-5}+2^{-6}+2^{-7}+2^{-8}+2^{-9}+2^{-10}+2^{-11}+2^{-12}) - 1\right\} \times 2^{-1} \times 2 = -0.0256348$$

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:

$D = (2^{-5}+2^{-9}+2^{-12}) \times 2 \times 200$ (deg.) = 13.378906 [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 5-12.

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 5-11.

Therfore,

$D_A = D \times 4.472 \fallingdotseq 2.29(V)$

f. Notes on high-speed transfer mode (TX1)

When a handshake is in trouble, send out a uniline message of IFC.

g. 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.

h. 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 ($1 \leqq N \leqq 2048$

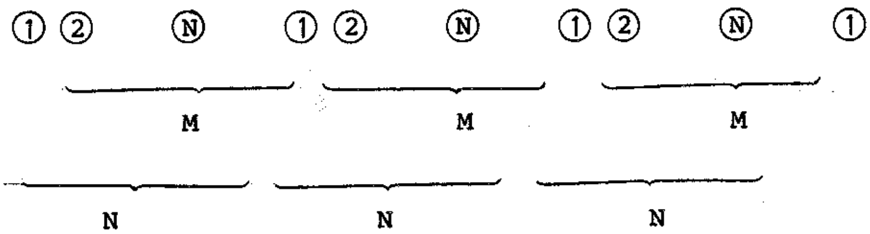
$0 \leqq M \leqq 2047$)

Number of data between blocks

Comma (,)

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.

(4) 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 TR9404, time data is expressed in the form of single precision, fixed point number as shown above. Therefore, time data can be read by the TR9404 by sending the pertinent time data in the same form as in the SQ4 mode (binary mode).

The data to be sent to the TR9404 must contain 2048 data points when in the single chennel 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 TR9404.

(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) Wait 500 ms before averaging execution of the data read by SQ5.

(g) Integration and differentiation of the data read by SQ5 can be executed only once. Send out SQ7 to clear the read data before executing integration and differentiation of a new data.

(5) 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

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 5-18 and 5-19 show program examples in which an octave listing is read with the read command and printed out on the controller.

5-3-5. GPIB Command List

See Table 5-15 Command list. The setup for the commands for which mark "o" is filled in the Setup Read column in this table are readable.

5-3-6. Notes on GPIB Command Execution

When the TR9404 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 5-15), such as LA, LB, RLA, RDT, RLD, etc.

(2) LA and LB commands
These commands must be specified in the following format:
(LB)

```
LA03XOOOOO________________________OOX
   | |                              |
   | |  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 5-13.

(3) SQ 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.

SQ0SQ3

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

AI○AI○

Set 2 or 3

Set 0 or 1

b. FU command

FU○FU○

Set 0 or 1

Set 2 to 5

c. VW command

VW○VW○ (in the BOTH mode)

LOWER DISPLAY mode

UPPER DISPLAY mode

␣␣␣VW2 (in the SINGLE mode)

d. SM command

SM○SM○

Set 0 or 1

Set 2 or 3

e. FL command

FL○FL○

Set 3 or 4

Set 0 to 2

f. CL command

CL○CL○

Set 2 to 5

Set 0 or 1

(4) VT and HT commands

When these commands are executed, the cursor is turned on. If the input is AC coupled for frequency domain data, 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.

(5) 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.

(6) 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.

(7) No other command than the IE command should be sent while the attached plotter is busy plotting (EXECUTE lamp ON).

(8) DATA WINDOW movement

When the DATA WINDOW switch in the GENERAL CURSOR section is set to ON, command number of set command VT determines the direction of data window.

Command number increment: ⇦ switch

decrement: ⇨ switch

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 span. Use the same procedure as the manual operation in setting up the step span.

(9) 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.

5-3-7. 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

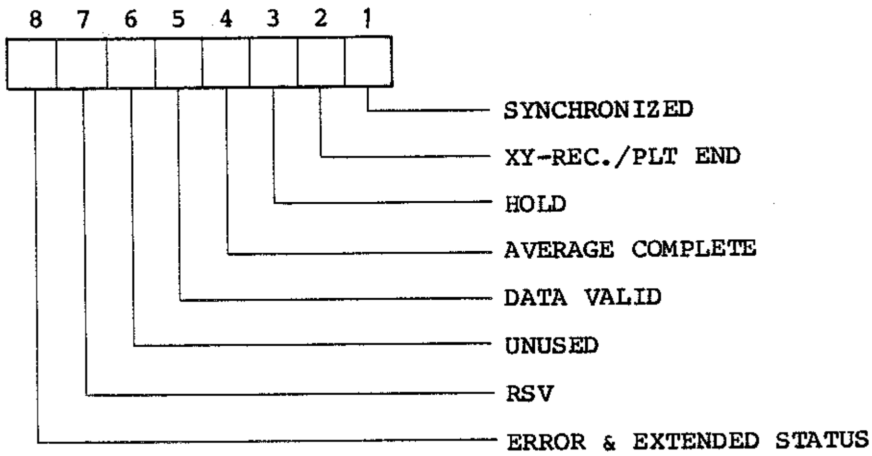
XX —— Maximum number of lines

(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

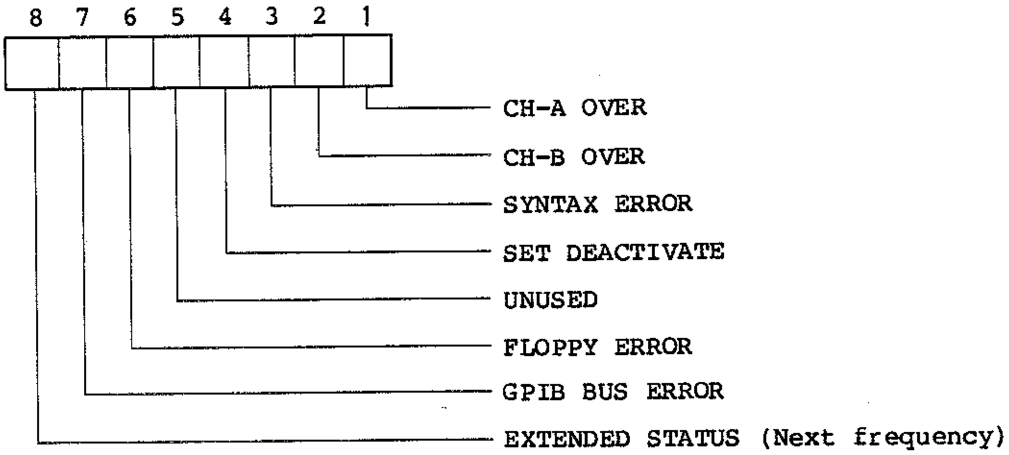
5-3-8. Service Request

(1) A Service Request (SRQ) is issued when any bit of the status byte 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. To avoid mis-operation caused by service requests generated before mask setting, execute serial poll once after setting mask.

5-3-9. Header Code List

Table 5-8 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
00	None

Table 5-9 Header code list (OVERLOAD)

Output code	Overload
O	Overload
␣	Normal (space)

Table 5-10 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 (μHz)
MH	mHz (mHz)
HZ	Hz
KH	kHz
DB	dB
DV	dBV
DG	deg
IV	V^{-1}
VV	V^2
QV	V^4
VZ	$V/\sqrt{Hz}$
VH	V^2/ 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 5-11 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^{-3}	1.414×10^{-3}

Table 5-12 Coefficient vs. input sensitivity in the "SPECT.", "CROSS SPECT.", and "TRANS. FCTN" modes

Input sensitivity, sensitivity difference & sum [dB][dBV]		Coefficient	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	Sum of	10^4	100
30	sensitivity	10^3	31.6
20	difference	10^2	10
10		10^1	3.16
0		1	1.0
-10	Sensitivity	10^{-1}	316E-3
-20		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 5-13 Special character codes for labels

Character	Corresponding 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
o (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 5-13. All other codes are included in ASCII code set listed in Table 5-14.

Table 5-14 ASCII character

ASCII	Equivalent code			ASCII	Equivalent code			ASCII	Equivalent code			ASCII	Equivalent code		
Code	Binary	Octal	Decimal	Code	Binary	Octal	Decimal	Code	Binary	Octal	Decimal	Code	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
HTAB	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
VTAB	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

Table 5-15 TR9404 command list

Commands marked ** are not usable with other commands.

Control item	Command		Description	Setup read
	Function	Setup		
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 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
Input sensitivity	AS BS	0 to :	INPUT SENSITIVITY 0 +30 dBV 1 +20 dBV 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 AS: CH-A BS: CH-B	o
Sampling clock	SC	0, 1	SAMPLING CLOCK 0 INTERNAL 1 EXTERNAL	o
Frequency range	FR	0 to ?	FREQUENCY RANGE 0 100 kHz 1 50 kHz 2 20 kHz 3 10 kHz 4 5 kHz 5 2 kHz 6 1 kHz 7 500 kHz 8 200 kHz 9 100 kHz	o

Table 5-15 TR9404 command list (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Frequency range	FR		: 50 kHz ; 20 kHz < 10 kHz = 5 kHz > 2 kHz ? 1 kHz	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	TRIGGER OUTPUT 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 3200	TRIGGER POSITION 0 to 3200 [%] Integer	o
	AL	0 to 6	ARM LENGTH 0 1K 1 2K 2 4K 3 8K 4 16K 5 32K 6 64K (single channel only)	o
	AR	0, 1	ARM MODE 0 NORMAL 1 ADVANCE	o
	BN	0 to 31	BLOCK NUMBER	o
	BR	---	RECALL BLOCK	x

Table 5-15 TR9404 command list (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
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	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
	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

Table 5-15 TR9404 command list (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
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
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	o
	** SF		SCALING FACTOR o dBMag display: ±NNN.N 0 to 9 Decimal point 0 to 9 0 to 9 0 to 9 (+), (-), space Set with 6 characters o 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

Table 5-15 TR9404 command list (Cont'd)

Control item	Command: Function	Command: Setup	Description	Setup read
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 5	PANEL STORE Panel Store 1 to 6	o *
	PR	0 to 5	Panel RECALL Panel Recall 1 to 6	x
Function	FU	0 to 5	FUNCTION 0 OFF 1 ON 2 <+> 3 <-> 4 <*> 5 </>	o
	FV	0 to 4	FUNCTION VIEW 0 OFF 1 $j\omega$ 2 $(j\omega)^2$ 3 $1/(j\omega)^2$ 4 $1/(j\omega)$	
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

* Reads the number last set up. With no command, ? is output.

Table 5-15 TR9404 command list (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
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
Display control	DM	0 to 4	DISPLAY MODE 0 TIME 1 HIST 2 V 3 V^2 4 dBV	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
View	VS	0, 1	VIEW CHANNEL SELECT 0 CH-A 1 CH-B	o
	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

Table 5-15 TR9404 command list (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
View	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
	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

Table 5-15 TR9404 command list (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Display scale	** VG	-5 to 9	VERTICAL GAIN (See Table 5-15(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 5-15(b) Vertical reference setup	o

Table 5-15(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 5-15(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 5-15 TR9404 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	VT	0 to 2047	VERTICAL CURSOR SET	o
	HT	0 to 1024	HORIZONTAL CURSOR SET	o
Label	** LA	-	LABEL 1	o
	** LB	-	LABEL 2	o
Hold mode	DH	0 to 3	DATA HOLD MODE 0 FREE RUN 1 ARM 2 HOLD 3 AUTO ARM	x

Table 5-15 TR9404 command list (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
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
	** EW	0 to 4	EXPAND WIDTH TIME SPECT 0 x1 x2 1 x2 x4 2 x4 x8 3 x8 4 x16	o
Others	SQ	0 to 7 (except 6)	0 Enables SRQ. *1 Disables SRQ. *2 Cursor mode 3 ASCII block transfer mode 4 Binary block transfer mode 5 Sets the listener in binary block transfer mode 7 Clears time data from GPIB	o
	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

Table 5-15 TR9404 command list (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Others	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	o
	SP	0 to 2047	START POINT * 0 to 2047 0: Denotes that this command is inoperative.	o
	ON	0 to 2047	OUTPUT NUMBER * 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 5-15 TR9404 command list (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Others	DS	0, 1	DATA SELECT *0 (ORBIT), REAL/MAG. (NYQUIST) 1 (ORBIT), IMAG./PHASE (NYQUIST)	o
	TX	0, 1	High-Speed Transfer Mode 0 SQ4 1 SQ4 high-speed mode	o
	DO	0, 1	Dual Display Output 0: Normal 1 BOTH Only available in SQ4 high-speed mode	o
Status	MK	0 to 65535	MASK STATUS * Masks the status bit of the binary pattern for a set number.	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	

* 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 5-15 TR9404 command list (Cont'd)

Control item	Command	Description
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.
	**ROA	Sends an overall value. For the output format, see paragraph 5-3-7.
	**RPR	Sends partial data. For the output format, see paragraph 5-3-7.
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%

Table 5-15 TR9404 command list (Cont'd)

Control item	Command	Description
DATA WINDOW	**RDP	Sends shift steps and the leftmost position of the present DATA WINDOW with the DATA WINDOW 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 5-16 Advanced analysis command list

Command marked with ** does not allow simultaneous use of other command.

Control item	Command		Description	Setup read
	Function	Setup		
Advanced Analysis	AA	0 to 3	Advanced Analysis Select 0 3-D DISP DISABLE 1 3-D DISP ENABLE 2 OCTAVE DISABLE 3 OCTAVE ENABLE	o
	AX	0, 1	Advanced Analysis Execute 0 STOP 1 START	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 o In case of 0 or no numbers, number of filters displayed is sent out. 1/3 Octave: 30 1/1 Octave: 10 o When filter numbers are set up, list of the filters is sent out.	
	**RLF		Block of center frequencies of filters is sent out.	
	**RLL		Block of level values is sent out.	
	**RLV		OVERALL is sent out.	

Table 5-16 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 5-17 I/O 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 2	I/O SELECT 0 X-Y RECORDER 1 PLOTTER 2 FLOPPY DISK 3 SIGNAL GENERATOR (option)	o
I/O control	** IE	0, 1	I/O EXECUTE 0 STOP 1 START	x
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
	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

Table 5-17 I/O command list (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Plotter control	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) (Demarcated with "," in the above order)	o
	PY	0, 1	PLOTTER TYPE 0 ADVANTEST (TR9834R, TR9831) 1 HP-GL (HP7470A, 7225A)	o
	PG	0, 1	PLOT ANGLE 0 NORMAL 1 90°	o
Floppy disk	**FL	0 to 4	FLOPPY LOAD MODE 0 CRT 1 PLOTTER 2 XY-RCDR 3 MODE=1 4 MODE=2 Note) Commands 0 to 2 are independent of 3 to 4.	o
	**FW	0 to 4	FLOPPY WRITE TRIG 0 DATA 1 AVGED 2 SYSTEM 3 COPY 1 4 COPY 2	o
	**FS	0 to 7	FLOPPY STACKING NO. 0 1 1 2 2 4 3 8 4 16 5 32 6 64 7 128	o

Table 5-17 I/O command list (Cont'd)

Control item	Command		Description	Setup read
	Function	Setup		
Floppy disk	**FD	0 to 2	READ VIEW 0 NOMANIP. 1 DEP. DATA 2 DEP. PANEL	o
	**FM	0 to 2	WRITE MODE 0 ORIGIN 1 UNADAPT 2 MASS TIME 3 GRAPHICS	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
	ET		FLOPPY START	
	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.

5-4. PROGRAMMING EXAMPLES

All the following examples are the programs created on the Hewlett Packard desk top computer System 45B.

Example 1. Setting up measurement conditions for the TR9404 with a SET command.

Example 2. Reading the current condition setup from the TR9404 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 TR9404 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 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 func. indi.
- 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
```

Fig. 5-6 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
LA000@* TR9404 DIGITAL SPECTRUM ANALYZER **@
LB010@ ****    MFD BY ADVANTEST         ****@
```

Fig. 5-7 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
```

Fig. 5-8 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     PRINT 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 ,   110.508
 ,    99.555 ,   135.016 ,    82.301 ,    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,+.3861E+02,+.8042E+02,+.7959E+02
```

Fig. 5-9 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    DIM Data(3000)
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 BFHS L 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
```

Fig. 5-10 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$[10000]
60    OUTPUT 701;"SQ3"                 ! SQ3=ASCII-BLOCK TRANSMISSION MODE
70    ENTER 701 USING "T";A$
80    PRINT A$
90    END
```

Fig. 5-11 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 INT #7 GOSUB Int          ! WHEN INTERRUPT FROM (#7) , JUMP LINE Int
60    CONTROL MASK 7;128
70    CARD ENABLE 7
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 HEAR
160   PRINT "INTERRUPT"
170   STATUS 701;Status            ! READ STATUS BYTE FROM DEVICE CODE OF (1)
180   PRINT Status                 ! PRINT STATUS BYTE
190   CARD ENABLE 7                ! ENABLE NEXT INTERRUPT
200   RETURN
```

Fig. 5-12 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 TR9404 through the GPIB. Figure 5-15 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 5-14.)

  Line 160: Generates the Data variable (time data)(-1<Data<1) .

  Line 190: Jump to line 800.

  Line 800-1260: Convert the variable (Data) into 16-bit pattern and divide the pattern into two bytes of high and low order bytes, before returning to the main program. This is illustrated as follows:

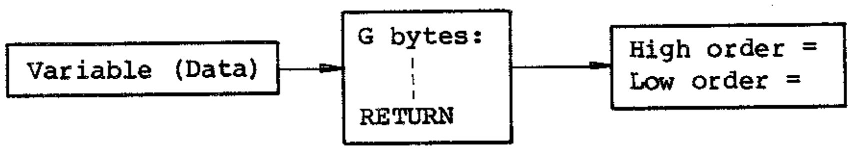


Fig. 5-13 SQ5 mode flow chart

  Line 310: Sets the last byte to send byte 2050 along with the EOI.

  Line 320: Re-defines the dimension to send bytes 1 through 2049.

  Line 330: Sends SQ5 to set the TR9404 into the time data read mode (be sure to send SQ5 every time before sending the time data to the TR9404).

  Line 340: Sends bytes 1 through 2049 (terminator CR/LF won't be sent by specifying format using "≦").

  Line 350: Sends the last byte along with the EOI (The EOI line, when activated, indicates the end of data).

  Line 370-580: Save bytes 1 through 2050 to the cartridge tape storage on the Model 45.

```
10    ! ***************************************
20    ! * CALCULATE TIME-DATA WITH SIN(X)/X   *
30    ! ***************************************
40    !
50    !
60    OPTION BASE 1
70    DIM A(16)                       ! A(1) ~ A(16)  (BIT(1) ~ BIT(16))
80    DIM Byte(2050)                  ! Byte(1) ~ Byte(2050)
90    !
100   RAD
110   REM
120   Byte(1)=0                       ! BLOCK EXPONENT=0 (UPPER BYTE)
130   Byte(2)=0                       ! BLOCK EXPONENT=0 (LOWER BYTE)
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     GOSUB Gbyte
200     Byte(Y+3)=Upper
210     Byte(Y+4)=Lower
220     Y=Y+2
230   NEXT X
240   !
250   !
260   ! *******************************************************
270   ! * SEND (1024)-POINTS TIME-DATA & EXPONENT WITH GPIB    *
280   ! *******************************************************
290 Sending:!
300   DISP CHR$(130)&"SENDING TIME-DATA TO (TR-9404) NOW!!!"
310   Last_byte=Byte(2050)
320   REDIM Byte(2049)
330   OUTPUT 701 USING "K";"SQ5"
340   OUTPUT 701 USING "#,B";Byte(*)        ! SEND 2047 BYTES WITHOUT (CR/LF)
350   EOI 7;Last_byte                       ! SEND LAST BYTE WITH "EOI"
360   !
370   OUTPUT 701 USING "K";"LA00@   Y(t)=7/5*SIN(X)/X-0.5@"
380   !
390   DISP "FINISHED SENDING DATA !!!"
400   !
410   !
420   !
430   ! *********************************************************
440   ! * SAVE (1024)-POINTS TIME DATA & EXPONENT INTO CARTRIDGE *
450   ! *********************************************************
460   INPUT "***** SAVE DATA(0) , NOT SAVE DATA(1) *****",Num
470   IF Num=0 THEN GOTO Save_data
480   GOTO Finish
490   !
500 Save_data:!
510   LINPUT "TYPE IN DATA-FILE NAME !!!",B$
520   DISP CHR$(130)&"SENDING DATA INTO FILE OF "&B$&" NOW !!!"
530   CREATE B$,1,16436                    ! 16436=8*3+8*2050+12
540   ASSIGN #1 TO B$                      ! B$ IS THE DATA-FILE NAME
550   PRINT #1;A,B,Peak,Byte(*),Last_byte
560 Finish:!
570   DISP CHR$(130)&"ALL WORK FINISHED !!!"
580   END
590   !
600   !
610   !
```

Fig. 5-14 Programming example 8

```
620   !
630   ! ******************************************
640   ! *  CONVERT (Data) INTO BIT-PATTERN        *
650   ! *                                         *
660   ! *  <NOTE>                                 *
670   ! *   BIT(16)=SIGN BIT                      *
680   ! *    * IF (Data) IS NEGATIVE THEN (16)=1  *
690   ! *                                         *
700   ! *  <INPUT>                                *
710   ! *   Data : DECIMAL FRACTION WITH SIGN     *
720   ! *                                         *
730   ! *  <OUTPUT>                               *
740   ! *   Upper : UPPER BYTE OF BIT-PATTERN     *
750   ! *   Lower : LOWER BYTE OF BIT-PATTERN     *
760   ! ******************************************
770   !
780   !
790 Gbyte:!
800   A(16)=Sign=0                    ! INITIALY SIGN BIT (16)="0" AND Sign=0
810   IF Data<0 THEN GOTO Negative    ! CHECK IF Data IS NEGATIVE ?
820   GOTO Pri
830 Negative:!
840   Data=ABS(Data)                  ! GET ABSOLUTE VALUE
850   A(16)=Sign=1                    ! SIGN BIT (16)="1" AND Sign="1"
860 Pri:!
870   IF Data<2^(-15) THEN Data=0
880     FOR I=15 TO 1 STEP -1
890       Data=2*Data
900       A(I)=Data DIV 1
910       Data=Data-A(I)
920     NEXT I
930   IF Sign=0 THEN GOTO End
940   ! *****************************************
950   ! *     JUMP HERE WHEN Data IS NEGATIVE   *
960   ! *****************************************
970      FOR I=1 TO 15                ! COMPLEMENT FROM A(1) TO A(15)
980        IF A(I)=0 THEN A1
990        IF A(I)=1 THEN A0
1000 A0:   A(I)=0
1010       GOTO Nxt
1020 A1:   A(I)=1
1030 Nxt:NEXT I
1040  ! *************************
1050  ! *    CALUCULATE (LSB)+1  *
1060  ! *************************
1070  A(1)=A(1)+1                     ! (LSB)+1
1080  FOR I=1 TO 15
1090    IF A(I)=2 THEN GOTO Up
1100    GOTO End
1110 Up:A(I)=0
1120    A(I+1)=A(I+1)+1
1130  NEXT I
1140  !
1150  !
1160  !
1170 End:!
1180    Upper1=2*A(16)+A(15)
1190    Upper2=4*A(14)+2*A(13)+A(12)
1200    Upper3=4*A(11)+2*A(10)+A(9)
1210  Upper=64*Upper1+8*Upper2+Upper3   ! GET UPPER BYTE
1220    Lower1=2*A(8)+A(7)
1230    Lower2=4*A(6)+2*A(5)+A(4)
1240    Lower3=4*A(3)+2*A(2)+A(1)
1250  Lower=64*Lower1+8*Lower2+Lower3   ! GET LOWER BYTE
1260  RETURN
```

Fig. 5-14 Programming example 8 (Cont'd)

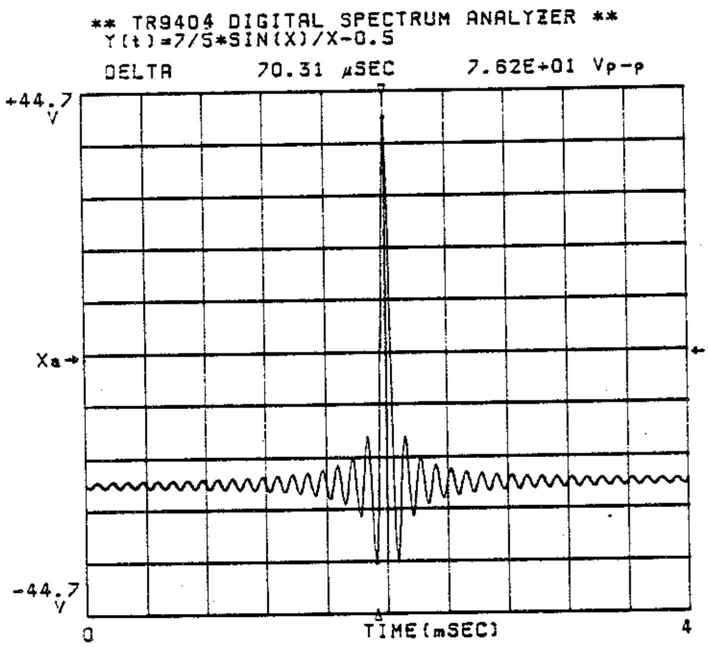


Fig. 5-15(a) Time-domain data example using function SIN(X)/(X)

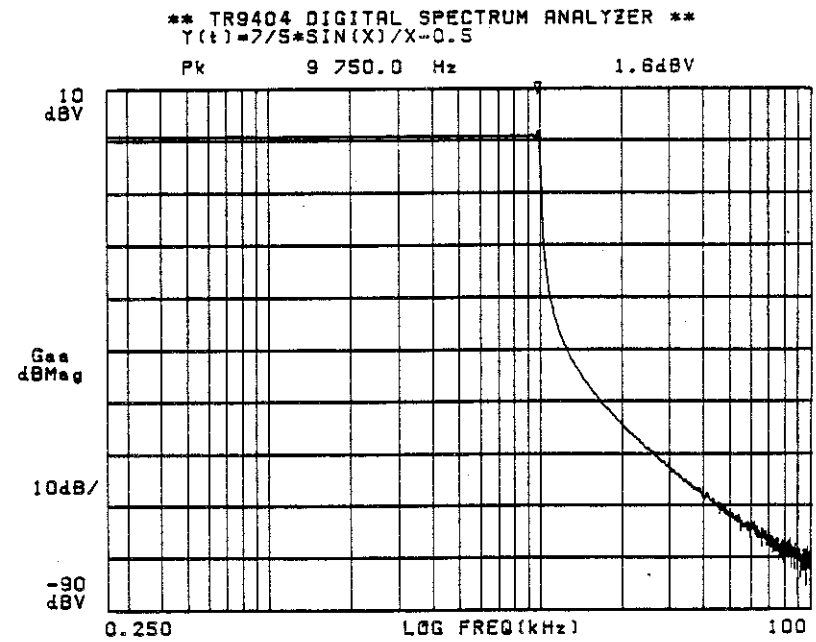


Fig. 5-15(b) Logarithmic display of frequency domain data converted from the above time domain data

Example 9. Transfer function measurement based on sinusoidal sweep with a GPIB compatible function generator

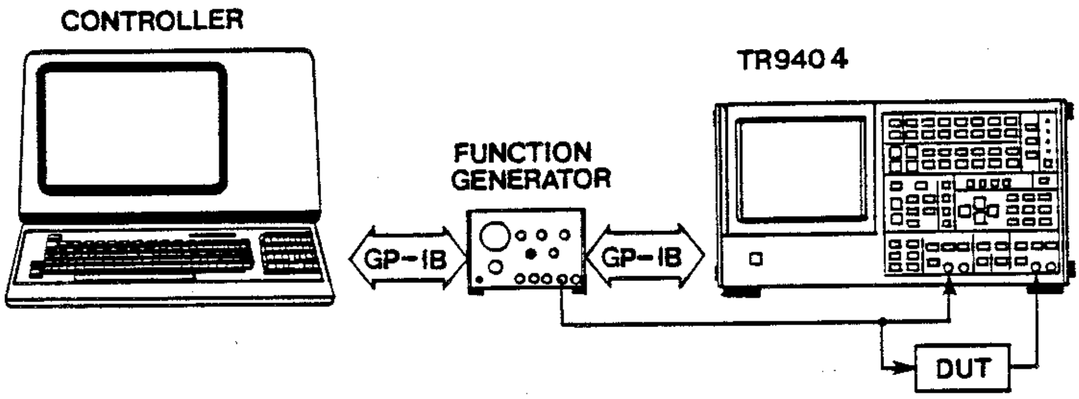


Fig. 5-16 Transfer function measurement with sinusoidal sweep scheme

Set up an interconnection between TR9404, the controller and a function generator as shown in Figure 5-16. Make necessary setups including "AVERAGE MODE" being set to "SWEEP". (For sweep average, see Selection of AVG PROCESS in 4-4-5. SETUP section 9 "AVG MODE")

* Program description (see Figure 5-16)

  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     ! *** GP-IB ADDRESS ***
80     !   TR9404=> 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$(Nn+48)      ! Set Average Number
170    !
180    OUTPUT 701;"AC2HA1"              ! Average Stop & Harm. Off
190    OUTPUT 701;"FU0IA0IB0DA0DB0"     ! Function OFF
200    OUTPUT 701;"ZO0"                 ! Zooming OFF
210    OUTPUT 701;"AI1"                 ! Test Signal OFF
220    OUTPUT 701;"BT1DU0VW6DU1VW7"     ! Display
230    OUTPUT 701;"DU0DV2DM4"
240    OUTPUT 701;"AM0AP2AO0AD0"        ! Average Mode
250    !
260    ON INT #7 GOSUB Int
270    CONTROL MASK 7;128
280    CARD ENABLE 7
290    !
300    STATUS 701;A                     ! Clear Old Status
310    OUTPUT 701;"RES"
320    !
330    Fr=Frs                           ! Set Start Frequency (GENERATOR)
340    OUTPUT 702;"FR";VAL$(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    !
500 Comp: !   Average Complete
510    OUTPUT 701;"AC2"                 ! Average Stop
520    BEEP
530    DISP " Average Complete // "
540    WAIT 2000
550    GOTO Start
560    !
570 Int: !  Interrupt Service Routine
580    STATUS 701;A                     ! 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    CARD ENABLE 7                    ! Interrupt Enable for Next SRQ
720    RETURN
```

Fig. 5-17 Programming example 9

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$[50]
80     !
90     DISP "  TR9404 Ready ? ,PUSH CONT. KEY //"
100    PAUSE
110    OUTPUT 701;"DH2HD0FX0"       ! Data Hold & Header OFF,FX0
120    !
130    OUTPUT 701;"RLN"             ! Read Line number
140    ENTER 701;Ln                 ! Line NO. 1/1 OCTAVE :10 ,1/3 OCTAVE :30
150    !
160    Oct$="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$
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:!
```

Fig. 5-18 Programming example 10

```
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: !
690    DISP " END "
700    END
```

Fig. 5-18 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
```

Fig. 5-19 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 5-20)

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 2000
190      OUTPUT 701;"FT"               ! Floppy Start
200     WAIT 1000
210    NEXT I
220    !
230    DISP " Write End // "
240    BEEP
250    !
260    OUTPUT 701;"WR0"                ! Floppy Read Mode
270    !
280    WAIT 3000                       ! 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 2000
380    !
390    GOTO Read
```

Fig. 5-20 Programming Example 11

SECTION 6

PERIPHERAL DEVICES AND THEIR USAGE

6-1. INTRODUCTION

For an extended application range, a wide variety of peripheral devices are available with the TR9404 Digital Spectrum Analyzer. Use of the appropriate peripheral devices with the analyzer will assure an extended application range as well as maximum performance of the instrument.
All peripheral (except the close-up camera) are controllable with the I/O and EXECUTE keys in the SETUP section on the analyzer front panel.
The attachable peripheral devices include the following:

- Close-up camera
- Analog X-Y recorder (single or dual pen) with +1 V fullscale and pen up-down control capability.
- Digital plotter: TR9834R/9831 by ADVANTEST
  7470A/7225A HP-GL plotter by Hewlett Packard
- Floppy Disk Digital Data Recorder: TR98102 by ADVANTEST
- Signal Generator: TR98201 by TADVANTEST (with Signal Generator interface of option 05)
- Universal Scanner: TR7200 series by ADVANTEST

6-2. CLOSE-UP CAMERA HANDLING PROCEDURE

Assemble the close-up camera by referring to Figure 6-2. The recommended photographing conditions are as follows:

Aperture	Exposure time
F11	1
F8	1/2

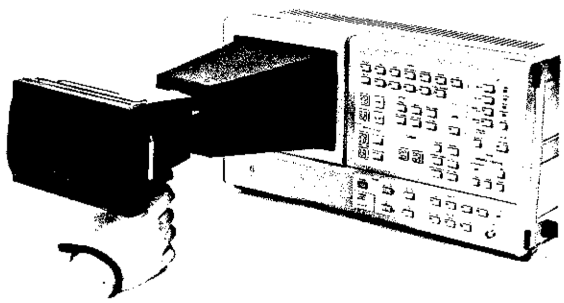


Fig. 6-1 Usage of close-up camera

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 paragraph 2-4 (10).
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.

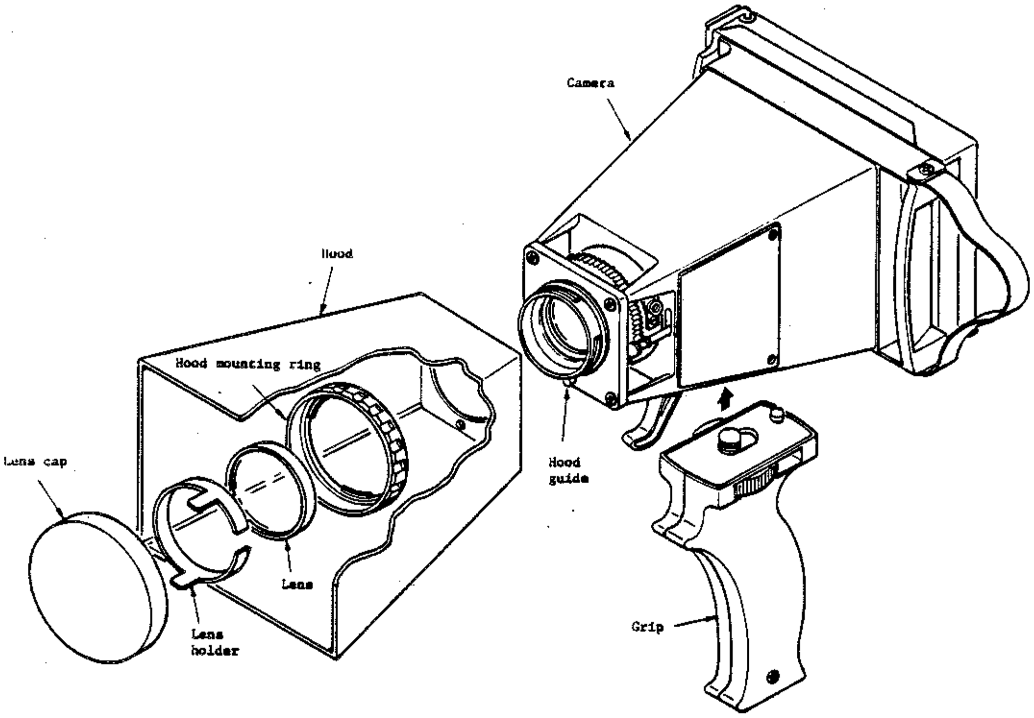


Fig. 6-2 Assembly illustration of M-085DII Polaroid Camera

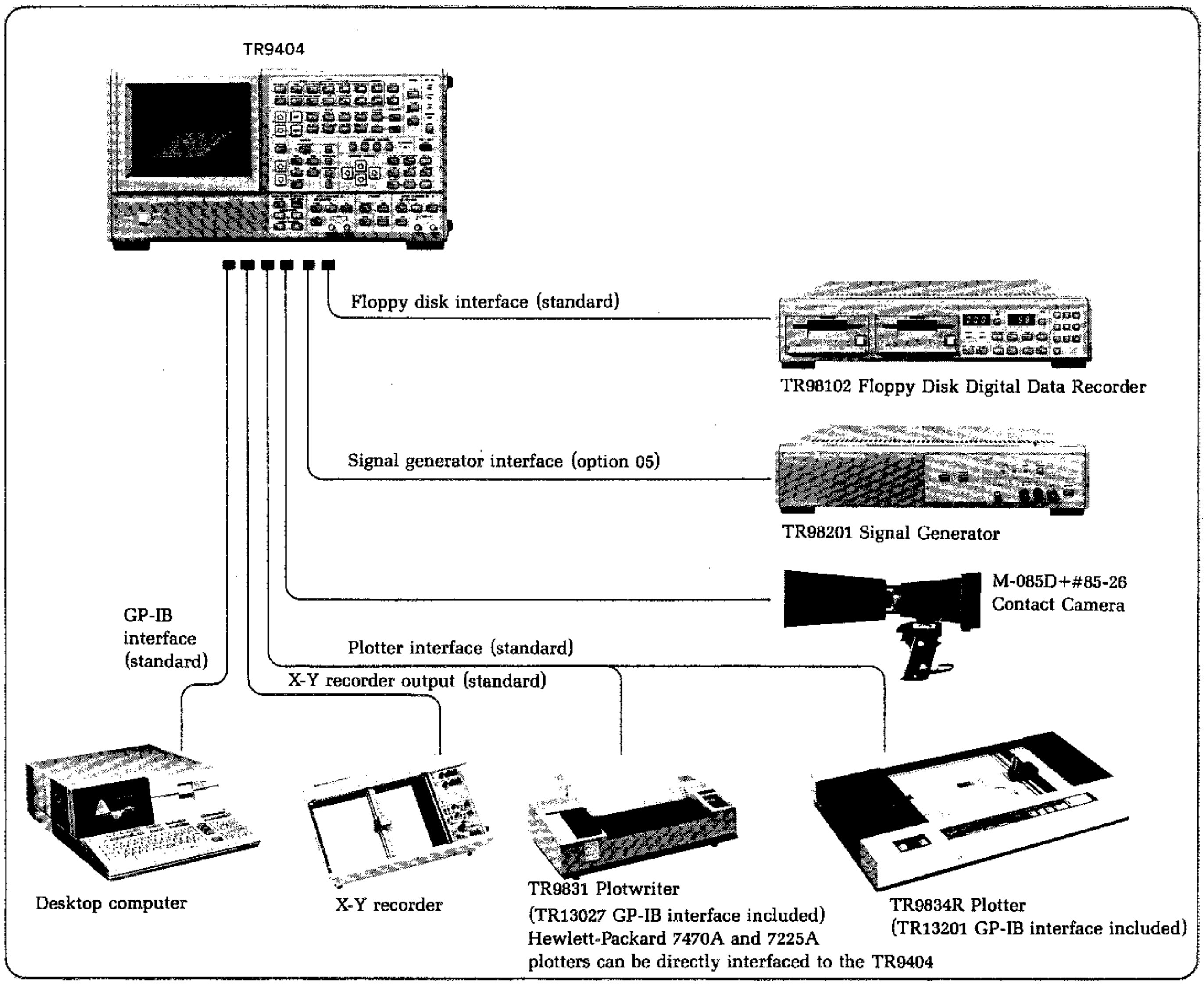


Fig. 6-3 System configuration with peripheral devices

6-3. PERIPHERAL DEVICE SELECTION AND HANDLING

6-3-1. I/O (I/O device select) key —— ①

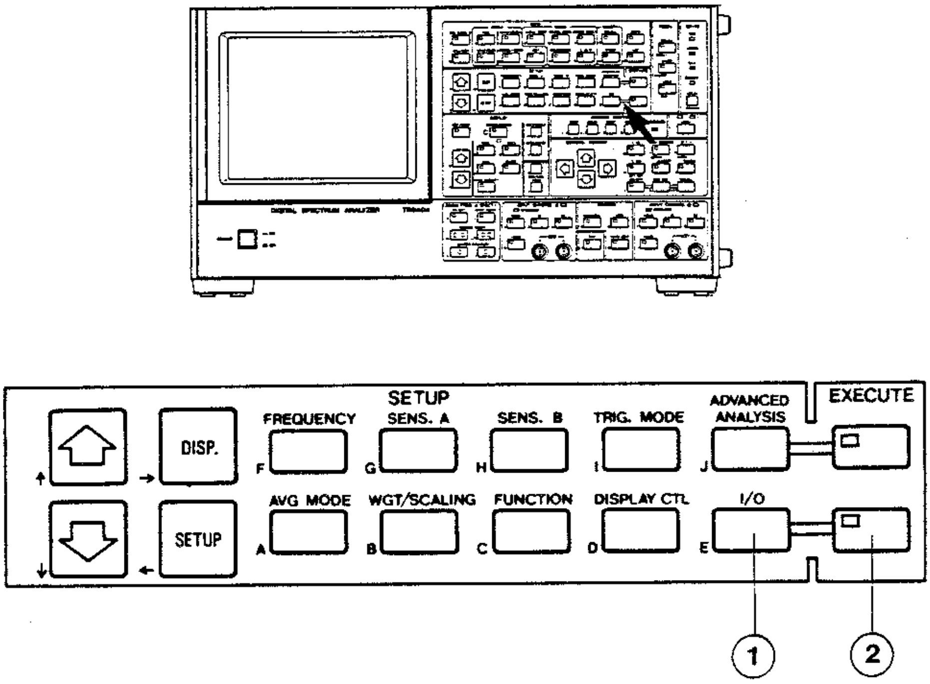


Fig. 6-4 Peripheral device control panel

If the I/O key in the SETUP section is pressed, an I/O select menu (shown in Figure 6-5) is shown in the right area of the CRT.

