For your reference:

Please note that this product is no longer available and is provided as a reference technical document.

TWO PHASE LOCK-IN AMPLIFIER

5610B／A

INSTRUCTION MANUAL

NF Corporation

D:59363-1

5610B/A

TWO PHASE
LOCK-IN AMPLIFIER

【INSTRUCTION MANUAL】

Notes

1. No part of this manual may be reproduced whthout permission of **NF CORPORATION** .

2. The contents of this manual may be changed without notice.

3. **NF CORPORATION** carefully checked for accuracy in the preparation of this manual. If, however, you find ambiguities, errors, or other deficiencies in this manual, please let us know about them.

Table of Contents

Figures

Tables

1. GENERAL DESCRIPTION

1.1 Overview

The model 5610B/A two phase lock-in amplifier is externally controllable through the GP−IB protocol. Also compatible with the RS−232C serial interface, this instrument can make automatic measurements in conjunction with a host computer.

Featuring a wide frequency range of 0.5 to 200,000Hz, the amplifier's maximum sensitivity is 100nVrms (1μVrms 5610A) through the entire range.

Since the 5610B/A is of the two phase type, there is no need for troublesome phase adjustment. A total of five automatic measuring modes, Auto Set, Phase Set, Auto Range, Auto Tune, and Auto Normalize are provided.

Through visual representation of measured data such as amplitude, phase, and of the values of various parameters, the liquid crystal display provides a user-friendly environment.

1.2 Features

(1) Amplitude Measurement without Phase Adjustment

High precision and stability of measurements can be obtained without manual phase adjustments, since data from the amplifier's two phase detectors (COS and SIN) are processed digitally by an onboard microprocessor. The phase adjustment can be made in 0.01° steps by conventional methods.

(2) Removal of Harmonic Effects

The 5610B/A uses a newly developed filter module and the auto-tuning function to completely remove the effects by harmonics contained in the input signal.

(3) Preamplifier with Differential Input, High CMRR, and Low Noise

The model uses a preamplifier of the differential type to remove the measuring error due to the ground loop. High performances of 120dB for CMRR and $3nV/\sqrt{Hz}$ (typ) input noise can be obtained.

(4) High Dynamic Reserve

The dynamic reserve can be selected according to the measuring conditions. If appropriately combined with the filter, a maximum of 110dB can be attained.

(5) Low Phase Noise

The analyzed frequencies are divided into four frequency bands. A reference signal circuit with minimal phase noise is used. Phase noises of 0.001° rms are realized, and the phase lock time is very short.

(6) Multiple functions

A high performance microprocessor realizes a multitude of automatic functions. This enables beginners to operate the 5610B/A easily , and provides a total of eleven items as given below :

A (amplitude), A dB (the ratio of the amplitude to a reference level in dB), A % (the amplitude as a percentage of the reference level) Φ (phase), X (A cos Φ), X dB, X %, Y (A sin Φ), reference signal frequency, external DC voltage, ratio (Only one of dB or percentage can be selected. The selected value is displayed simultaneously with A or X)

(7) X and Y Analog Meters

Two zero-centered meters for the X (A cos Φ) and Y (A sin Φ) values are used, providing ease of understanding of data. The meter sensitivity can be multiplied tenfold.

(8) GP-IB

The model is externally controllable by GP-IB or RS-232C.

(9) Built in Oscillator (Optional)

This high performance oscillator covers a wide frequency range from 0.5Hz to 120kHz and provides output amplitude stability (100ppm / °C) and low distortion (0.01%). Its oscillation frequency and output amplitude are GP-IB and RS-232C controllable.

