ADVANTEST®
ADVANTEST CORPORATION

INSTRUCTION MANUAL

TQ88091

Optical Actuator Test Head

MANUAL NUMBER 88091 OEB 611

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.

Printed in Japan

RECORD OF REVISIONS

Rev. No.	Date	Remarks	Rev. No.	Date	Remarks
OEA	May 9/86				
OEB	Nov 4/86				

LIST OF EFFECTIVE PAGES

#	Record of Revisions	R - 1	Nov 4/86
#	List of Effective Pages	P - 1	Nov 4/86
	Table of Contents	C - 1	May 9/86
	1 - 1		May 9/86
	1 - 2		May 9/86
	1 - 3		May 9/86
	1 - 4		May 9/86
	1 - 5		May 9/86
	2 - 1		May 9/86
	2 - 2		May 9/86
	2 - 3		May 9/86
	3 - 1		May 9/86
	3 - 2		May 9/86
	3 - 3		May 9/86
	3 - 4		May 9/86
	3 - 4		May 9/86
	3 - 5		May 9/86
	3 - 6		May 9/86
	3 - 7		May 9/86
	3 - 7		May 9/86
	3 - 8		May 9/86
	3 - 9		May 9/86
	3 - 10		May 9/86
#	3 - 11		Nov 4/86
	3 - 12		May 9/86
	3 - 13		May 9/86
	3 - 14		May 9/86
	3 - 15		May 9/86
#	3 - 16		Nov 4/86
#	3 - 17		Nov 4/86
	3 - 18		May 9/86
	4 - 1		May 9/86
	4 - 2		May 9/86
	4 - 3		May 9/86
	4 - 4		May 9/86
	4 - 5		May 9/86
	4 - 6		May 9/86
	4 - 7		May 9/86
	4 - 8		May 9/86
	4 - 9		May 9/86
	4 - 10		May 9/86
	4 - 11		May 9/86
	4 - 12		May 9/86
	4 - 13		May 9/86
	4 - 14		May 9/86
	4 - 15		May 9/86
	4 - 16		May 9/86
	4 - 17		May 9/86
	5 - 1		May 9/86
	5 - 2		May 9/86
	6 - 1		May 9/86
	6 - 2		May 9/86
	6 - 3		May 9/86
	List of Figures	F - 1	May 9/86
	List of Tables	T - 1	May 9/86
	List of Examples	E - 1	May 9/86

Note: Pages with # are revised.
Pages with ## are added.
Pages with ( ) are deleted.

TABLE OF CONTENTS

1. GENERAL INFORMATION

1.1 GENERAL

When used together with the frequency response analyzer (T592A), TQ88091 optical actuator test head can convert the vibrating object displacement of DC to 50 kHz into voltage, and can measure the vibrating object response and displacement.

TQ88091 uses an He-Ne (Helium-Neon) laser having stable spatial coherence as a source of light for testing. By selecting the laser tube with extremely low-level noise, it can secure wide dynamic range from 4 mm to 0.04 μm (110 dB) of test displacement. TQ88091 expands the outgoing optical beam from the laser tube by using a high-precision optical system, and positions a slit (0.5 x 4.0 mm) at the center of the tube to form a stable beam having uniform optical intensity. TQ88091 tests DUT (device under test) using a simple method, that is, by setting the DUT so that its vibrating section (actuator vibrating section) shuts out approx. half of the test optical beam.

The amount of light of the test beam (not reflecting light) is varied by the vibrating section. TQ88091 receives the test beam directly through the photodiodes to be converted into an electrical output, thus ensuring high sensitivity (0.4 μm/mV), and enabling measurement outside a darkroom.

The solidly built TQ88091 combines the chassis constituting the optical system and the base on which DUT is placed into the unit. Accordingly, TQ88091 requires no special equipment such as a vibration isolator panel and can perform stable testing over a long period.

1.2 FEATURES

(1) Can measure in wide displacement ranges from 4 mm to 0.04 μm (100 dB). Furthermore, this test head can enhance the dynamic range in the equivalent testing over the range from 4 mm to 0.0014 μm (130 dB) when combined with the frequency response analyzer (T592A).

(2) Uses a photo electric conversion system. The photo electric conversion is made from a direct light whose quantity varies with DUT vibration. Thus, the TQ88091 achieves a high basic sensitivity (0.4 μm/mV).

(3) Because an He-Ne laser is used as a light source, the test beam can be visually confirmed when setting a DUT. Furthermore, this TQ88091 can test the DUT rapidly because it does not require high positional precision.

(4) The focus and tracking characteristics in the measurement of actuator's displacement can be switched only by rotating the test beam outgoing tube. Therefore, no switching of the DUT position is required.

(5) Because the actuator coil bias power source is installed, no other power sources are required.

(6) Because of the solid structure of the test head, it requires no special equipment such as a vibration isolator panel.

1.3 ACCESSORIES SUPPLIED

Accessories supplied with this unit are given below.

Item	Stock No.	Qty	Remarks
Interconnection cable	MI-39	1	For DC bias connection
Time-lag fuse	MDX-1.25 A	1	For 100 V AC
3-pin-to-2-pin adaptor	A09034	1	
Instruction manual		1	

Use the cable provided for the frequency response analyzer (T592A) to connect the output signal from the signal generator.

1.4 SPECIFICATIONS

(Specifications for TQ88091 only)

Type	: Displacement measurement of traversed optical beam
Shape of DUT	: Smaller than 100 x 50 x 50 mm (the vibrating section should have a convex configuration.)
Test optical beam	: Slit transmission light of 0.5 x 4.0 mm (light intensity 60 µW, wave length 0.633 µm)
Test amplitude displacement	: 4 mm to 0.04 µm
Basic sensitivity	: 0.4 µm/mV (When setting the mode selector to the CAL mode to adjust the level meter pointer to the center)
Test precision	: ±10%
Response frequency	: DC - 50 kHz
Bias power source for actuator	: 0 to 4 V 100 mA max.
Signal output	: 0 to -10 Vp-p, applied to the frequency response analyzer (T592A)
Operating environment	: Temperature 0°C to +40°C
Relative humidity	: 85% Max.
Storage temperature	: -20°C to +60°C
Warmup time	: 15 minutes (time required for obtaining stable laser tube temperature)
Power source	: 100 V AC, 50/60 Hz, 25 VA Max.
External dimensions	: 420 mm (width), 300 mm (height), 420 mm (depth)
Weight	: Approx. 18 kg

(Specifications of TQ88091 in combination with T592A)

Effective test range	: 4 mm to 0.0014 µm (130 dB)
Test time	: Approx. 6 minutes (2 Hz to 20 kHz/4 decades, measurement for 112 points, averaging number: 2)
Signal processing	: Signal detection and processing with T592A tracking filter

1.5 SETTING FACILITY

TQ88091 has no facility for fixing and setting DUTs; however, the following stage is recommended:

- Y-Z mechanical stage (Made by Chuo Seiki C-88)

  Installed on the TQ88091 base to move the DUTs in any of three directions: upward, forward, and backward.

2. PREPARATIONS AND PRECAUTIONS BEFORE USE

2.1 CHECKING

At the time of delivery, check if any damage has occurred to TQ88091 during shipping. If there is any damage or it does not function normally, contact your nearest Advantest representative.

2.2 PRECAUTIONS FOR TRANSPORTATION

When transporting TQ88091, use the originally sent packaging material or material of equal or better quality.

2.3 OPERATION ENVIRONMENT

(1) Do not place the equipment where it may be covered with a lot of dust, exposed to direct sunlight, or corrosive gases. Operating temperatures should be between 0°C and +40°C, and humidity should be 85% Max.
Since condensation may occur on the equipment, avoid any environment with extreme temperature fluctuations.

(2) TQ88091 has been designed to withstand noise generation from an AC power source line: however, choose an environment with the least possible noise.

(3) Avoid any environment where vibration occurs frequently.

(4) Because of the solid construction of TQ88091, it is relatively heavy, so prepare a solid working table and set TQ88091 on it firmly.

2.4 POWER SOURCE AND FUSE

(1) Grounding

To avoid AC power source electric shock hazards, ground the center prong of the TQ88091 power source connector to the ground. The plug consists of three pins; the center round-shaped prong is used as the ground. Thus, when the plug is connected to the three-pole plug socket, the center pin is grounded.

When using the accessory adaptor A09034 (KPR-18) for this plug, ground the "ground line" (See Figure 2-1 (a)) connected to the adaptor when inserting it into a plug socket. This adaptor A09034 conforms to Electrical Appliance and Material Control Law. Since the widths of electrodes A and B of the adaptor are different, confirm the orientation of the adaptor before inserting it into the plug socket.

If A09034 cannot be connected to the plug, buy another KPR-13 adaptor.

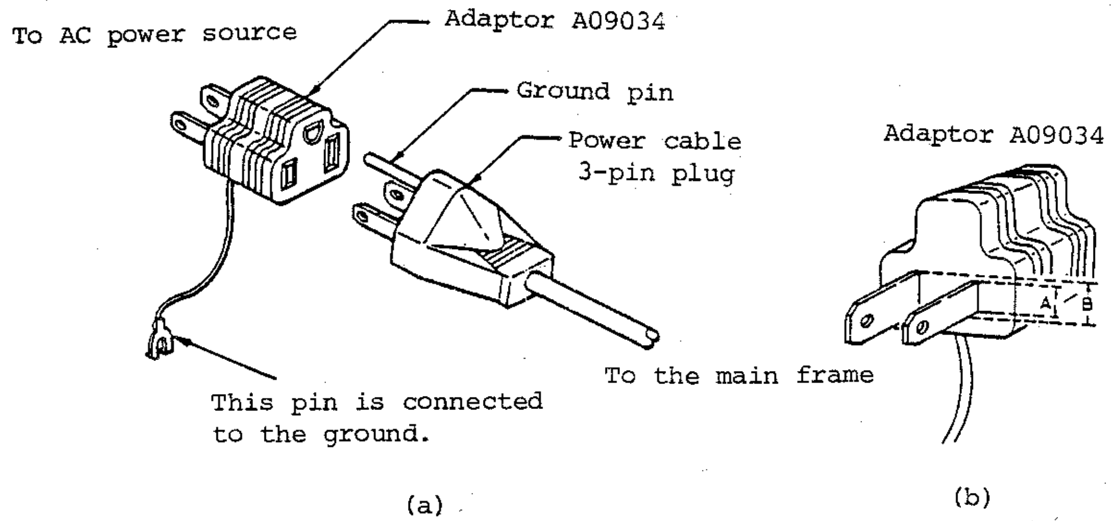


Figure 2-1 Power Cable Plug and Adaptor

(2) Replacing fuses
When replacing a fuse, be sure to remove the power cable from the AC line connector.
Then, insert the flat-tipped screwdriver into the fuse holder cap, and turn the driver counterclockwise to remove the fuse. Note that this fuse should be replaced with the standard type fuse as below.

Power supply	Rating
100 V ac	MDX-1.25A

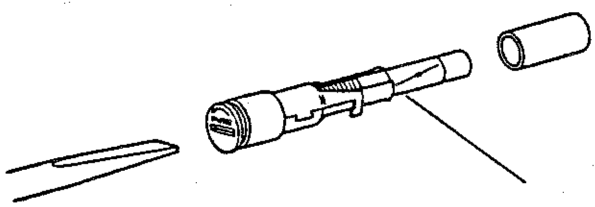


Figure 2-2 Fuse Replacement

3. OPERATING TQ88091

3.1 DESCRIPTION OF PANEL SECTION

(1) POWER ON/OFF
Switch to supply AC power to TQ88091.

NOTE

Confirm that the supply voltage matches the indicated voltage value of the TQ88091 panel before supplying power.

(2) Sensor cable connector
A connector to input the signals which have been photoelectrically converted by the sensor head. The signals are sent to the internal TQ88091 via this connector.

(3) Ground terminal
A terminal for a ground.

(4) Power cable
The plug has a three-pin structure; the center round pin is for the ground. To connect the plug socket using the adaptor, ground either the ground line connected to the adaptor or the ground terminal of item (3).

(5) Fuse holder
See subsection 2.4.

(6) SIGNAL OUT
A terminal from which the electric signals are output.
Note that photoelectric conversion must be made to these signals beforehand. This terminal analyzes the output signals from this terminal by using the frequency response analyzer. For an interconnection cable, use the accessory cable provided on the frequency response analyzer (T592A).

(7) DC OUT
A terminal from which DC bias is output. This DC bias must be applied to the actuator focus coil. Output voltage ranges from 0 to 4 V by turning the ADJUST knob as explained in (8).
The internal DC resistance is 20 Ω and the current is limited to 120 mA max to avoid damage to the actuator.

(8) DC OUT ADJ
A knob to adjust the bias voltage (current) applied to the focus coil.

(9) Sensor head
Photodiodes and photoelectric conversion circuits are provided.

(10) CALIBRATOR
A knob to control the amount of the outgoing light beam. Turn it to the right to increase light power, and to the left to decrease.