XY-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 (option 05 Signal Generator interface is required)

One of these four modes can be selected by controlling the pointer with ⇧ ⇩ keys and then operating SETUP or DISP. key in the SETUP section. In the example shown in Figure 6-5, the item for the X-Y recorder is selected with the pointer.

```
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
```

Fig. 6-5 I/O select mode menu

6-3-2. EXECUTE (I/O device execute) key —— ②

This key is used to control for the selected I/O device. While the lamp within the key illuminates, the selected I/O device is in operation.

Operation of the I/O device can be suspended by pressing the key a second time (the key lamp goes off).

6-4. PLOTTER HANDLING PROCEDURE

6-4-1. Connection and Preparation

(1) Connection

The digital plotters attachable to the TR9404 Analyzer include ADVANTEST's TR9834R/9831 and Hewlett Packard's HP-GL plotters. The plotters require GPIB interface of the TR13201 for the TR9834R or the TR13207 for the TR9831. As for the HP-GL plotters, use the one having the HP-IB interface capability. Connect the 24-pin GPIB connector on the rear of the TR9404 to the 24-pin GPIB connector on the rear of a plotter with the GPIB standard bus cable (to be purchased separately).
Use the ground line as thick as possible to enhance the reliability of operation and tie together the GND terminals of the TR9404 and a plotter.

NOTE

Before starting and turning power on, be sure to read the instruction manual of the plotter in use. Use a shielded GPIB cable to prevent improper operation of a plotter and introducing noise.

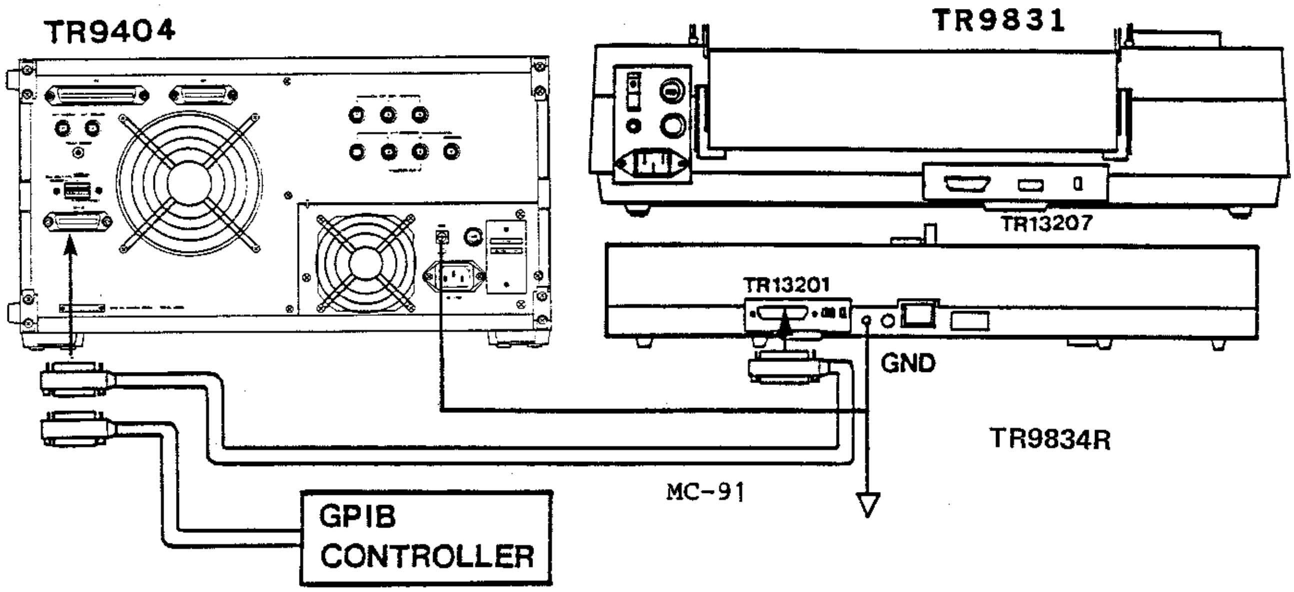


Fig. 6-6 Connecting the TR9834R or TR9831 to the TR9404

(2) TR9834R operation panel

The controls on the operation panel of the TR9834R Plotter are illustrated in Figure 6-7. The following paragraphs describe the control key operations on the TR9834R Plotter.

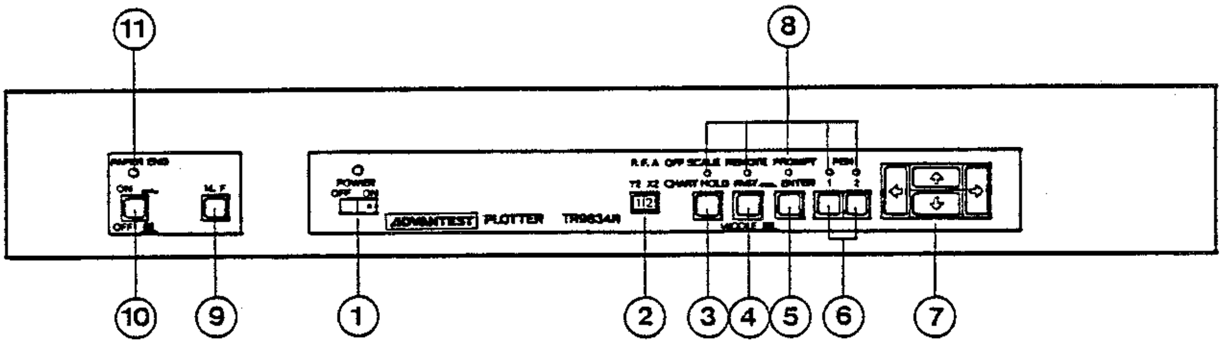


Fig. 6-7 Controls on the TR9834R operation panel

① POWER switch

Pressing the dotted (.) side of this switch turns on the power for the TR9834R; the POWER indicator lamp just above the switch will come on.

NOTE

The POWER switch of the TR9834R should be operated while the TR9404 analyzer mainframe is powered. If a GPIB controller is included in the system, the POWER switch on the TR9834R should be operated while both the TR9404 and the GPIB controller are powered.

② P.F.A. (Pen Fine Adjustment) thumbwheel switch

This thumbwheel switch is used for fine adjustment of the distance between the two pens. For more details see item (4) Pen position adjustment.

③ CHART HOLD key (lock-in type)

This key functions in different ways depending on whether roll type of paper or leaf type of paper is used on the TR9834R.

a) When leaf paper is used:

If the CHART HOLD key is pressed in (ON), the recording paper is electrostatically held on the writing panel. If the key is raised to the OFF position, the paper hold is released.

b) When roll paper is used:

If the CHART HOLD key is pressed in (ON), the automatic paper feed is disabled and the "Overwrite" mode is entered. In this case, the recording paper will not be held on the writing panel. If the key is raised to the OFF position, automatic paper feed is enabled, in which the recording paper is automatically fed for a new area when plotting in the old area is finished.

(4) FAST/MIDDLE key (lock-in type)

This key is used to select the maximum plotting speed: 25 cm/sec in the FAST position, and 12.5 cm/sec in the MIDDLE position. Normally, use of the FAST position is recommended.

(5) ENTER key (non-lock type)

This key is used to select between the REMOTE and LOCAL modes. When the plotter is initially powered on, the REMOTE mode is selected, and the LOCAL and REMOTE mode is alternately selected each time the ENTER key is pressed. Which mode is being currently selected can be checked with the REMOTE indicator lamp (8).

(6) PEN 1, 2 keys (non-lock type)

When the TR9834R is powered on, PEN 1 is normally selected. To select the other pen, first depress the ENTER key (5) to place the plotter in the LOCAL mode, then press the PEN 2 key. Next, press the ENTER key again to return the plotter into the REMOTE mode. The selected pen is indicated by the indicator lamp provided just above each key.

The PEN 1 and 2 keys are also used for pen up/down control when the plotter is in the LOCAL mode. If the PEN key already selected is pressed, the corresponding pen is lowered. If the same key is pressed again, the pen is raised. In other words, the pen for the selected key goes up and down each time the key is operated.

In the REMOTE mode in which the TR9834R is controlled by the TR9404, pen up/down is selected by the pen mode menu shown on the TR9404's display.

7. POSITION keys (non-lock type)

   These keys are used to control pen position in the LOCAL mode. Note that, however, the pen position set up with these keys will not give the coordinate origins for plotting. The origin is always located at the bottom left corner of the chart.

8. Status indicator lamps

9. M.F. (Manual Feed) key (non-lock type)

   This key is used for manual paper feed in the LOCAL mode. The paper is continuously fed while this key is depressed and held after the plotter is placed in the LOCAL mode by operating the ENTER Key.

10. PAPER END key (lock-in type)

    If this key is pressed in (ON) when roll paper is used on the plotter, the paper end detector is activated when the residual paper is about 1 meter in length and the PAPER END indicator lamp 11 comes on. When using roll paper, be sure to place this key in the ON (in) position.

    When leaf paper is used on the plotter, the paper end detector is always active. So the PAPER END key must be placed in the OFF (out) position.

11. PAPER END indicator lamp (red)

    This lamp comes on if the residual length of roll paper is approximately 1 meter when the PAPER END key 10 is placed in the ON position.

(3) Paper loading for the TR9834R

When the TR9834R plotter is attached to the TR9404 analyzer, the plotting area is limited to the size of an A4 sheet of paper.

a. When using roll paper:

   When using roll paper, refer to paragraph 3-6-2, Recording Paper Loading on TR9834R, in the instruction manual of the TR9834R. Paper feed automatically takes place over a feed span of 21 cm each, with a cut mark provided at the end of each plotting area as shown in Figure 6-9.

b. When using sheet paper:

The sheet paper loading method is shown in Figure 6-8. Set the sheet paper on the left half section of the writing panel. Press the CHART HOLD key on the operation panel into the ON (in) position to electrostatically hold the paper on the writing panel.

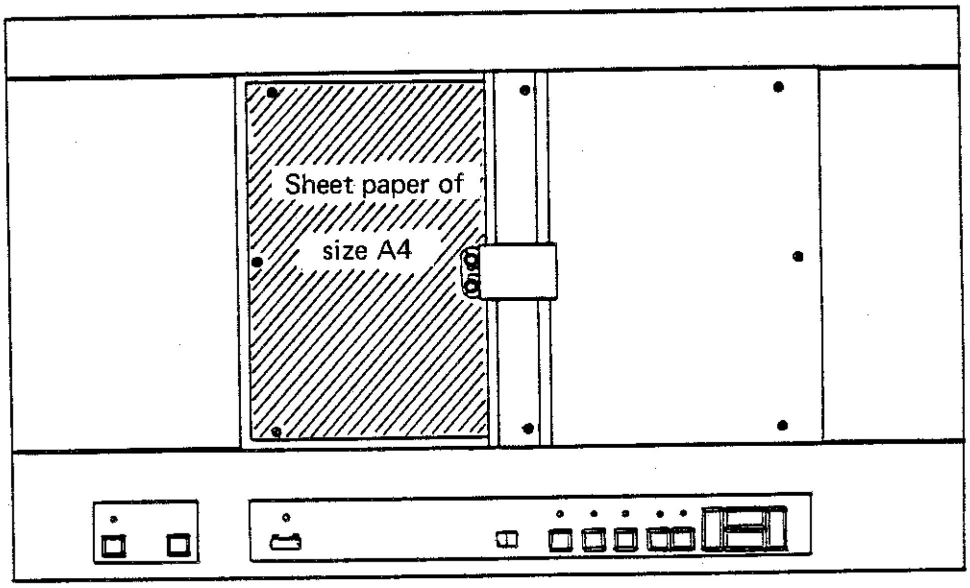


Fig. 6-8 Sheet paper loading method

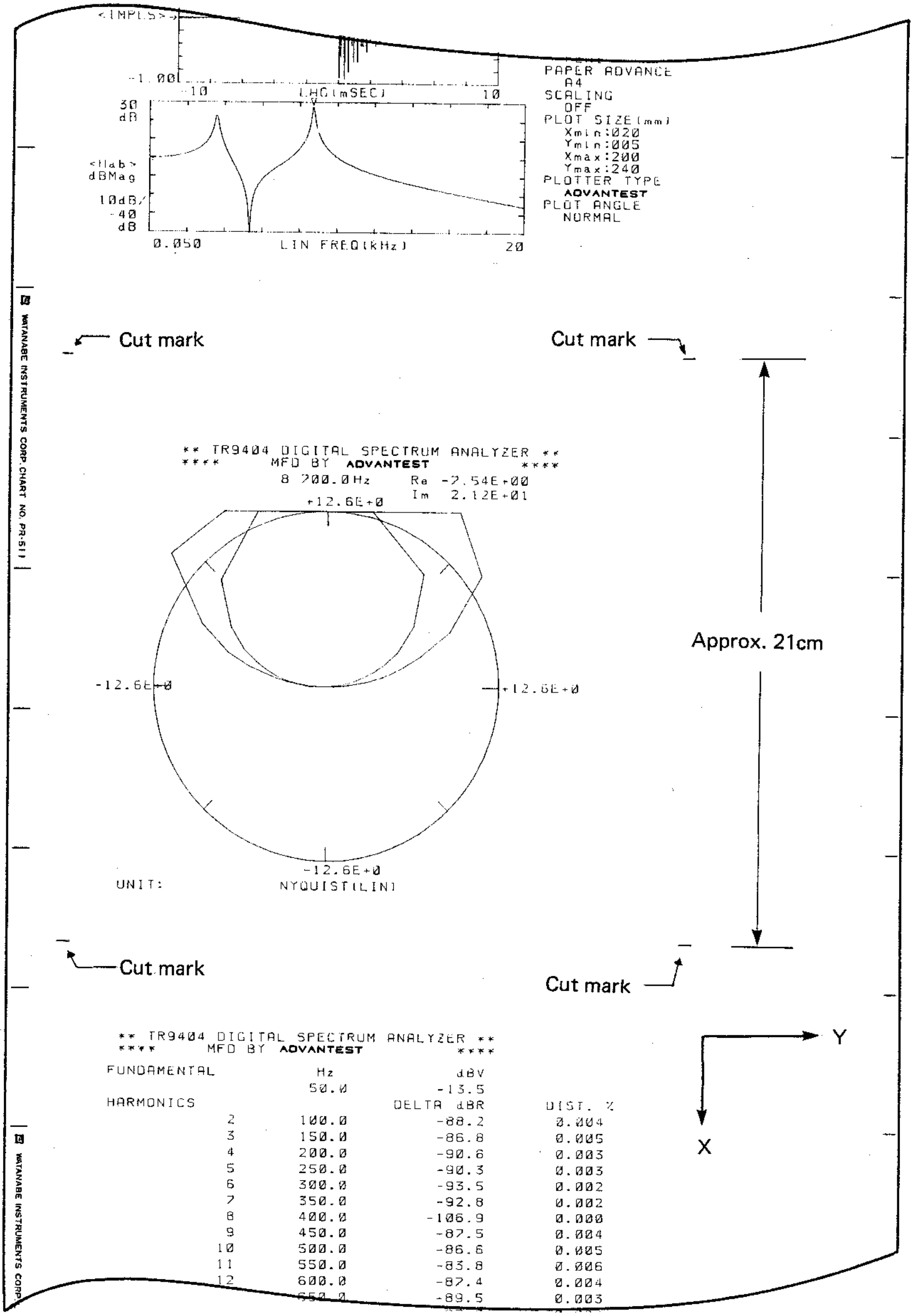


Fig. 6-9 Recording example on roll paper (reduced to 50%)

(4) Relative pen position adjustment

The TR9834R plotter requires relative pen position adjustment for its dual pen. The relative pen position is adjustable with the P.F.A. thumbwheel switch on the TR9834R's operation panel. The adjusting procedure follows:

1. Switch on the TR9834R plotter.
2. Press the ENTER key to place the plotter in the LOCAL mode.
3. Operate the POSITION keys to set the pens to any position.
4. Press the PEN 1 key to lower pen 1.
5. Press POSITION key [⇨] (X axis ⊕) to plot a line along the X axis (Figure 6-10 (a)).
6. Press the PEN 2 key twice to lower pen 2.
7. Press POSITION key [⇦] (X axis ⊖) to plot another line along the X axis. (Figure 6-10 (b)).
8. Press the PEN 1 key to select pen 1.
9. Operate the Y2 digit of the P.F.A. thumbwheel switch to adjust the relative position of pen 2. Each increment of the Y2 digit shifts pen 2 by 0.1 mm in the +Y direction. Each decrement of the Y2 digit of the switch shifts pen 2 by 0.1 mm in the -Y direction.
10. Repeat adjustment steps ③ through ⑨ until the two lines plotted by pens 1 and 2 completely coincide.
11. Operate the POSITION keys to position the pens in any position.
12. Press the PEN 1 key to lower pen 1.
13. Press POSITION key [⇧] (Y axis ⊕) to plot a line along the Y axis (Figure 6-10 (c)).
14. Press the PEN 2 key twice to lower pen 2.
15. Press POSITION key [⇩] (Y axis ⊖) to plot another line along the Y axis (Figure 6-10 (d)).
16. Press the PEN 1 key to select pen 1.
17. Use the X2 digit of the P.F.A. thumbwheel switch to adjust the relative position of pen 2. Each increment of the X2 digit shifts pen 2 by 0.1 mm in the +X direction.

Each decrement of the X2 digit shifts pen 2 by 0.1 mm in the -X direction.

(18) Repeat steps (11) through (17) until the lines plotted by the two pens completely overlap.

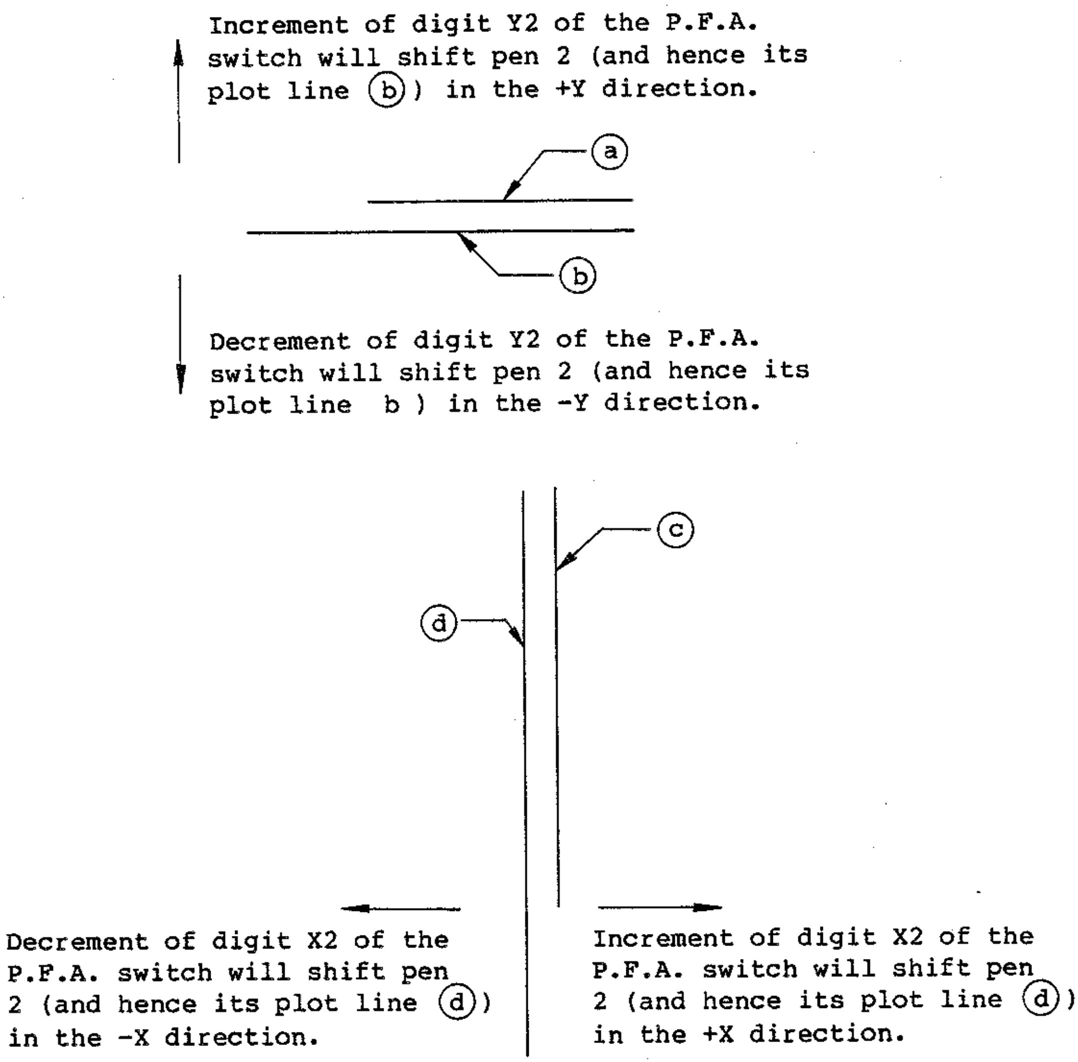
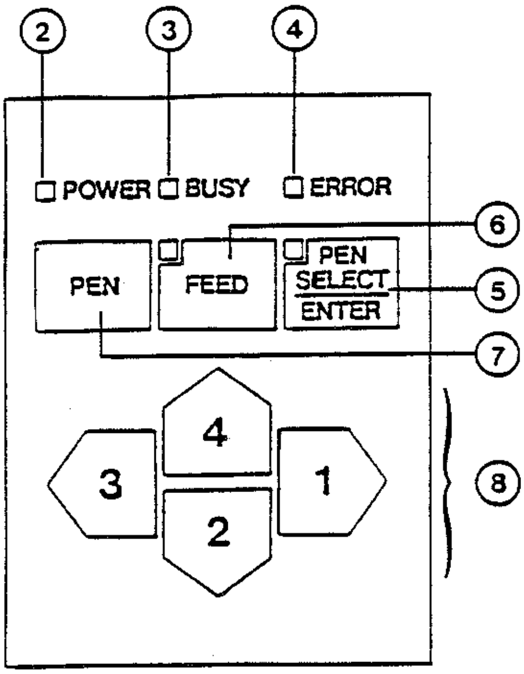
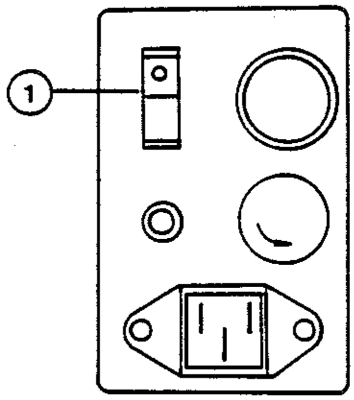


Fig. 6-10 Relative pen position adjustment on the TR9834R

(5) TR9831 operation panel



Operation panel



Power supply panel (rear panel)

Fig. 6-11 TR9831 operation panel

① POWER switch

When the TR9831 is connected to the TR9404, press this switch to the dotted (.) side while pressing the FEED switch ⑥ (the A3 size of paper can be used); power is supplied and the POWER lamp ② (green) is on.

NOTE

Before operating the TR9831 POWER switch, check that the TR9404 is powered. When the GPIB controller is connected, the POWER switch must be operated while both the TR9404 and controller are powered on.

② POWER lamp

This lamp illuminates in green when the POWER switch is set to the dotted side (.).

(3) BUSY lamp

This lamp illuminates in green when data is entered from outside. This lamp remains on until processing of the input data is completed. This lamp blinks when the ENTER switch (5) is pressed to set the LOCAL state.

(4) ERROR lamp

This lamp illuminates in red when a pen mounting error, paper end, or I/O error is detected.

(5) PEN SELECT/ENTER key

This key is used for selection between the REMOTE and LOCAL modes.
The BUSY lamp (3) blinks in the LOCAL mode. If both the PEN key and this key are pressed at once, the ENTER lamp is on and the PEN SELECT mode is selected. If one of 1, 2, 3, and 4 keys (8) is pressed, the corresponding pen is selected. Once pens are changed, the PEN SELECT mode is canceled and the ENTER lamp goes off.

(6) FEED key

If this key is pressed in the LOCAL mode, the FEED lamp turns on and the PRINT/FEED mode is set; the 2 and 4 keys are enabled. Paper can be fed to the direction of the pressed key. If the FEED key is pressed again, the PRINT/FEED mode is canceled and the FEED lamp turns off. If the POWER key is set to the dotted side (.) while pressing the FEED key, the A3 size (42x30cm) set mode is selected. If the TR9404 is connected for plotting, the A3 size set mode must be selected.

⑦ PEN key

If this key is pressed in the LOCAL mode, the pen in the up position goes down. If this key is pressed again, the pen goes up. If this key is pressed along with the ENTER key, the PEN SELECT mode is set and the ENTER lamp turns off.

⑧ POSITION key

This key is used for pen movement and paper feed in the LOCAL state.

(6) Loading the TR9831 with paper

When the TR9404 is connected to the TR9831, the plotting area is limited to the size of an A4 sheet (about 21x30cm). The paper for the TR9831 must be a specially prepared roll paper. Refer to Section 3-8 "Recording Paper Loading" in the TR9831 Plot Writer Instruction Manual for the roll paper loading.

As well as the TR9834R, plotting is performed by feeding paper 21 cm for one screen, with a cut mark provided at the end of each plotting area.

(7) HP-GL plotter

Refer to Instruction Manuals of respective plotters.

(8) Interface setup

- Connection between the TR9404 and the plotter alone

  Set the TALK ONLY/ADDRESSABLE bit of the ADDRESS switch on the rear of the TR9404 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 TR9404 and the REMOTE and PEN 1 lamps on the operation panel of the TR9834R or POWER lamp on the TR9831 will come on.

NOTE

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.

o Setup including a GPIB controller

Set the TALK ONLY/ADDRESSABLE bit of the ADDRESS switch on the TR9404 to ADDRESSABLE. Then set the LISTEN ONLY/ADDRESSABLE switch on the plotter to ADDRESSABLE. After completion of these setup, switch on the controller, TR9404, and plotter.

NOTE

The power to the plotter should be turned on or off while the TR9404 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 TR9404 and GPIB controller are powered. To turn on the TR9831, press the POWER switch while pressing the FEED switch (Paper size A3 [approx. 42x30 cm] mode is thus achieved).

5-4-2. Plotting

(1) Menu selection and plotting operation

Press the I/O key in the SETUP section on the TR9404 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 6-12.

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.

```
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
```

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).

SCALING:
- OFF: Plotting is made in A4 size.
- ON: Plotting is made in the size specified by PLOT SIZE.

PLOT SIZE: Set four points to define the plotting area as desired.

PLOT ANGLE:
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 TAKEDA.

Fig. 6-12 "PLOTTER" 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 TR9404 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 TR9404 are now enabled and the next plotting data transfer becomes ready.

If the lamp within the TR9404 EXECUTE key goes off, the TR9834R/9831 plotter will continue plotting so far as plotting data still remains in its buffer memory. When plotting is completed, the plotter 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 TR9834R/9831 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 TR9404 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 TR9404 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 TR9404'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 TR9834R.

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 (TR9834R) 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 (see Figure 6-17). In the latter mode, the plotter plots only the signal traces (see Figure 6-18). 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 (TR9834R) 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. Figure 6-19 shows an example plotted in this mode. 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 (TR9834R) 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.

(4) "PAPER ADVANCE" setup

This menu is effective for the TR9834R/9831 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 TR9834R/9831, press the ENTER key on the plotter operation panel to set the LOCAL mode. When paper is fed with the TR9834R, press the M.F. (Manual Feed) key. For the TR9831, press FEED and then press the 4 or 2 key. 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 (TR9834R) is set to OFF, the paper is automatically fed "Xmax" (mm) to the left.

"SCALE" : Cut mark is automatically plotted upon completion of plotting at a place of "Xmax." If the CHART HOLD switch (TR9834R) is OFF, this mode allows automatic paper feed "Xmax" (mm) to the left.

If the CHART HOLD switch is not set to OFF for the HP-GL plotter, plus signs (+) are plotted at corners (four corners of square enclosed by Xmin, Ymin, Xmax, and Ymax), then plotting is completed.

(5) "SCALING" setup

"OFF" : Plotting is performed for A4 size. A4 size is equivalent to the "PLOT SIZE" as follows:

a. TR9834R/9831 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: 190 (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 ⇦ or ⇨ 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 TR9834R/9831. When the lower left and upper right corners are set, the plotting area is set as shown in Figure 6-13.

Where, ΔX = Xmax - Xmin (mm)

ΔY = Ymax - Ymin (mm)

Scaling is performed within the range enclosed by four points (Xmin, Ymin), (Xmin, Ymax), (Xmax, Ymax), and (Xmax, Ymin) as shown in Figure 6-13. (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.

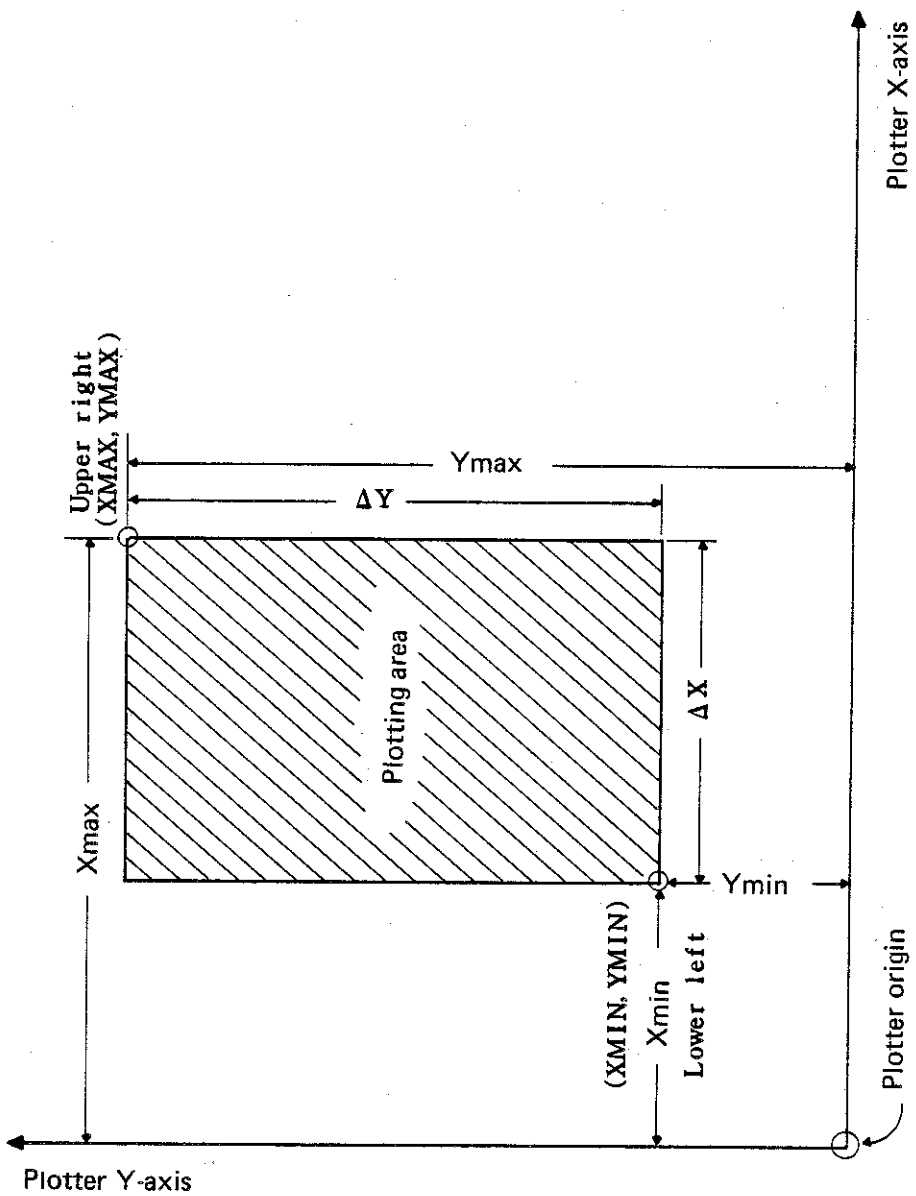


Fig. 6-13 Plotting area set by "PLOT SIZE" setup

Values of ΔX and ΔY which gives a graticule frame whose one side length is 10 cm are as follows:

			TR9834R/9831		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

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

"TAKEDA" : This is set when the TR9834R/9831 is used.

"HP-GL" : This is set when the HP-GL plotter (Hewlett Packard) is used.

(8) "PLOT ANGLE" setup

"NORMAL : a. TR9834R/9831 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. TR9834R/9831 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.

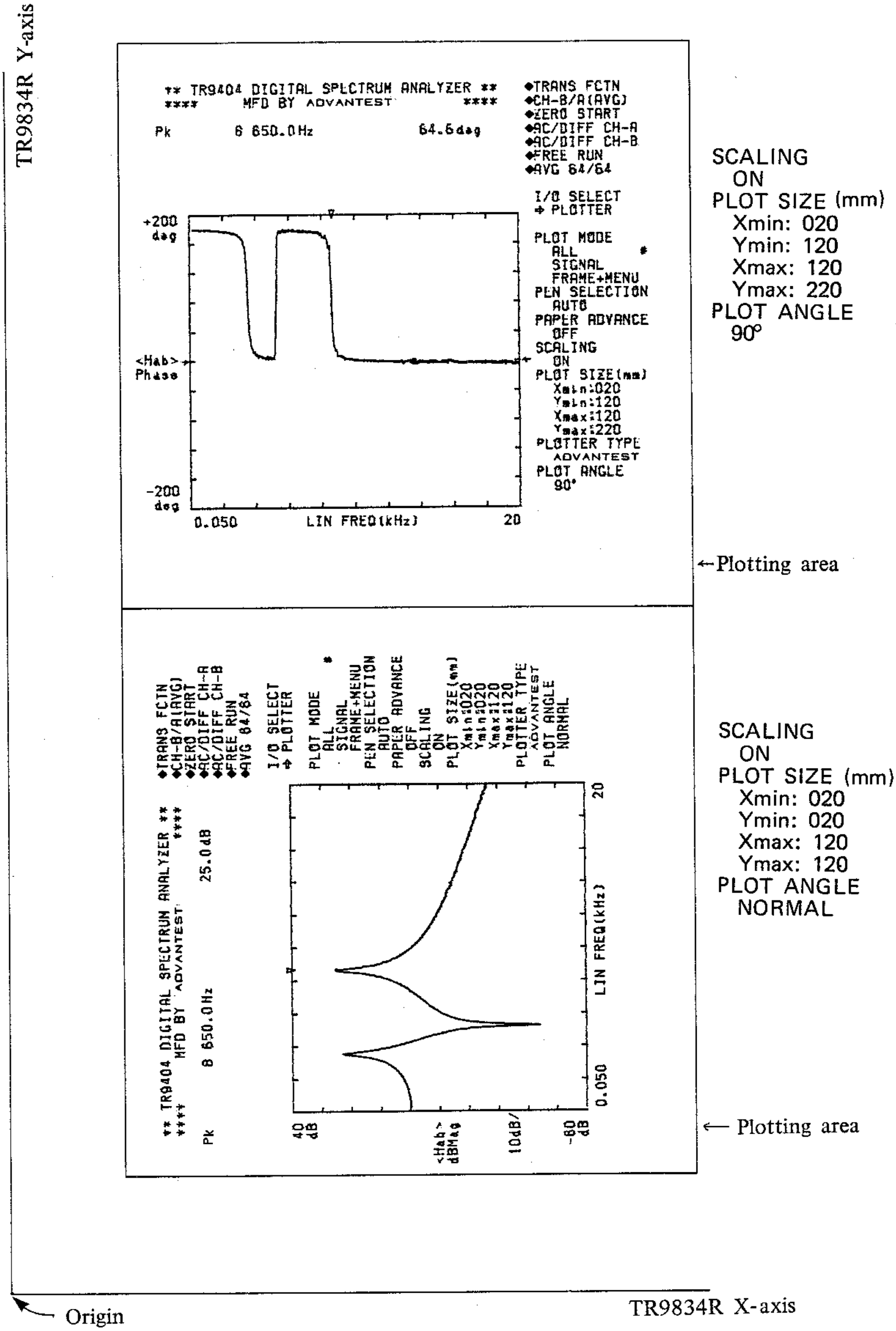


Fig. 6-14 Example of plotting by TR9834R

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 6-4-2.