1.3 Applications

(1) Spectroscopy
(2) Auger electron spectroscopy
(3) PAS (photo-accoustic spectroscopy)
(4) Raman spectroscopy
(5) Evaluation of infrared ray sensor
(6) Evaluation of optical fiber
(7) Evaluation of solar cells
(8) Measurement of the B-H curve of the core of the transformer
(9) Measurement of electrochemical impedance
(10) Calorimetry
(11) SQUID magnetic sensor
(12) Continuous wave ESR, NMR
(13) Measurement of cross-talk of multichannel amplifiers
(14) Measurement of CMRR and IMRR of differential amplifiers and isolation amplifiers

1.4 Specifications

1.4.1 Input Signal Channel

Input type	Differential or single-ended (switched by the change-over switch)
Input Impedance	10MHz ±2%, shunted by 40 ±10pF
Common-mode rejection ratio	110dB min, (120dB typ) (100Hz to 1kHz, 1μV range)
Noise	5nV/ $\sqrt{Hz}$ max., 3nV/ $\sqrt{Hz}$ (typical) referred to input (1kHz, with input short-circuited)
Maximum input voltage without damage	DC : ±200V (Including AC component) AC : 30V peak-to-peak
Maximum allowable input voltage (for linear operation)	AC : 28V peak-to-peak
Sensitivity	100nV(1μV 5610A) to 1Vrms fullscale, 1−3 sequence 15 ranges (13 ranges 5610A)
Accuracy between ranges	±2% (at 1kHz)
Frequency range	0.5Hz to 200kHz ±3dB
Overflow	Indicated on the liquid crystal display

1.4.2 Filter

Mode	Bandpass (BP), Lowpass (LP), Highpass (HP), Through (THRU), switchable
Frequency variable range	0.5Hz to 120.0kHz
Frequency fine adjustable range	Twice the resolution in the set range
Frequency ranges and resolutions	0.5Hz to 120Hz Resolution : 0.1Hz 100Hz to 1200Hz Resolution : 1Hz 1.00kHz to 12.00kHz Resolution : 10Hz 10.0kHz to 120.0kHz Resolution : 100Hz
Q (Selectivity)	LP, HP : 0.7 (fixed) (12dB /oct, maximally flat type) BP : The following 9 selections Normal types 1, 5, 30 LPF types 1, 5, 30 HPF types 1, 5, 30
Frequency accuracy	Within ±1% (100Hz to 10kHz) Within ±5% (0.5Hz to 100Hz, 10kHz to 120kHz)

Passband gain accuracy	Q=1, 5	
	Within ±0.2dB	(100Hz to 10kHz)
	Within ±1dB	(0.5Hz to 100Hz, 10kHz to 120kHz)
	Q=30	
	Within ±1dB	(100Hz to 10kHz)
	Within ±3dB	(0.5Hz to 100Hz, 10kHz to 120kHz)

1.4.3 Phase Sensitive Detector (PSD)

Dynamic reserves for the L, M and H selections are given in Figures 1-1 and 1-2 and in Table 1-1.

Dynamic reserve setting range

L :	Input sensitivity	100μV	to 1V
M :	Input sensitivity	10μV	to 100mV
H :	Input sensitivity	100nV (1μV 5610A)	to 10mV

Gain Stability

L 20 ppm / °C (typ)
M 50 ppm / °C (typ)
H 300 ppm / °C (typ)

Time constant (TC)	1ms to 30s in 1-3 sequence (10 ranges)
Rolloff	6dB /oct or 12dB /oct (switchable)
Phase noise	0.003° rms (typ) (at 100Hz, TC : 300ms, 6dB /oct rolloff)
	0.001° rms (typ) (at 1kHz, TC : 300ms, 6dB /oct rolloff)
	0.001° rms (typ) (at 10kHz, TC : 300ms, 6dB /oct rolloff)

Table 1-1 Dynamic Reserve (dB)

DYN RES	L		M		H	
SENSITIVITY	DR 1	DR 2	DR 1	DR 2	DR 1	DR 2
1V	30	30	–	–	–	–
300mV	30	40	–	–	–	–
100mV	30	50	50	50	–	–
30mV	30	60	50	60	–	–
10mV	30	70	50	70	70	70
3mV	30	40	50	80	70	80
1mV	30	50	50	90	70	90
300μV	30	60	50	60	70	100
100μV	30	70	50	70	70	110
30μV	–	–	50	80	70	80
10μV	–	–	50	90	70	90
3μV	–	–	–	–	70	100
1μV	–	–	–	–	70	110
300nV *	–	–	–	–	70	110
100nV *	–	–	–	–	70	110

DR1 : Dynamic reserve for THRU

DR2 : Maxdimum value of dynamic reserve when passed through a filter.