(11) OUTPUT LEVEL meter
The pointer fluctuates only when the mode selector in (12) is set to CAL or SET position and the SIGNAL OUT is connected to this OUTPUT LEVEL meter. This meter has been designed so that the pointer fluctuates at the center of the meter when appropriately adjusted.

(12) Mode selector
This selector has three positions: CAL, MEAS, and SET. To perform calibration, set the actuator in the CAL position; to set up the actuator, set it the SET position; to perform test, set it in the MEAS position.

(13) Optical beam head
A slit (0.5 x 4.0 mm) is fixed on the extreme end of this head. The slit orientation can be changed according to the direction for tracking or focus characteristics tests of the actuator.

(14) Light-interrupting attachment
An accessory to eliminate the influence of strong disturbing light. This attachment can be installed on the sensor head by a one-touch operation.

(15) Height adjustment legs
When setting TQ88091 on an uneven table, adjust the leg heights by turning the leg height adjusters.

(This page has been intentionally left blank.)

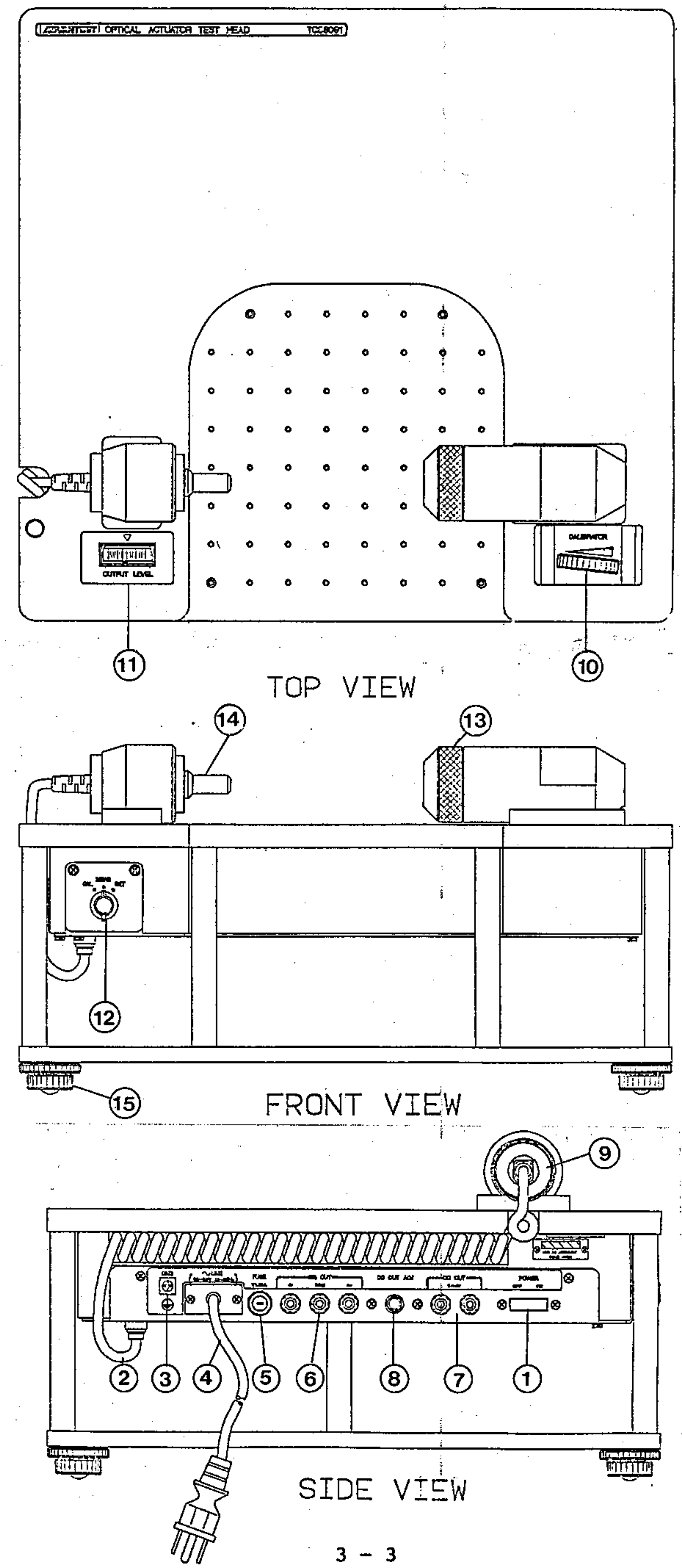


Figure 3-1 Description of the Panel

3.2 PREPARATION AND CALIBRATION BEFORE TESTING

(1) Warmup

TQ88091 uses an He-Ne laser as a light source.
Just after turning the POWER switch, the light output amount varies unstably because laser tube is not warmed up. Therefore, start measurement after approx. 15 minutes (the time required to stabilize output from the tube).

(2) Setting a slit

There are two kinds of tests for testing actuator characteristics (displacement): focus direction and tracking direction tests. The slit that forms the optical beam for measurement is 0.5 x 4.0 mm. Adjust its direction as illustrated in (a) and (b) [Figure 3-1] according to the required measurement.

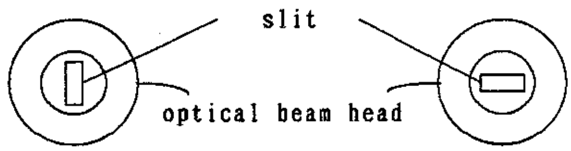


Figure 3-2 Slit Directions

⟨Setting the slit⟩
When changing the slit direction, turn the slit part for 90 degrees as shown in Figure 3-3.
After the slit part is fixed, visually check that the entire optical beam is coming into the light-receiving part of the photodiode correctly.

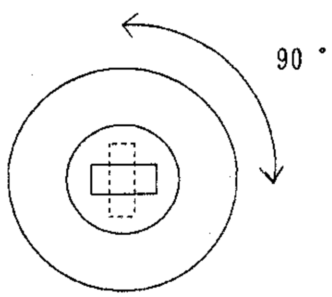


Figure 3-3 Turning the slit part

(3) Calibration
An He-Ne laser output varies with the ambient temperature. This laser output variation causes variations in the test optical beam power. Therefore, before measurement, turn the calibrator knob, explained in the previous subsection ⑩ to yield uniform power.

<Calibration method>
① Adjust the mode selector to the CAL position.
② Turn the calibrator knob so that the output level meter pointer fluctuates in the center of the scale.

<Calibration precision>
Precision of calibration can be read out from the meter pointer position. If, for example, the optical beam power varies and is indicated by the pointer position shown in Figure 3-4, this pointer indicates that the precision has declined by 2% compared with the reference power. When setting the displacement value, the pointer indicates that the basic sensitivity has declined by 2%. When the pointer is at the center of the scale, the basic sensitivity becomes 0.4 μm/mVp-p.

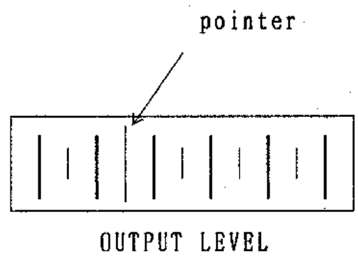


Figure 3-4 Meter Pointer Position

<Calibration intervals>
For performing a precise measurement for the displacement, calibration must be done before the test is performed. Two to three hours after POWER is switched on, the inside of TQ88091 reaches a stabilized temperature. This condition allows stable optical output, enabling high precision testing, with calibration operations required only every two or three hours.

3.3 SETTING ACTUATOR

(1) Precautions for setting actuator

① When the dimensions of DUT are larger than 100 x 50 x 50 mm, note that sometimes the actuator may not be able to be set.
② Remove the light-interrupting attachment to prevent it from being an obstacle during setting.
③ Set the actuator so that its vibrating section is close to the slit section. Set it to shorten the length ⊿L. (50 mm Max.)

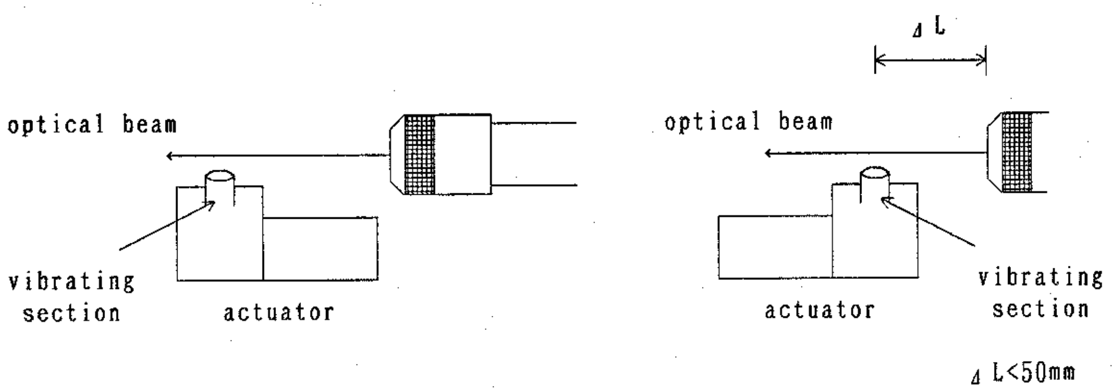


Figure 3-5 Distance between Actuator (Vibrating Section) and Slit

(2) Setting method

(a) For focus direction testing

① Connect the DC OUT terminal of the panel section with the focus coil terminal on the actuator via the accessory cable (MI-39).
② Turn the DC OUT ADJUST knob to the right, and apply the DC bias voltage so that the actuator vibrating section is approximately the same height as when under actual operation.
③ Set the mode selector to the SET position.
④ Turn the feeding facility (screws) to set the actuator fixed on the Y-Z stage (recommended) so that the vibrating section interrupts only half of the optical beam.

⑤ In this condition, confirm that the OUTPUT LEVEL meter pointer fluctuates around the center of the scale. This setting does not affect test precision, thus ensuring measurement in the range (±2 scales) as shown in Figure 3-7.

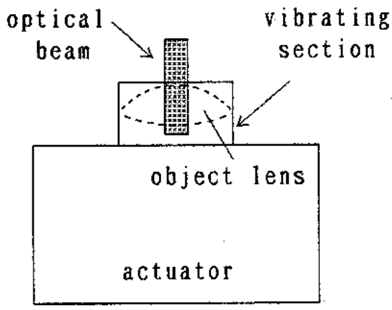


Figure 3-6 Setup of the Actuator (for the Focus Test)

⑥ If the pointer slips from the center, move the stage up and down to adjust it. A correct test cannot be performed if there is large actuator displacement.

(b) For tracking direction testing

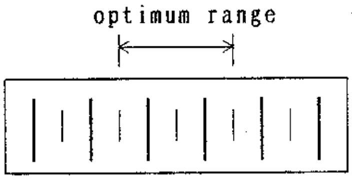


Figure 3-7 Meter Pointer at the Actuator Setup

To execute a tracking direction measurement, set the actuator in the same way as for focus direction measurement with the only difference in that the optical beam direction is 90 degrees rotated to the actuator. Move the actuator with the Y-Z stage as illustrated in Figure 3-8, and position the actuator so that the vibrating section interrupts half of the optical beam. Then, confirm that the OUTPUT LEVEL meter pointer fluctuation is within the optimum range as in Figure 3-7. If the pointer deviation is large, move the stage forward or backward to adjust the pointer.