(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 Y/ X is equivalen to the ratio of A4 size, that is,

$\Delta Y/\Delta X = 235/180 \quad 1.3$ (for TR9834R/9831)

$\Delta Y/\Delta X = 180/260 \quad 0.69$ (for HP-GL plotter),

a circle is displayed in the ORBIT or NYQUIST mode.

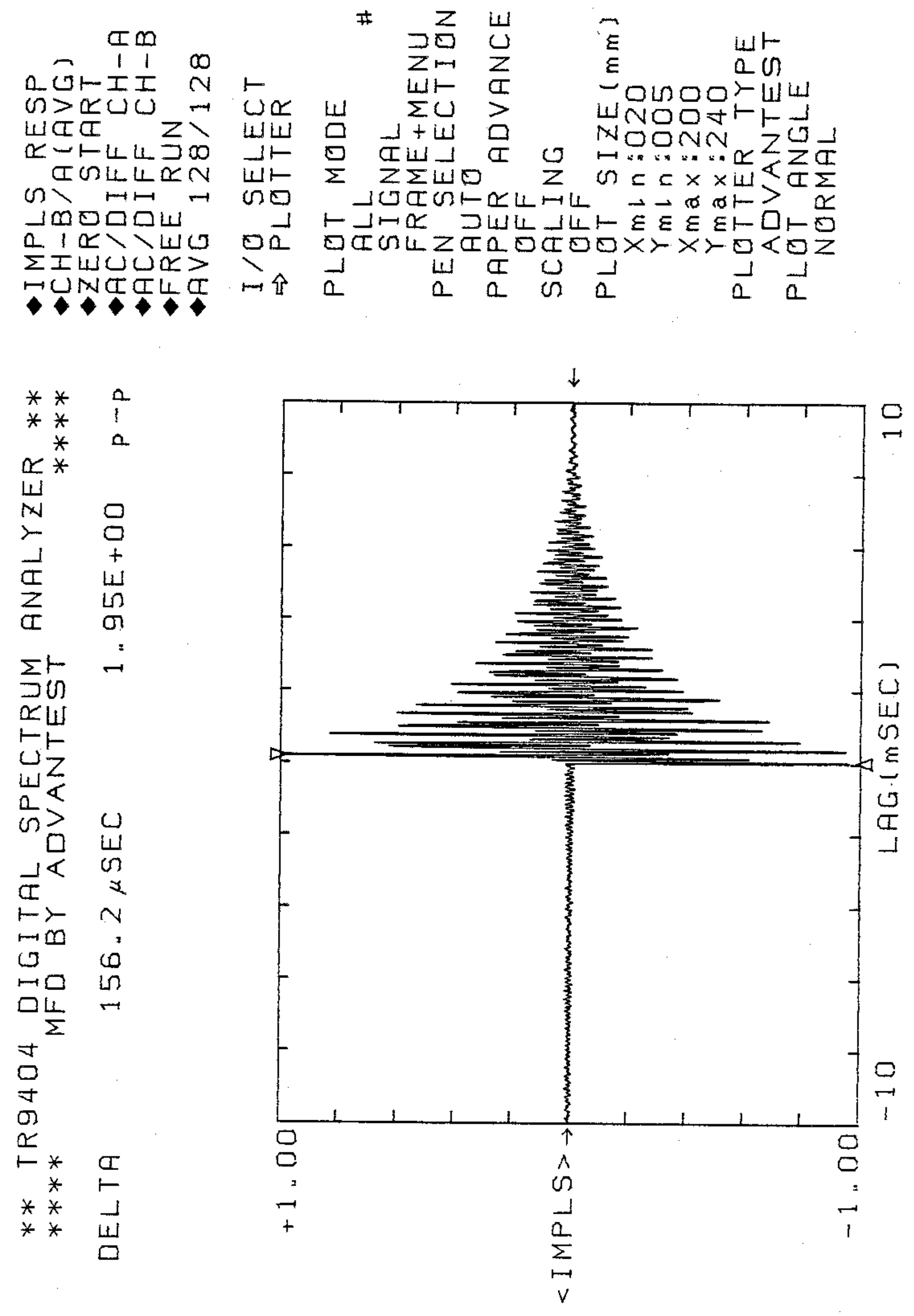


Fig. 6-15 Plot example by TR9834R

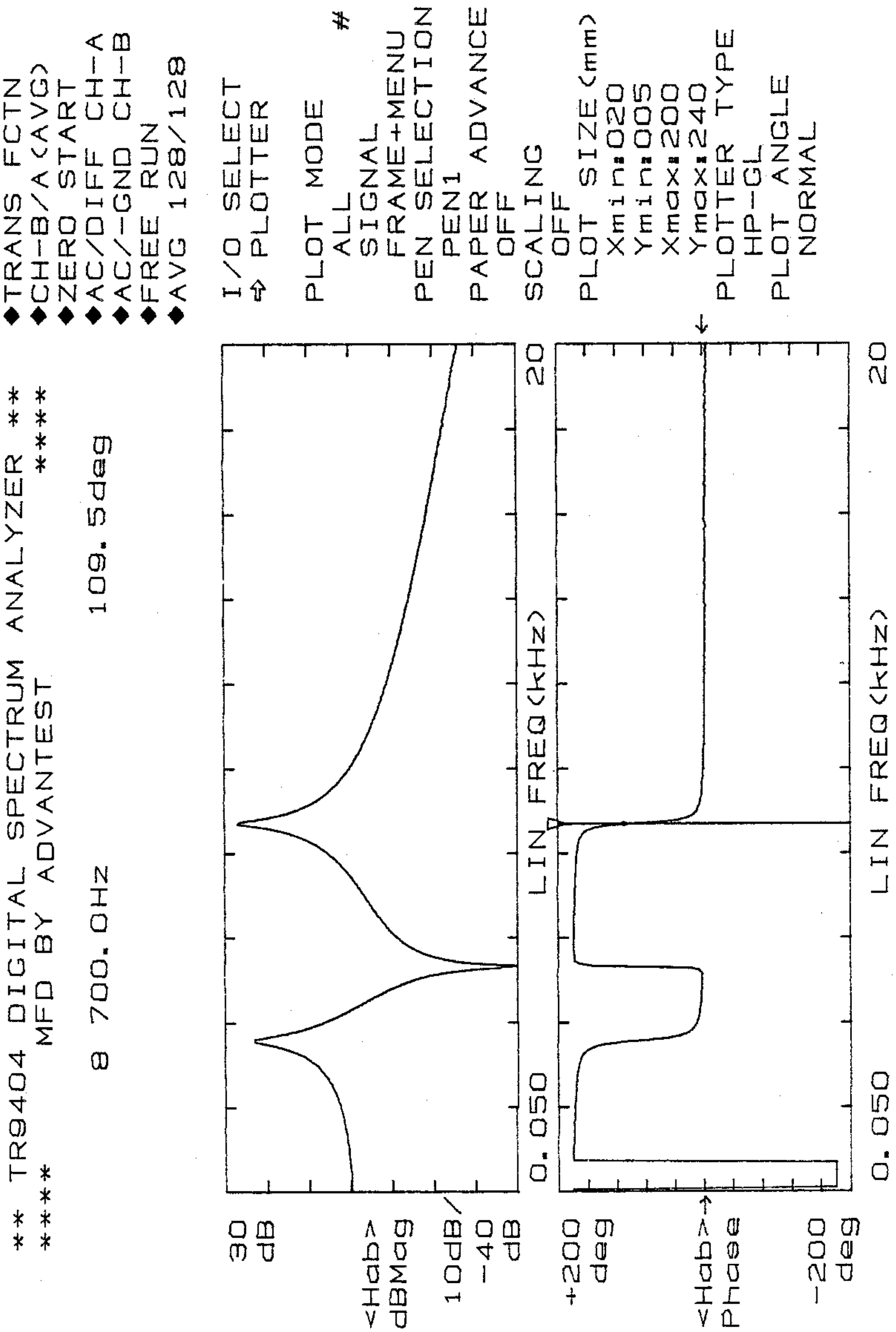


Fig. 6-16 Plot example by HP-GL plotter (HP7470A)

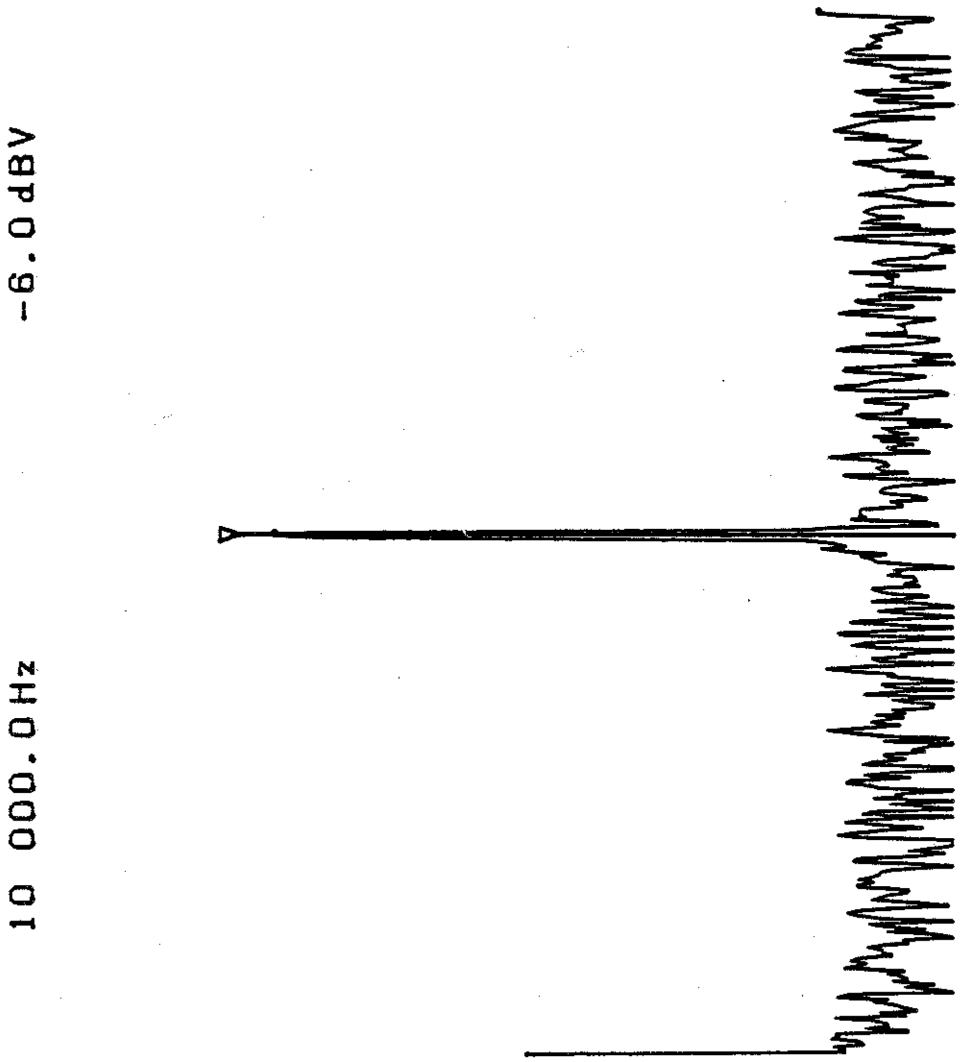


Fig. 6-17 Plot example

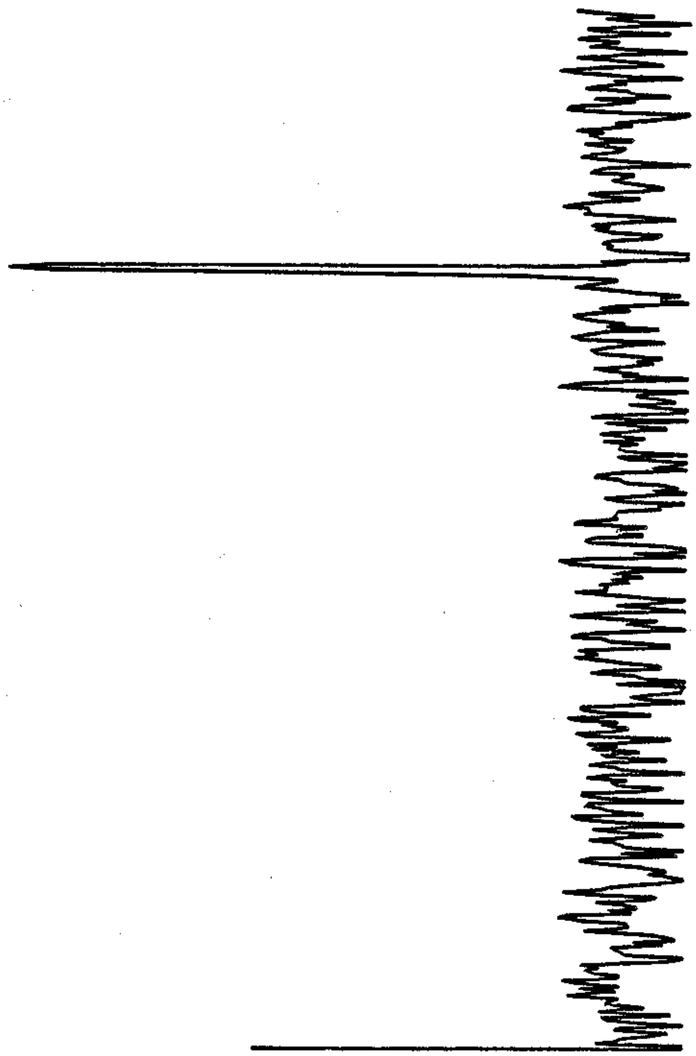


Fig. 6-18 Plot example

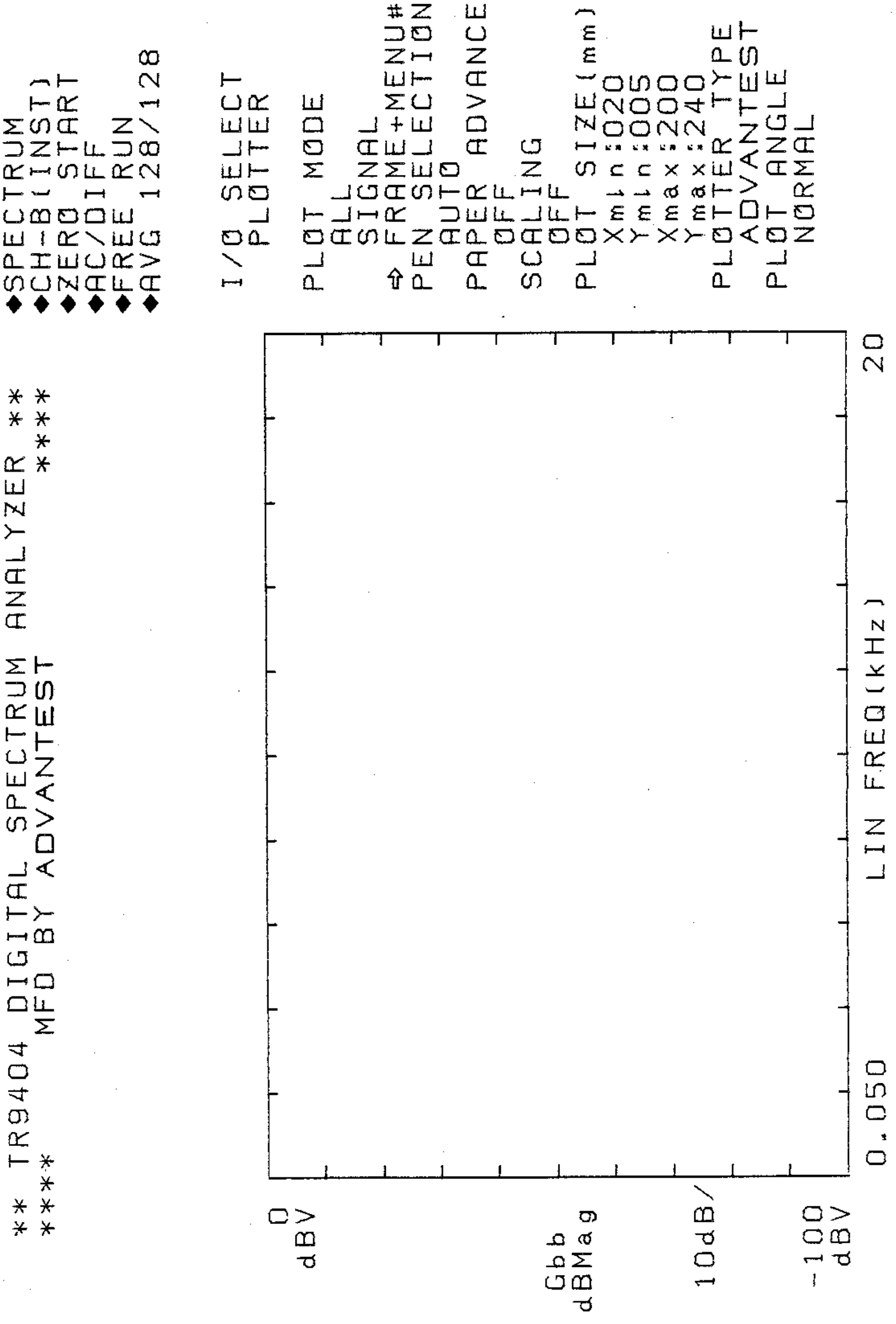


Fig. 6-19 Plot example

6-4-3. 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 TR9404 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 TR9404 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 TR9404'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 TR9404. 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 (TR9834R/9831 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.

Figures 6-20 and 6-21 show plotting examples obtained through the above plotting procedure.

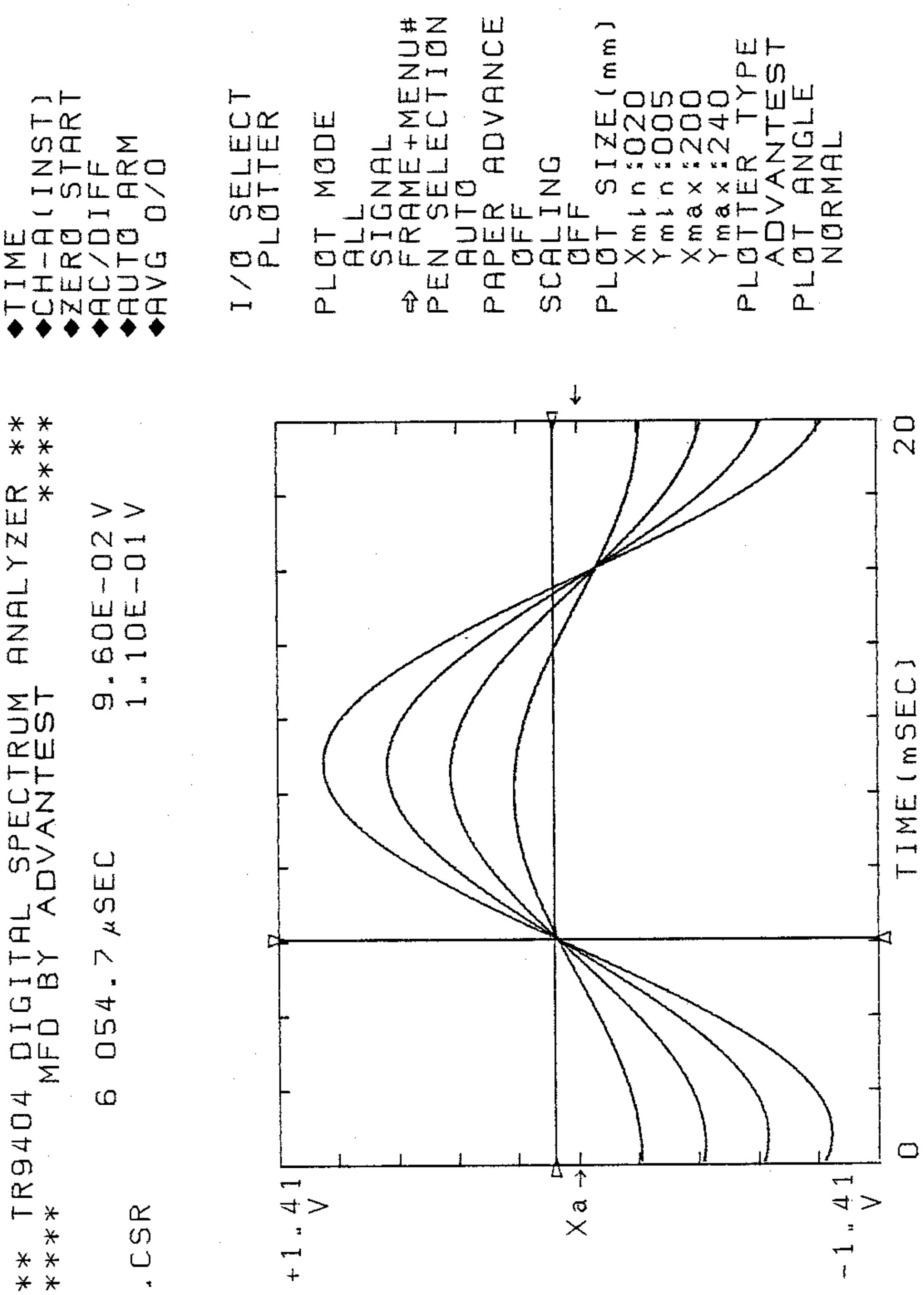


Fig. 6-20 Plotting example (superimposed plotting)

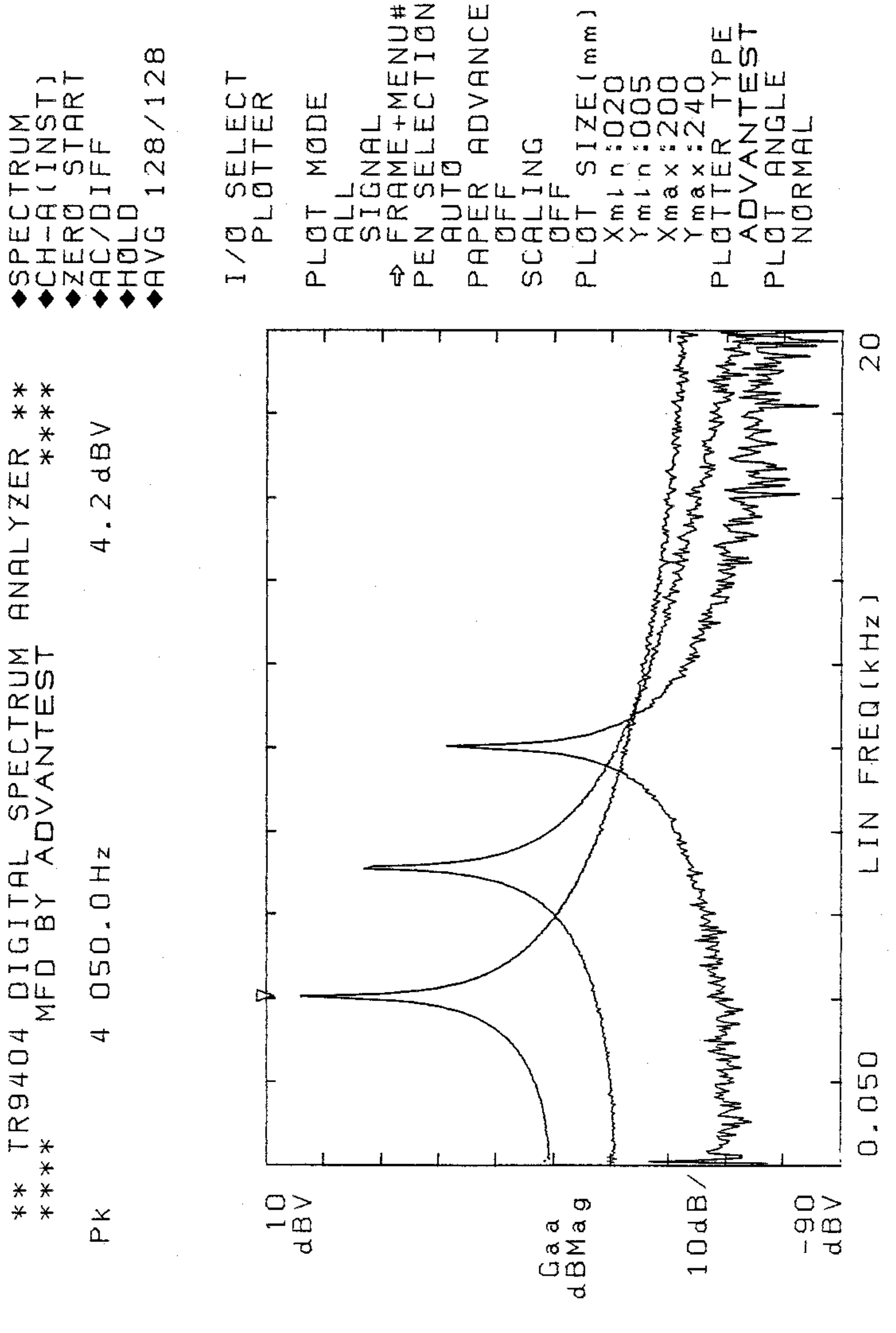


Fig. 6-21 Plotting example (superimposed plotting)

o Explanation of scaling plot examples

(1) Figure 6-22: Example of plotting by TR9834R

PLOT ANGLE 90°

Lower	Upper
Xmin: 020	Xmin: 020
Ymin: 005	Ymin: 120
Xmax: 200	Xmax: 200
Ymax: 130	Ymax: 240

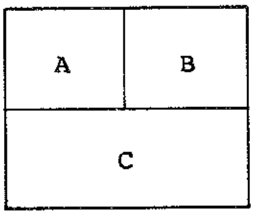
(2) Figure 6-23: Example of plotting by HP-7470A

PLOT ANGLE 90°

Lower	Upper
Xmin: 135	Xmin: 000
Ymin: 000	Ymin: 000
Xmax: 270	Xmax: 135
Ymax: 190	Ymax: 190

Since "PAPER ADVANCE" is set to other than OFF, plus signs are plotted at four corners.

(3) Figure 6-24: Example of plotting by HP-GL plotter



A:	Xmin : 000		B:	Xmin : 000
	Ymin : 000			Ymin : 100
	Xmax : 100			Xmax : 100
	Ymax : 100			Ymax : 200

C: Xmin : 100

Ymin : 000

Xmax : 260

Ymax : 200

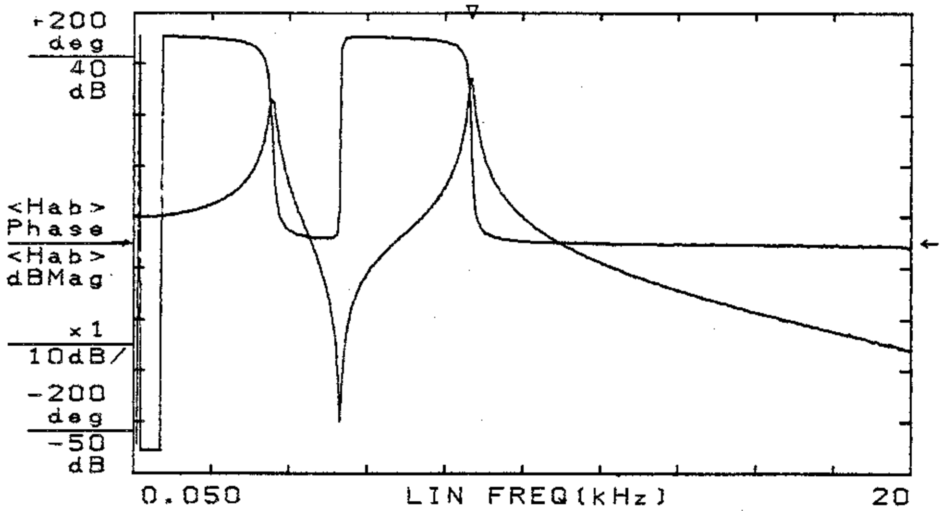
** TR9404 DIGITAL SPECTRUM ANALYZER **
**** MFD BY ADVANTEST ****

Pk 8 700.0Hz 27.1dB

◆TRANS FCTN
◆CH-B/A(AVG)
◆ZERO START
◆AC/DIFF CH-A
◆AC/-GND CH-B
◆FREE RUN
◆AVG 128/128

I/O SELECT
PLOTTER

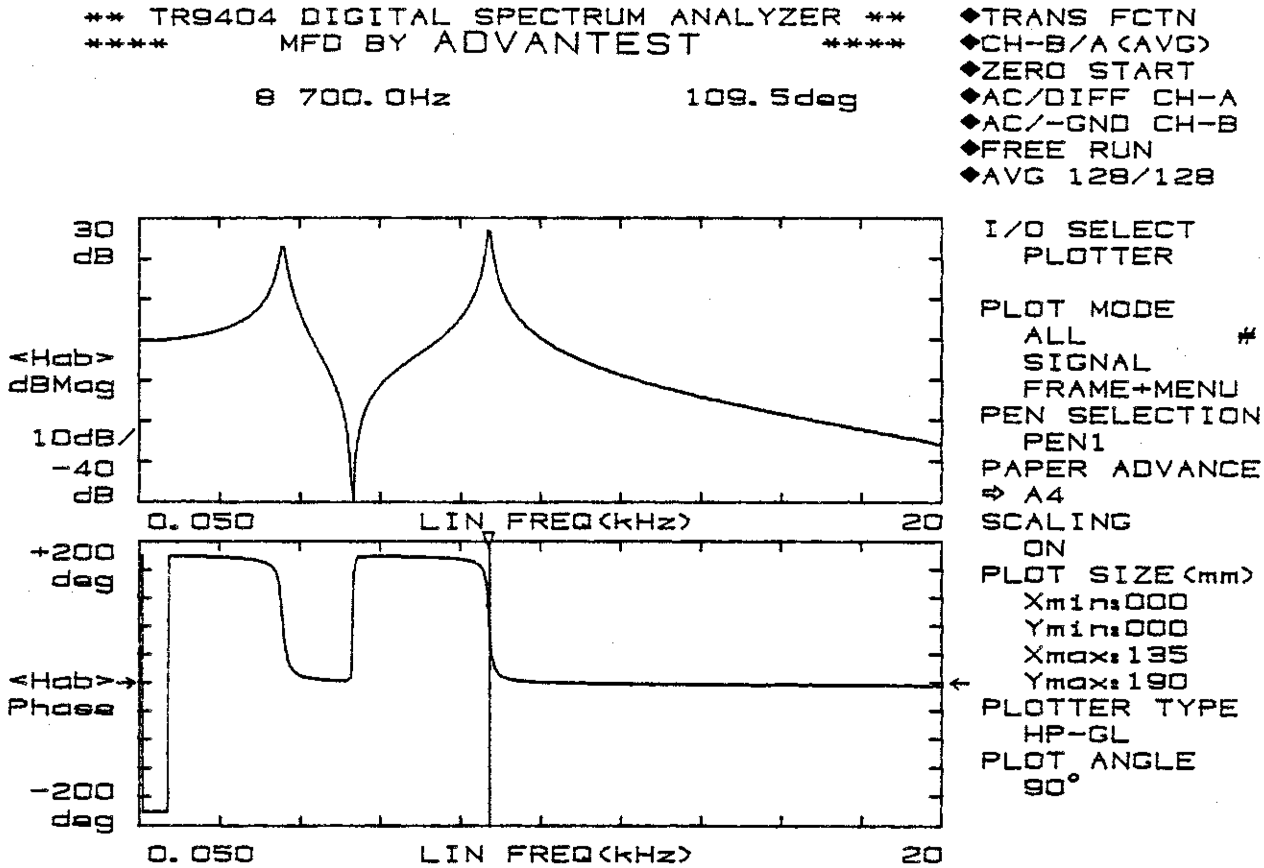
PLOT MODE
⇒ ALL #
SIGNAL
FRAME+MENU
PEN SELECTION
AUTO
PAPER ADVANCE
OFF
SCALING
ON
PLOT SIZE(mm)
Xmin:020
Ymin:120
Xmax:200
Ymax:240
PLOTTER TYPE
ADVANTEST
PLOT ANGLE
90°



** TR9404 DIGITAL SPECTRUM ANALYZER **
**** MFD BY ADVANTEST ****

		FREQUENCY Hz	TRANS FCTN Phase deg	TRANS FCTN dBMag dB
SET NO.	1	500.0	0.1	0.1
	2	850.0	-0.0	0.4
	3	900.0	-0.1	0.4
	4	1 250.0	-0.5	0.9
	5	1 600.0	-1.0	1.5
	6	1 950.0	-1.7	2.4
	7	2 600.0	-4.1	5.1
	8	3 250.0	-13.9	12.4
	9	3 900.0	-166.2	9.2
	10	4 550.0	-175.4	-4.7
	11	5 200.0	-173.9	-25.2
	12	5 850.0	-0.8	-12.9
	13	6 500.0	-1.3	-6.5
	14	7 150.0	-2.0	-1.9
	15	7 800.0	-4.1	3.5
	16	8 450.0	-15.2	15.2
	17	9 100.0	-172.5	10.1
	18	9 750.0	-177.6	2.0
	19	10 400.0	-179.1	-2.4
	20	11 050.0	-179.8	-5.4

Fig. 6-22 Example of scaling plot with the TR9834R



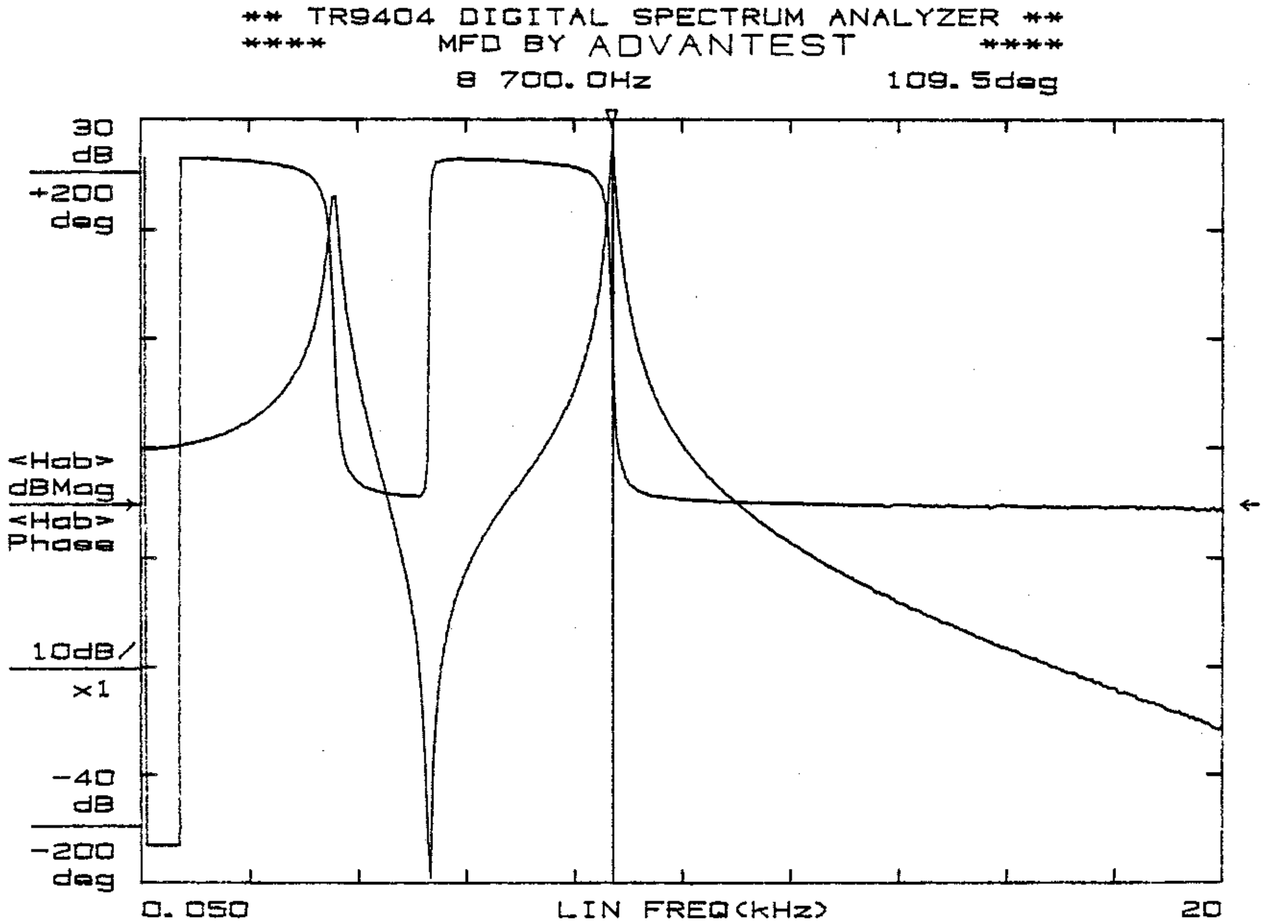


Fig. 6-23 Example of scaling plot with the HP-GL plotter (1)

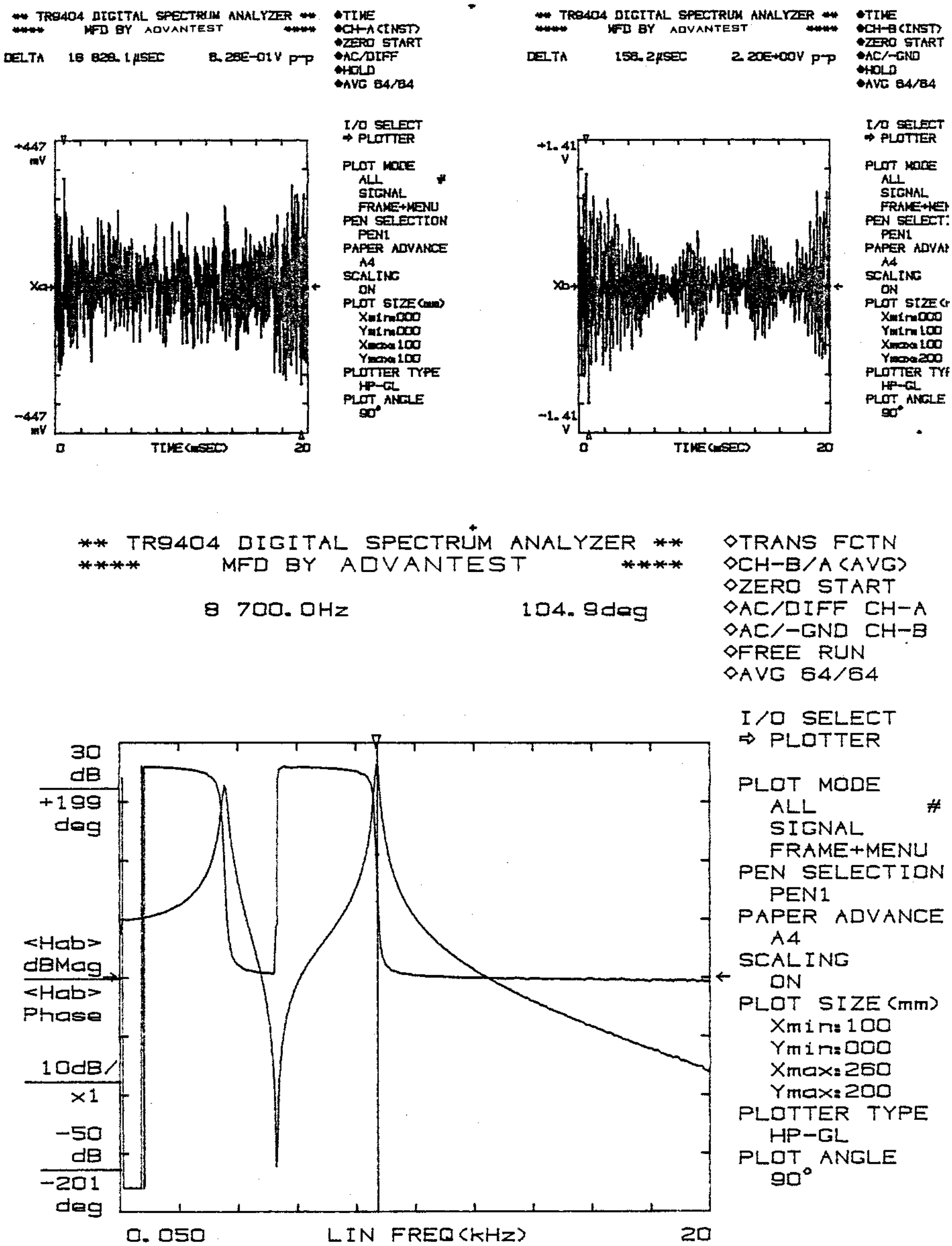


Fig. 6-24 Example of scaling plot with the HP-GL plotter (2)