* : 5610B only

$$\text{Dynamic reserve} = \frac{\text{Maximum unclipped noise voltage (p-p)}}{\text{Input fullscale sensitivity (rms)}}$$

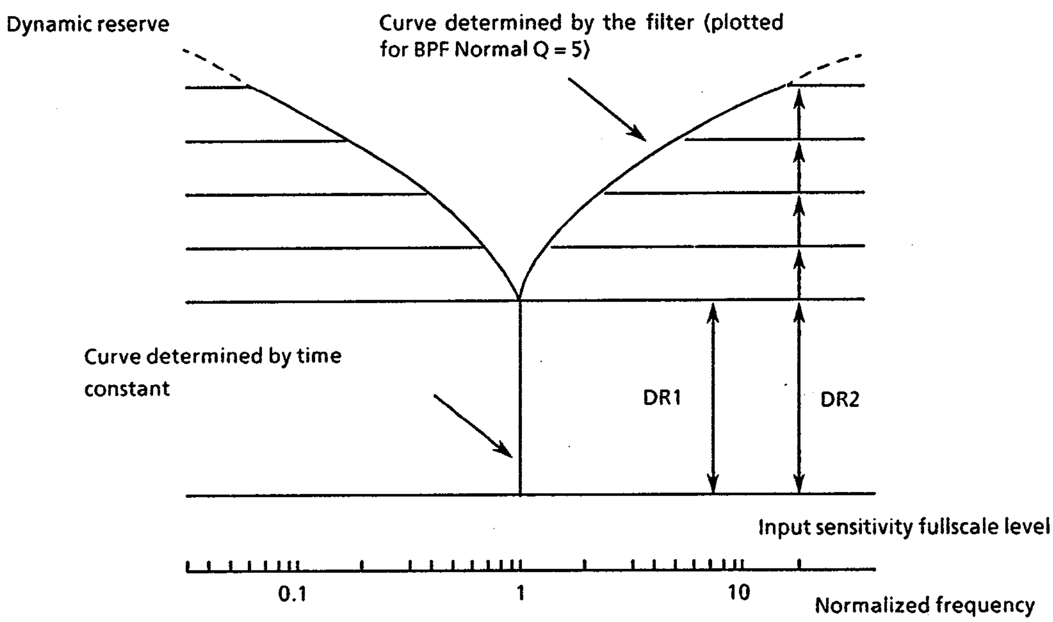
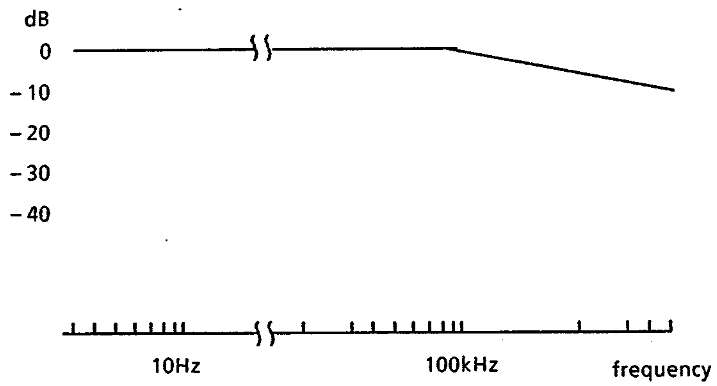


Fig.1－1 Dynamic Reserve (Dynamic reserve when BPF Normal Q=5)



Dynamic reserve decreases as above by the frequency component of noise applied to the input

Fig.1－2 Dynamic Reserve Reduction Characteristics

1.4.4 A-D Converter

Mode	Integrating type
Sampling period	100ms, 300ms, 1s, 3s, and 10s, switchable
Resolution	13 bit linear digitizing
Stability	40ppm / °C (typ)