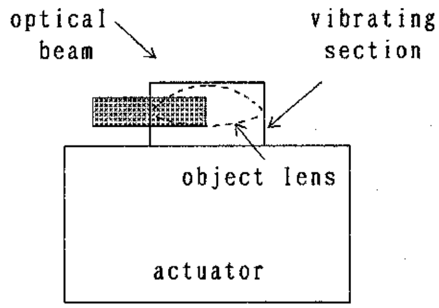
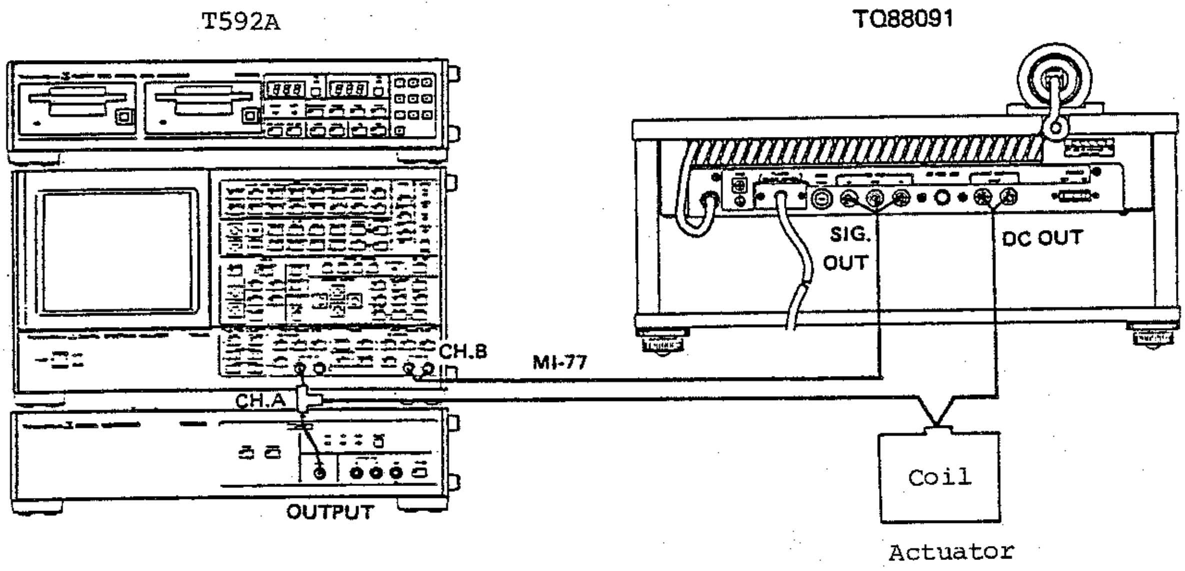


Figure 3-8 Setup of the Actuator (for the Tracking Test)

3.4 MEASUREMENT PROCEDURES

(1) Connecting TQ88091 with the frequency response analyzer (T592A)



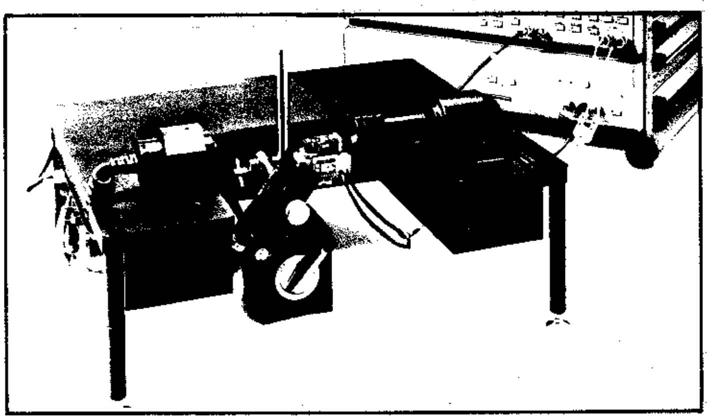


Figure 3-9 Connection of TQ88091 with the Frequency Response Analyzer

① Connect the SIG. OUT terminal on the TQ88091 panel with the input terminal (CH. B) on the frequency response analyzer by using the cable (MI-77 <alligator clip>) supplied with the frequency response analyzer.
② Connect the output terminal (via T-shaped connector) on the frequency response analyzer's signal generator (TR98201) with the actuator focus (or tracking) coil terminal via a cable. Simultaneously, connect the output terminal of the signal generator with the input terminal (CH. A) of the analyzer via a cable.

(2) Determining signal level applied to the actuator coil

① Set the mode selector to the MEAS position.
② Generate and apply about 0.5 Vp-p signals from the frequency response analyzer (signal generator) with the actuator frequency at about the first resonance point. (The level varies with the actuator.)
③ Observe the signal level for the channel B (TQ88091 output) (<Gbb>) by using the frequency response analyzer.
④ Alter the signal frequency to search for the frequency of the maximum output in channel B.
⑤ Adjust the signal level from the frequency response analyzer so that the channel B output level ranges from 2 to 8 dBV (magnitude of displacement is between 1.4 and 3.0 mm).
⑥ At this time, observe the channel B signals in the time domain, and confirm that the upper or lower portion of waveforms are not clipped or distorted. For focus direction measurement, especially, if the applied direct bias from TQ88091 is improper (insufficient), the channel B output waveform will be distorted as illustrated in Figure 3-10. Apply the direct bias voltage so that the vibration amplitude range always goes over the Section A as shown in (a) of Figure 3-10.

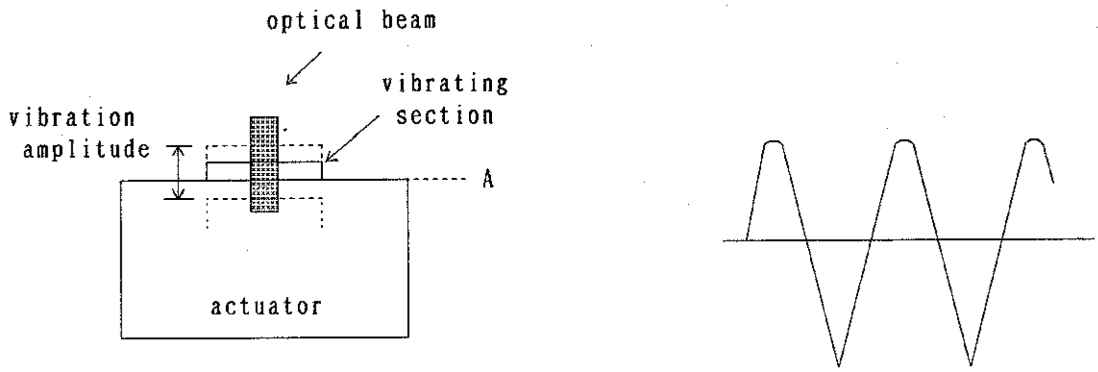


Figure 3-10 Output Waveform When Direct Bias is Insufficient

(3) Measurement with signal sequences

The previous subsection described how the signal level to be applied to the actuator could be specified. The characteristics required for the actuator are depicted in Figure 3-11. From Figure 3-11 it can be seen that the larger the signal frequency is, the smaller the response level becomes. When the frequency is 5 kHz or more, the response will be below the system noise level. For the measurement of the actuator, therefore, in wide dynamic ranges from 120 to 130 dB, use the signal sequence method of the TR592A frequency response analyzer.

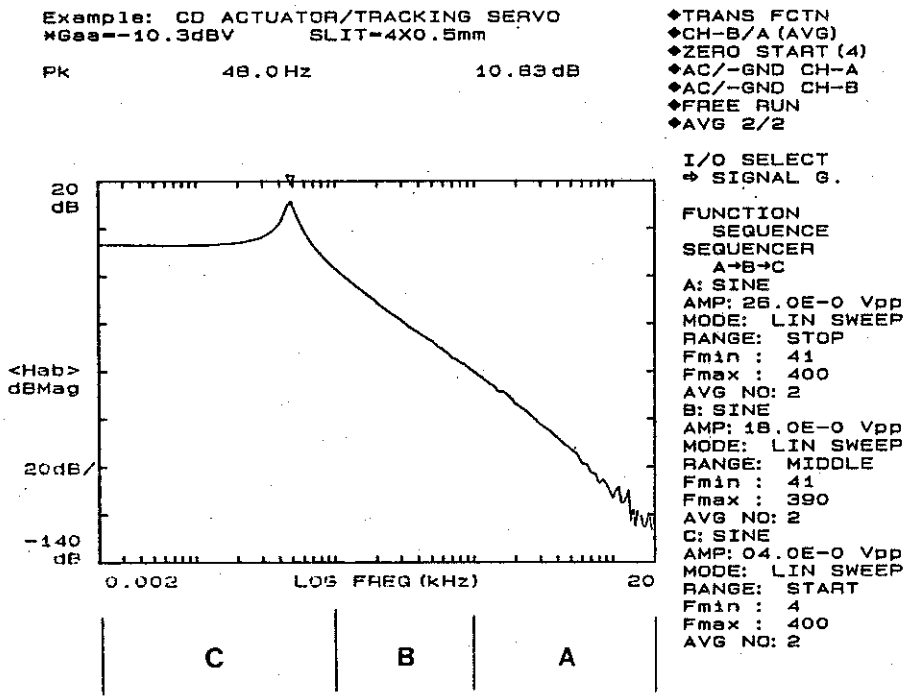


Figure 3-11 Characteristics of Actuator

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

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

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

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

(4) Precautions on operating and measuring with the frequency response analyzer (T592A)

① When setting signals for the signal sequence scheme, be sure to turn off the OPERATE key of the signal generator (TR98201). If the frequency range has been set to low frequencies, the actuator vibration amplitude will become greater and will exceed the mechanical clearance value by a large margin.

② Before starting the frequency response analyzer averaging function, confirm that frequency range is set correctly.

③ If the DC resistance of the actuator is low, starting the averaging operation with the signal sequence function may turn off the OPERATE key of the signal generator during starting operation. This means that too much current is flowing to the actuator, which shuts the circuit automatically. In this case, decrease the programmed signal level.

④ To measure the actuator response correctly over a wide range from 120 to 130 dB, the entire measurement system connected to the actuator should be fully isolated in the input and output.
Note that when the cable is not suitable the response may deteriorate in the high frequency range. The measurement system isolation mechanism presents no problem if the channel B response is the same as the noise level, with the averaging operation acted on the channel B response by placing the light-interrupting panel at the front of the sensor head as shown in Figure 3-12.

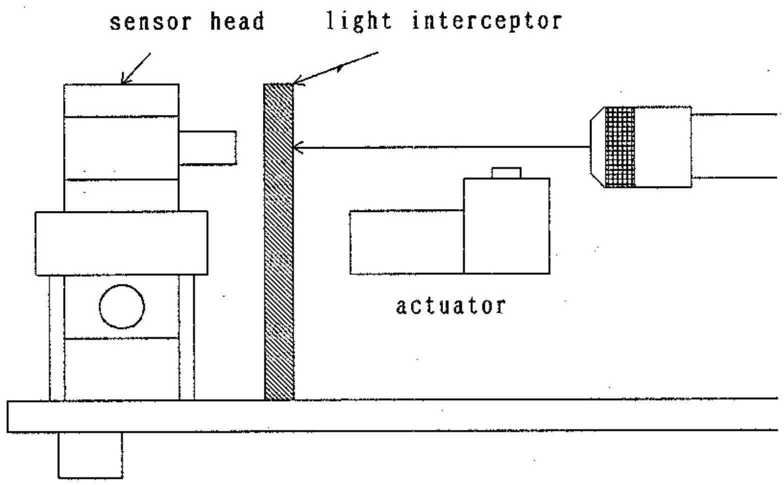


Figure 3-12 Measurement System Isolation Checking

3.5 CONVERTING MEASUREMENT RESULTS INTO DISPLACEMENT VALUES

Shown in Figure 3-13 is a plot of the frequency response (transfer function) of the actuator yielded by the TQ88091 and the frequency response analyzer (T592A).

The transfer function is expressed by the output Fourier spectrum $\langle Sb \rangle$ ratio against the input Fourier spectrum $\langle Sa \rangle$ as follows.

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

or

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

That is, the transfer function can be expressed by the cross spectrum ratio against the input power spectrum.

Since the measurement is performed when the coherence function is "1" (the transfer function is the least susceptible to noise), this function can also be expressed as follows:

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

By testing the actual input level applied to the actuator, output level $\langle Gbb \rangle$ for each frequency can be obtained ds follows:

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

Levels in the low frequency range applied from the signal generator to the actuator are displayed on menu C: of the signal sequence in Figure 3-11.

This value incorporates a load of 50 ohm. Since the actual value applied to the actuator varies according to the actuator, measure the actual value of $\langle Gaa \rangle$.