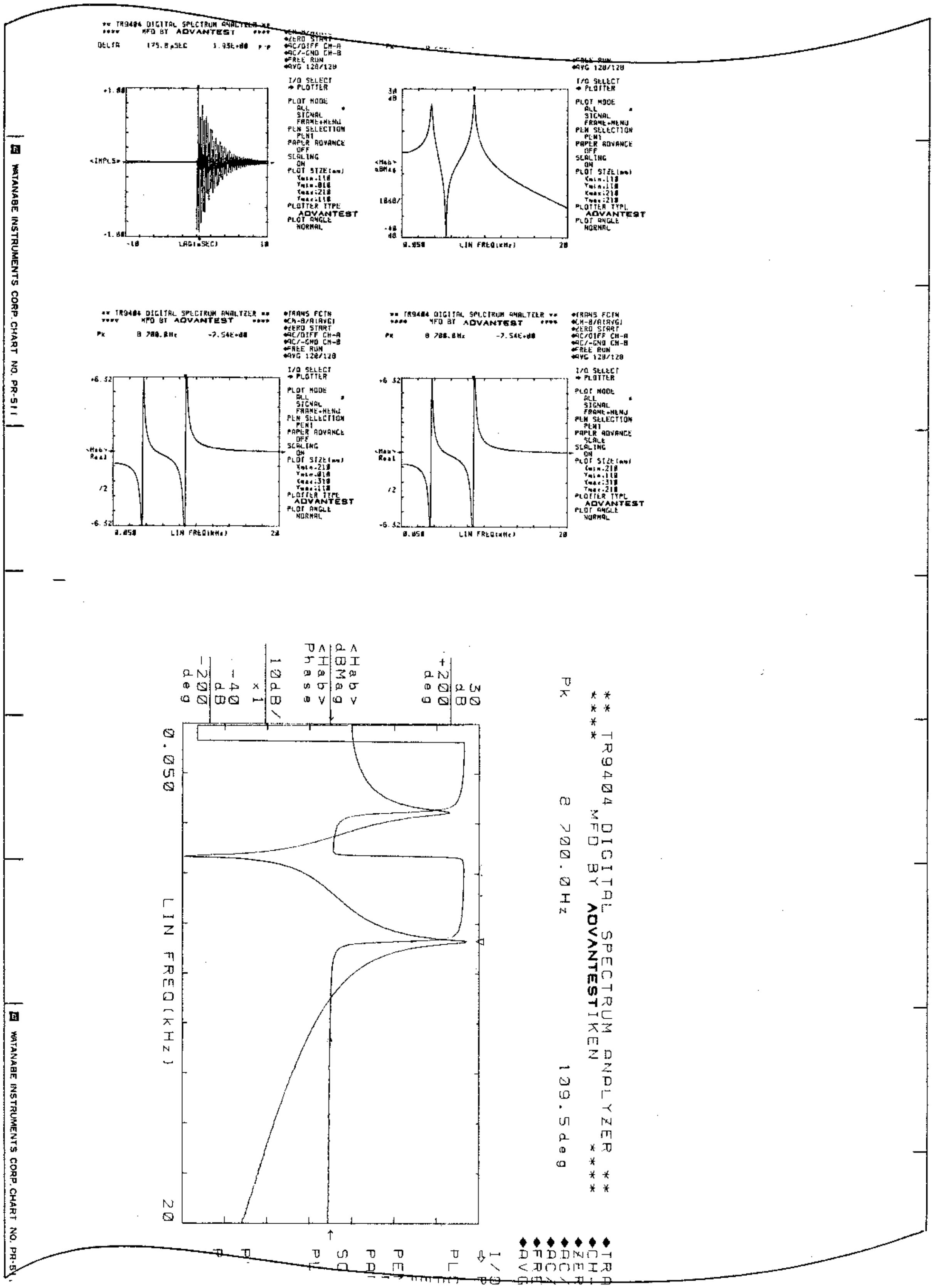
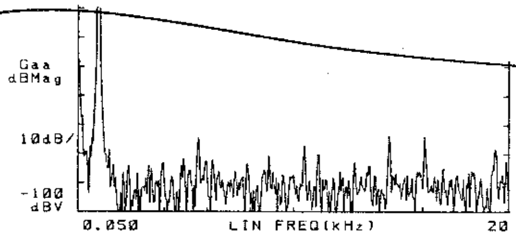


Fig. 6-25 Example of scaling plot on roll paper

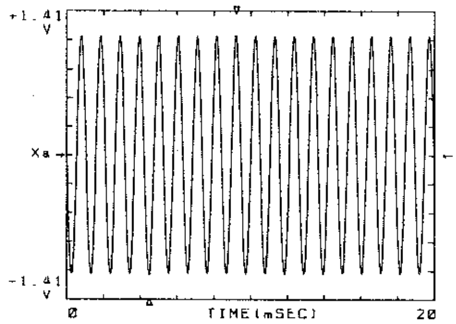


ON
PLOT SIZE(mm)
Xmin:010
Ymin:010
Xmax:160
Ymax:210
PLOTTER TYPE
ADVANTEST
PLOT ANGLE
NORMAL

** TR9404 DIGITAL SPECTRUM ANALYZER **
**** MFD BY **ADVANTEST** ****

DELTA 4 726.6 μSEC 2.34E+00V p-p

◆TIME
◆CH-A(INST)
◆ZERO START
◆AC/DIFF
◆FREE RUN
◆AVG 128/128

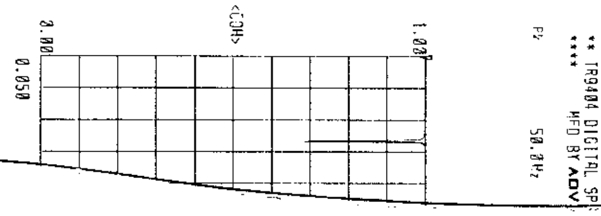


I/O SELECT
⇨ PLOTTER
PLOT MODE
ALL
SIGNAL
FRAME+MENU
PEN SELECTION
PEN1
PAPER ADVANCE
SCALE
SCALING
ON
PLOT SIZE(mm)
Xmin:010
Ymin:010
Xmax:160
Ymax:210
PLOTTER TYPE
ADVANTEST
PLOT ANGLE
NORMAL

** TR9404 DIGITAL SPECTRUM ANALYZER **
**** MFD BY **ADVANTEST** ****

		Hz	dBV	
FUNDAMENTAL		950.0	-1.7	
HARMONICS			DELTA dBR	DIST. %
	2	1 900.0	-81.5	0.008
	3	2 850.0	-83.6	0.007
	4	3 750.0	-88.0	0.004
	5	4 900.0	-80.8	0.009
	6	5 600.0	-71.0	0.028
	7	6 500.0	-84.3	0.006
	8	7 650.0	-87.5	0.004
	9	8 700.0	-90.1	0.003
	10	9 350.0	-82.9	0.007
	11	10 500.0	-76.1	0.016
	12	11 200.0	-75.1	0.018
	13	12 200.0	-87.2	0.004
	14	13 500.0	-85.0	0.006
	15	14 450.0	-75.0	0.018
	16	14 900.0	-81.9	0.008
	17	16 100.0	-74.4	0.019
	18	17 350.0	-82.5	0.007
	19	18 450.0	-81.1	0.009
	20	18 700.0	-84.7	0.006

TOTAL HARMONIC RMS : HANNING -67.5 dBV
TOTAL HARMONIC DISTORTION 0.051 %



WATANABE INSTRUMENTS CORP. CHART NO. PR-511

Fig. 6-25 (Continued)

6-4-4. Plotter Control over the GPIB

If a GPIB controller and a plotter are attached to the GPIB connector on the TR9404 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 TR9404, 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, TR9404, and plotter. Power supply to the TR9831 should be accompanied with the pressing of FEED switch.

(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:

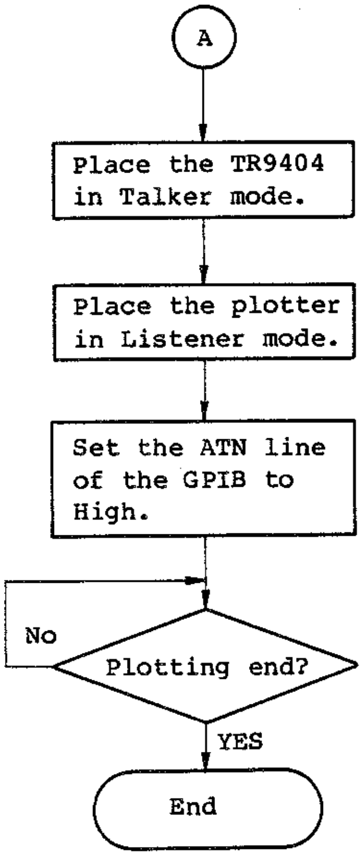
Table 6-1 GPIB command list for plotter control

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 (option)	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

Table 6-1 GPIB command list (Continued)

Command		Description	Setup
Function	Setup		read
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) (Demarcated with " ," in the above order)	o
PY	0, 1	PLOT ANGLE 0 ADVANTEST 1 HP-GL (7470A,7225A HP-GL plotter)	o
PG	0, 1	PLOT ANGLE 0 NORMAL 1 90°	o

START	
Measurement	Set up TR9404'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)
Set up plotting start for the TR9404	Set up the TR9404 for I/O EXECUTE "IE1".
A	



When the ATN line is changed from Low (command mode) to High (data mode), plotting data is transferred from the TR9404 to the plotter.

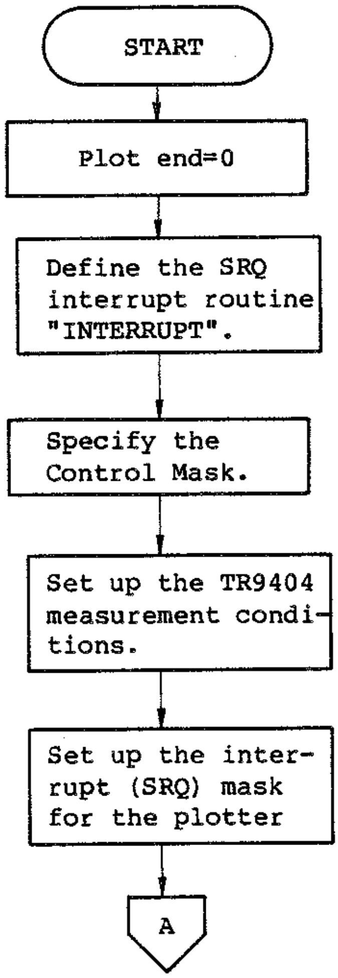
Upon the end of plotting, the XY-REC/PLT END bit of the status byte is set in the TR9404. If the TR9404 is set up for the "SQ0" mode, it issues a service request (SQR) to the controller.

CAUTION

During plotting, do not deliver any command other than the I/O Execute Stop command "IEO" 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

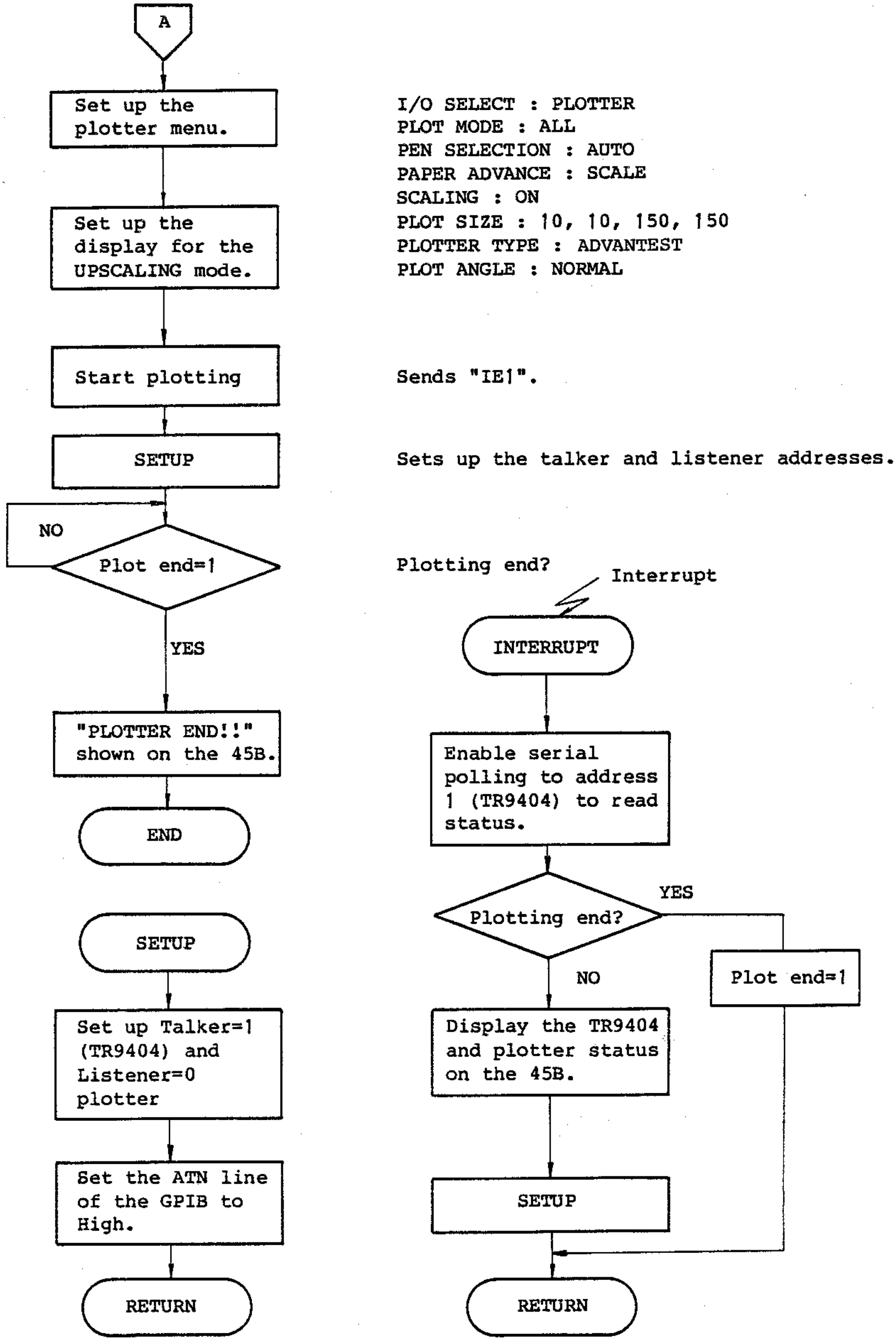
The following programming example is obtained on the Hewlett Packard desk-top computer Model 45B:



Resets the plotting end flag.

Sets up the System 45B.

The display shows 50 kHz, +10 dBV range, and SPECTRUM.


A
Set up the plotter menu.
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
Set up the display for the UPSCALING mode.
Start plotting
Sends "IE1".
SETUP
Sets up the talker and listener addresses.
NO
Plot end=1
Plotting end?
YES
"PLOTTER END!!" shown on the 45B.
END
Interrupt
INTERRUPT
Enable serial polling to address 1 (TR9404) to read status.
Plotting end?
YES
NO
Plot end=1
Display the TR9404 and plotter status on the 45B.
SETUP
RETURN
SETUP
Set up Talker=1 (TR9404) and Listener=0 plotter
Set the ATN line of the GPIB to High.
RETURN

```
10   !
20   ! ***********************************************
30   ! *                                             *
40   ! *   TR9404/6 Plotting Program With GP-IB Control   *
50   ! *   MT File Name: "PLOTEX"                    *
60   ! *                                             *
70   ! *   GP-IB ADDRESS--- TR9404/6=1,TR9834R/31=0  *
80   ! *                                             *
90   ! ***********************************************
100  !
110 Start:    REMOTE 7
120           Plotend=0                  ! Clear Flag
130           ON INT #7 GOSUB Interupt
140           CONTROL MASK 7;128
150           OUTPUT 701;"FR1VW1AS2"     ! 100KHz,VIEW=SPECTRUM,A-CH SENSE +10dBV
160           WAIT 1000
170           OUTPUT 701;"MK189"         ! Set MASK to TR9404/6
180           OUTPUT 701;"SQ0DL1"        ! Enable SRQ, Delimiter Code=<LF>
190           OUTPUT 701;"IO1"           ! I/O Selection is "PLOTTER"
200           OUTPUT 701;"PM0"           ! Plotting  Mode is "ALL"
210           OUTPUT 701;"PP0"           ! Pen Mode is "AUTO"
220           OUTPUT 701;"PA2"           ! Paper Advance is "SCALE"
230           OUTPUT 701;"PL1"           ! Scaling "ON"
240           OUTPUT 701;"PZ010,010,150,150" ! Plot Size (10,10,150,150) mm
250           OUTPUT 701;"PY0"           ! Plotter type is TR9834R/TR9831
260           OUTPUT 701;"PG0"           ! Plot Angle is "NORMAL"
270           OUTPUT 701;"IE1"           ! I/O EXECUTE (Start Plotting)
280           GOSUB Setup                ! Set TALKER(TR9404/6)&LISTENER(TR9834R/31)
290 Wait:     IF Plotend=1 THEN GOTO Dispend     !Plotting END ?
300           DISP "  PLOTTER IS PLOTTING  //  "
310           GOTO Wait                          !No. Wait
320  !
330 Dispend: DISP "PLOTTER END !!"               !Yes
340           STOP
350  !
360  !
370  ! *********************************
380  ! * TALKER,LISTENER SETUP ROUTINE *
390  ! *********************************
400 Setup:    CONFIGURE 7 TALK = 1 LISTEN = 0  ! Set Listener & Talker
410           STATUS 7;A,B,C                   ! Set ATN to HIGH (DATA MODE)
420           CARD ENABLE 7                    ! Interrupt Enable
430           RETURN
440  !
450  ! *********************************
460  ! * INTERRUPT SERVICE ROUTINE     *
470  ! *********************************
480 Interupt:STATUS 701;S                      ! Serial Pole
490           S1=BINAND(S,66)
500           IF S1=66 THEN GOTO Int1          ! PLOTTER END ?
510           DISP "9404 INTERRUPT=";S
520           STATUS 700;S
530           PRINT "9834R/31 STATUS=";S
540           GOSUB Setup
550           GOTO Int2
560 Int1:     Plotend=1
570           CARD ENABLE 7
580 Int2:     RETURN
590           END
```

Fig. 6-26 Programming example for plotter control over the GPIB

6-5. OPERATING INSTRUCTIONS OF X-Y RECORDER

6-5-1. 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

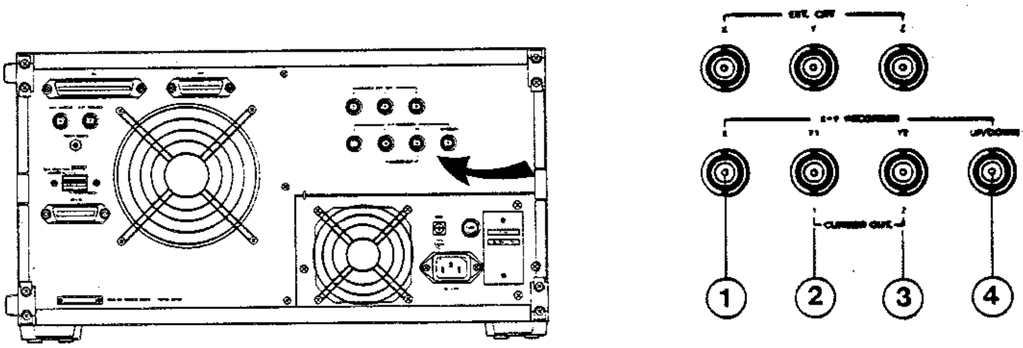


Fig. 6-27 X-Y recorder outputs

The outputs for the X-Y recorder and CURSOR OUT mode are provided at the the BNC connectors on the TR9404 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 } : Y axis output for the X-Y recorder or the output of
(3) Y2 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.