1.4.5 Reference Signal Channel (REF)

Mode and frequency ranges	EXT F 0.5Hz to 200kHz
	EXT 2F 0.5Hz to 100kHz
	INT F 0.5Hz to 120kHz (optional)
	INT 2F 0.5Hz to 100kHz (optional)
External Reference Signal Input	
Input type	Unbalanced
Input impedance	1MΩ ± 10%, shunted by 100pF ± 30pF (10Ω impedance between the input signal ground and the external reference signal ground)
Maximum input voltage without damage	DC ± 200V (Including AC component) AC : 50V peak-to-peak
Allowable Input voltage range	0.3V to 30V p-p
Input waveform	Any time invariant waveform whose voltage passes through the average value exactly twice per cycle. For pulse signals, the minimum pulse width is 1μs and the duty cycle should be in the range 1 : 10 to 10 : 1.
UNLOCK Display	When the internal circuit is not synchronized to the reference signal and not in a stationary state, this is indicated on the liquid crystal display.
Reference signal phase adjustment	0 to ± 180° (0.01° resolution) adjustable
Accuracy of phase adjustment	± 1° (typ) 0.5Hz to 10kHz ± 5° (typ) 10kHz to 100kHz
(Accuracy of orthogonality)	± 0.1° (typ) 0.5Hz to 10kHz ± 0.5° (typ) 10kHz to 100kHz

1.4.6 Internal Oscillator (Optional)

Frequency ranges and resolutions						
	0.5Hz	to	120.0Hz	Resolution	:	0.1Hz
	100Hz	to	1200Hz	Resolution	:	1Hz
	1.00kHz	to	12.00kHz	Resolution	:	10Hz
	10.0kHz	to	120.0kHz	Resolution	:	100Hz
Frequency accuracy	±1% in the setting range of 100 to 1000 (setting value ignoring the decimal point) for each range					
Output amplitude ranges and resolutions						
	0 to 25.5mVrms	(no load)	Resolution	:	0.1mVrms	
	0 to 255mVrms	(no load)	Resolution	:	1mVrms	
	0 to 2.55Vrms	(no load)	Resolution	:	10mVrms	
Output impedance	600Ω ±1%					
Output amplitude	±1% of fullscale (at 1kHz)					
Output amplitude stability	200ppm/°C or less (for 1kHz) 100ppm/°C or less (typ)					
Distortion	0.01% maximum (at 1kHz, fullscale amplitude)					

1.4.7 Output

Liquid crystal display

Number of char-acters 40 characters×2 lines

DATA 1	display
A (amplitude)	100nV (1μV 5610A) to 1V, 1000or 3162 fullscale. Overflow indication appears when X or Y output overflows.
AdB	The ratio of the measured value of A to a given reference value is displayed in dB. 0 to ±120dB with 0.1dB resolution.
A%	Indicates the given reference value and the measured value of A in %.
X(A cosΦ)	100nV (1μV 5610A) to 1V, 1000 or 3162 fullscale. Overflow indication appears when exceeding 120% or more of the fullscale value.
XdB	The ratio of the measured value of A to a given reference value is displayed in dB. 0 to ±120dB with 0.1dB resolution.
X%	Indicates the measured value of A in percentage with respect to the reference value.

The indication of A or X is selected by [DISPLAY DATA 1].
The indication of dB or % is selected by [NORMALIZE MODE] key.

DATA 2 display

Φ (phase)	0 to ±180° with 0.1° resolution.
Y(A sinΦ)	100nV (1μV 5610A) to 1V, 1000 or 3162 fullscale. Overflow indication appears when exceeding 120% or more of the fullscale value.

The indication of Φ or Y is selected by [DISPLAY DATA 2].

DATA 3 display

Reference Signal frequency	Indicates the frequency of a signal applied to the REF input. 3−4 digits display in the range of 100 to 1200 (value ignoring decimal point.)
EXT DC	Displays the DC value of a signal applied to the external DC input. ±10V fullscale, 10mV resolution, fixed range. Overflow indication appears for voltages exceeding 120% or more of the fullscale value.
RATIO	Displays a ratio of X or Y to DC voltage applied to the EXT DC, with a fullscale of 1.200.

$$\text{Ratio} = K \times \frac{\text{Percentage of X or Y to the fullscale of range}}{\text{Percentage of EXT DC to the fullscale of range}}$$

K is a constant. Setting range : 0.100 to 9.999

A desired display is selected by [DISPLAY DATA 3].

Analog meters: Two meters are provided for X (A cos ϕ) and Y (A sin ϕ). Meter fullscall agrees with the set sensitivity.
Meter sensitivity is magnified by a factor of 10 at the METER MAG operation.