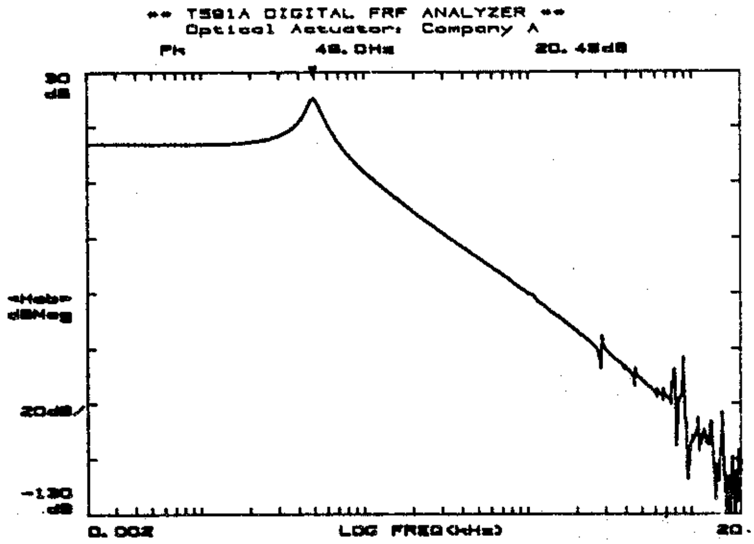


Figure 3-13 An Example of Actuator Transfer Function

<A practical example of scaling>

Try actual scaling by using the measurement data shown in Figure 3-11. Suppose the <Gaa> measurement value in low frequency range "C" is -10.3 dBV. Since the actuator value of |<Hab>| at the frequency of 48.0 Hz is 10.8 dB, then:

<Gbb> = 10.8 + (-10.3) = 0.5 (dBV)

where voltage gain = 0.5 dBV = 20log X. This can be linearly expressed as

<Gbb> = 1.06 Vrms = 3.00 Vp-p

The basic sensitivity of TQ88091 is 0.4 μm/mVp-p, therefore, the magnitude of displacement (amplitude) is 1.20 mm. This is illustrated in Figure 3.14. To perform scaling, the scaling factor must be entered with the WEIGHTING menu of the analyzer. This is described as follows:

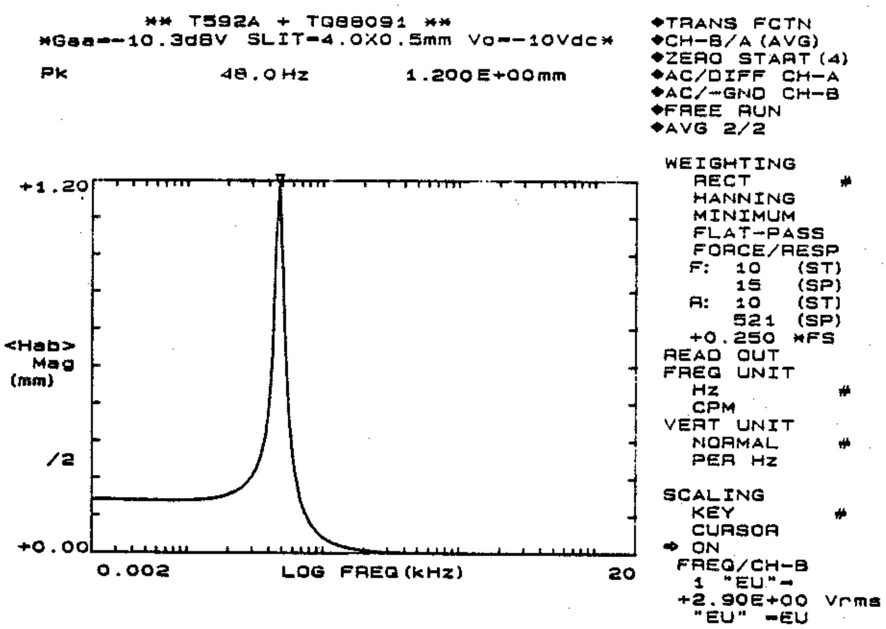
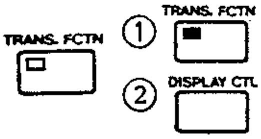


Figure 3-14 A Scaling Example of Actuator Characteristic

<Operating T592A on scaling>



① Display the transfer function.

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

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

➡ Mag        L
   Mag²
   dBMag       *

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

DATA WINDOW
   AUTO       *
   MANUAL
STEP (D.WINDOW)
   0/1024
```

Figure 3-15 DISPLAY CTRL Menu

③ Displays the scaling menu to perform scaling. Set SCALING:KEY (move the pointer (⇨) to the KEY position,

and press [SETUP] .)

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

<Gbb> = 20 dB + (-10.3) dBV = 9.7 dBV

As X = 3.05 is obtained by substituting 9.7 dBV = 20log X for the above equation, then:

9.7 dBV = 3.05 Vrms = 8.63 Vp-p

Since the TQ88091 basic sensitivity is 0.4 μm/mVp-p, the displacement value becomes 3451 μm. Accordingly, 3.45 mm corresponds to 20 dB. That is,

20 dB ..... 10 Vrms ..... 3.45 mm

where 0 dB = 1 Vrms.
Therefore, 10/3.45 = 2.90 Vrms/mm is obtained. Finally, 1EU = 2.90E + 00Vrms can be entered (Refer to the menu display in Figure 3-14) as the scaling factor for CH. B.

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

1EU = 1.00E00 Vrms

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

4. APPLICATION TEST EXAMPLE (MODAL ANALYSIS)

4.1 MODAL ANALYSIS OF SWING ARM

As an applied example of the measurements with the TQ88091, this section describes modal analysis of the swing arm which is combined with T592A.

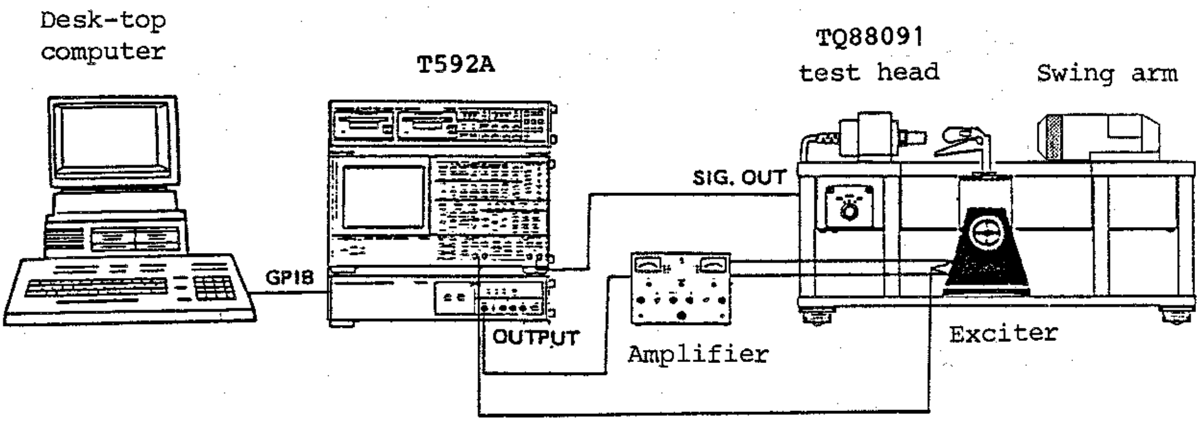


Figure 4-1 Connection of Equipment

NOTE

In setting up the system, be sure to use the differential input method for T592A channel B. Also, do not mistake the polarities of the exciter and channel B.

(1) General procedure for measurement

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

⑤ Enter these data to the computer to perform modal analysis. For details, refer to the modal analysis reference manual.

4.1.1 Measurement of Transfer Function of Paper

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

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

② Measure the transfer function of the reference point and store it on the floppy disk with the WRITE MODE:ORIGIN (See Figure 4-3.)