6-5-2. 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 SETUP or DISP. 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
```

CALIBRATION: For calibration of the output amplitude scale. Select either 0-0 or FS-FS (full scale) using the SETUP switch.

RECORD MODE:

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.

PEN MODE: Select TWO for the dual display mode.

PLOT SPEED: Select the desired plotting speed; there is a tradeoff between speed and accuracy.

Fig. 6-28 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 TR9404 analyzer.

  The output amplitude can be calibrated by selecting the "0-0" and "FS-FS" items from the CALIBRATION menu.

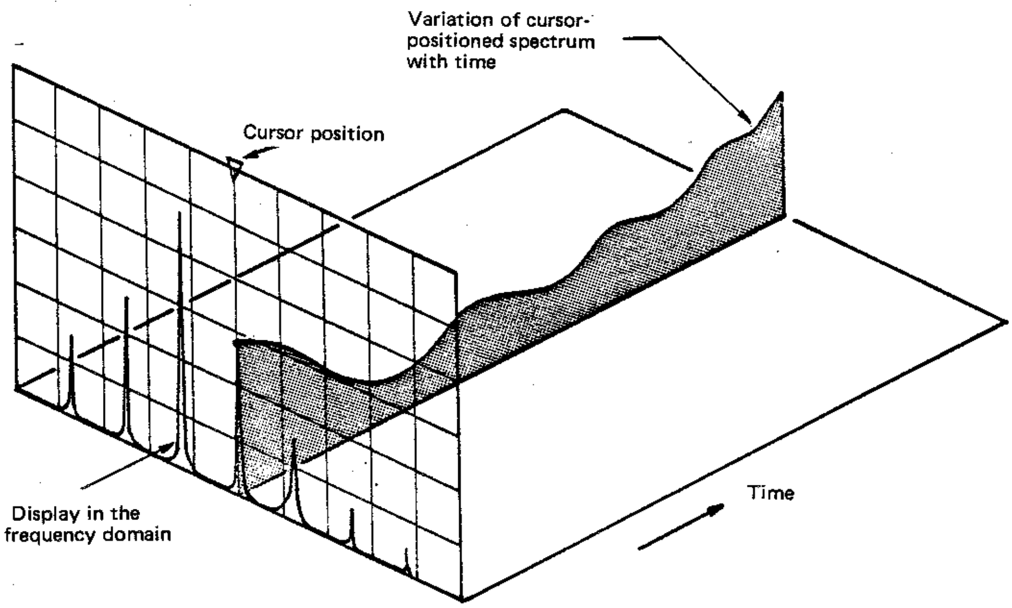


Fig. 6-29 Spectrum variation with time observed in the CURSOR OUT mode

- 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 6-30 and 6-31 show plotting examples in this mode.
- SIGNAL : In this mode the X-Y recorder plots only the signal trace displayed on the CRT. Figure 6-32 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 6-33 shows a plotting example obtained in this mode.

Figures 6-30 through 6-33 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. An example of superimposed plotting is shown in Figure 6-34.

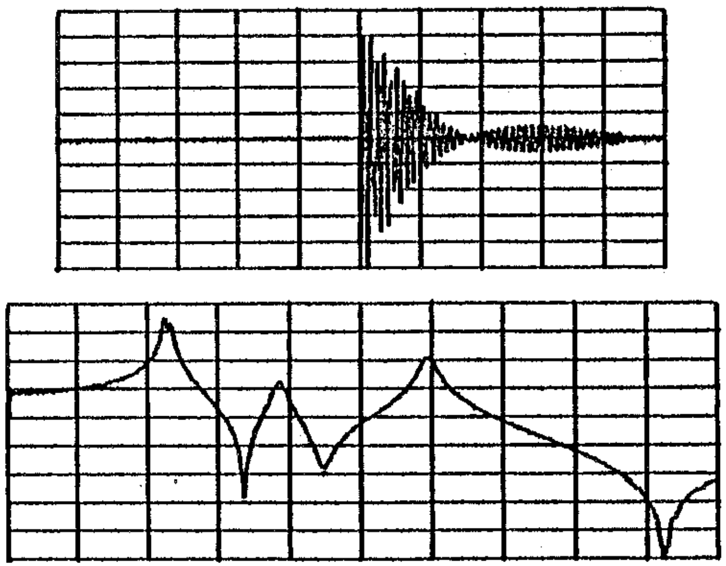


Fig. 6-30 Plotting example in the ALL mode

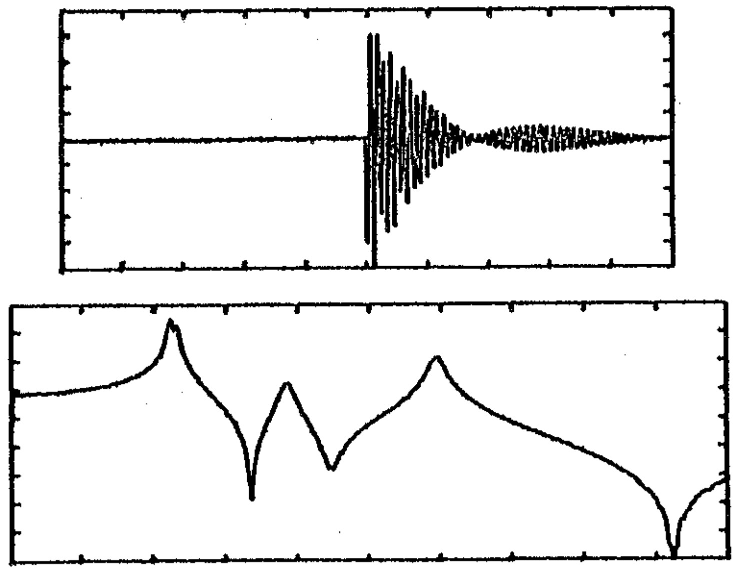


Fig.6-31 Plotting example in the ALL mode

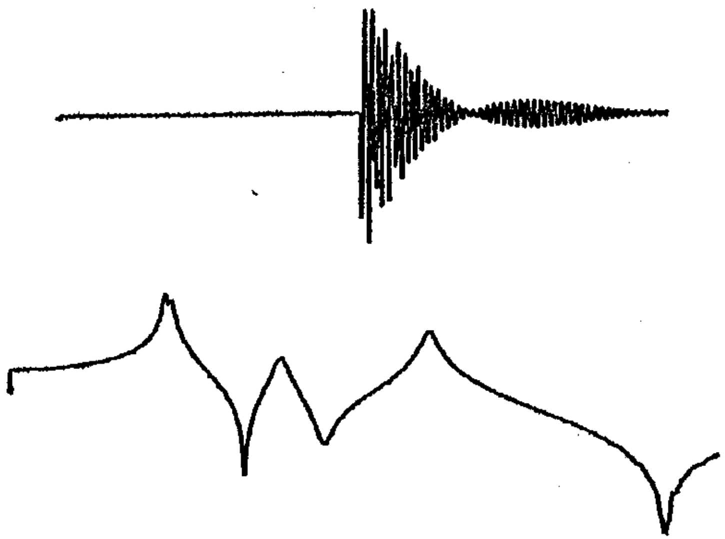


Fig. 6-32 Plotting example in the SIGNAL mode

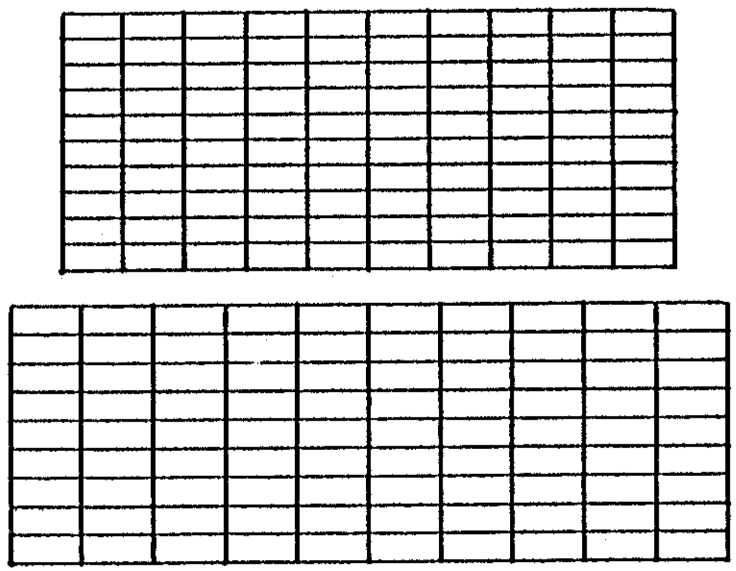


Fig. 6-33 Plotting example in the FRAME mode

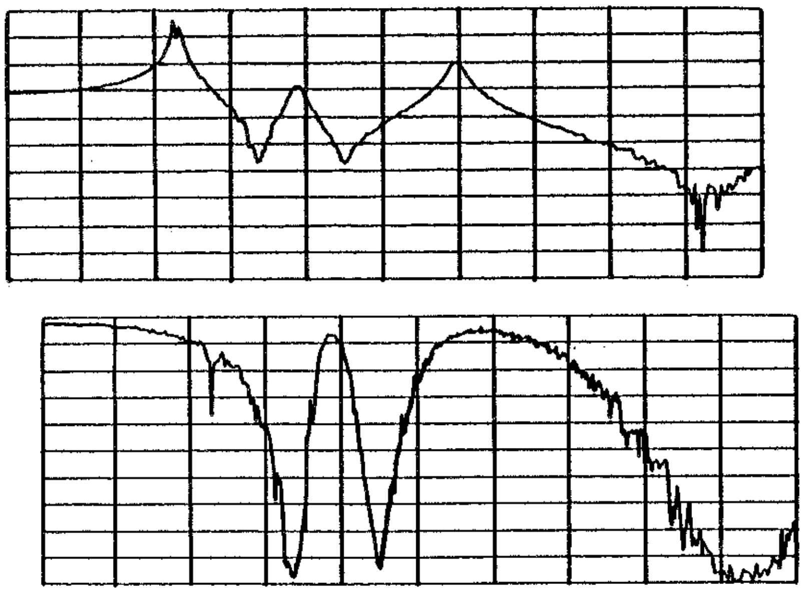


Fig. 6-34 Concurrent plotting example in the ALL mode

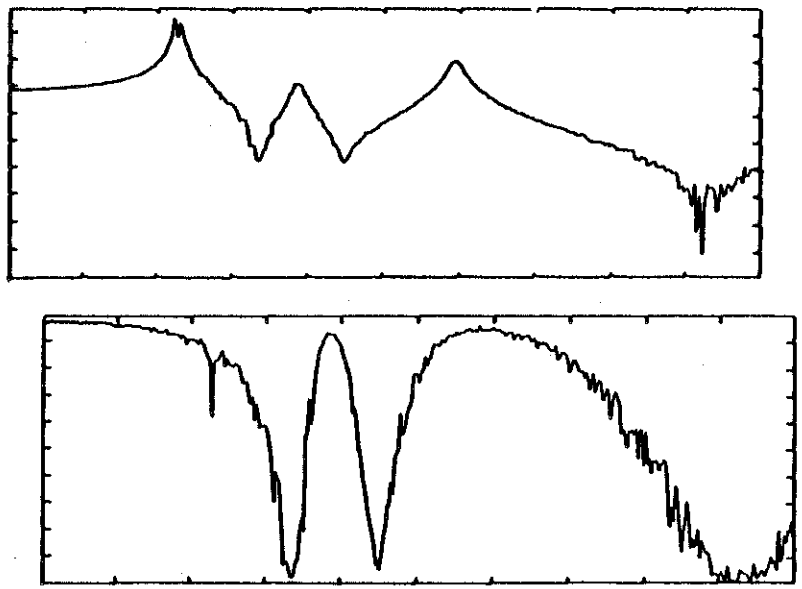


Fig. 6-35 Concurrent plotting example in the ALL mode

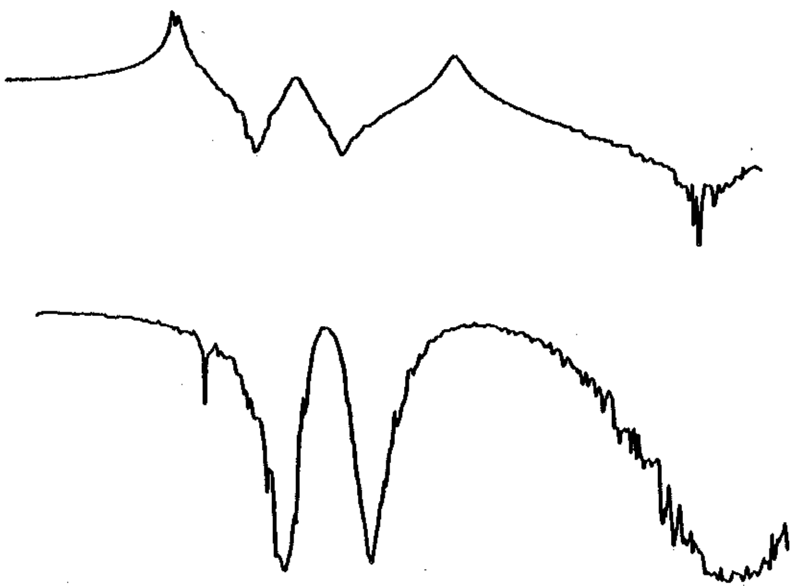


Fig. 6-36 Concurrent plotting example in the SIGNAL mode

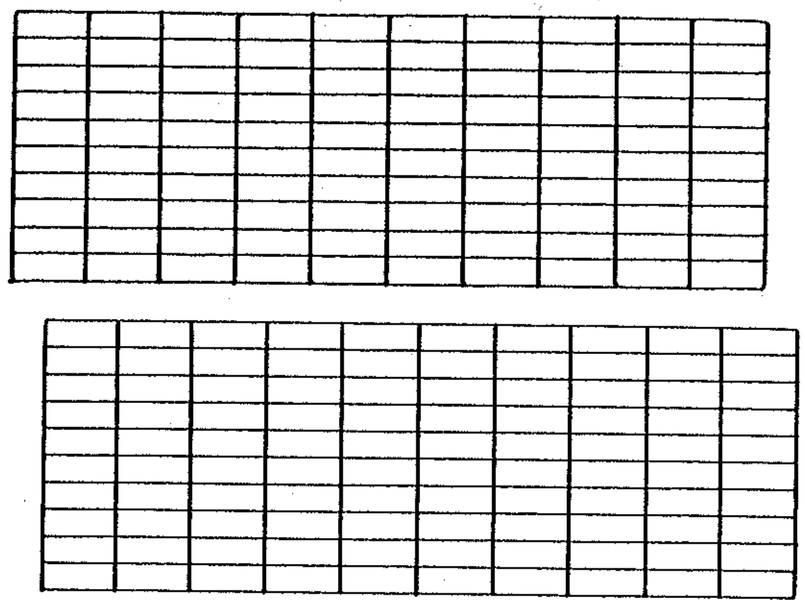


Fig. 6-37 Concurrent plotting example in the FRAME mode

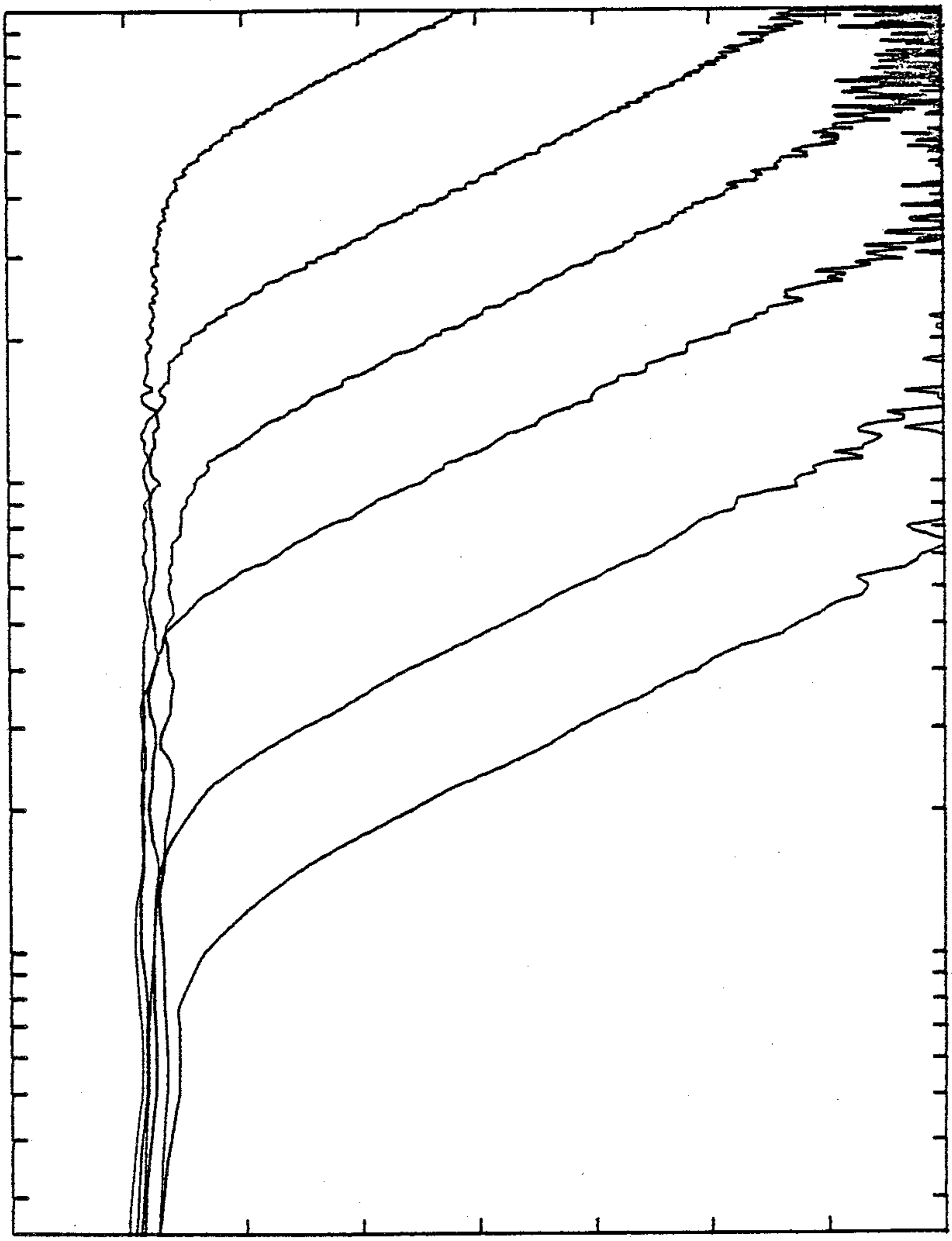


Fig. 6-38 Example of superimposed plotting

(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 TR9404.
- "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 cailbration 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.
Figures 6-39 and 6-4- show plotting examples obtained in the TWO-pen mode.

(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 6-41 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".

Figure 6-42 shows another plotting example using the same X-Y recorder, with the plotting speed setting at 2 and the record mode setting in ALL. At this plotting speed, the recorder completely follows up both scale and signal trace.

Figure 6-43 shows plotting for the same signal trace with the plotting speed set at "4". In this example, the recorder cannot follow the plotting for scale information. 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 6-2 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. Table 6-3 is an actual time taken in PEN MODE set to TWO. Actually, the plotting speed may depend greatly on the complexity of the signal response trace to be plotted.

Table 6-2 Required plotting time (PEN MODE: "ONE")

Unit: minutes (') seconds (")

PLOT SPEED	Fig. 6-42	Fig. 6-30	Fig. 6-31	Fig. 6-32
SLOW	5'05"	12'00"	9'55"	7'55"
2	3'25"	9'15"	7'55"	6'15"
3	2'36"	7'20"	6'25"	4'55"
4	1'53"	5'35"	4'50"	3'40"
5	1'20"	4'00"	3'30"	2'30"
FAST	0'50"	2'35"	2'00"	1'16"

Table 6-3 Required plotting time (PEN MODE: "TWO")

PLOT SPEED	Fig. 6-34	Fig. 6-35	Fig. 6-36
SLOW	4'55"	3'42"	2'37"
2	3'30"	2'47"	1'55"
3	2'45"	2'13"	1'30"
4	2'05"	1'42"	1'05"
5	1'35"	1'15"	0'45"
FAST	1'05"	0'50"	0'24"

(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 TR9404 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.

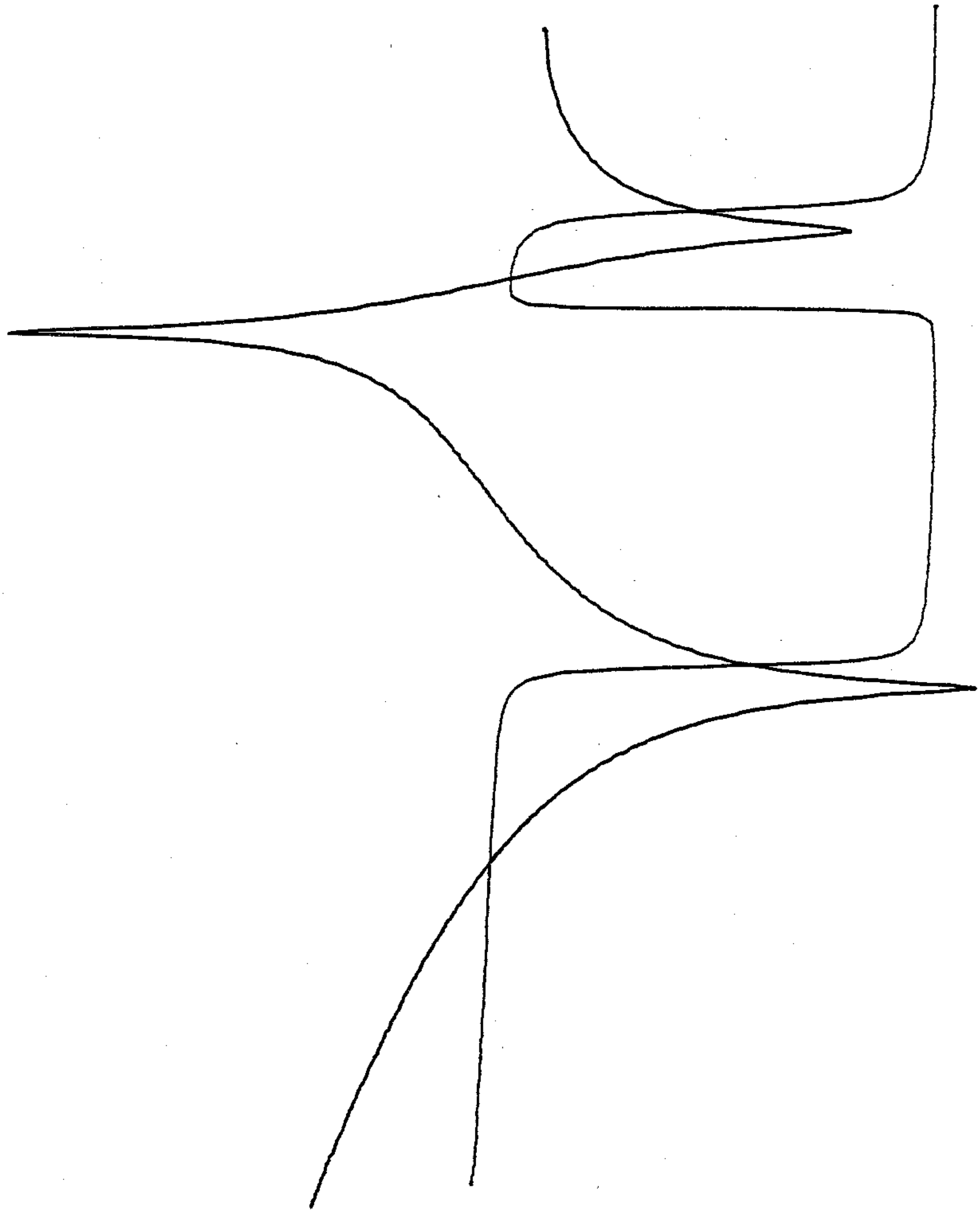


Fig. 6-39 Plotting example obtained in TWO-pen mode

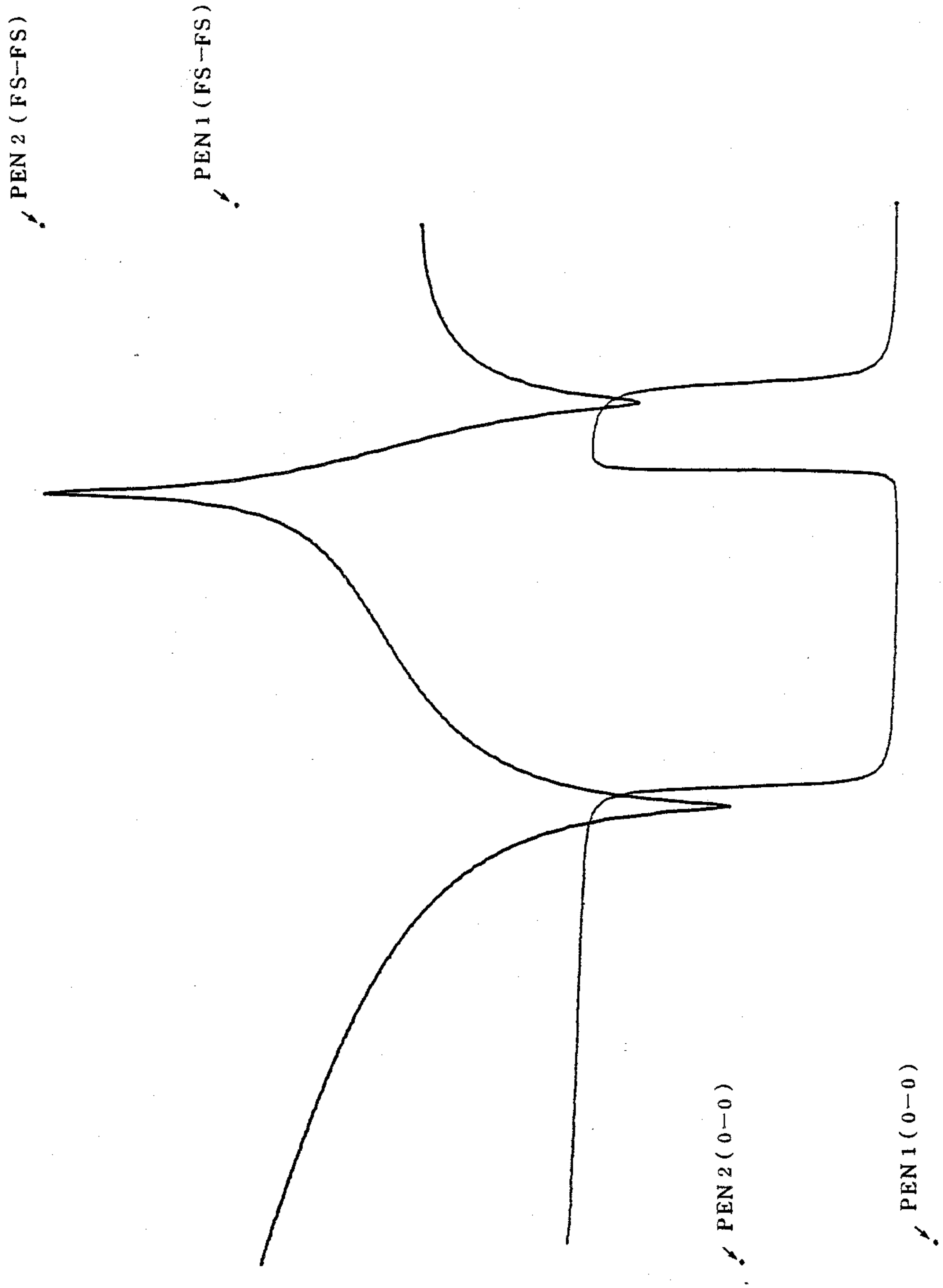


Fig. 6-40 Plotting example obtained in TWO-pen mode

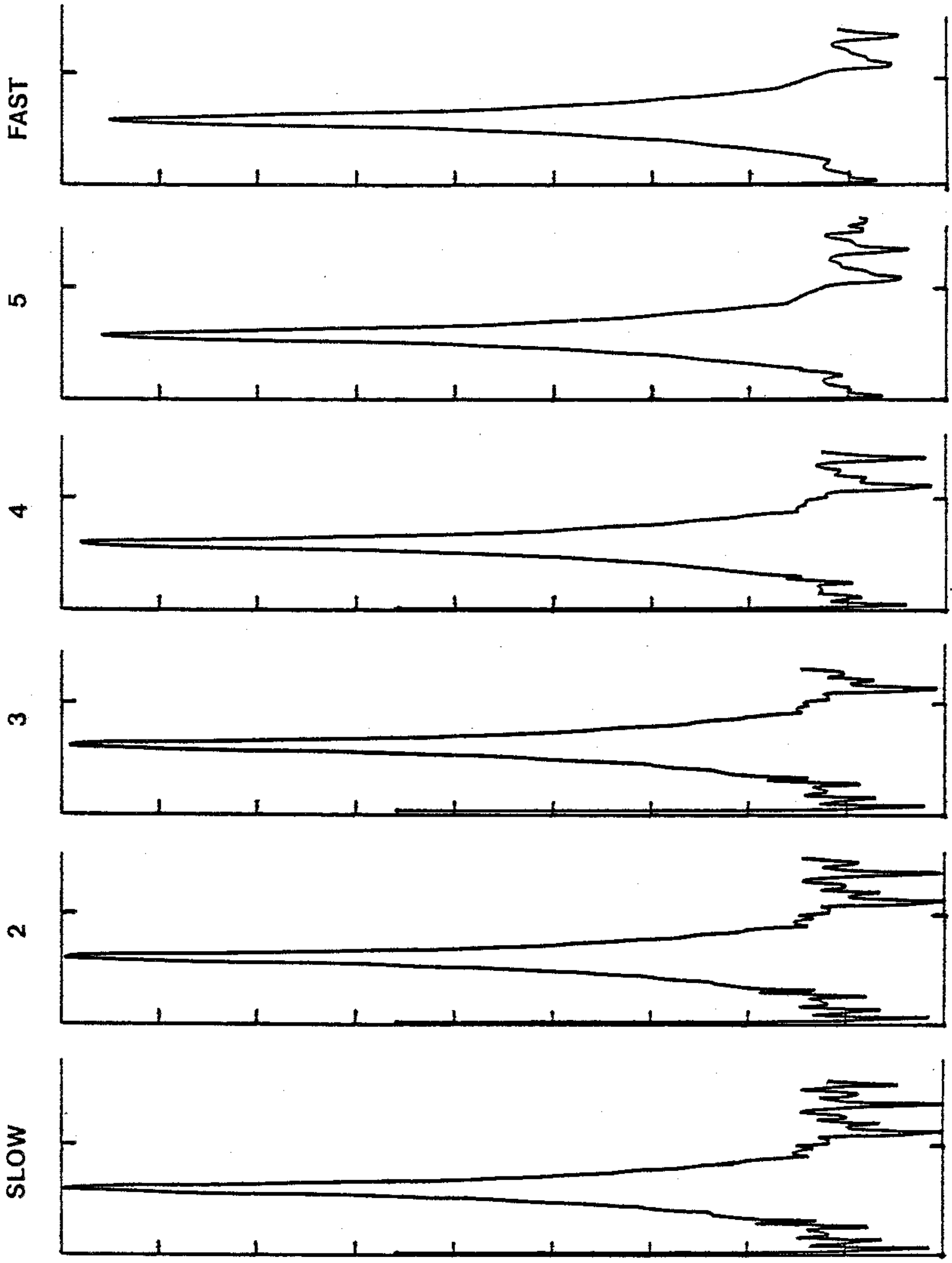


Fig. 6-41 Plotting example obtained at each plotting speed

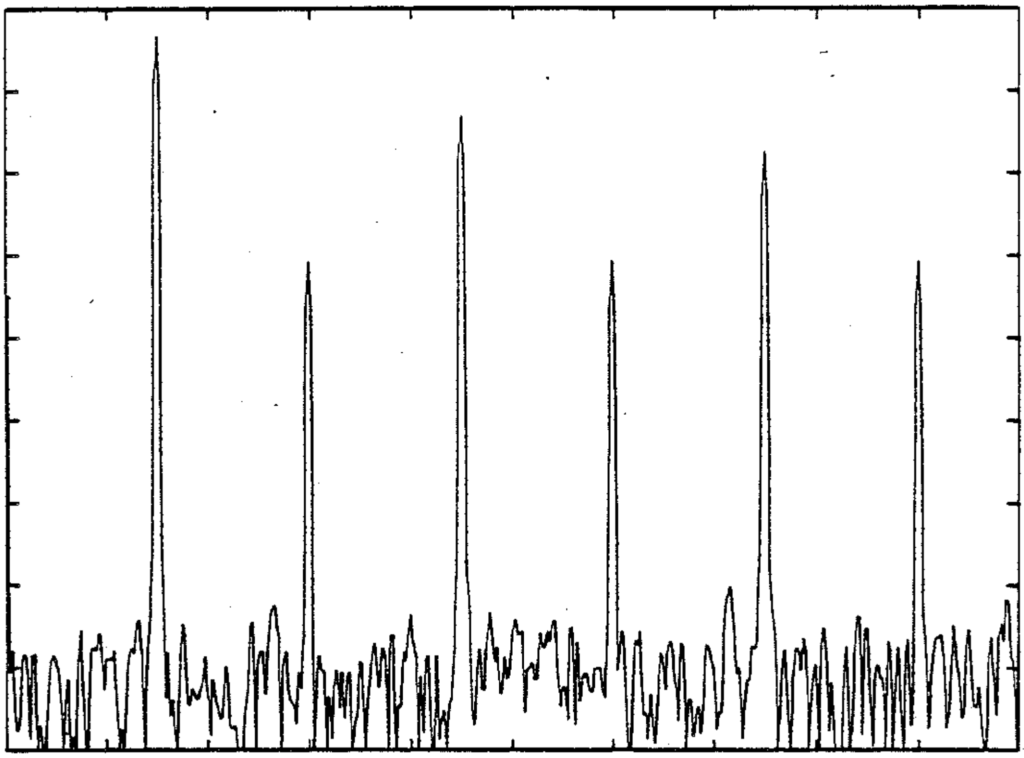


Fig. 6-42 Plotting example obtained at plotting speed of "2" and in the ALL mode

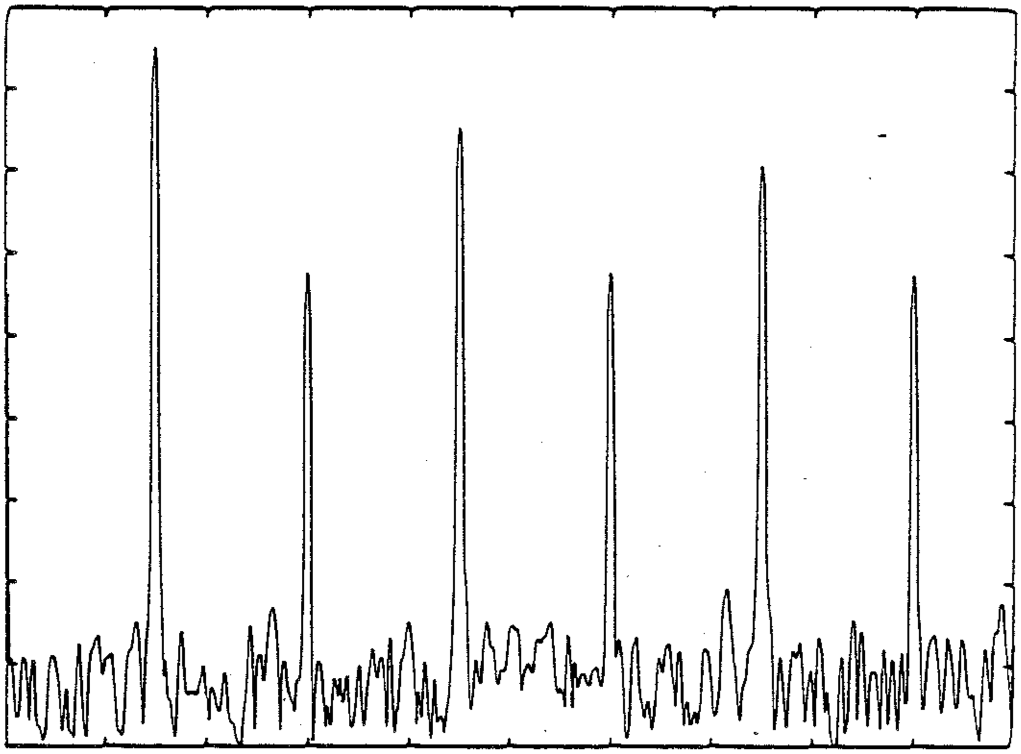


Fig. 6-43 Plotting example obtained at plotting speed of "4" and in the ALL mode

(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 the I/O key 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 the SETUP key. 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 6-4. The calibration points for several signal traces are shown in Figures 6-44, 6-45, and 6-46.

Table 6-4 Calibration voltage

0 - 0		FS - FS	
X	Y1, Y2	X	Y1, Y2
0 V	0 V	Approx. +1 V	Approx. +1 V

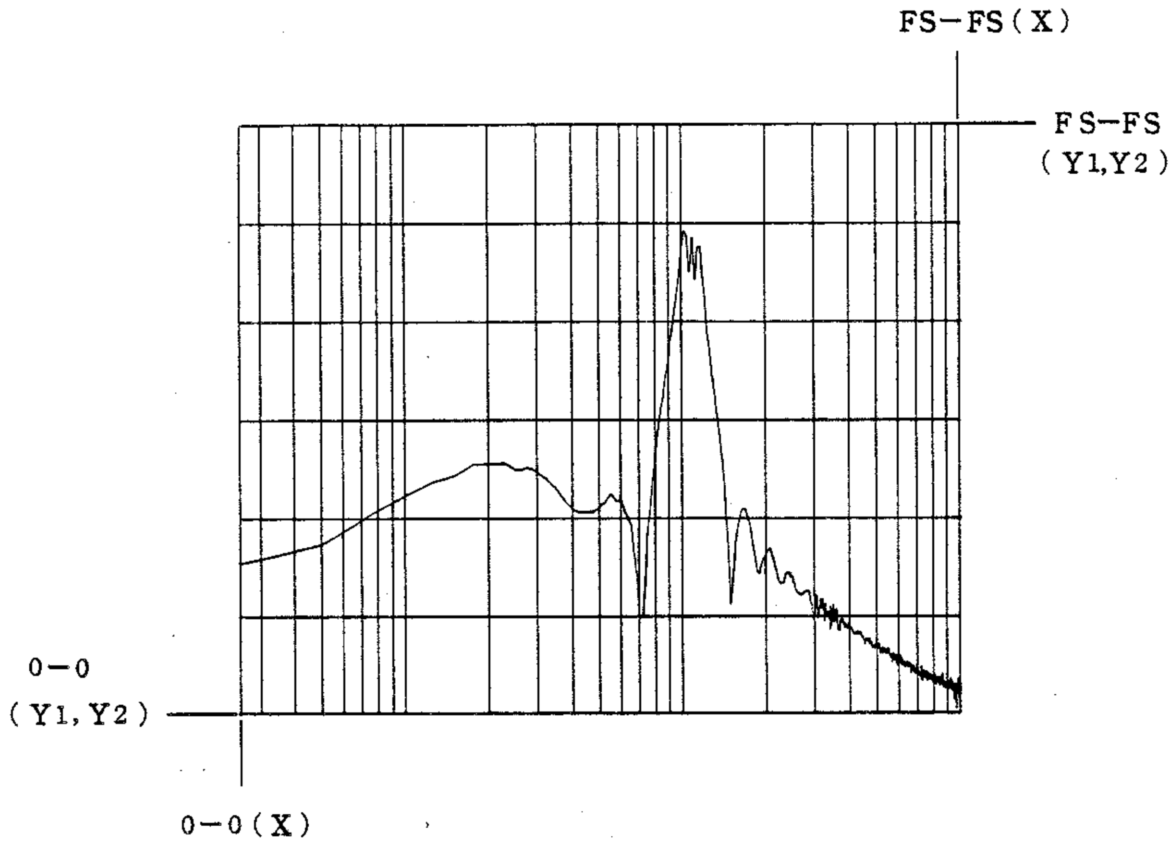


Fig. 6-44 Calibration value (SINGLE display)

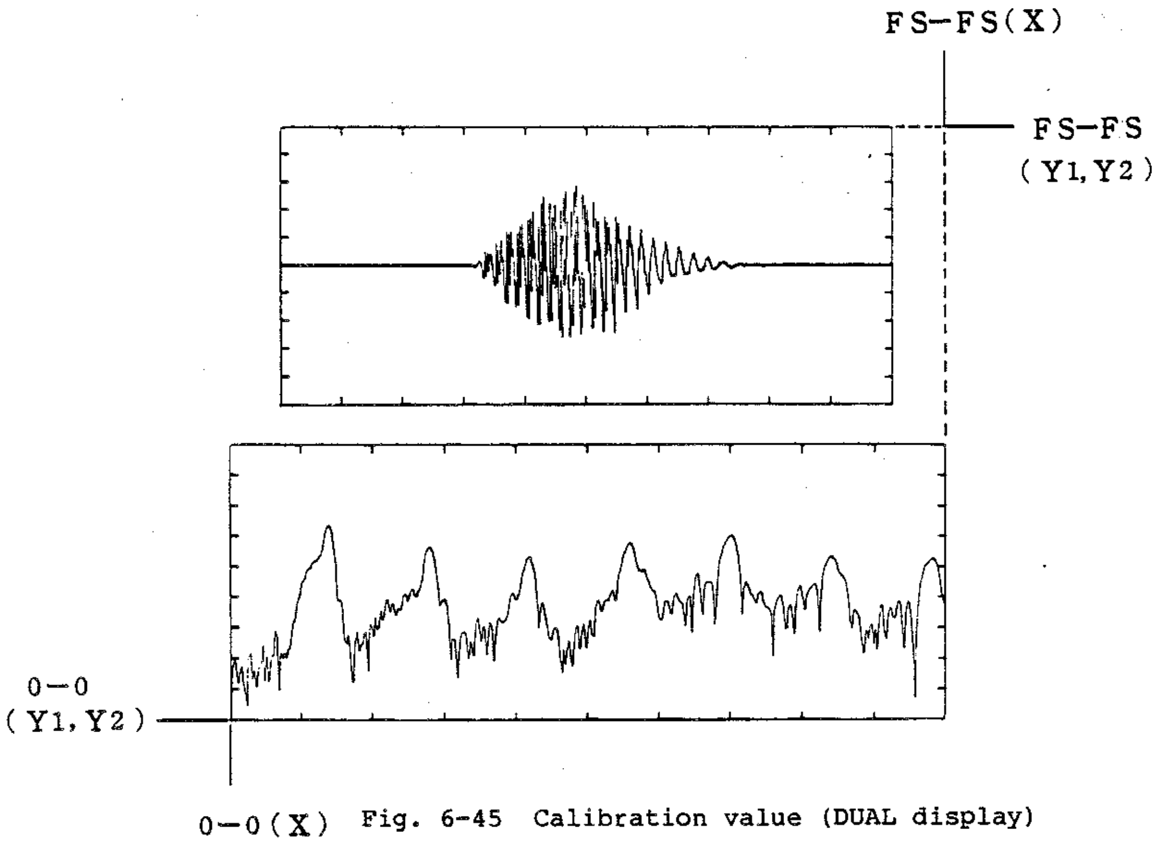


Fig. 6-45 Calibration value (DUAL display)

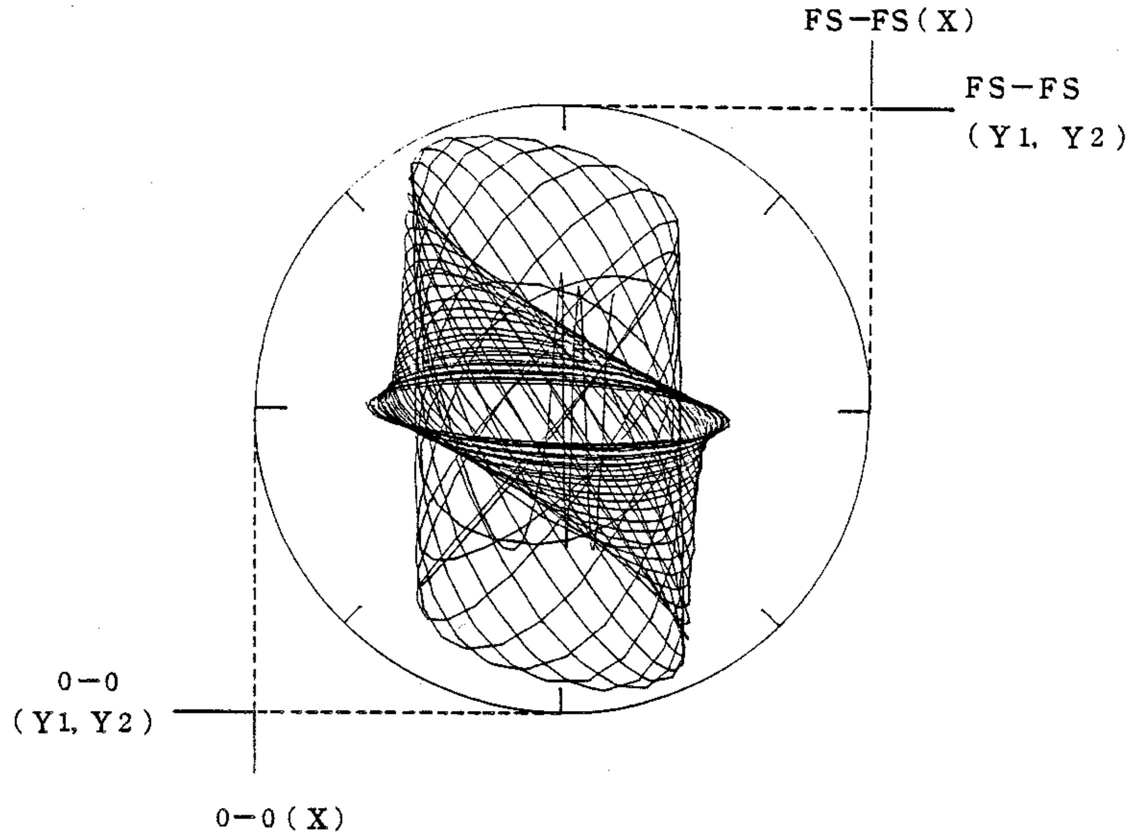
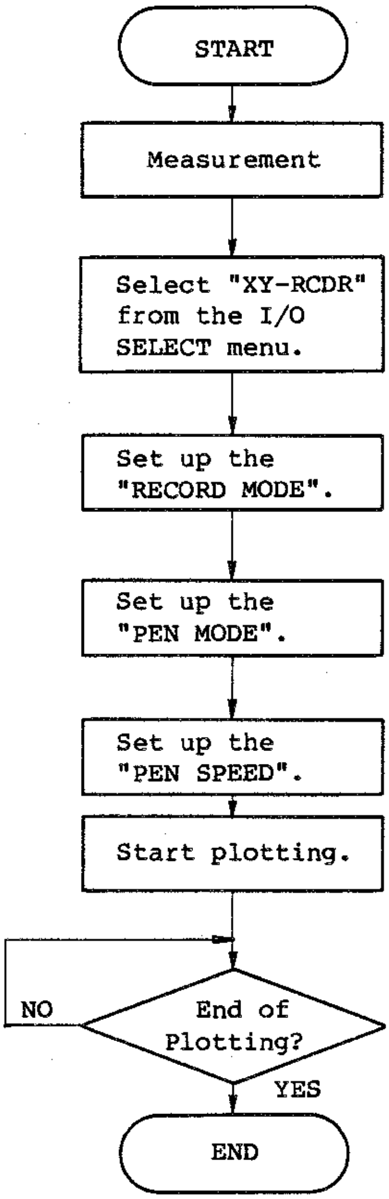


Fig. 6-46 Calibration value

6-5-3. X-Y Recorder Control over the GPIB

The TR9404 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 TR9404'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 "IEO".

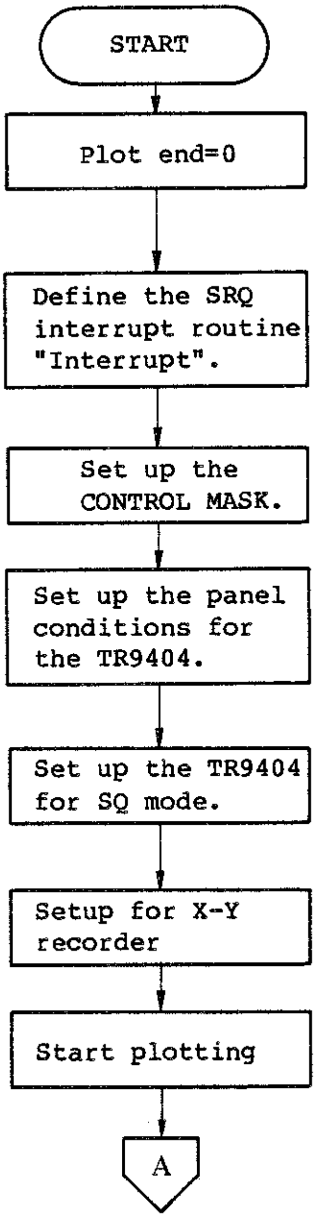
(2) List of GPIB commands concerning X-Y recorder control

Table 6-5 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 Model 45B:



Resets the plotting end flag.

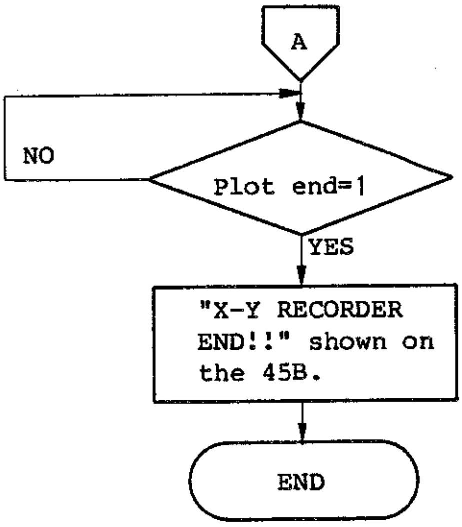
Set up the 45B.

Display shows 50 kHz, +10 dBV range, and SPECTRUM.

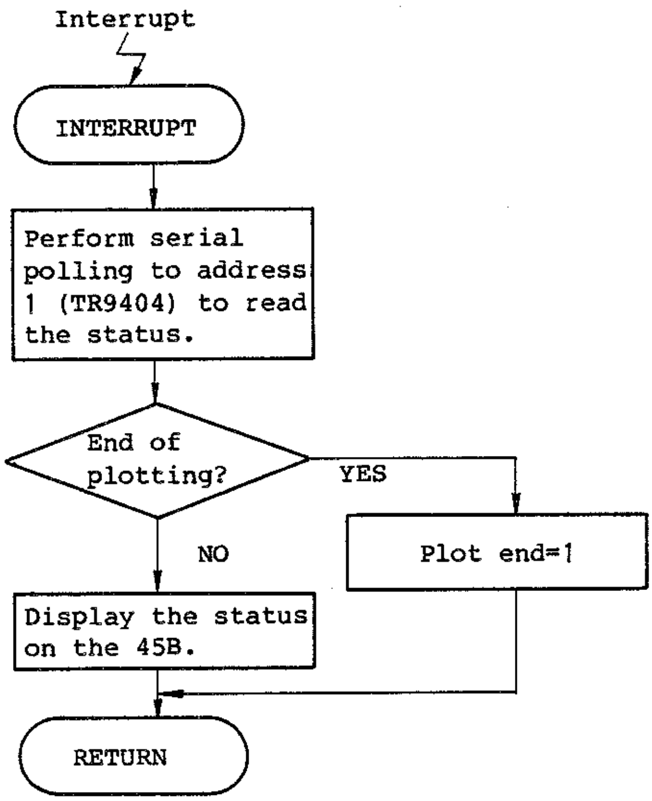
Set up the TR9404 for the SQO mode (SRQ output mode).

I/O SELECT : XY-RCDR
RECORD MODE : ALL
REN MODE : ONE PEN
PEN SPEED : 3

Sends "IE1"



End of plotting?



```
100  !
110  ! ****************************************
120  ! *                                      *
130  ! *   TR9404 XY-RECORDR Plotting Program *
140  ! *          With GP-IB Control          *
150  ! *   MT File Name: "RECEX"              *
160  ! *                                      *
170  ! *   GP-IB ADDRESS---TR9404=1           *
180  ! ****************************************
190  !
200 Start:   REMOTE 7
210          Plotend=0                 !Clear Flag
220          ON INT #7 GOSUB Interupt
230          CONTROL MASK 7;128
240          OUTPUT 701;"FR1VW1AS2"   !100KHz,VIEW=SPECTRUM,A-CH SENSE +10dBV
250          WAIT 1000
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          CARD ENABLE 7            !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:STATUS 701;S              !Serial Poll
440          S1=BINAND(S,66)
450          IF S1=66 THEN GOTO Int1
460          DISP "9405 INTERRUPT=";S
470          CARD ENABLE 7
480          RETURN
490 Int1:    Plotend=1
500          RETURN
510          END
```

Fig. 6-47 Programming example for X-Y recorder control over the GPIB

SECTION 7

ADVANCED ANALYSIS

7-1. ADVANCED ANALYSIS CAPABILITIES

TR9404's advanced analysis features the following capabilities:

(1) 1/3- and 1/1-octave analysis

(2) 3-D display

7-2. MENU FOR ADVANCED ANALYSIS

An advanced analysis menu as shown in Figure 7-1 will be displayed when ADVANCED ANALYSIS switch in the SETUP section is depressed. Use ⇧ ⇩ switches to move the pointer (⇨) to the place either "3D DISPLAY" or "OCT ANALYSIS" in the menu and depress SETUP . Menu in Figure 7-1 or Figure 7-5 will be displayed respectively.