```
I/O SELECT
  FLOPPY

FLOPPY MODE
  READ
→ WRITE          *
  EDIT
  CATALOGUE

WRITE MODE
  ORIGIN         *
  FIXED
  MASS TIME
  GRAPHICS
  PANEL

WRITE TRIG.
  DATA
  FREE RUN
   CH-A

M.TIME FCTN
  OFF
  K→1.00
```

Figure 4-2 Floppy WRITE Menu

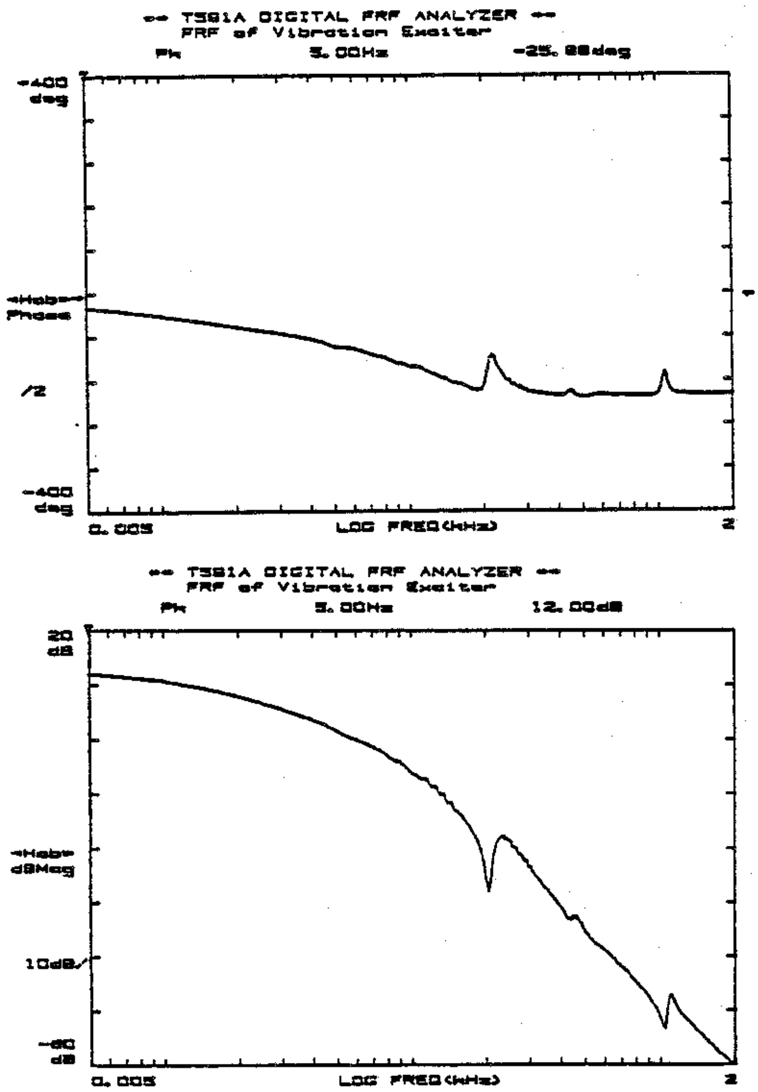


Figure 4-3 Transfer Function of Exciter

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

③ Attach the paper to the edge of the fixed point of the arm. Seal it at a suitable position where it blocks 50% of the beam in the focus direction. (See subsection 3.3.)

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

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

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

⑥ Read the transfer function of paper.

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

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

$$= \frac{\text{Paper displacement}}{\text{Exciter displacement}}$$

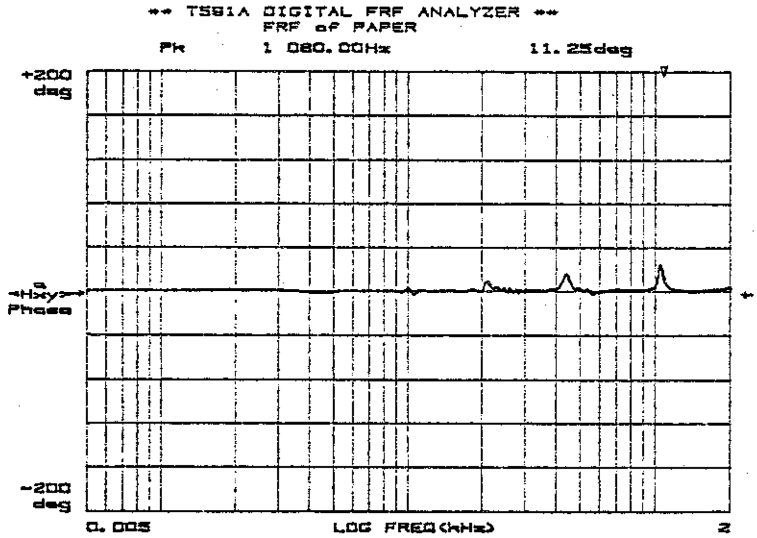
With these equations, only the characteristics of paper (removing the influence from the exciter) can be obtained as illustrated in Figure 4-5. $\overset{e}{\langle Hxy \rangle}$ in the leftmost position of the figure indicates that transfer function is being equalized. Figure 4-5 shows the paper characteristics is almost flat.
Use lighter paper with strong adhesive capability.

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

Figure 4-4 Magnetic Disk Swing Arm

NOTE

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



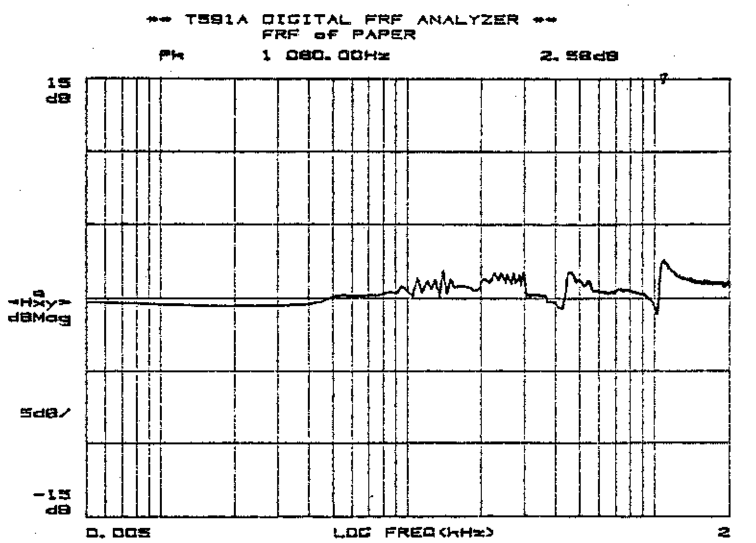


Figure 4-5 Frequency Response of Paper

4.1.2 Measurement of Displacement at Each Point on the Arm

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

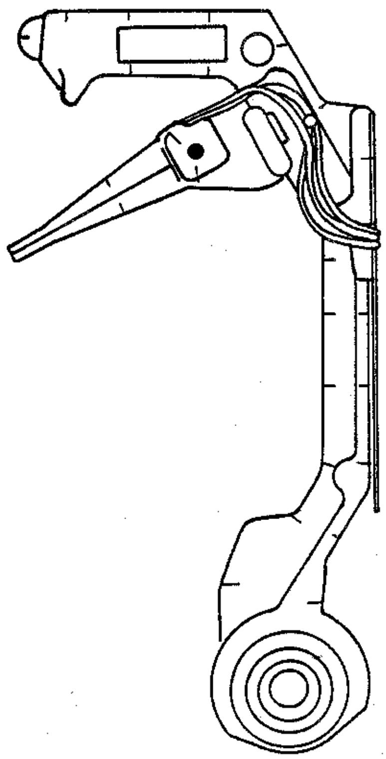


Figure 4-6 Notching the Arm (Actual Size)

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

NOTES ON TESTING

1. When the location of DUT needs to be changed because of the test point, select the size of the exciter so that it can be mounted on the work table, neat and stable.
   When the table is small, use the table with a stage apron. If there is a height gap between the DUT and the table, remove the table. When using it away from the table, be sure to place a vibration isolator under the accelerator.

   <Taking off the table>

   ① Raise TQ88091 to look at the bottom.
   ② Loosen the height-adjusting legs at the four corners and remove them. Then, remove the Phillips screws.
   ③ After taking off the table, refix the height-adjusting leg screws to the legs.

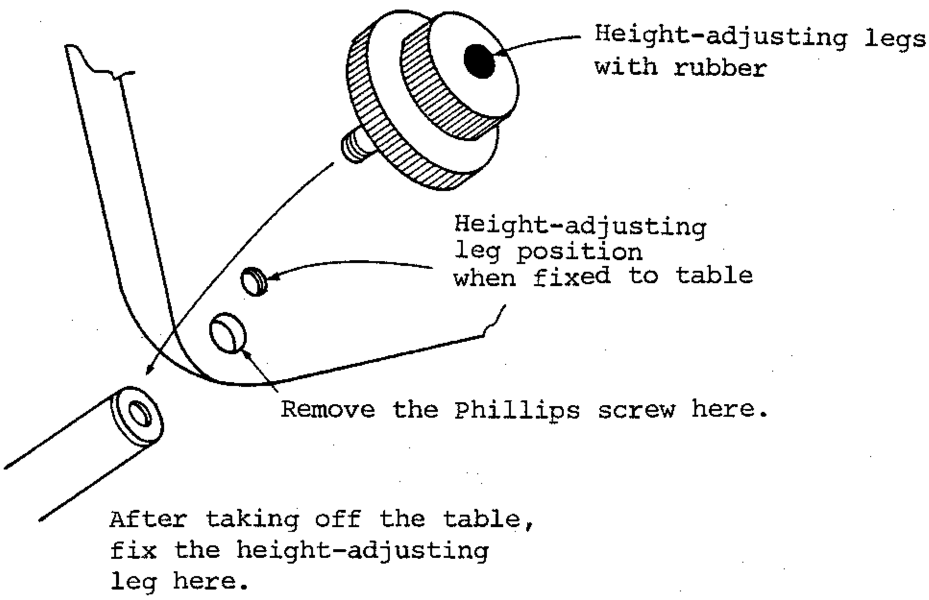


Figure 4-7 How to Take Off the Table

2. Find position where the arm does not separate from the arm slit any more than 5 cm. (See Subsection 3.3.)
3. When changing the test point, take care during DUT positioning that the other arm sections do not interrupt the beam. When the DUT has a complex shape, confirm that no obstacle is blocking the beam by moving a paper along the beam with tweezers to check the beam point.

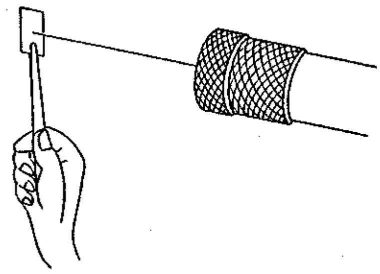


Figure 4-8 Confirming There is No Beam Obstruction

4. By setting SG OPERATION in the servo menu to ON-AVERAGING, signals are made to generate from the signal generator only during averaging execution. This setting enables minimizing any noise generated by DUT.

(3) Setting signal sequence

Figure 4-9 illustrates the swing arm magnetic head characteristics. Signal sequence in this example divides the frequency band into four regions of A, B, C, and D. Each region is tested on different conditions.

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

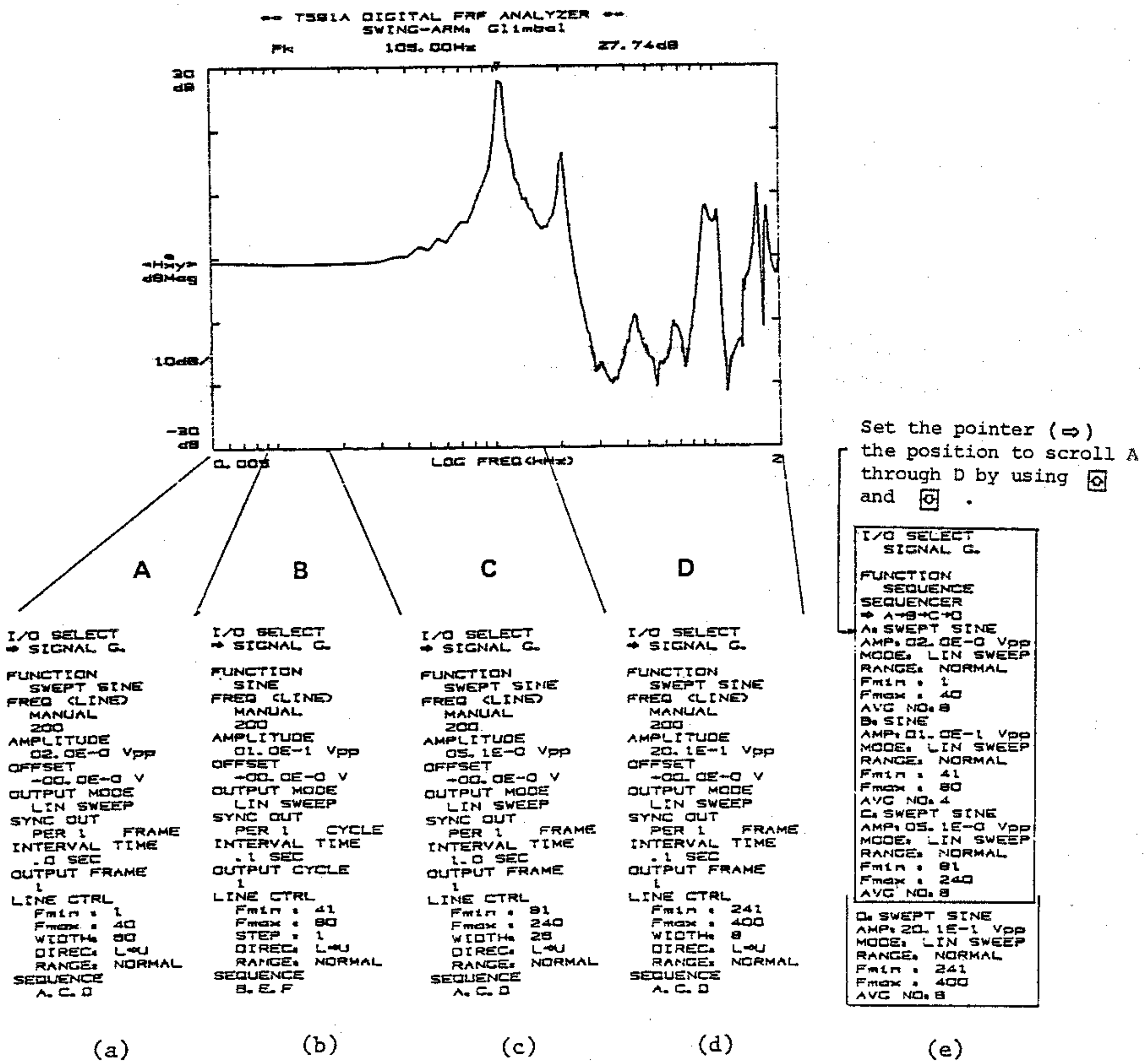


Figure 4-9 Setting Signal Sequence

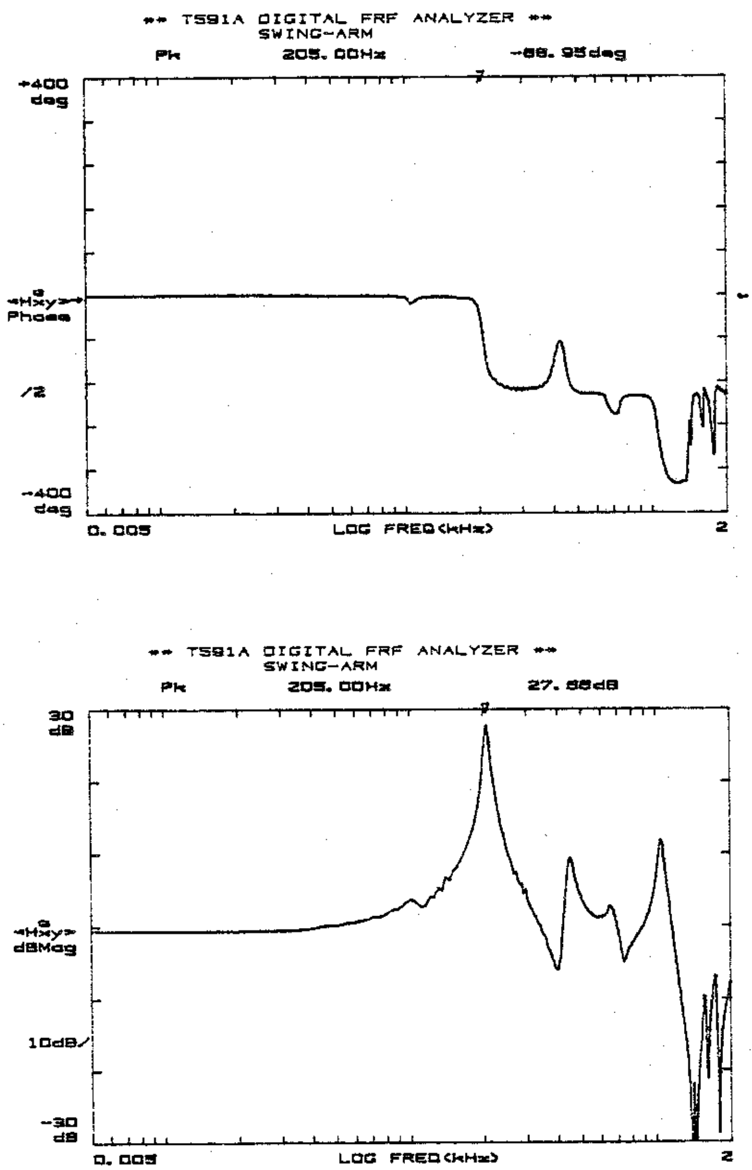


Figure 4-10 An Example of Display of Characteristics for Swing Arm Point

4.1.3 Modal Analysis

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

It is best to perform the Modal analysis in the free support mode. In this case, fix the arm base to the exciter for the measurement. This may vibrate both the exciter and the arm together. To cancel this effect, measure the transfer function at the fixed point of the arm on the exciter and divide the measurement transfer function with it to remove the effects of the exciter. In short, the user measures the transfer function of the two displacement values. Since mode separation ratio is relatively good, this analysis uses the SDOF (1st degree of freedom) curve fitting.

Modal analysis may not be possible at joint sections when parts of the DUT are made up of different materials. To measure the characteristics in actual operating conditions, it is important to perform analysis in integrated conditions, in which whole sections are tested en bloc, rather than to use the building block method.

Note: MODAL 3.0 software allows simulation for design change. No animation display is possible for a displacement-to-displacement transfer function. Therefore, the data is analyzed as a power-to-acceleration transfer function.

Enter CHART in the desk-top computer to display the following:

```
SETUP    =>     INITIALIZE Test     Job name:
.....................................................
GEOMETRY        EDIT Coordinates
                EDIT Display Sequence
                DISPLAY Geometry
                SAVE Geometry
.....................................................
MEASURE         GET MEASUREMENT Monitor
.....................................................
ANALYSIS        DISPLAY a measurement and FIT Modes
                AUTOFIT Modes and SAVE FIT Data
                SORT FIT Data and SAVE SHAPE Data
.....................................................
DOCUMENT        DISPLAY (ANIMATE) Mode Shape
                LIST Data Tables
.....................................................
                EXIT CHART