```
◆TIME
◆CH-A(INST)
◆ZERO START
◆AC/DIFF
◆FREE RUN
◆AVG 0/0

 ADVANCE SELECT
 ⇨ 3D DISPLAY   #
   <DISABLE>
   OCT ANALYSIS
   <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
```

Fig. 7-1 Advanced analysis menu (3-D display)

7-3. 1/1- AND 1/3-OCTAVE ANALYSIS

This capability is used to operate on and convert the narrow band spectrum to 30 third-octave filter outputs. Third-octave analysis involves synthesis of a 1200-line (400 lines/range) spectrum convering three frequency ranges, and conversion of the center frequencies from 1.6 Hz to 80 kHz of the third-octave band according to the setting of the frequency range to be analyzed. The 1/1-octave analysis is performed on 1/3-octave analysis results. This enables results to be displayed during, and after the actual analysis.

7-4. SPECIFICATIONS OF 1/1- AND 1/3-OCTAVE ANALYSIS

Filter characteristics: Filter center frequency, bandwidth, and rolloff characteristics conform to ANSI S1.11 CLASSII (1/1 octave) and CLASSIII (1/3 octave) standards.
See Figure 7-3. (ANSI: American National Standards Institute)

ANSI band number, center frequency, and setting frequency range relation:
See Table 7-1 below.
Center frequency uses ANSI standard type E.

Weighting : Characteristics A (ANSI S1.4 1971) (See Figure 7-2)

Analyzing time :

Frequency range	Analyzing time	
	CH-A or CH-B	Dual channel
100 kHz	Approx. 2.9 seconds	Approx. 3.5 seconds
50 kHz	Approx. 3.4 seconds	Approx. 4.0 seconds
20 kHz	Approx. 4.5 seconds	Approx. 5.1 seconds
10 kHz	Approx. 6.7 seconds	Approx. 7.2 seconds
5 kHz	Approx. 11.3 seconds	Approx. 11.8 seconds
2 kHz	Approx. 24.5 seconds	Approx. 25.0 seconds

Table 7-1 Relation between filter number, center frequency and set frequency range

Filter No.	Cent. Freq. Hz	OCTAVE 1/1	OCTAVE 1/3	Set Frequency range (kHz) 100	50	20	10	5	2
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		←						↓

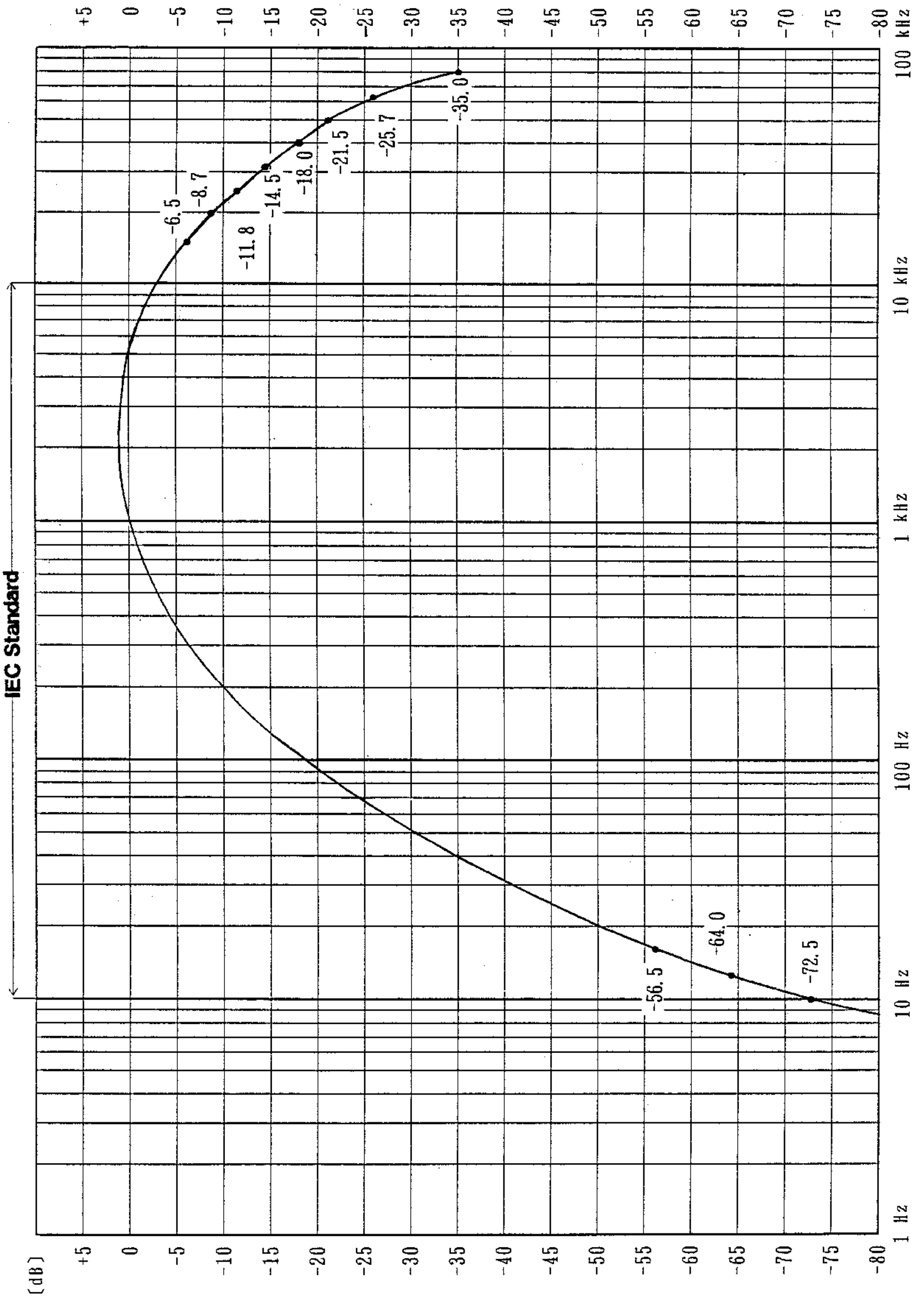


Fig. 7-2 A-Weighting curve

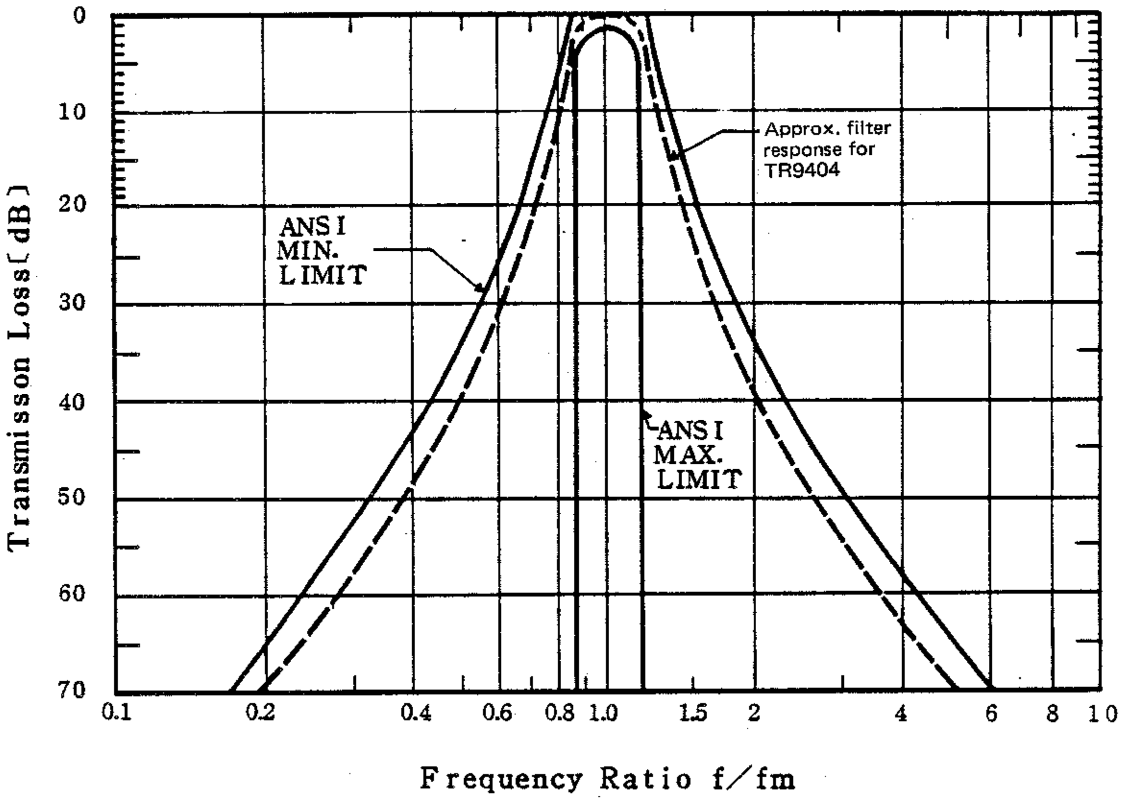


Fig. 7-3 Transmission loss limit of third-octave band filter, ANSI S1.11-1966

7-5. OCTAVE ANALYSIS STARTING PROCEDURE

7-5-1. STATIONARY Octave Analysis

To execute stationary octave analysis, use the following procedure:

(1) OCT ANALYSIS menu selection

① Press [ADVANCED ANALYSIS] in the SETUP section to display the advanced analysis menu as shown in Figure 7-1.

② Move the pointer (⇨) to OCT ANALYSIS using [⇧] [⇩] switches and press [SETUP] switch to display the octave menu as Figure 7-4.

③ Move the pointer to <DISABLE> and press [SETUP] or [DISP.] to change into <ENABLE> with each press of [SETUP] or [DISP.], displays of <DISABLE> and <ENABLE> alternate with each other.

④ Setup of STATIONARY mode

Move the pointer to "STATIONARY" in the OCT MODE and press [SETUP] switch.

```
◆TIME
◆CH-A(INST)
◆ZERO START
◆AC/DIFF
◆FREE RUN
◆AVG 0/0

 ADVANCE SELECT
   3D DISPLAY
   <DISABLE>
 ⇨ OCT ANALYSIS*
   <DISABLE>

 OCT MODE
   STATIONARY   *
   TRANSIENT
   VIEW POWER
 ANALYSIS CHAN
   CH-A         *
   CH-B
   DUAL
 BANDWIDTH
   1/3 OCT      *
   1/1 OCT
 A-WEIGHTING
   OFF
```

Fig. 7-4 Octave menu

⑤ ANALYSIS CHANNEL selection

To select a channel or channels for octave analysis execution, move the pointer (⇨) to CH-A, CH-B, or DUAL by using the [⇧] and [⇩] keys in the SETUP section, and press the [SETUP] key.

If either the CH-A or CH-B is selected, octave analysis is executed only for the signals input to the selected channel.

⑥ Octave band setting (1/3 or 1/1)

To select an octave band, 1/3 or 1/1, move the pointer (⇨) to "1/3 OCT" or "1/1 OCT" and press the [SETUP] key.

⑦ A-WEIGHTING setting

To select A-WEIGHTING ON or OFF, move the pointer (⇨) to "OFF" and press the [SETUP] (or [DISP.]) key. Selection between A-WEIGHTING ON and OFF is alternated every time the [SETUP] (or [DISP.]) key is pressed.

⑧ Frequency range setting

See Table 7-1 for setting the required octave analysis frequency range. The minimum frequency is 2 kHz. Setting of 1 kHz and less will not permit octave analysis to be executed by the following procedure.

⑨ Octave analysis start

After completing steps ① through ⑧, press the VIEW section SPECTRUM [□] key to display the spectrum of a desired channel on the CRT display.

Octave analysis will begin when the EXECUTE switch to the right of the ADVANCED ANALYSIS switch is pressed.

⑩ End of octave or third-octave analysis

Octave/third-octave analysis is completed and normal narrow band spectrum displayed by pressing the EXECUTE key beside I/O [ ]. The frequency range is set at this time to the frequency set before execution of the octave/third-octave analysis.

If the execution of steps 1 through 9 does not start octave analysis, check the following:

(1) Make sure that the CH-A or CH-B is set to ACTIVATE. If it is set to DEACTIVATE, change the setting to ACTIVATE. See 4-4-1.

(2) Make sure that the frequency range is set to 2 kHz or above. If it is not, change the setting to 2 kHz or above.

(3) Make sure that spectrum zooming is off. If it is on, turn it off. See 4-4-9.

(4) Make sure that the DATA WINDOW key is off. If it is on, turn it off. See item 7 in 4-4-7.

If any of the above-mentioned settings has not been made, octave analysis cannot be started and the following message is displayed on the CRT:

"OCTAVE IS NOT AVAILABLE"

NOTE

- Changing OCT MODE and ANALYSIS CHANNEL selection during octave analysis is prohibited.
- Thirty filters are displayed for 1/3-octave analysis and ten for 1/1-octave analysis in TR9404; the third-octave display frequency is switched in three stages, which is clarified by the FREQ. menu displayed on the CRT (see Figure 7-5). Furthermore, the 30 third-octave filter outputs are calculated together with the frequency conversion. For example, when the set frequency is 100 kHz, that frequency is switched to 100 kHz, 10kHz and 1 kHz, and ten filter outputs are calculated for each frequency range (a total of 30 filter outputs for the three switching ranges).

Frequency range	Calculated filter number
100 kHz	40 to 49 (ten filters)
10 kHz	30 to 39 (ten filters)
1 kHz	20 to 29 (ten filters)

With set frequency ranges of 50, 20, 10, 5, and 2 kHz, the frequency can also be switched by a factor of 10, and a total of 30 filter outputs calculated and displayed.

```
◆TIME
◆CH-A(INST)
◆ZERO START
◆AC/DIFF
◆FREE RUN
◆AVG 0/0

 FREQ RANGE
 SAMP CLK
   INT        #
   EXT

 ⇨ 100   kHz  #
   50
   20
   10
   5
   2
   1
   500    Hz
   200
   100
   50
   20
   10
   5
   2
   1

 FRAME TIME
    4  mSEC
```

Fig. 7-5 FREQ. menu

7-5-2. TRANSIENT Octave Analysis

TRANSIENT octave analysis works without any change in frequency, while frequency changes in three ranges in STATIONARY octave analysis. Therefore, only 10 filter outputs are required in TRANSIENT mode while 30 are needed in STATIONARY Mode. Since there is no frequency change, TRANSIENT mode provides correct octave analysis even in the AUTO ARM mode. Table 7-2 shows relationships between analysis frequencies and 10 filter outputs. Figures 7-6, 7-7, and 7-8 show the results of TRANSIENT octave analysis at frequency settings of 10 kHz, 200 Hz, and 50 Hz, respectively.

Table 7-2 Relationships between setup frequency in the TRANSIENT and VIEW POWER modes and filter numbers required

Frequency range	Filter number
100 kHz	40 to 49
50 kHz	37 to 46
20 kHz	34 to 43
10 kHz	31 to 40
5 kHz	28 to 37
2 kHz	22 to 31
1 kHz	21 to 30
500 Hz	18 to 27
200 Hz	12 to 21
100 Hz	11 to 20
50 Hz	8 to 17
20 Hz	2 to 11

- Starting TRANSIENT Octave Analysis

  TRANSIENT octave analysis can be started by following steps 1 to 9 for starting STATIONARY octave analysis. Note that frequencies 20 Hz or above are effective in TRANSIENT mode while frequencies 2 kHz or above are effective in STATIONARY mode.

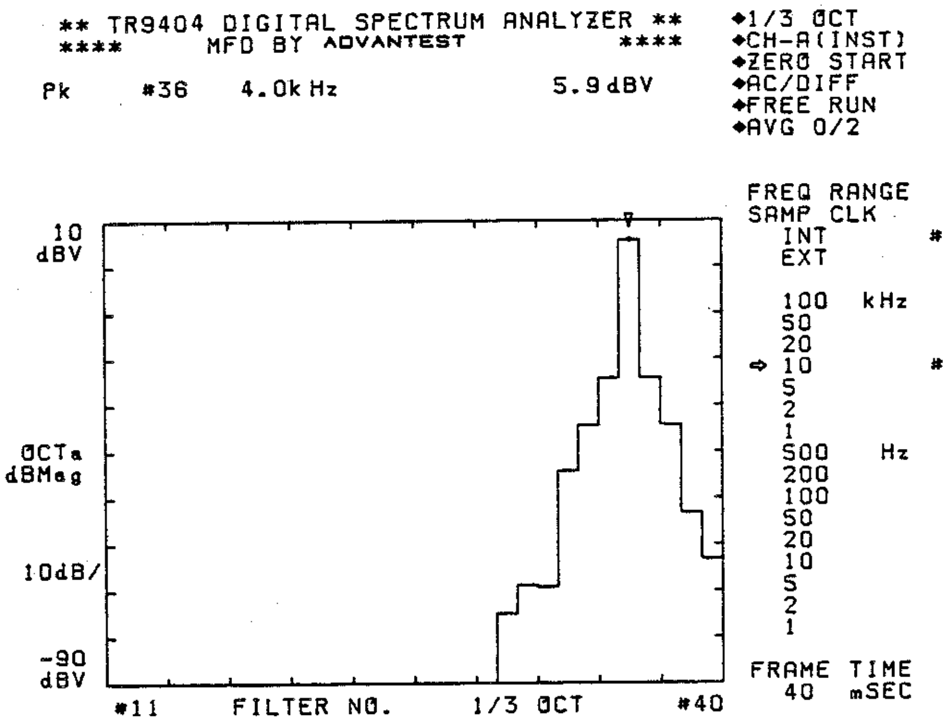


Fig. 7-6 TRANSIENT octave analysis at 10 kHz range

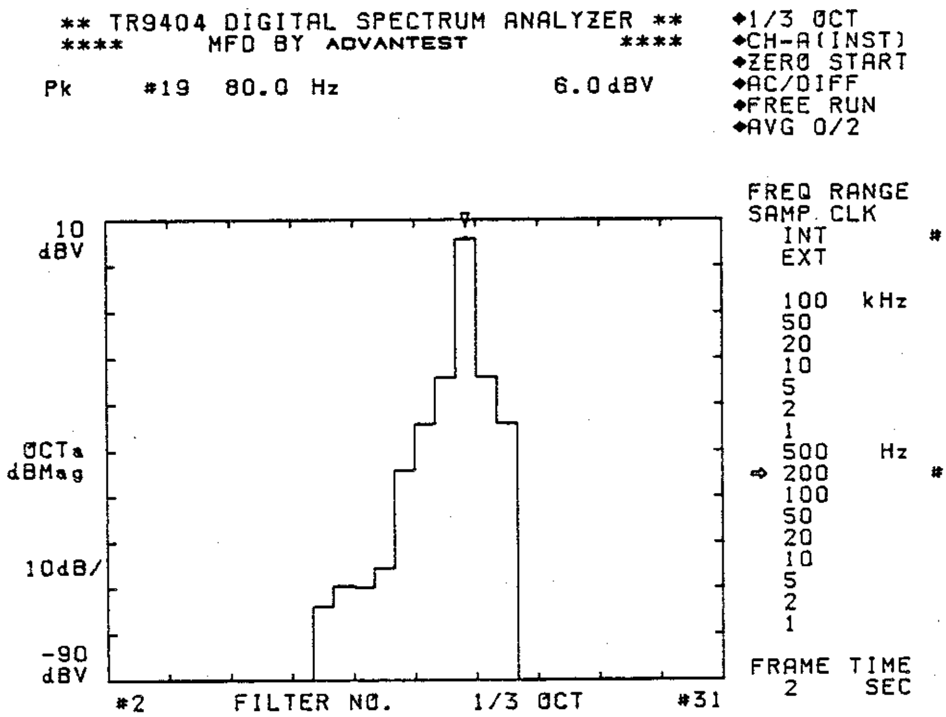


Fig. 7-7 TRANSIENT octave analysis at 200 Hz range

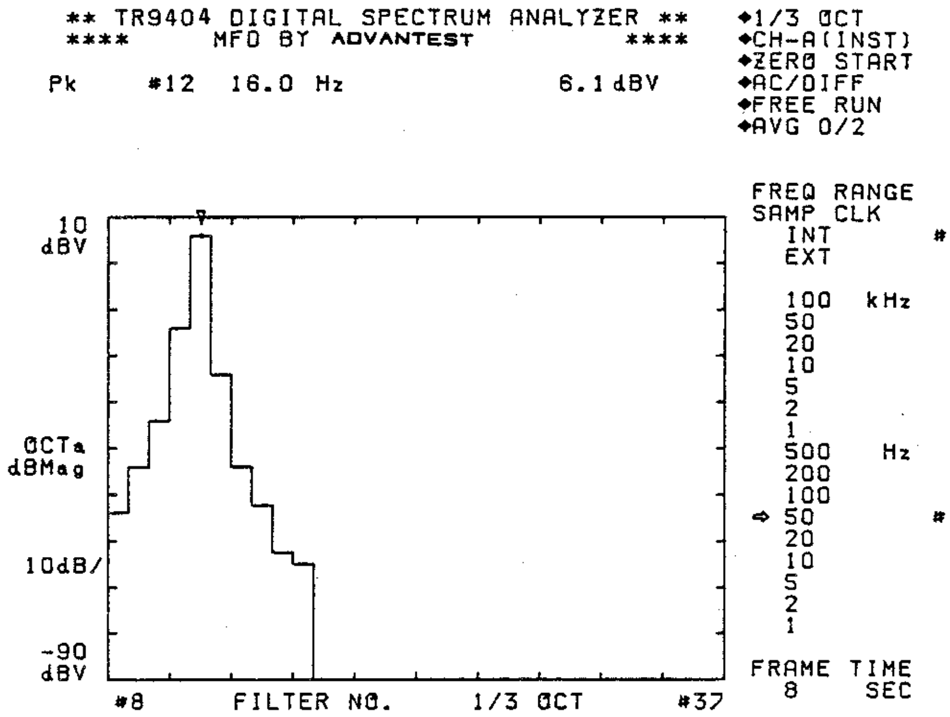


Fig. 7-8 TRANSIENT octave analysis at 50 Hz range

7-5-3. VIEW POWER Octave Analysis

VIEW POWER octave analysis provides octave display for the power spectrum (in the lower display in the BOTH display mode) currently shown on the CRT. In this mode, only 10 filter outputs are required, as with TRANSIENT mode. The relationship between frequency ranges and filter numbers is the same shown in Table 7-2. The following shows power spectrum types which enable the VIEW POWER octave display:

- Gaa, Gbb, <Gaa>, <Gbb>, <C.O.P.>, <Hab> Mag

  (Symbols given in brackets < > indicate averaged data.)

CAUTION

- Octave displays are not available for the power spectrum of cross spectrum Gab or <Gab>.
- To execute octave analysis on the "FUNCTION" result between the power spectra, temporarily store the result in memory, then recall it in the lower display area before executing VIEW OCTAVE analysis.
- If Gbb is displayed after VIEW POWER octave analysis is executed on power spectrum Gaa, and then octave display for Gaa is executed, VIEW POWER octave analysis for Gbb will not be executed. To carry out the octave analysis of Gbb, first press the EXECUTE key beside ADVANCED ANALYSIS to complete octave analysis on Gaa and press the EXECUTE key a second time to start the analysis.

Figure 7-9 shows a <C.O.P.> display and Figure 7-10 the result of VIEW POWER octave analysis executed on the <C.O.P.>.

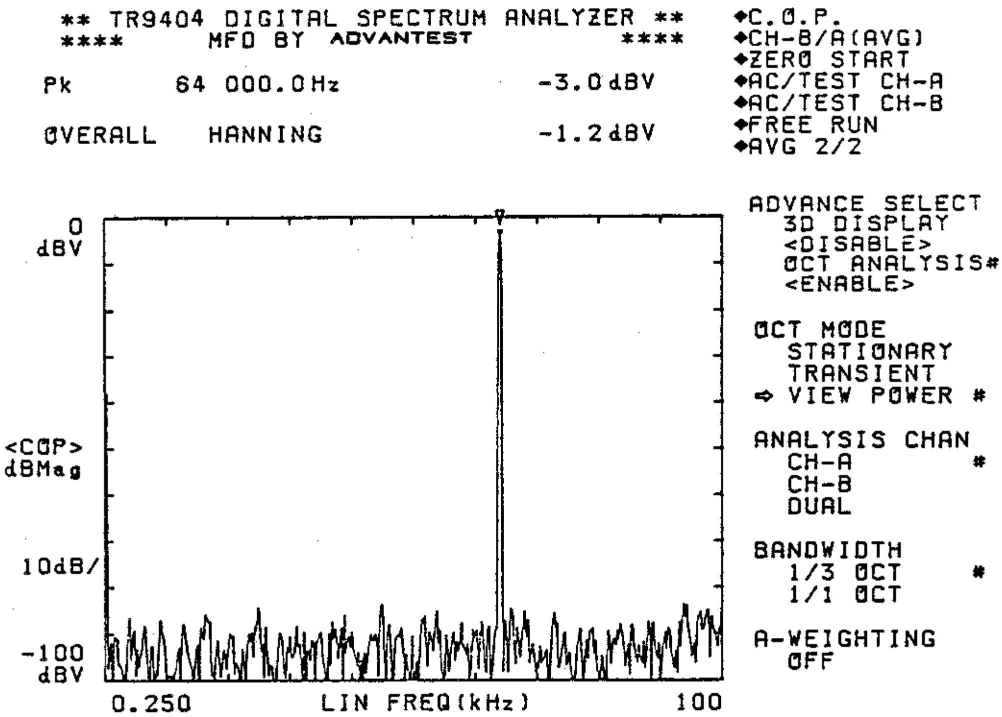


Fig. 7-9 Display example of C.O.P.

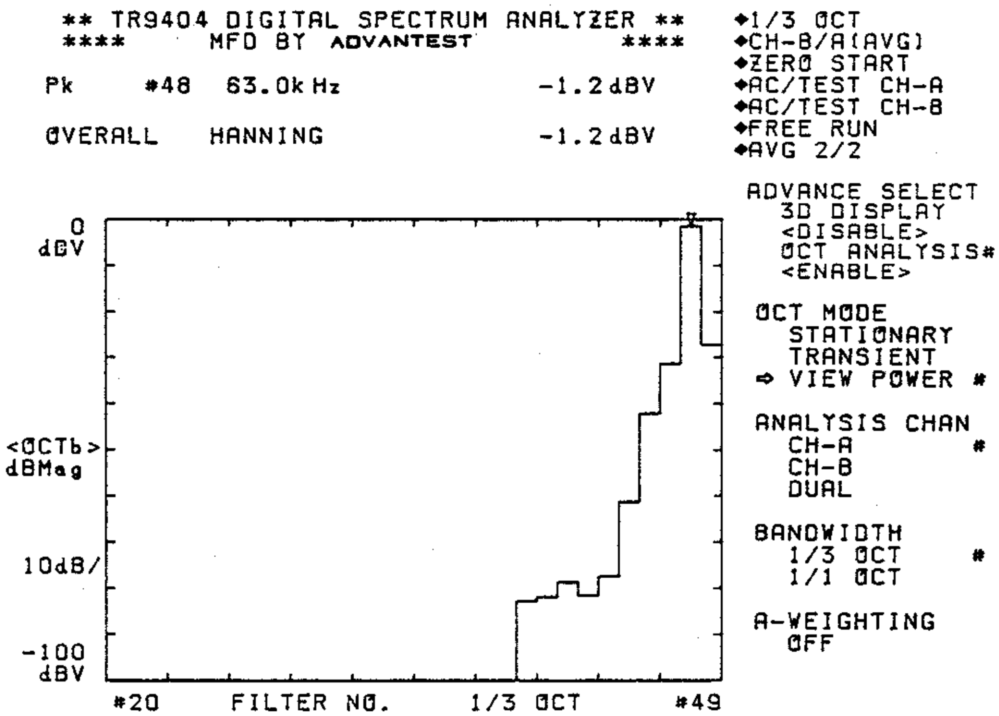


Fig. 7-10 "VIEW POWER" octave analysis

7-6. OCTAVE ANALYSIS AVERAGING DISPLAY

Use the following procedure when averaging of octave analysis is required. Refer to item 4-4-5. (9).

(1) AVG MODE setting

Display the AVG MODE menu by pressing the [AVG MODE] key in the SETUP section. Set averaging mode to "SUM(N)", "SUM(L)", "DIFF", "EXP" or "PEAK".

(2) AVG WHAT? setting

Set the POWER SPECT mode for averaging.

In reality, this setting may be omitted, since the POWER SPECT mode is automatically set even if octave averaging is started in a different mode.

(3) AVG NUMBER setting

Set the averaging number with [DISP.] or [SETUP] keys.

(4) Execute STATIONARY or TRANSIENT octave analysis by using the procedure described above in section 7-5-1 or 7-5-2.

(5) Display the averaging data on the CRT by pressing the [AVG/INST.] key in the VIEW section.

(6) Set the AVERAGE CONTROL keys in the following sequence.

[STOP] [ERASE] [START] Do not press the [ERASE] key when averaging mode has been set to "DIFF".

Octave analysis averaging is started by the above procedure.

NOTE

a. For the octave averaging, frequency band is changed in three ranges in STATIONARY mode but there is no frequency changeover in TRANSIENT mode. When octave analysis averaging is executed in STATIONARY mode with an averaging number of 16, frequency range of 100 kHz, and third-octave setting, this averaging will be executed as shown in Figure 7-11 below.

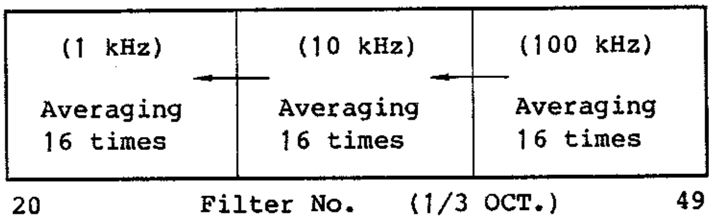


Fig. 7-11 Third-octave averaging execution diagram
(Frequency range: 100 kHz, average count: 16)

b. Octave or third-octave analysis averaging is started from the frequency range set when the AVERAGE CONTROL section START key is pressed.

For example, when stationary third-octave analysis is started from the set frequency range of 100 kHz, the frequency range is switched from 100 kHz, to 10 kHz, 1 kHz and then 100 kHz.

If the START key is pressed when the range is set to the 10 kHz range, averaging is executed in the 10 kHz, 1 kHz, 100 kHz, 10 kHz sequence.

c. If an averaging number greater than 32 is set, averaging is executed 16 times for each frequency range, until it reaches the averaging number set for the total.

For example, averaging with frequency range set to 100 kHz, averaging number to 64, and 1/3 OCT., is outlined in the following diagram (Figure 7-12)

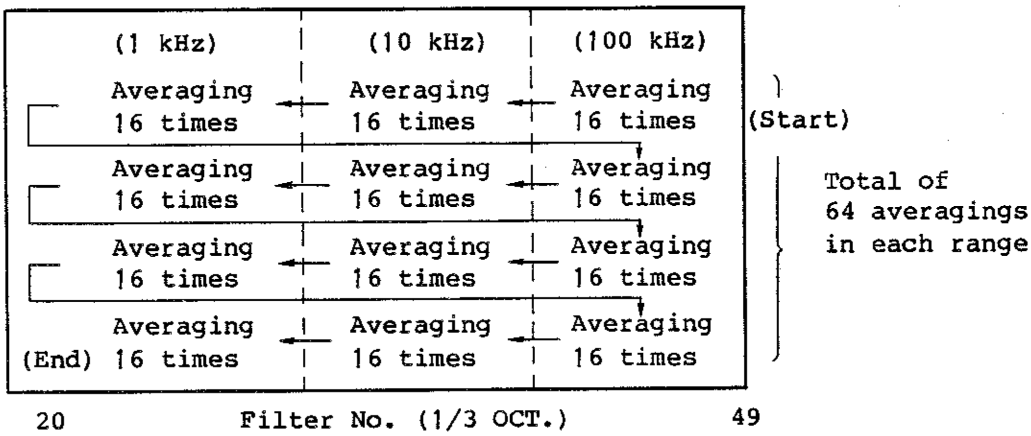


Fig. 7-12 Averaging execution diagram for AVG. NO.=64

The reason for averaging in this way is due to the time involved. In the above set conditions (frequency range of 100 kHz and averaging number of 64) for example, where all 64 averaging operations are executed by switching to each of the three ranges (100 kHz, 10 kHz, 1 kHz), and the overall analysis time is assumed to be two minutes with averaging time of 20 seconds required for 100 kHz averaging, 40 seconds for 10 kHz averaging, and 60 seconds for 1 kHz averaging, there will be only 20 seconds of averaging after starting third-octave analysis at 100 kHz. And when "PEAK" and "EXP" are specified in the AVG MODE menu, averaging is executed 16 times in each range, the averaging being terminated after a total of 8192 (16 times x 512) averagings have been executed.

d. If averaging is attempted during VIEW POWER octave analysis, averaging for octave analysis will not be executed. In this case, averaging is executed in the normal mode.

7-7. "A-WEIGHTING"

A-WEIGHTING compensation values are listed in Table 7-3. When the ADVANCED ANALYSIS menu A-WEIGHTING ON/OFF is set to A-WEIGHTING ON, the respective filter outputs are compensated by the values listed in Table 7-3. For example, when A-WEIGHTING ON is set after a reading of -10 dBV is obtained for filter no.49 when in A-WEIGHTING OFF position, the reading will be compensated as follows:

(-10.0)+(-35.0)=-45.0 dBV

In other words, the reading obtained in the A-WEIGHTING ON setting is equal to

(A-WEIGHTING OFF reading)+(A-WEIGHTING compensation) dBV

NOTE

Since the IEC standards only specify values from 10 Hz to 20 kHz, values obtained from the curve in Fig. 7-2 are used as A-WEIGHTING compensation values in TR9404 octave analysis.

Table 7-3 A-WEIGHTING compensation values

****
* 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]

7-8. OCTAVE ANALYSIS LIST DISPLAY

The analytical results for both 1/3 and 1/1 octaves can be displayed in list form. The procedure is described below.

① Display the octave analytical results on the CRT. Display them in the bottom half if in dual display mode.

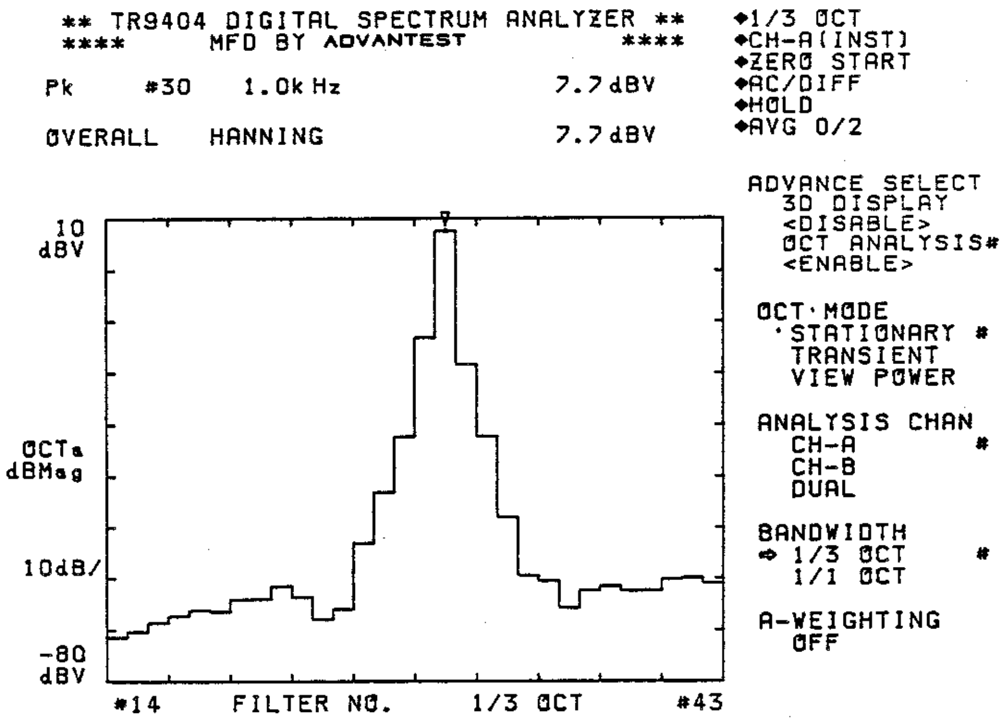
② Press the VIEW section LIST key.

With these two steps, the octave analytical results can be displayed in list form. The following list items are included in the display.

- "FILTER NO."
- "CENTER FREQ."
- "LEVEL:(level units V and V^2 are not displayed)
- A-WEIGHTING ON/OFF.
- Type of WINDOW
- OVERALL value

Lists of 1/3- and 1/1-octave analytical results are shown in Figures 7-13 and 7-14 respectively.

(a)



(b)

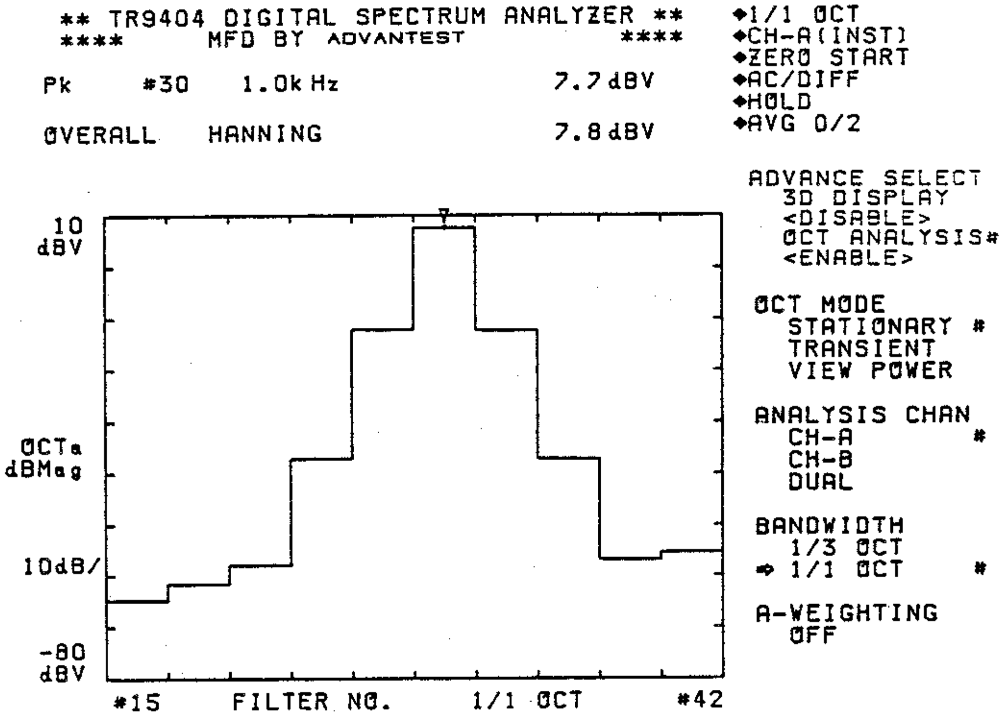
** TR9404 DIGITAL SPECTRUM ANALYZER **
**** MFD BY ADVANTEST ****

1/3 OCTAVE LIST : A-WEIGHT OFF
WINDOW HANNING
OVERALL 7.7 dBV

FILTER NO.	CENTER FREQ.	LEVEL dBV	FILTER NO.	CENTER FREQ.	LEVEL dBV
#14	25.0 Hz	-71.3	#29	800 Hz	-13.0
#15	31.5	-70.2	#30	1.0k	7.7
#16	40.0	-68.4	#31	1.25k	-18.4
#17	50.0	-67.2	#32	1.6k	-32.3
#18	63.0	-66.1	#33	2.0k	-48.0
#19	80.0	-66.3	#34	2.5k	-59.4
#20	100	-63.9	#35	3.15k	-60.4
#21	125	-63.8	#36	4.0k	-65.7
#22	160	-61.3	#37	5.0k	-62.2
#23	200	-63.6	#38	6.3k	-61.4
#24	250	-67.8	#39	8.0k	-62.3
#25	315	-65.9	#40	10.0k	-62.3
#26	400	-53.0	#41	12.5k	-60.1
#27	500	-43.0	#42	16.0k	-59.7
#28	630	-32.3	#43	20.0k	-60.9

Fig. 7-13 Third-octave analytical results and corresponding list display

(a)



(b)

** TR9404 DIGITAL SPECTRUM ANALYZER **
**** MFD BY ADVANTEST ****

1/1 OCTAVE LIST : A-WEIGHT OFF
WINDOW HANNING
OVERALL 7.8 dBV

FILTER NO.	CENTER FREQ.	LEVEL dBV
#15	31.5 Hz	-64.6
#18	63.0	-61.3
#21	125	-57.7
#24	250	-37.0
#27	500	-11.9
#30	1.0k	7.7
#33	2.0k	-12.2
#36	4.0k	-37.2
#39	8.0k	-56.8
#42	16.0k	-55.3

Fig. 7-14 Octave analytical results and corresponding list display

7-9. OCTAVE ANALYSIS PRECAUTIONS

(1) Octave analysis cannot be executed when the following conditions are set.

- SPECTRUM ZOOM : ON
- CH-A or CH-B : DEACTIVATE
- Frequency range: 1 kHz or below
- DATA WINDOW : ON

(2) In TR9404, outputs equivalent to ANSI standards 1/3- and 1/1-octave filters are calculated by using frequency analytical results for 400-line constant narrow bandwidth.
Consequently, the upper limit rolloff characteristics for the highest frequency filters are eliminated by antialiasing filters (low-pass filters) when the set frequency range is 20 kHz, 10 kHz, or 5 kHz for both 1/3- and 1/1-octave analysis.

(3) Since TR9404 1/3- and 1/1-octave analysis involves analysis with the frequency switched in three stages, the respective 30- and 10-filter output values are guaranteed only after once switching three stages such as 100 kHz, 10 kHz, and 1 kHz in the 100 kHz range.

(4) The following functions are suspended during octave analysis.

- ZOOM
- ARM and AUTO-ARM
- One channel mode
- Auto range
- Frequency setting
- INSTANT CORRELATION
- Horizontal axis LOG. display (H-LOG.)
- HARMONICS SEARCH
- DATA WINDOW

7-10. OCTAVE ANALYSIS TEST METHOD

The best test method in octave analysis involves input of white noise (flat). Since the bandwidth is increased by a factor of two in 1/1-octave analysis, the amplitude level is increased in 3 dB steps for each filter. Likewise, this level is increased in 1 dB steps in 1/3-octave analysis.

The input signal (white noise) is shown in Figure 7-15, the 1/3-octave analytical results in Figure 7-16 and 1/1-octave analytical results in Figure 7-17.

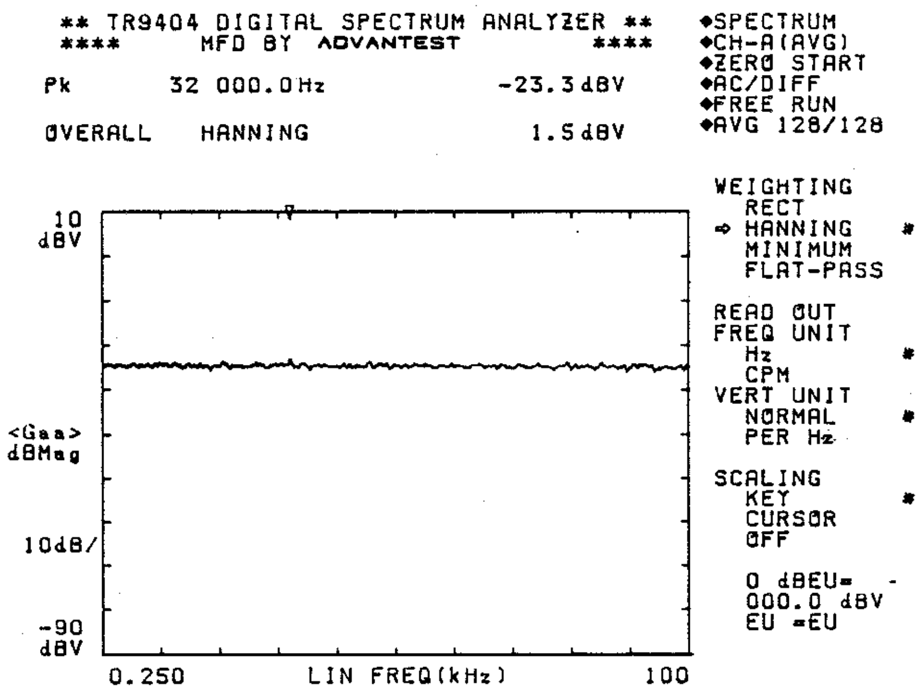
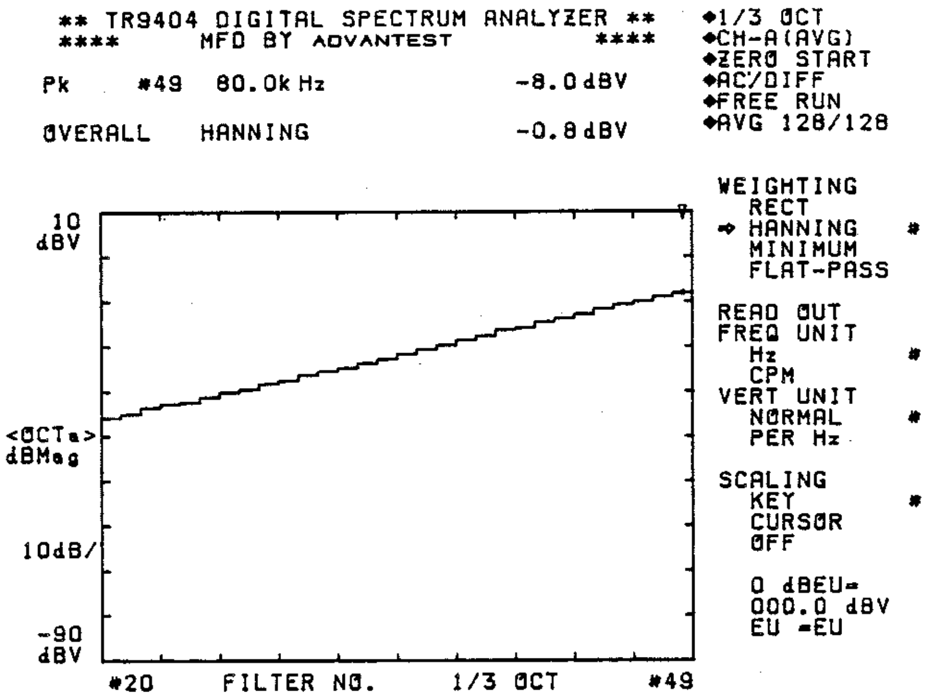


Fig. 7-15 Input signal (white noise)

(a)



(b)

** TR9404 DIGITAL SPECTRUM ANALYZER **
**** MFD BY ADVANTEST ****

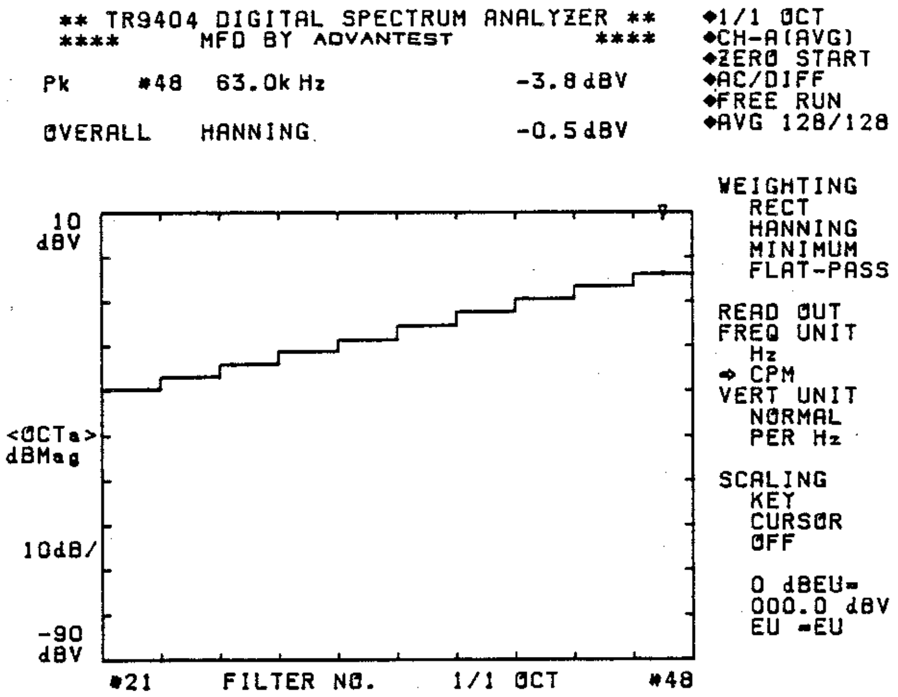
1/3 OCTAVE LIST : A-WEIGHT OFF
WINDOW HANNING
OVERALL -0.8 dBV

FILTER NO.	CENTER FREQ.	LEVEL dBV
#20	100 Hz	-35.8
#21	125	-34.9
#22	160	-33.4
#23	200	-32.7
#24	250	-32.3
#25	315	-31.1
#26	400	-29.9
#27	500	-29.3
#28	630	-28.1
#29	800	-27.4
#30	1.0k	-26.1
#31	1.25k	-25.3
#32	1.6k	-24.7
#33	2.0k	-23.5
#34	2.5k	-22.6

FILTER NO.	CENTER FREQ.	LEVEL dBV
#35	3.15kHz	-21.6
#36	4.0k	-20.5
#37	5.0k	-19.6
#38	6.3k	-18.4
#39	8.0k	-17.5
#40	10.0k	-16.1
#41	12.5k	-15.7
#42	16.0k	-14.4
#43	20.0k	-13.6
#44	25.0k	-12.6
#45	31.5k	-11.5
#46	40.0k	-10.5
#47	50.0k	-9.8
#48	63.0k	-8.7
#49	80.0k	-8.0

Fig. 7-16 Third-octave analytical results of white noise

(a)



(b)

** TR9404 DIGITAL SPECTRUM ANALYZER **
**** MFD BY ADVANTEST ****

1/1 OCTAVE LIST : A-WEIGHT OFF
WINDOW HANNING
OVERALL -0.5 dBV

FILTER NO.	CENTER FREQ.	LEVEL dBV
#21	125 Hz	-29.5
#24	250	-26.8
#27	500	-23.9
#30	1.0k	-21.1
#33	2.0k	-18.4
#36	4.0k	-15.3
#39	8.0k	-12.2
#42	16.0k	-9.4
#45	31.5k	-6.4
#48	63.0k	-3.8

Fig. 7-17 Octave analytical results of white noise

7-11. CALIBRATION USING NOISE METER CALIBRATION SIGNAL

(1) Noise meter

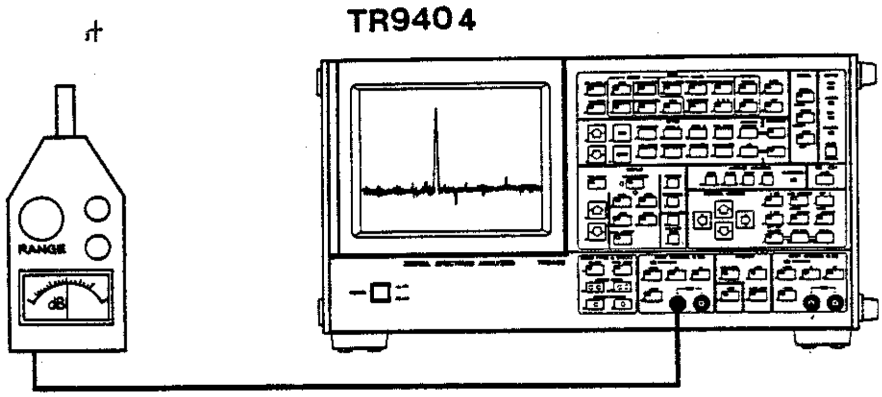


Fig. 7-18 Calibration method using noise meter CAL. signal

Connect the noise meter calibration signal to the TR9404 input connector as shown in Figure 7-18. The relevant calibration procedure in the channel A octave analysis is described below.

① Press the SETUP section [ADVANCED ANALYSIS] key, then set the octave menu in the following way.

ANALYSIS CHAN ..... CH-A

BANDWIDTH .... 1/3 OCT

A-WEIGHTING .... OFF

② Set a frequency range suitable for the noise meter calibration signal.

③ Display the spectrum by pressing the VIEW section [SPECTRUM] key. (See Figure 7-19)

④ Start octave analysis by pressing the EXECUTE key of [ADVANCED ANALYSIS] in the SETUP section. (See Figure 7-20)

⑤ Press the SETUP section [FUNCTION] key, and set the "OVERALL" menu to "ALL".

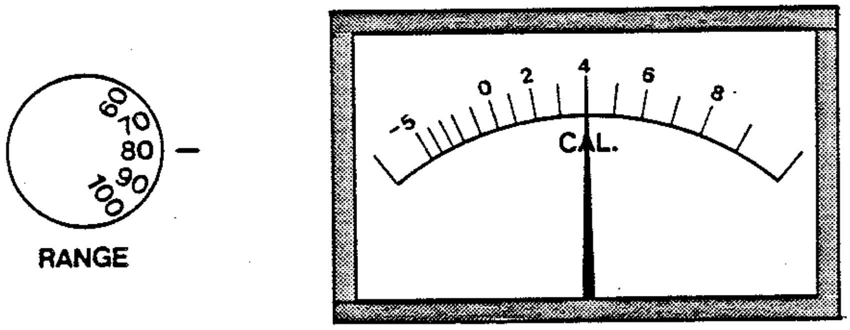


Fig. 7-19 Meter deflection in calibration

⑥ Press the SETUP section WGT/SCALING key to set up "KEY" mode.

⑦ If the noise meter pointer and range readings are assumed to be 84 dB, select a SCALING value of 0 dBEU to obtain a TR9404 OVERALL value of +84.0 dBEU (+7.7 dBV in Figure 7-21).

In this case, if

0 dBEU=-76.3 dBV

is selected, the OVERALL value will be

(+7.7)-(-76.3)=(84.0) [dBEU]

See Figures 7-21 and 7-22.

For procedural details for setting, see 4-4-5. "SETUP", ⑩ SCALING menu.

The TR9404 reading is thereby calibrated, and TR9404 readings in subsequent measurements will be taken as actual sound pressure levels. If measurements are executed after switching the noise meter range, however, the difference between the calibration range and the switched range is subtracted from the TR9404 reading, and the result being used as the actual sound pressure level.

For example, if calibration was conducted in 80 dB range on the noise meter, but the actual measurement is executed after switching to the 90 dB range, the actual sound pressure level for a TR9404 reading of A [dBEU] will be,

A-(80-90)=A+10 [dB]

If a pistonphone is also used in the calibration, the same procedure as described above (steps ① through ⑦) can be used.

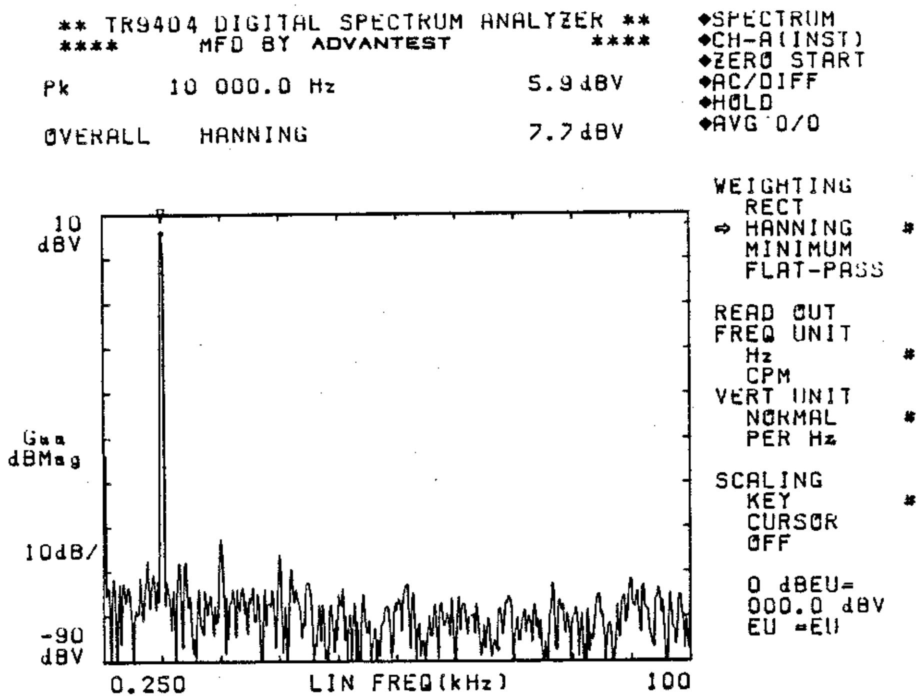


Fig. 7-20 Noise meter CAL. signal

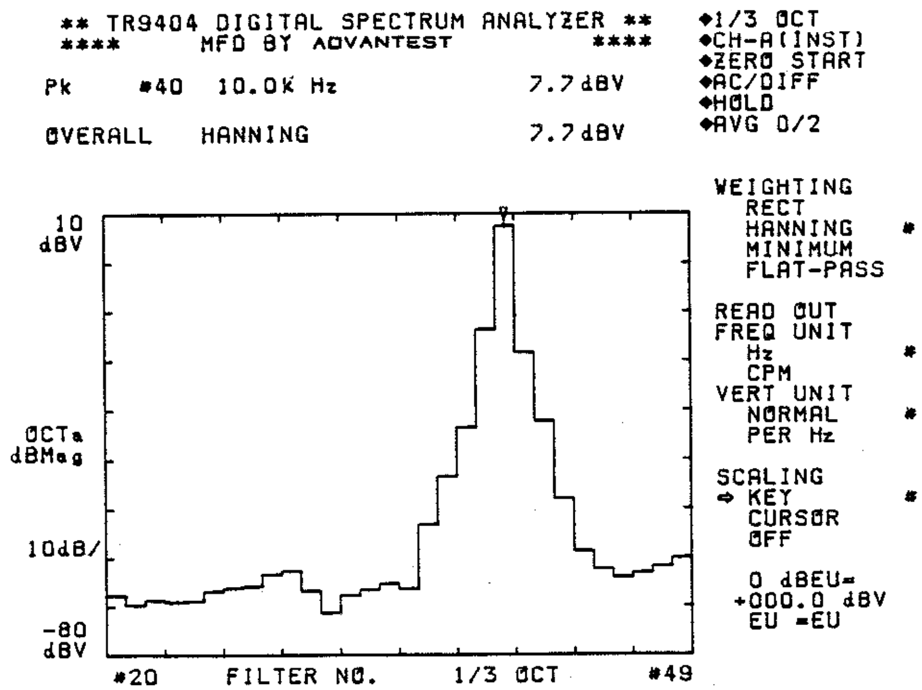


Fig. 7-21 Third-octave analytical results of CAL. signal

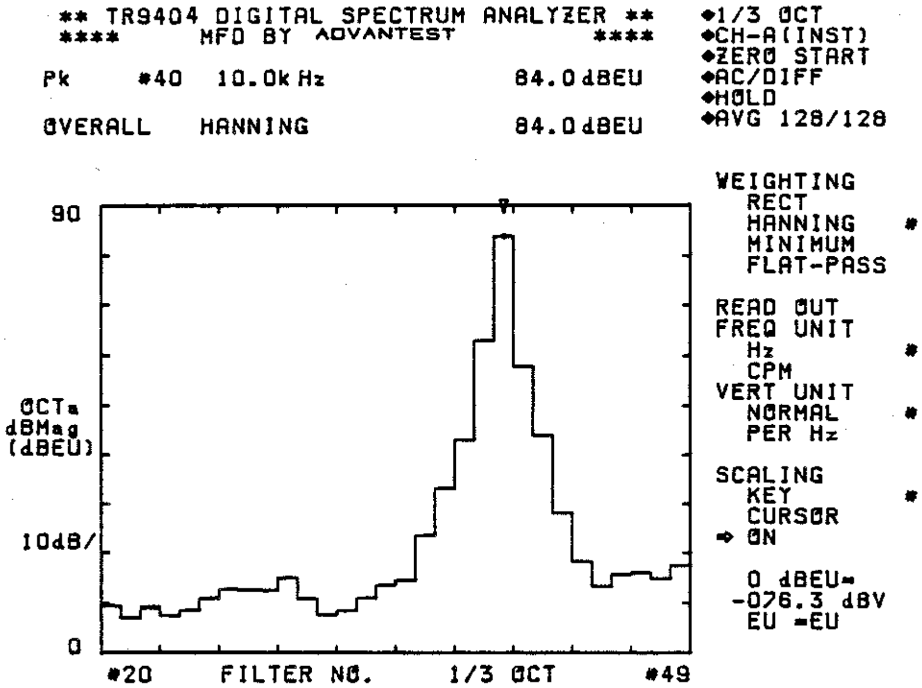


Fig. 7-22 Calibration by scaling

7-12. OUTLINE OF 3-DIMENSIONAL DISPLAY

In the 3-dimensional display (3D DISPLAY) mode, the time-varying waveforms (lower waveforms in the BOTH mode) on the TR9404 CRT are displayed. This mode is very effective to observe the waveform change with time. This display mode is not available for the following:

o List display

o Orbit display

o Nyquist display

These cannot be displayed in the 3-dimensional mode if displayed on the CRT display.

7-13. 3-DIMENSIONAL DISPLAY START PROCEDURE

Press the [ADVANCED ANALYSIS] key in the "SETUP" section to display the menu shown in Figure 7-1. The 3-dimensional display is performed in the following procedure:

① Menu Display for 3-dimensional display

Press the [ADVANCED ANALYSIS] key to display the menu on the CRT, move the pointer (⇨) to "3D DISPLAY" by the [⇧] or [⇩] key in the "SETUP" section, then press the [SETUP] key to display the menu for 3-dimensional display. (If the [SETUP] key is pressed with the pointer at "OCT ANALYSIS", the menu for an octave analysis is displayed.)

② Setting "3D DISPLAY" to <ENABLE>

Move the pointer (⇨) to <DISABLE>, then press the [SETUP] (or [DISP.]) key to set <ENABLE>. After this, <DISABLE> and <ENABLE> are alternately set each time the [SETUP] (or [DISP.]) key is pressed.

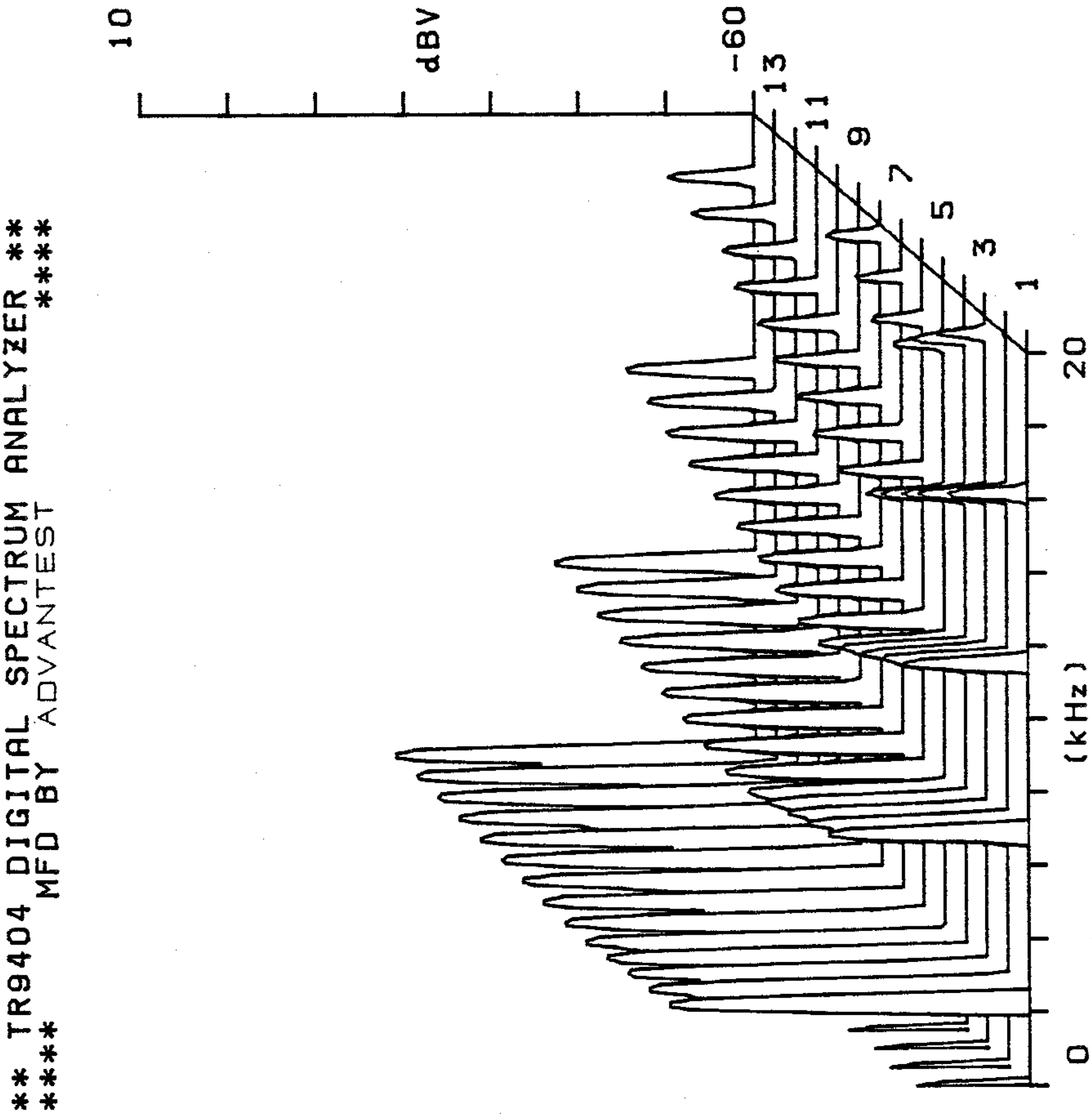


Fig. 7-23 3-dimensional display on CRT display

③ "3D DISP TRIG" setup

There are five timings to display the traces shown on the CRT display in the 3-dimensional mode.

a. "AUTOMATIC"

3-dimensional display is performed according to the TR9404 system's internal timing.

b. "DATA WINDOW"

3-dimensional display is performed each time the data window moves.

c. "AVERAGING"

3-dimensional display is performed each time averaging is performed.

d. "AUTO ARM"

3-dimensional display is performed each time the HOLD state is generated after execution of AUTO ARM or ARM.

e. "GP-IB"

3-dimensional display is performed each time a "DT" command is received from the GP-IB.

Move the pointer (⇨) to one of the above timings, then press the [SETUP] key to set "3D DISP TRIG".

④ Setting "START LINE NO." (See Subsection 7-14, (5).)

Only 14 traces can be displayed on the TR9404 CRT display in the 3-dimensional display mode (output to the plotter allows up to 128 traces). However, 32 traces are stored in the TR9404 memory and the 14 traces can be retrieved and displayed in the 3-dimensional display mode.

"START LINE NO." indicates the line number at which 14 traces start to display in the 3-dimensional display mode.

Figure 7-24 shows the 3-dimensional display when "START LINE NO." is set to "4/32".

NOTE

Setting of "START LINE NO." is effective only when the scrolling is off. See subsection 7-14. (5) for scrolling. Generally, the "START LINE NUMBER" setting can be omitted because latest 14 waveforms are displayed in three dimension.

To set "START LINE NO.", move the pointer (⇨) to the "START LINE NO." setting position, then press the DISP. (or SETUP) key; numbers will change as follows:

1, 2, 3,..., 19, 1, 2, 3,... (or 19, 18, 17,...,1, 19, 18,...)

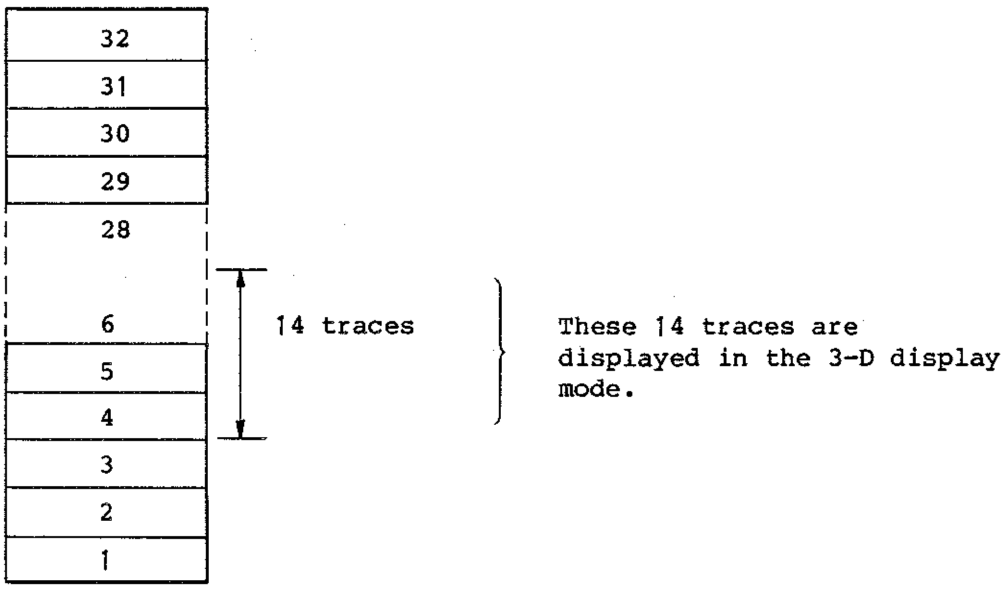


Fig. 7-24 3-dimensional display when START LINE NO. = 4/32

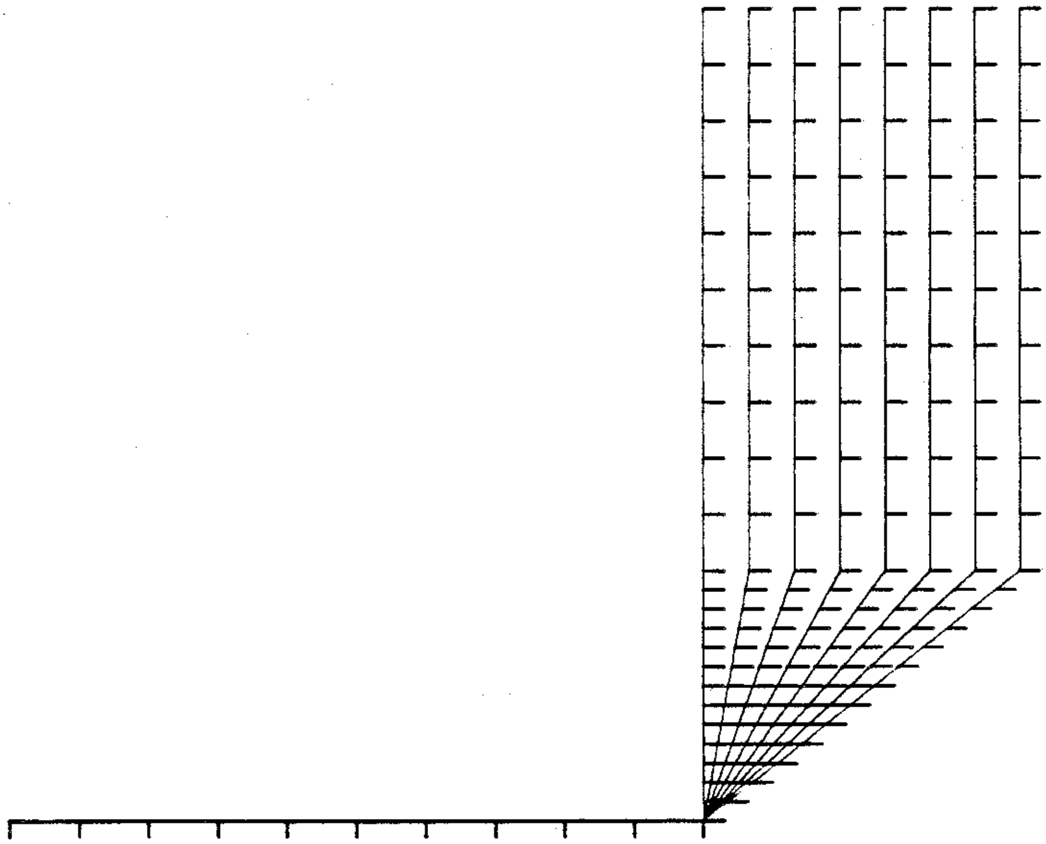


Fig. 7-25 Display angles in 3-D display mode

⑤ Setting "ANGLE FACTOR" (See Subsection7-14, (4).)

In the 3-dimensional display mode of the TR9404, eight types of display angles are settable as shown in Figure 7-25.

Th setting method is the same as that for "START LINE NO." Move the pointer (⇨) to the 0 (90°) position, then press the [DISP.] (or [SETUP]) key; 90°, 84°, 77°, 71°, 60°, 56°, and 51° will be displayed in sequence by sellecting an angle.

⑥ Setting "3D DISP SOURCE"

If the "3D DISP SOURCE" is set to the "SYSTEM", the trace shown on the CRT is displayed in the 3-dimensional mode. If it is set to "FLOPPY", the trace of the data read from the floppy disk to the TR9404 is displayed in the 3-dimensional display mode. Set the "3D DISP SOURCE" to the "SYSTEM" when the TR98102 is not used.

When the "3D DISP SOURCE" is set to the "FLOPPY", see the instruction manual of TR98102.

⑦ Setting "3D DISP OUTPUT" (See Subsetion 7-14, (3).)

This setup is used to determine whether the CRT screen, plotter, or X-Y recorder is used for 3-dimensional output.

Move the pointer (⇨) to "CRT" or "HARD COPY", then press the [SETUP] key.

⑧ Setting "STACK LINE NO." (See Subsection 7-14, (3).)

If the "3D DISP OUTPUT" is set to the "HARD COPY" in step ⑦, the pointer (⇨) can be moved to "STACK LINE NO." (When the CRT screen is used for 3-dimensional display, the number of traces that can be displayed is fixed to 14. If the CRT is selected in step ⑦, the pointer cannot be moved to "STACK LINE NO.")

Move the pointer to the specified position, then press the [DISP.] (or [SETUP]) key; 16, 32, 64, 128, 16,... will be displayed in sequence by selecting a number.

⑨ 3-dimensional display start

Settings for 3-dimensional display are completed by executing steps ① to ⑧. Display the data you want in the 3-dimensional display mode (display it in lower portion in the BOTH mode), press the EXECUTE key on the right of the [ADVANCED ANALYSIS] key in the "SETUP" section.

(10) 3-dimensional display stop

If the ADVANCED ANALYSIS EXECUTE key is pressed during 3-dimensional display, the execution of 3D display stops. This key is also used to start and stop an octave analysis. See Subsection 7-5-1 for details.

7-14. NOTES ON 3-DIMENSIONAL DISPLAY

(1) Relationship with 1/1- or 1/3-octave analysis

Since the EXECUTE key beside the [ADVANCED ANALYSIS] is common to 1/1- or 1/3-octave analysis and 3-dimensional display, these two functions are executed if the "OCT ANALYSIS" and the "3D DISPLAY" are both set to the <ENABLE>.

To execute only the 3-dimensional display function, set the "OCT ANALYSIS" to <DISABLE>.

To display the result of the octave analysis in the 3-dimensional display mode, set the "OCT ANALYSIS" and the "3D DISPLAY" to the ENABLE , then press the EXECUTE key to execute both functions. If the TR9404 is under the setup conditions which inhibit the 1/1- or 1/3-octave analysis (for example, the "OCT MODE" is set to the "STATIONARY" with the frequency range set to 1 kHz or less (refer to the 1/1- or 1/3-octave analysis for details)), both functions are not executed.

(2) Notes on setting other than the "3D DISP TRIG" = "AUTOMATIC"

When an item other than the "AUTOMATIC" is selected in the "3D DISP TRIG" menu, the 3-dimensional display is not performed if the other involved functions are not performed. For example, if the "3D DISP TRIG" is set to the "AVERAGING", the 3-dimensional display cannot be achieved without averaging because it is advanced every time averaging is carried out.

The same is true for the other functions; when "DATA WINDOW" is selected, movement of the data window is to be started; when the "AUTO ARM" is selected, ARM (or AUTO ARM) is to be started; when "GP-IB" is selected, the DT command should be issued.

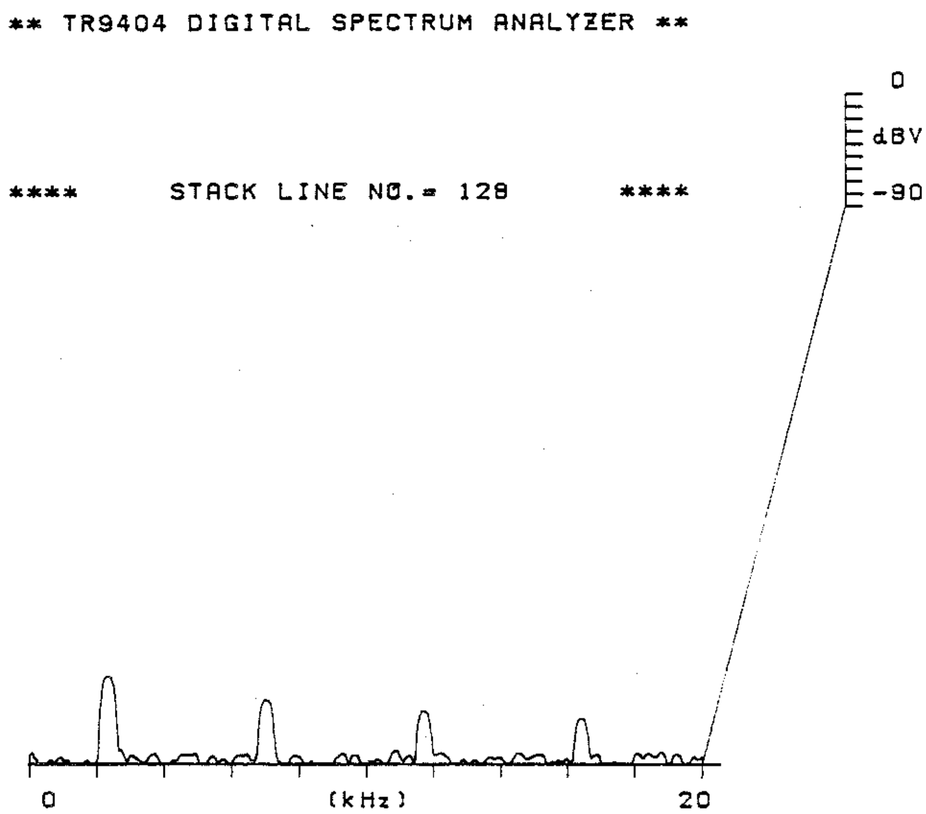
(3) There are two methods to output 3-dimensional data to the plotter as shown in Table 7-4.

Table 7-4 Output of 3-D display to the plotter (XY recorder)

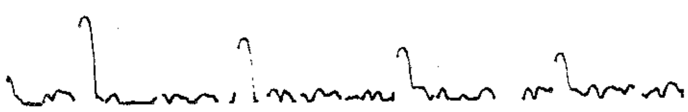
3D-display / menu	"3D DISP OUTPUT" = CRT	"3D DISP OUTPUT" = HARD COPY
Plotting features	14 traces on the CRT thinned out in 200 lines are plotted to the external device (200-line data irrespective of display domain)	The traces with the resolution (lines) equivalent to the CRT display (traces not thinned out) are plotted
I/O SELECT menu	Set to "PLOTTER" or "XY-RCDR" ("PLOTTER TYPE" should also be defined in case of "PLOTTER")	
Setup of "STACK LINE NO."	Not available (3-D traces on the CRT are fixed to 14)	Stacking display according to the preset number (16, 32, 64, 128)
ADVANCED ANALYSIS	Pressing EXECUTE key starts 3-D display on the CRT	Pressing EXECUTE key starts 3-D display and plotting
I/O	Pressing EXECUTE key start plotting	LED lamp within the EXECUTE key is lit up
To stop in process of plotting	Press EXECUTE key at the right of I/O	