Use KNOB to move arrow and ENTER/RETURN to select.
```

Press [ENTER] in order from top to bottom for each row, to execute the following sequences (2) to (5), which include the setting of geometric information required for analysis, to data transfer and animation display, all done interactively with the screen.

(1) Copy DUT by copy machine.

(2) Notch the copy of the actual size arm using a scale.
The arm in Figure 4-6 and Figure 4-11 is notched every 1 cm interval.
Set X and Y axes in the appropriate orientation to determine the coordinate of each test point.
R01 to R12, L01 to L12, and H01 to H05 in Figure 4-11 correspond to 1 to 29 in Figure 4-12.

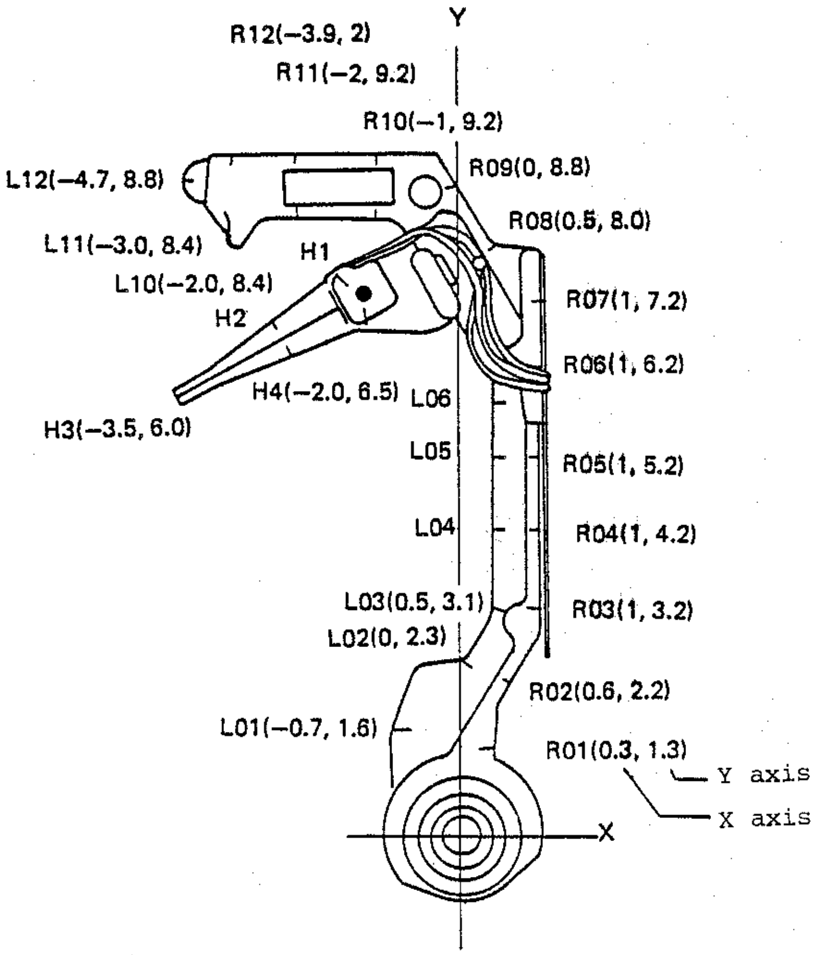


Figure 4-11 Setting Coordinates on DUT

*** COORDINATES ***

POINT	COORD1	COORD2	COORD3
....	....	....	....
1.	.30	1.30	0.00
2.	.60	2.20	0.00
3.	1.00	3.20	0.00
4.	1.00	4.20	0.00
5.	1.00	5.20	0.00
6.	1.00	6.20	0.00
7.	1.00	7.20	0.00
8.	.50	8.00	0.00
9.	0.00	8.80	0.00
10.	-1.00	9.20	0.00
11.	-2.00	9.20	0.00
12.	-3.00	0.20	0.00
13.	-.70	1.60	0.00
14.	0.00	2.30	0.00
15.	.50	3.10	0.00
16.	.50	4.20	0.00
17.	.50	5.20	0.00
18.	.50	6.20	0.00
19.	0.00	7.20	0.00
20.	-.50	7.80	0.00
21.	-1.00	8.40	0.00
22.	-2.00	8.40	0.00
23.	-3.00	8.40	0.00
24.	-4.70	8.80	0.00
25.	-1.50	7.50	0.00
26.	-2.50	7.00	0.00
27.	-3.50	6.00	0.00
28.	-2.00	6.50	0.00
29.	-1.00	7.00	0.00

Figure 4-12 Coordinate Table

(3) Entering display sequence
Decide the display sequence for the test points 1 to 29 referred to in the previous subsection.

	START POINT	END POINT
1.	1	12
2.	-13	19
3.	-20	24
4.	12	
5.	-25	29
6.	19	
7.	-25	
8.	20	

Figure 4-13 Display Sequence

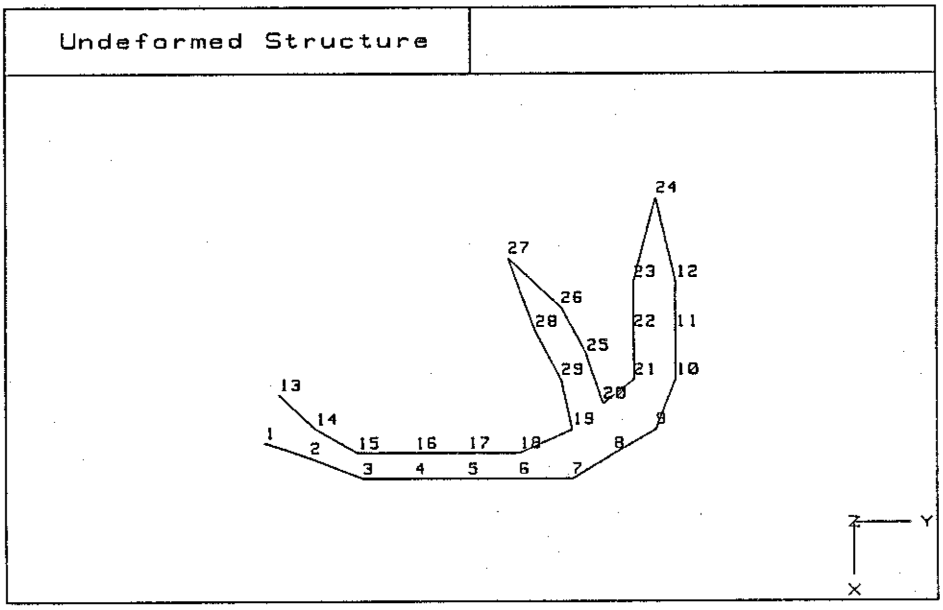


Figure 4-14 Coordinate Points and Display Sequence Entry Result

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

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

(5) Perform analysis on the computer

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

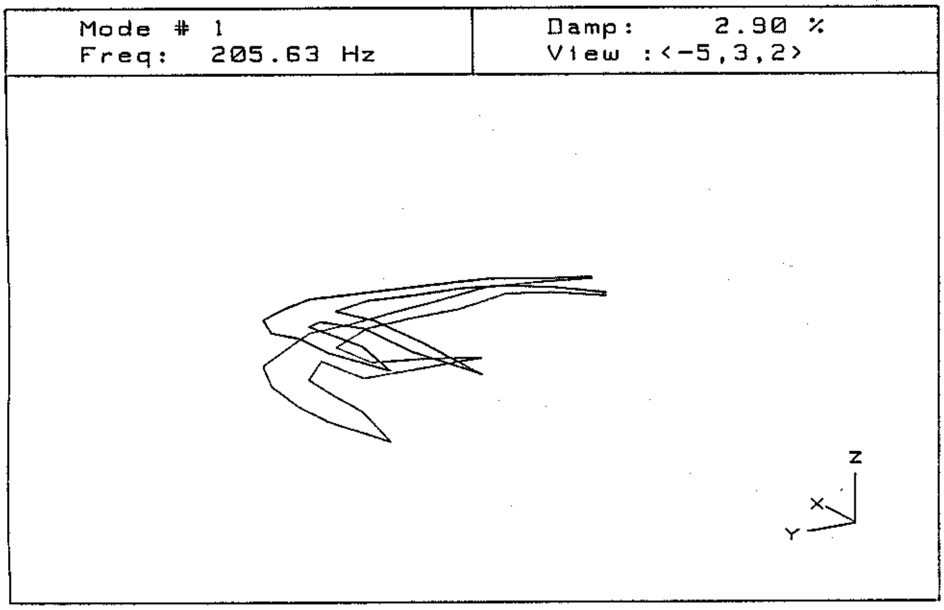
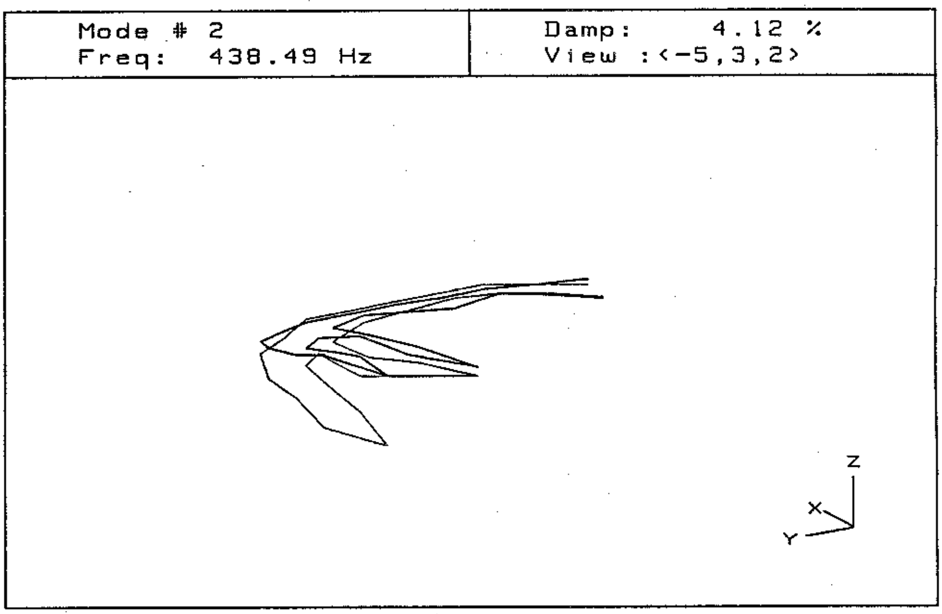


Figure 4-15 Mode Shape of Swing Arm (Animation Display) (1)



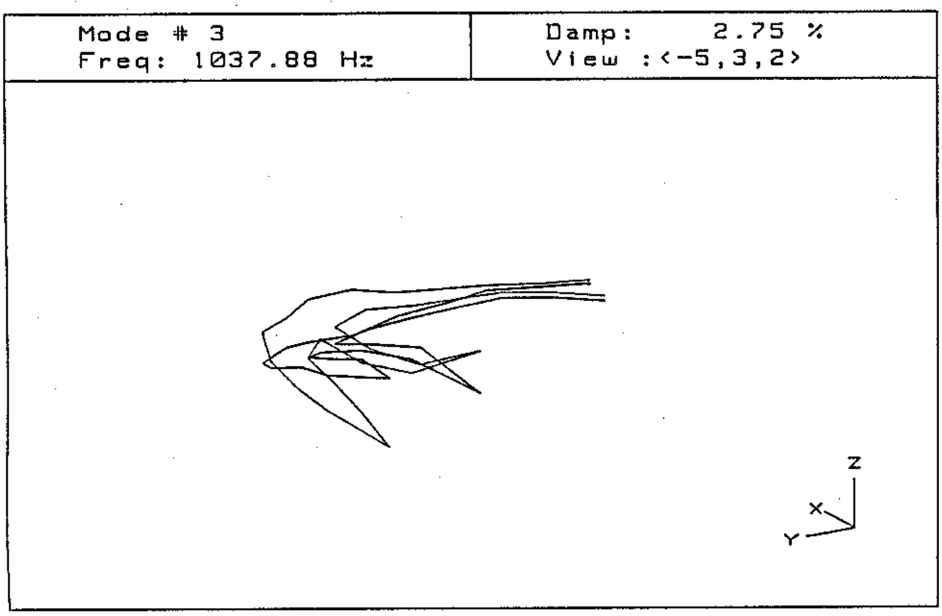


Figure 4-15 Mode Shape of Swing Arm (Animation Display) (2)

5. CALIBRATION AND REPAIR REQUEST

5.1 CALIBRATION BEFORE MEASUREMENT

TQ88091 uses an He-Ne laser, therefore, it has a long interval power variation of 5%, about two hours after power is switched on, until both the laser tube and the peripherals reach a stable temperature. Therefore, during the measurement of this period, calibrate once or twice in 15 to 30 minutes. After two hours, do the same at 2 to 3 hours intervals. Refer to 3.2 (3) calibration for the method.

5.2 CALIBRATION OF THE MEASUREMENT BEAM

TQ88091 determines the measurement precision by the uniformity of the distribution of the beam's light intensity. Advantest measures the beam profiles of every equipment during assembly and shipping inspections, thus guaranteeing high precision.

The beam is formed by the laser tube or optical systems. Its optical parts are fixed on heavy-duty aluminum panels, so they do not have to be calibrated.

In case the unit receives an abnormal shock (i.e., fall), contact your nearest Advantest representative.

5.3 HOW TO ASK A REPAIR REQUEST

From the viewpoint of measurement principle, TQ88091 has a simple electrical circuit structure. Therefore, breakdowns or trouble should be rare during normal operation. If there is any abnormality, confirm the following points before making a repair request; then, if the abnormality persists, contact your nearest Advantest representative:

Symptoms	Cause	Action
Calibration cannot be done.	• The cable connector between the sensor head and the chassis has been disconnected. • Fuse is blown. • The beam does not hit the photodiode due to DUT or other obstruction.	• Connect the connector firmly. • Replace with the spare fuse. • Remove DUT and the obstacle.
Bias power is not supplied.	• Load is shorted. • Fuse is blown.	• Confirm the load resistance. • Replace with the spare fuse.
Measurement value error	• Correct beam is not generated because no calibration was performed before measurement. • The mode selector is not set to MEAS. • The connection cable is not connected correctly or has been disconnected. • Input coupling of analyzer has been set in DC state.	• Calibrate the beam correctly. • Set the selector to MEAS. position. • Confirm the cable status. • Set the coupling to AC mode.

6. PRINCIPLE OF OPERATION

6.1 MEASUREMENT METHOD

TQ88091 generates the optical beam whose intensity is spatially uniform. This beam is set so that it is interrupted by the actuator vibrating section. This setting causes the variation of magnitude of the light transmitted via the vibrating section according to the vibrating amplitude. The light displacement vary in proportion to the amplitude (displacement). When the values are converted electrically, the signal output corresponding to the displacement can be obtained. This signal output is measured in the frequency domain with the T592A frequency response analyzer.

6.2 OPTICAL SYSTEM CONFIGURATION

TQE88091 uses an He-Ne (Helium-Neon) laser as a highly reliable light source with good spatial coherence as shown in Figure 6-1. This light beam is used in the transverse simple mode, thus giving stable Gaussian distribution. This beam is magnified six to seven times by the beam expander which consists of several lens combinations.

An accurately made slit (0.5 x 4.0 mm) is positioned in the center of this magnified beam. Transmitted light through this slit has regular light intensity, and guarantees linearity of displacement with regard to magnitude variation of light.

6.3 ELECTRIC CIRCUIT CONFIGURATION

Figure 6-1 illustrates the low-noise PIN photodiode receiving the variable optical beam. The circuit generates electrical signals with a current-to-voltage converter. When performing the calibration (CAL.) operation, the electric signal is connected by the signal selector switch to the circuit where the level meter pointer fluctuates in the center of the scale driven by the 10 Vdc output. When setting (SET) DUT, the electrical signal is set to approx. 5 Vdc to the driving circuit where the pointer fluctuates connected in the center of the scale with the approx. 5 Vdc output.

During the measurement (MEAS.), the electrical signal is output directly to the signal output terminal.
The optical pickup actuator is generally driven by two coils of focus and tracking coils. During actual operation of the actuator, bias (direct current) is applied to the focus direction of the actuator to control position. In the actual measurement, therefore, bias (direct current) is also applied in the focus direction. This bias power source is derived from the variable supply circuits so that voltage ranging from 0 to 4 V can be set by turning the DC OUT ADJ control. The output impedance of this circuit is higher than that of the actuator (R = 20Ω); connecting the load decreases the voltage.

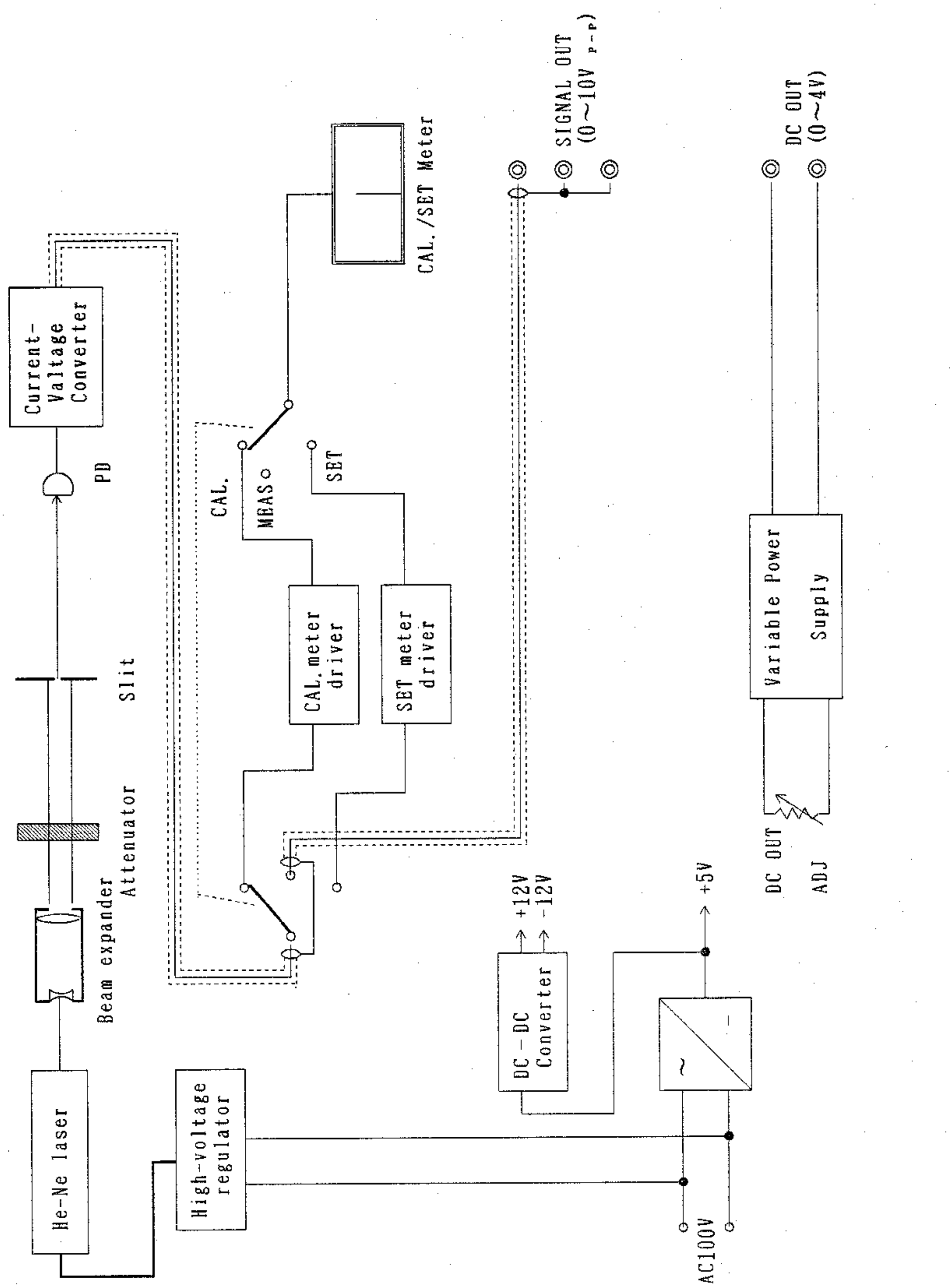


Figure 6-1 Block Diagram of the TQ88091

LIST OF FIGURES

LIST OF TABLES

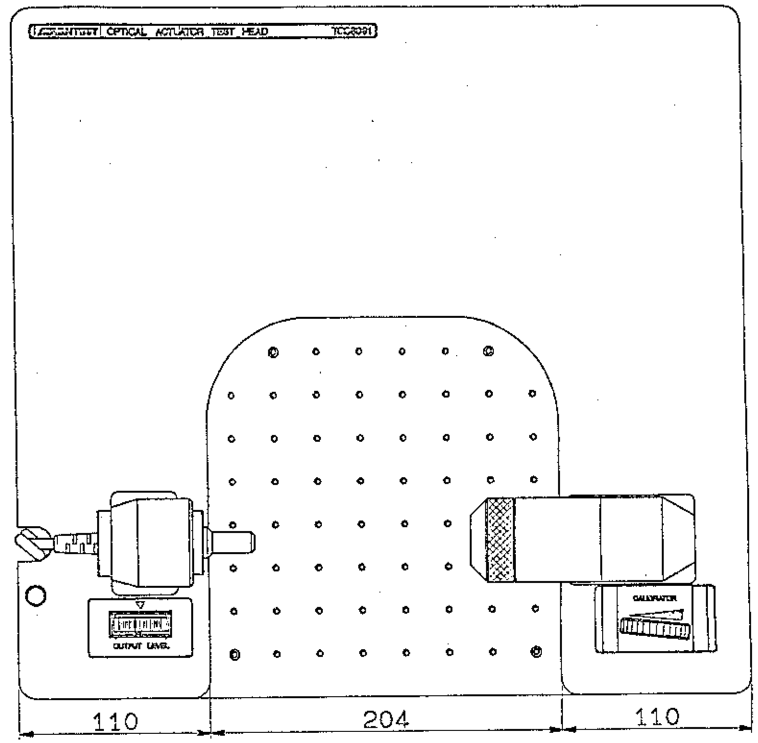
Table No.	Title	Page

(No table numbers are assigned in this manual.)

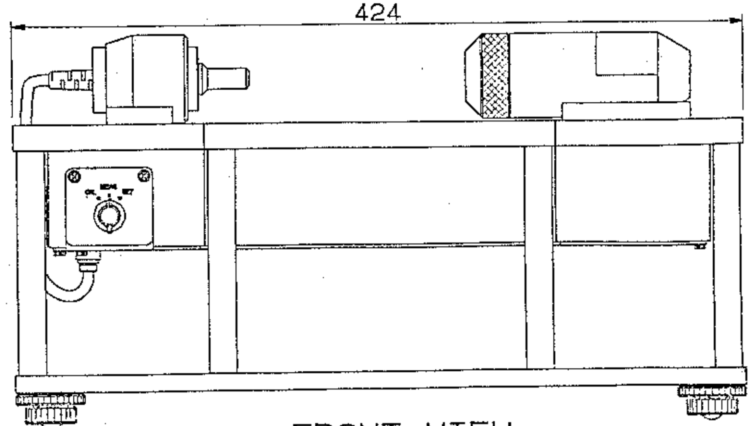
LIST OF EXAMPLES

Example No.	Title	Page

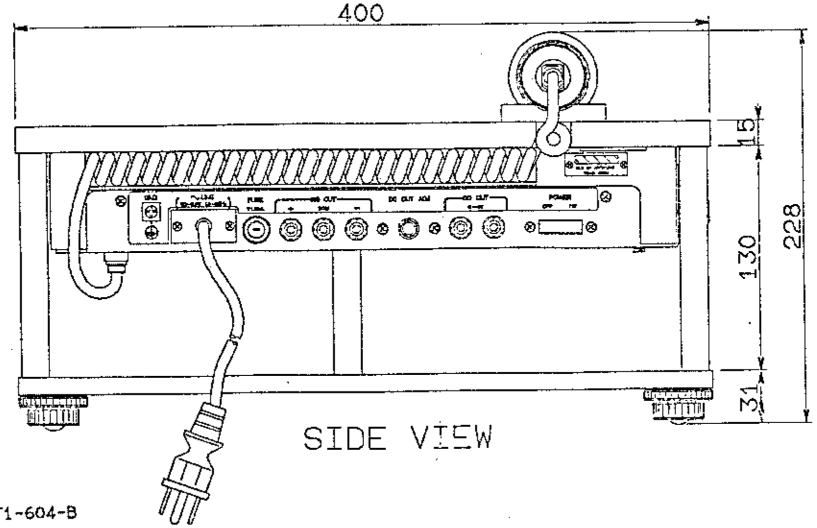
(No example numbers are assigned in this manual.)



TOP VIEW



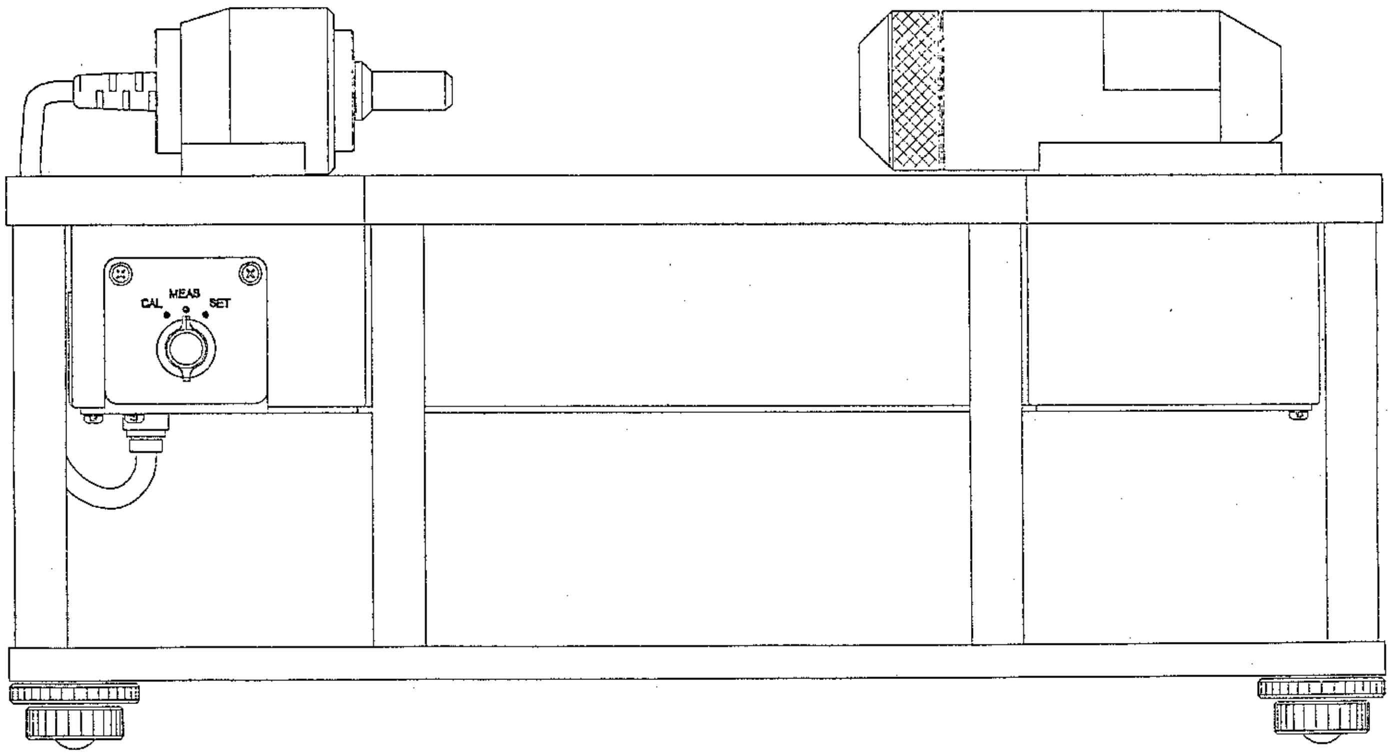
FRONT VIEW



SIDE VIEW

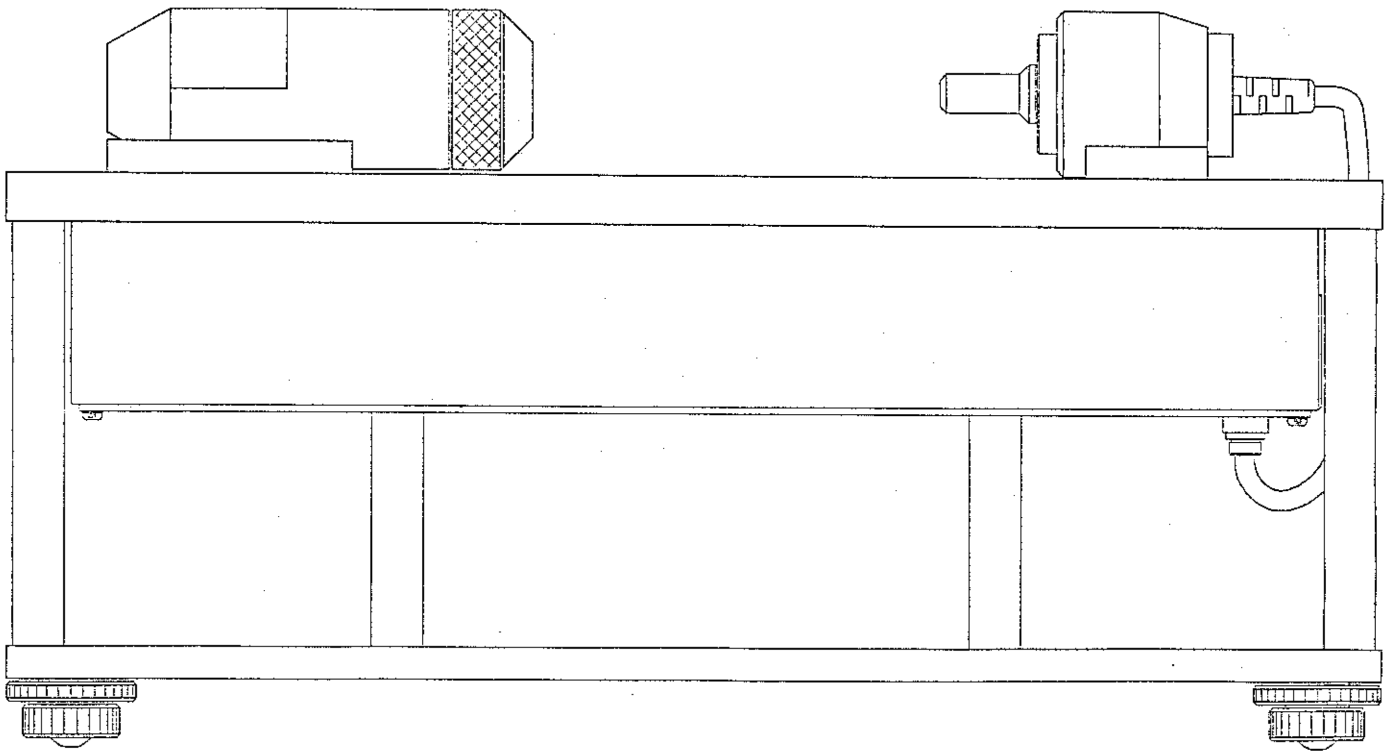
88091EXT1-604-B

TQ88091
EXTERNAL VIEW



TQ88091 FRONT VIEW

88091EXT2-604-B



TQ88091 REAR VIEW

88091EXT3-604-B

IMPORTANT INFORMATION FOR ADVANTEST SOFTWARE

PLEASE READ CAREFULLY: This is an important notice for the software defined herein. Computer programs including any additions, modifications and updates thereof, operation manuals, and related materials provided by Advantest (hereafter referred to as "SOFTWARE"), included in or used with hardware produced by Advantest (hereafter referred to as "PRODUCTS").

SOFTWARE License

All rights in and to the SOFTWARE (including, but not limited to, copyright) shall be and remain vested in Advantest. Advantest hereby grants you a license to use the SOFTWARE only on or with Advantest PRODUCTS.

Restrictions

(1) You may not use the SOFTWARE for any purpose other than for the use of the PRODUCTS.
(2) You may not copy, modify, or change, all or any part of, the SOFTWARE without permission from Advantest.
(3) You may not reverse engineer, de-compile, or disassemble, all or any part of, the SOFTWARE.

Liability

Advantest shall have no liability (1) for any PRODUCT failures, which may arise out of any misuse (misuse is deemed to be use of the SOFTWARE for purposes other than it's intended use) of the SOFTWARE. (2) For any dispute between you and any third party for any reason whatsoever including, but not limited to, infringement of intellectual property rights.

LIMITED WARRANTY

1. Unless otherwise specifically agreed by Seller and Purchaser in writing, Advantest will warrant to the Purchaser that during the Warranty Period this Product (other than consumables included in the Product) will be free from defects in material and workmanship and shall conform to the specifications set forth in this Operation Manual.

2. The warranty period for the Product (the "Warranty Period") will be a period of one year commencing on the delivery date of the Product.

3. If the Product is found to be defective during the Warranty Period, Advantest will, at its option and in its sole and absolute discretion, either (a) repair the defective Product or part or component thereof or (b) replace the defective Product or part or component thereof, in either case at Advantest's sole cost and expense.