```
I/O SELECT
   XY-RCDR
=> PLOTTER      #
   FLOPPY

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
   TAKEDA
PLOT ANGLE
   NORMAL
```

Fig. 7-26 "I/O SELECT" menu



(a) Example of display and plotting of first trace



(b) Example of display and plotting of second trace

Fig. 7-27 Example of 3-dimensional display

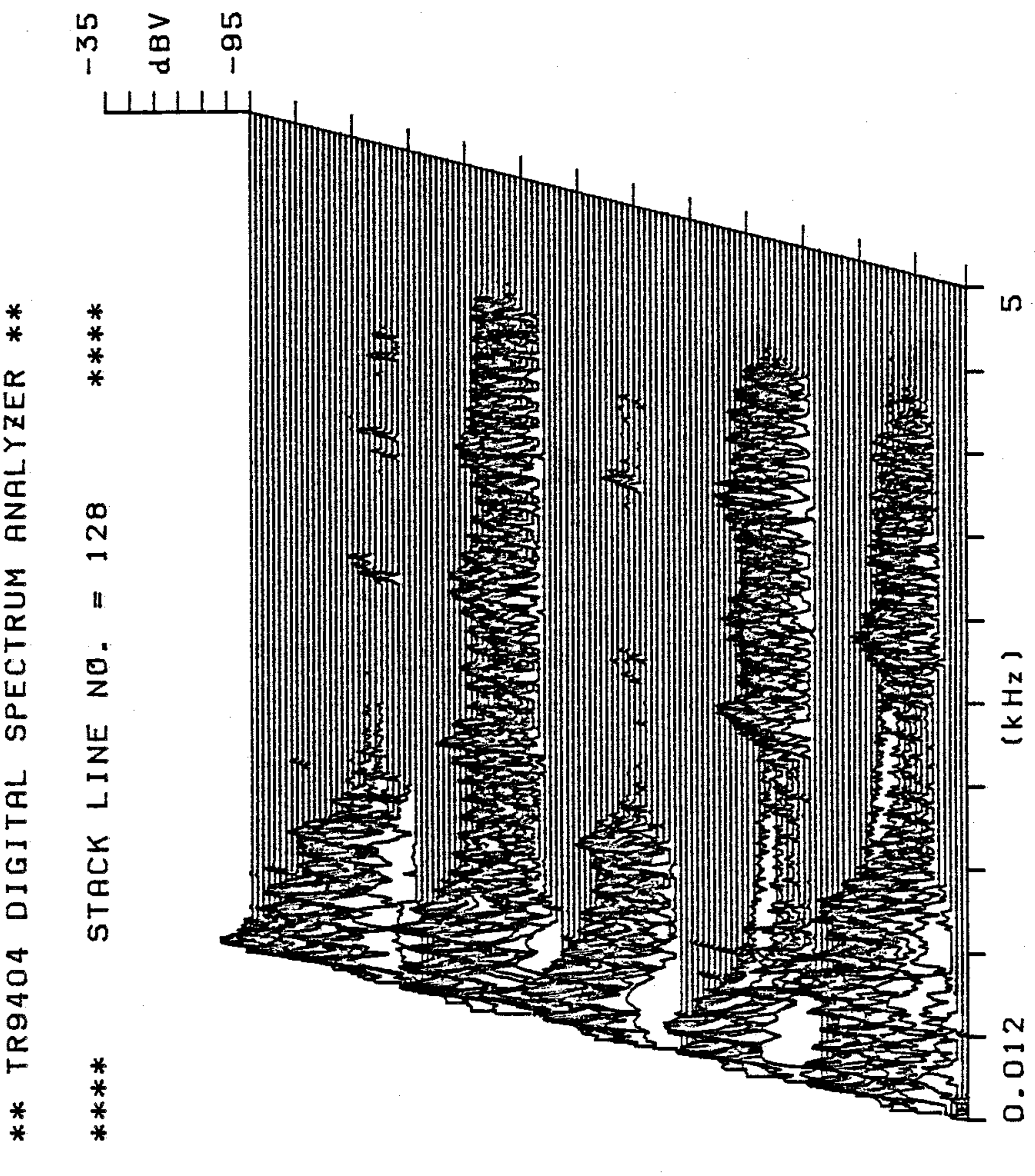


Fig. 7-28 Example of 3-dimensional display
(Stack line number = 128)

(4) Angle factor

An "ANGLE FACTOR" is an angle of 3-dimensional display when the "3D DISP OUTPUT" is set to the "CRT". When the "3D DISP OUTPUT" is set to "HARD COPY", the 3-dimensional display angle is dependent on the stack line number and an angle factor as shown in Table 7-5.

Table 7-5 3-dimensional display angle ("3D DISP OUTPUT" = "HARD COPY")

STACK LINE No.	ANGLE FACTOR	Actual angle (deg)
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

NOTE

The 3-dimensional display angle can be changed during the 3-D display with the ⇧ or ⇩ key if the pointer (⇨) is set to the "ANGLE FACTOR" before execution of 3-D display (When the "3D DISP OUTPUT" is set to "HARD COPY", the 3-dimensional display angle cannot be changed while the 3-D display is in progress.)

(5) START LINE NO. and memory

The start line number indicates the number of the line from which 14 traces (out of 32 traces stored in memory) are to be displayed on the CRT in the 3-dimensional mode. (See Subsection 7-13, 4 .) The start line number is effective when the "3D DISP OUTPUT" is set to the "CRT" and the scrolling is off; not effective when "3D DISP OUTPUT" is set to the "HARD COPY".

If the ADVANCED ANALYSIS EXECUTE key is pressed after setting the "3D DISP OUTPUT" to the "CRT", the 3-dimensional display may not be started immediately. This occurs when "START LINE NO." is set to a value other than 1 (2 to 19). The reason is as follows:

The system incorporates memory to store 1-32 traces.

Traces are sequentially stored from memory 1 to memory 32 every time the "3D DISP TRIG" conditions ("AUTOMATIC", "DATA WINDOW", AVERAGING", "AUTO ARM", "GP-IB") are satisfied. When a trace is stored in memory 32, the contents of memory 1 is dumped. The contents of memory 1 are replaced with the contents of memory 2; the contents of memory 2 are replaced with the contents of memory 3; and, similarly, the contents of memory 31 are replaced with the contents of memory 32.

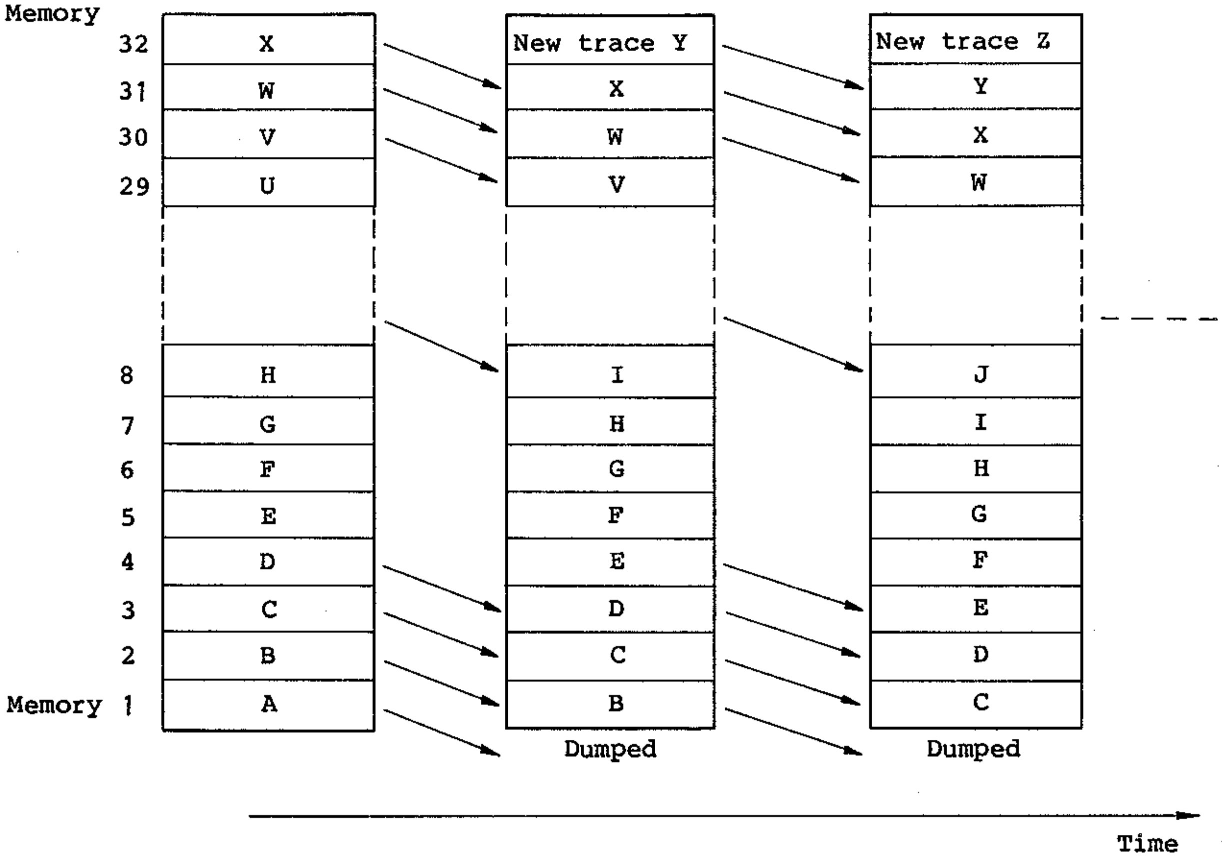


Fig. 7-29 System memory scrolling

The trace that meets the "3D DISP TRIG" menu setup requirement is stored in memory 32. Then, the above operation is repeated; the contents of memory 1 are always dumped and the latest trace is stored in memory 32. (See Figure 7-30.)

The 3-dimensional display starts scrolling after traces are stored up to memory 32.

To stop this scrolling, press the C (⇕) key in the "GENERAL CURSOR" section (the lamp in the key turns on). While the 3-dimensional display is performed, this key turns on or off the scrolling (scrolling ON: the lamp is off, scrolling OFF: the lamp is on). Accordingly, the lamp of this key is off when the 3-dimensional display starts; the scrolling mode is activated.

If the C (⇕) key is pressed to deactivate the scrolling mode and the ⇧ (or ⇩) key in the "GENERAL CURSOR" section is pressed, the start line number can be automatically incremented (or decremented) by 1. Thus, the assigned 14 traces from among 32 traces stored in the system can be displayed in the 3-dimensional display mode.

If the ⇧ key (or ⇩ key) is pressed again, the start line number is fixed. (See Figure 7-30.)

The upper and lower limits of the start line number are 1 and 19 respectively.

(6) 3-dimensional display when "+1 AVG" is set

With the "3D DISP TRIG" set to the "AVERAGING" and the average setting condition "AVG PROCESS" set to "+1 AVG" as shown in Figure 7-31, the 3-dimensional display is not realized even if the START key in the "AVERAGE CONTROL" section is pressed to start averaging. The averaging is carried out each time the CONT. key in the "AVERAGE CONTROL" section is pressed. In this case, the 3-dimensional display is seen for approximately 1 second, then normal display is shown on the CRT. The +1 AVG mode is used to measure a transfer function of a certain system according to the impulse method. In this case, it is necessary to check the incoming signal for the appropriateness of the input to the system. While the 3-dimensional data is displayed on the CRT the input signal cannot be monitored; the 3-dimensional display is shown only for approximately 1 second at each press of the CONT. key to increment averaging. When averaging is completed (after averaging is performed 16 times when AVG NUMBER is set to 16), the 3-dimensional display is continued on the CRT.

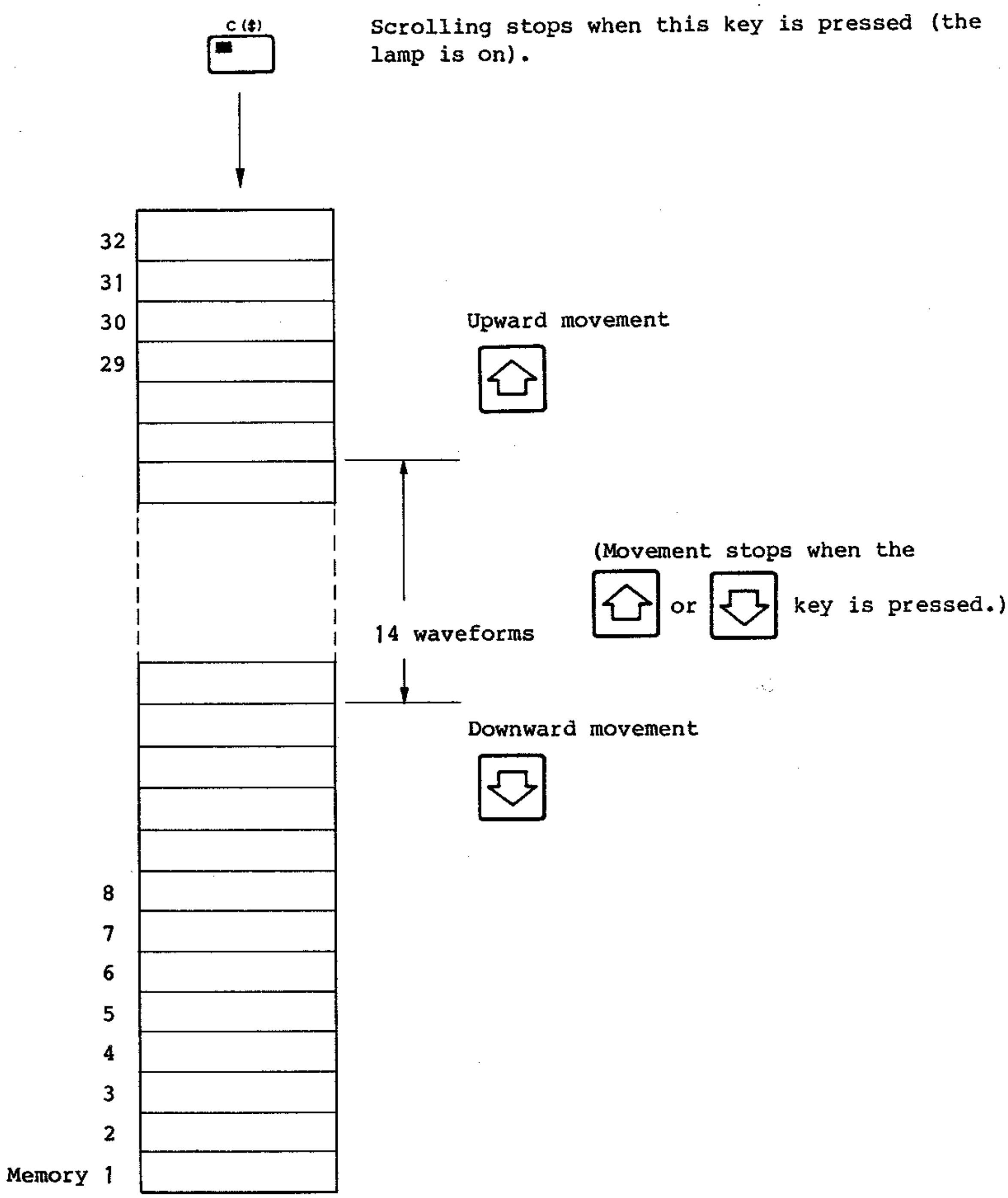


Fig. 7-30 Change of a start line number after stopping scrolling

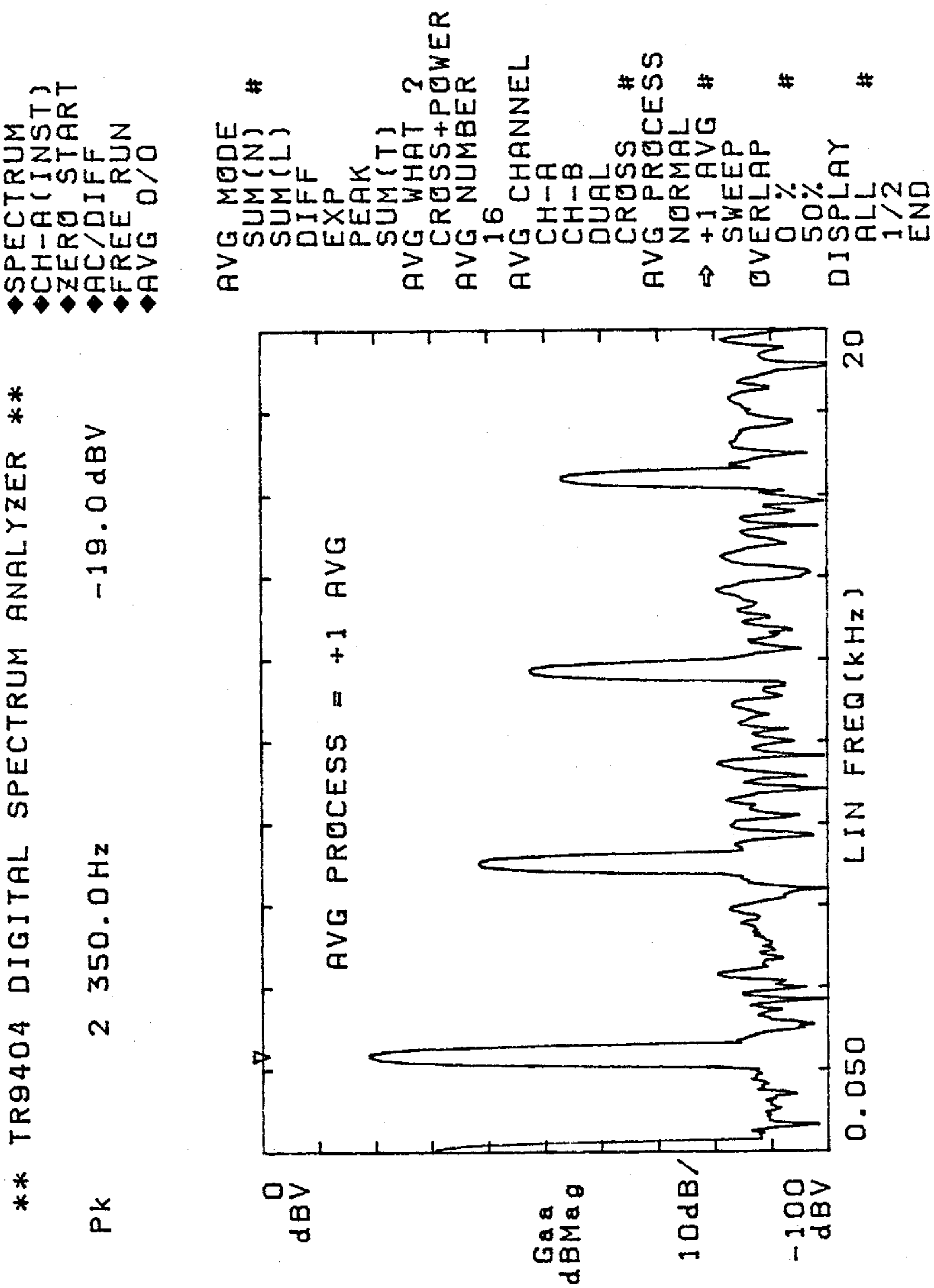
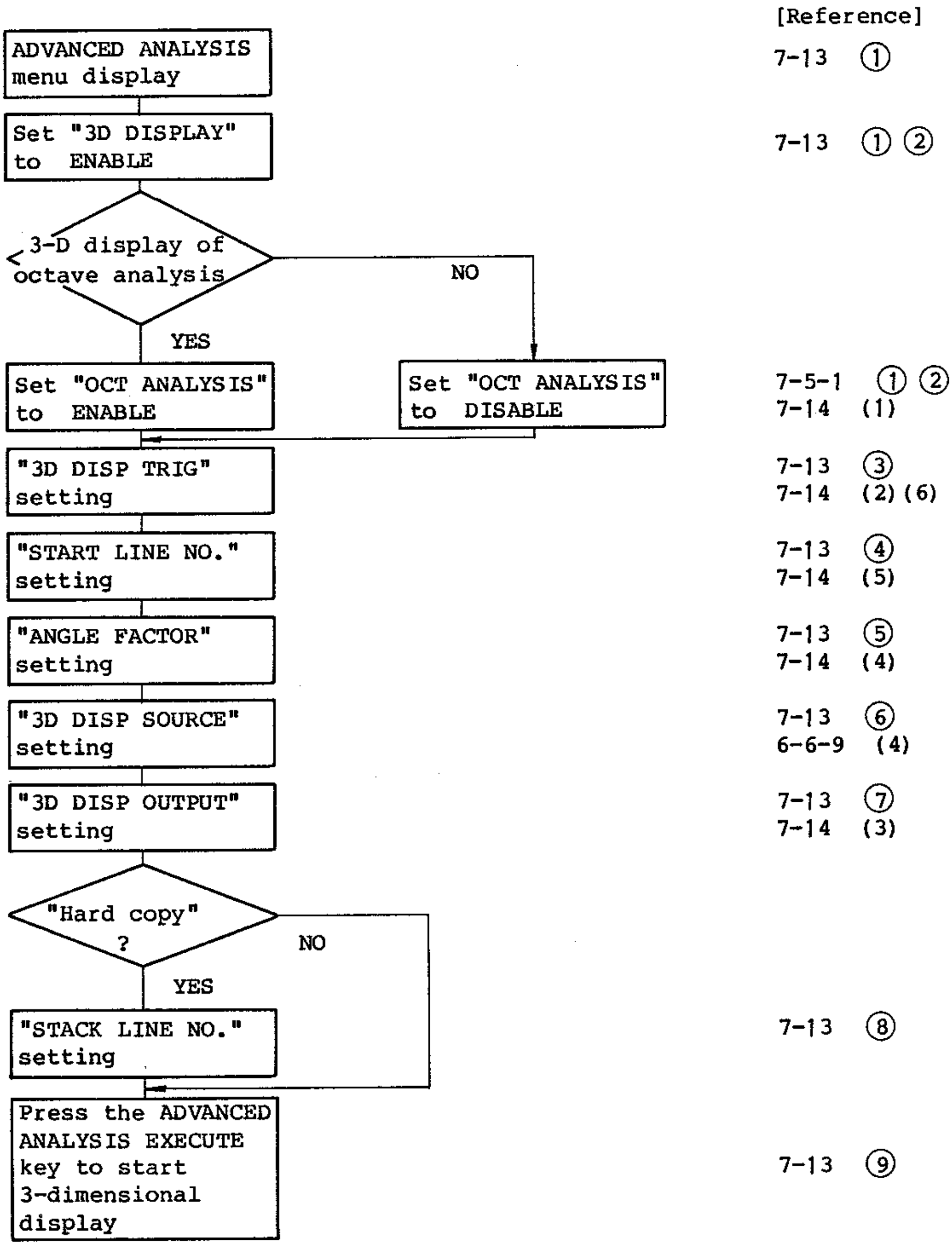


Fig. 7-31 AVG PROCESS = +1 AVG setting

7-15. 3-DIMENSIONAL DISPLAY START PROCEDURE IN FLOWCHART

Setting procedure for the 3-dimensional display is shown as follows:



7-16. EXECUTION AND CANCELLATION OF THE 3-D DISPLAY AND OCTAVE ANALYSIS

Press the EXECUTE key on the right of the ADVANCED ANALYSIS key to start execution of two ADVANCED ANALYSIS functions: the 3-dimensional display and the 1/1- and 1/3-octave analysis.

Methods for execution and cancellation of these functions are as follows;

(1) Executing only the 1/1- and 1/3-octave analysis function
Set only the "OCT ANALYSIS: to ENABLE , then press the ADVANCED ANALYSIS EXECUTE key to start execution.

(2) Executing only the 3-dimensional display function
Set only the "3D DISPLAY" to ENABLE , then press the ADVANCED ANALYSIS EXECUTE key to start execution.

(3) Executing simultaneously both functions
Set both functions to < ENABLE >, then press the ADVANCED ANALYSIS EXECUTE key to start execution.

(4) Executing the 3-dimensional display function during the octave analysis explained in (1) above
Set "3D DISPLAY" to ENABLE to start the 3-dimensional display.

(5) Cancelling only the 3-dimensional display function during execution of both functions
Set the "3D DISPLAY" to DISABLE to cancel only the 3-dimensional display function. However, the menu is not displayed while the 3-dimensional display is shown on the CRT screen; move the pointer (⇨) to ENABLE of the "3D DISPLAY" before starting the 3-dimensional display. Thus, the "3D DISPLAY" is set to DISABLE by pressing the [DISP.] or [SETUP] key during execution of both functions, that is, only the 3-dimensional display function can be cancelled.

(6) Cancelling simultaneously both functions
Press the ADVANCED ANALYSIS EXECUTE key when both functions are executed; they will be cancelled at the same time.

(7) Cancelling either the octave analysis or the 3-dimensional display function
Press the ADVANCED ANALYSIS EXECUTE key to cancel the executing function.

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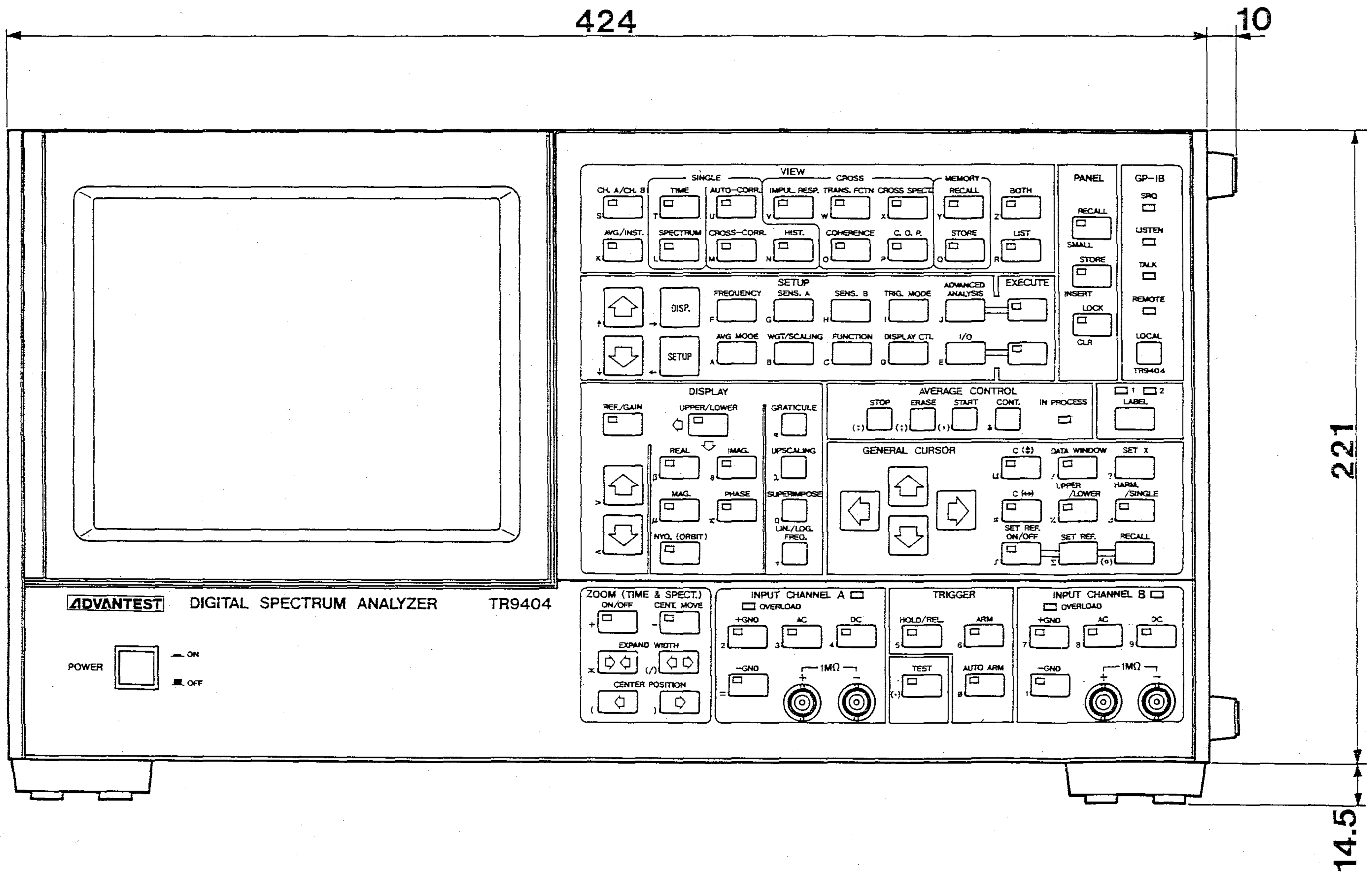
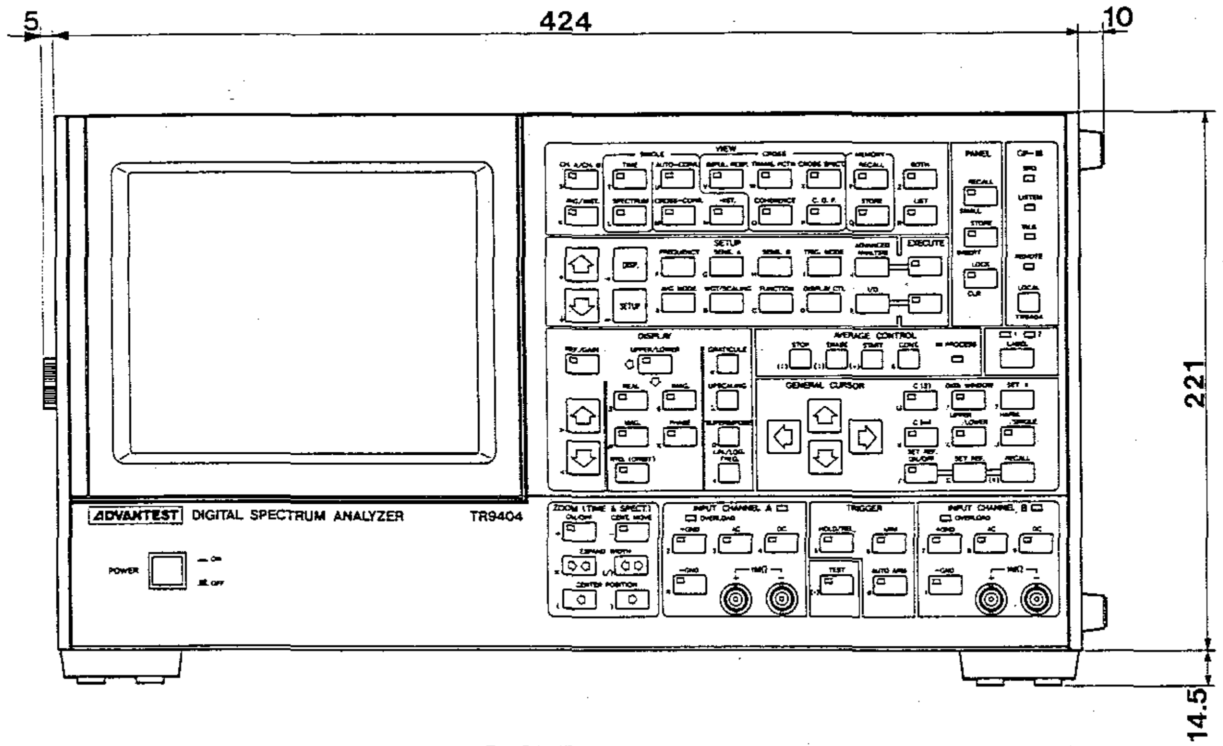
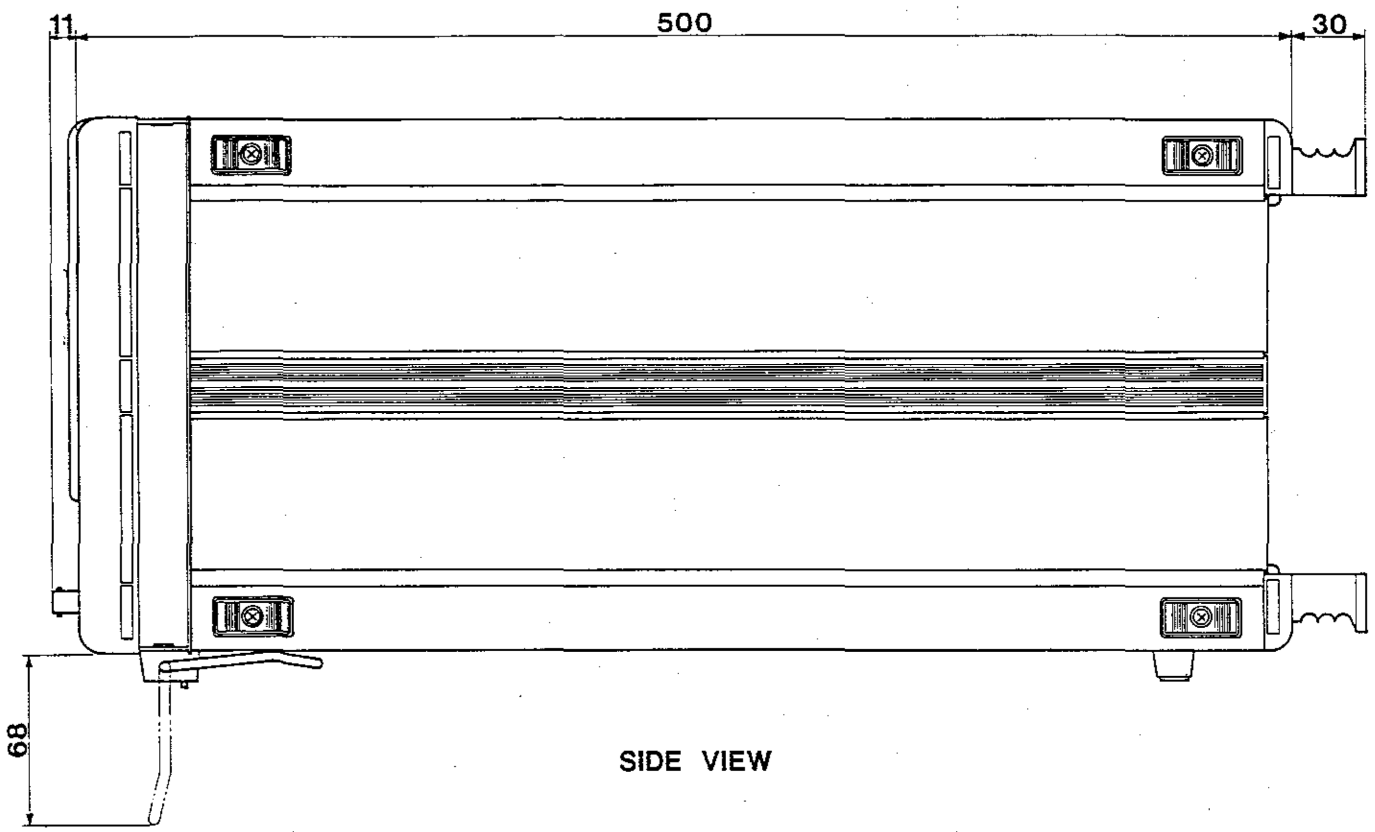


424
10
221
14.5
ADVANTEST
DIGITAL SPECTRUM ANALYZER
TR9404
POWER
ON
OFF
VIEW
SINGLE
CROSS
MEMORY
CH. A/CH. B
TIME
AUTO-CORR.
IMPUL. RESP.
TRANS. FCTN
CROSS SPECT.
RECALL
BOTH
AVG/INST.
SPECTRUM
CROSS-CORR.
HIST.
COHERENCE
C. O. P.
STORE
LIST
SETUP
DISP.
FREQUENCY
SENS. A
SENS. B
TRIG. MODE
ADVANCED ANALYSIS
EXECUTE
AVG MODE
WGT/SCALING
FUNCTION
DISPLAY CTL
I/O
PANEL
RECALL
SMALL
STORE
INSERT
LOCK
CLR
GP-IB
SRQ
LISTEN
TALK
REMOTE
LOCAL
TR9404
DISPLAY
REF./GAIN
UPPER/LOWER
GRATICULE
REAL
IMAG.
UPSCALING
MAG.
PHASE
SUPERIMPOSE
NYQ. (ORBIT)
LIN./LOG. FREQ.
AVERAGE CONTROL
STOP
ERASE
START
CONT.
IN PROCESS
LABEL
GENERAL CURSOR
DATA WINDOW
SET X
UPPER /LOWER
HARM. /SINGLE
SET REF. ON/OFF
SET REF.
RECALL
ZOOM (TIME & SPECT.)
ON/OFF
CENT. MOVE
EXPAND WIDTH
CENTER POSITION
INPUT CHANNEL A
OVERLOAD
+GND
AC
DC
−GND
1MΩ
TRIGGER
HOLD/REL.
ARM
TEST
AUTO ARM
INPUT CHANNEL B
OVERLOAD
+GND
AC
DC
−GND
1MΩ

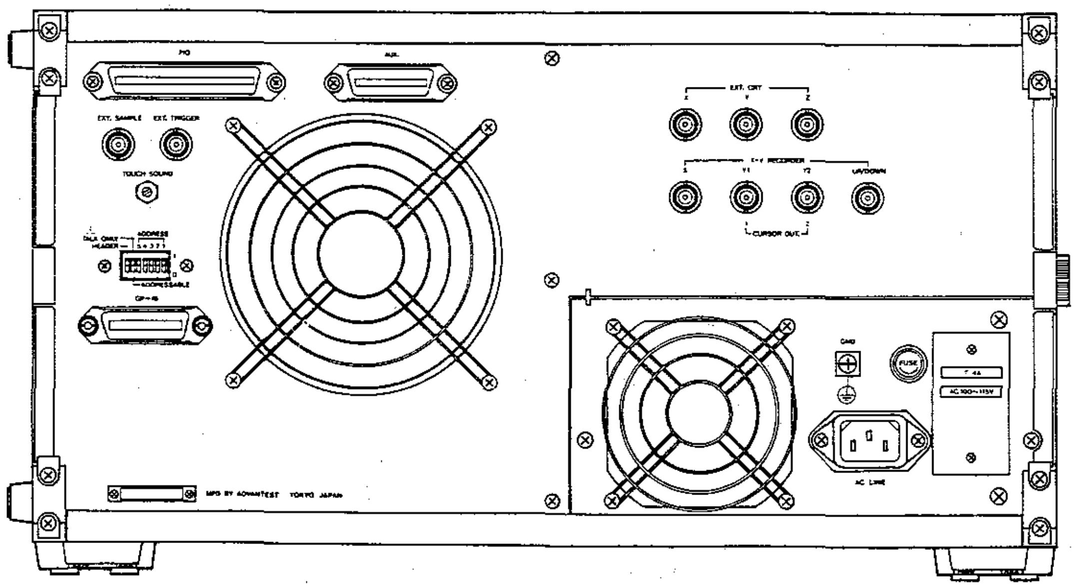
FRONT VIEW



FRONT VIEW



SIDE VIEW



REAR VIEW

TR 9404
EXTERNAL VIEW

2

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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.

Some of the components and parts of this Product have a limited operating life (such as, electrical and mechanical parts, fan motors, unit power supply, etc.). Accordingly, these components and parts will have to be replaced on a periodic basis. If the operating life of a component or part has expired and such component or part has not been replaced, there is a possibility that the Product will not perform properly. Additionally, if the operating life of a component or part has expired and continued use of such component or part damages the Product, the Product may not be repairable. Please contact the nearest Advantest office listed at the end of this Operation Manual or Advantest's sales representatives to determine the operating life of a specific component or part, as the operating life may vary depending on various factors such as operating condition and usage environment.

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