4. This limited warranty will not apply to defects or damage to the Product or any part or component thereof resulting from any of the following:

   (a) any modifications, maintenance or repairs other than modifications, maintenance or repairs (i) performed by Advantest or (ii) specifically recommended or authorized by Advantest and performed in accordance with Advantest 's instructions;

   (b) any improper or inadequate handling, carriage or storage of the Product by the Purchaser or any third party (other than Advantest or its agents);

   (c) use of the Product under operating conditions or environments different than those specified in the Operation Manual or recommended by Advantest, including, without limitation, (i) instances where the Product has been subjected to physical stress or electrical voltage exceeding the permissible range and (ii) instances where the corrosion of electrical circuits or other deterioration was accelerated by exposure to corrosive gases or dusty environments;

   (d) use of the Product in connection with software, interfaces, products or parts other than software, interfaces, products or parts supplied or recommended by Advantest;

   (e) incorporation in the Product of any parts or components (i) provided by Purchaser or (ii) provided by a third party at the request or direction of Purchaser or due to specifications or designs supplied by Purchaser (including, without limitation, any degradation in performance of such parts or components);

   (f) Advantest's incorporation or use of any specifications or designs supplied by Purchaser;

   (g) the occurrence of an event of force majeure, including, without limitation, fire, explosion, geological change, storm, flood, earthquake, tidal wave, lightning or act of war; or

   (h) any negligent act or omission of the Purchaser or any third party other than Advantest.

5. **EXCEPT TO THE EXTENT EXPRESSLY PROVIDED HEREIN, ADVANTEST HEREBY EXPRESSLY DISCLAIMS, AND THE PURCHASER HEREBY WAIVES, ALL WARRANTIES, WHETHER EXPRESS OR IMPLIED, STATUTORY OR OTHERWISE, INCLUDING, WITHOUT LIMITATION, (A) ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE AND (B) ANY WARRANTY OR REPRESENTATION AS TO THE VALIDITY, SCOPE, EFFECTIVENESS OR USEFULNESS OF ANY TECHNOLOGY OR ANY INVENTION.**

6. **THE REMEDY SET FORTH HEREIN SHALL BE THE SOLE AND EXCLUSIVE REMEDY OF THE PURCHASER FOR BREACH OF WARRANTY WITH RESPECT TO THE PRODUCT.**

7. **ADVANTEST WILL NOT HAVE ANY LIABILITY TO THE PURCHASER FOR ANY INDIRECT, INCIDENTAL, SPECIAL, CONSEQUENTIAL OR PUNITIVE DAMAGES, INCLUDING, WITHOUT LIMITATION, LOSS OF ANTICIPATED PROFITS OR REVENUES, IN ANY AND ALL CIRCUMSTANCES, EVEN IF ADVANTEST HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES AND WHETHER ARISING OUT OF BREACH OF CONTRACT, WARRANTY, TORT (INCLUDING, WITHOUT LIMITATION, NEGLIGENCE), STRICT LIABILITY, INDEMNITY, CONTRIBUTION OR OTHERWISE. TORT (INCLUDING, WITHOUT LIMITATION, NEGLIGENCE), STRICT LIABILITY, INDEMNITY, CONTRIBUTION OR OTHERWISE.**

8. **OTHER THAN THE REMEDY FOR THE BREACH OF WARRANTY SET FORTH HEREIN, ADVANTEST SHALL NOT BE LIABLE FOR, AND HEREBY DISCLAIMS TO THE FULLEST EXTENT PERMITTED BY LAW ANY LIABILITY FOR, DAMAGES FOR PRODUCT FAILURE OR DEFECT, WHETHER ARISING OUT OF BREACH OF CONTRACT, TORT (INCLUDING, WITHOUT LIMITATION, NEGLEGENCE), STRICT LIABILITY, INDEMNITY, CONTRIBUTION OR OTHERWISE.**

CUSTOMER SERVICE DESCRIPTION

In order to maintain safe and trouble-free operation of the Product and to prevent the incurrence of unnecessary costs and expenses, Advantest recommends a regular preventive maintenance program under its maintenance agreement.

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.

SALES & SUPPORT OFFICES

Advantest Korea Co., Ltd.
22BF, Kyobo KangNam Tower,
1303-22, Seocho-Dong, Seocho-Ku, Seoul #137-070, Korea
Phone: +82-2-532-7071
Fax: +82-2-532-7132

Advantest (Suzhou) Co., Ltd.
Shanghai Branch Office:
Bldg. 6D, NO.1188 Gumei Road, Shanghai, China 201102 P.R.C.
Phone: +86-21-6485-2725
Fax: +86-21-6485-2726

Shanghai Branch Office:
406/F, Ying Building, Quantum Plaza, No. 23 Zhi Chun Road,
Hai Dian District, Beijing,
China 100083
Phone: +86-10-8235-3377
Fax: +86-10-8235-6717

Advantest (Singapore) Pte. Ltd.
438A Alexandra Road, #08-03/06
Alexandra Technopark Singapore 119967
Phone: +65-6274-3100
Fax: +65-6274-4055

Advantest America, Inc.
3201 Scott Boulevard, Suite, Santa Clara, CA 95054, U.S.A
Phone: +1-408-988-7700
Fax: +1-408-987-0691

ROHDE & SCHWARZ Europe GmbH
Mühldorfstraße 15 D-81671 München, Germany
(P.O.B. 80 14 60 D-81614 München, Germany)
Phone: +49-89-4129-13711
Fax: +49-89-4129-13723

ADVANTEST

http://www.advantest.co.jp

ADVANTEST CORPORATION
Shin-Marunouchi Center Building, 1-6-2 Marunouchi, Chiyoda-ku, Tokyo 100-0005, Japan
Phone: +81-3-3214-7500