Analog Outputs (BNC Connector)

SIG MON: Monitor outputs of input signals (after filtering)

Frequency response	:	0.5Hz to 200kHz ±3dB	
Maximum Output Voltage	:	±10V	

Rated output voltage (for a fullscale coherent sine wave input)

DYN RES L	:	2Vp-p	(no load)
DYN RES M	:	0.2Vp-p	(no load)
DYN RES H	:	20mVp-p	(no load)
Output impedance	:	600Ω±10%	
Maximum output current	:	±5mA	

OUTPUT A cos ϕ

X (A cos ϕ) Analog Output of PSD (Phase Sensitive Detector)

PSD Rated output current	±10V
Output impedance	1Ω or less
Maximum Output Current	±5mA

OUTPUT A sin ϕ

Y (A sin ϕ) Analog Outputs of PSD

PSD Rated output current	±10V
Output impedance	1Ω or less
Maximum Output Current	±5mA

DAC1 12 bit D−A converter output. One of the following four signals can be obtained as an analog DC output.

•A	±10V for the fullscale value
•AdB/A%	±10V for the 100dB/100% value
•X (A cosϕ)	±10V for the fullscale value
•XdB/X%	±10V for the 100dB/100% value

DAC2 12 bit D−A converter output. One of the following five signals can be obtained as an analog DC output.

•ϕ (phase)	±10V for ±180°
•Y(A sinϕ)	±10V for the fullscale value
•RATIO	±10V for ±1.000
•EXT DC	±10V for 10V input voltage
•REF frequency	10V when the value ignoring the decimal point is 1000.

Output impedance : 1Ω or less

Max. output current : ±5mA

Output Data Averaging Functions

Averaging of the values of DATA1 and DATA2

Mode Moving average, exponential average

Number of averaging times 2^1 to 2^9

DC Power Supply Output

A ±24V (50mA max.) power supply output is available for use with NF preamplifiers and other devices.

1.4.8 Accuracy

A (amplitude) (Accuracy between ranges) + (PSD Stability) + (ADC Stability) + (±1 digit)

ϕ(phase) *2

		0.5Hz to 10kHz	10kHz to 100kHz
When phase offset is 0°	:	≦3°	≦10°
After calibration of phase offset	:	≦1°	≦3°

X(A cosϕ) Same as that of the amplitude

Y(A sinϕ) Same as that of the amplitude

EXT DC 1% of fullscale value ±1 digit

REF Frequency ±1 digits

*1 : It applies to an input signal of 30 to 100% fullscales.

*2 : It applies for the dynamic reserve L, and a REF signal of 1V to 3Vrms sine wave.

1.4.9 AUTO Functions

AUTO SET Sensitivity, dynamic reserve, frequency range, time constant and filter frequency are automatically optimized for the input signal.

PHASE SET REF phase is automatically set so that the Y (A sin ϕ) output reaches its minimum value.

AUTO RANGE If the input signal exceeds 110% of its fullscale level, the sensitivity is automatically lowered and if the input is below 20% of the fullscale level, the sensitivity rises automatically. The maximum sensitivity can also be limited by LIMIT (Auto Range Limit). The limiting value can also be removed (LIMIT OFF).

AUTO TUNE The frequency range and bandpass filter frequency are automatically set according to the REF input signal frequency.

AUTO NORMALIZE X or Y value is converted into a decibel or percentage with respect to the set reference value. The converted value is automatically displayed.

1.4.10 Other Functions

K Value setting function for ratio measurements (range : 0.100 to 9.999)

CAL Function

PSD ZERO Function

Beeper on/off Function

LAMP on/off Function

Initializing Function

Key lock Function

Battery backup function for setting values (60 day hold capacity on a full charge)

1.4.11 General Specifications

Power Requirements	100, 120, 220, and 240VAC switch selectable ±10%, 48 to 62Hz Approx. 60VA (including options)
Operating temperature and humidity	0 to 40 °C, 10 to 90%RH (no condensing)
Storage temperature and humidity	−10 to 50 °C, 10 to 80%RH (no condensing)
Outer dimensions	432(W)×132.5(H)×500(D) mm (Not including protruding sections)
Weight	Approx. 13.5kg (with internal oscillator) Approx. 29.8lb

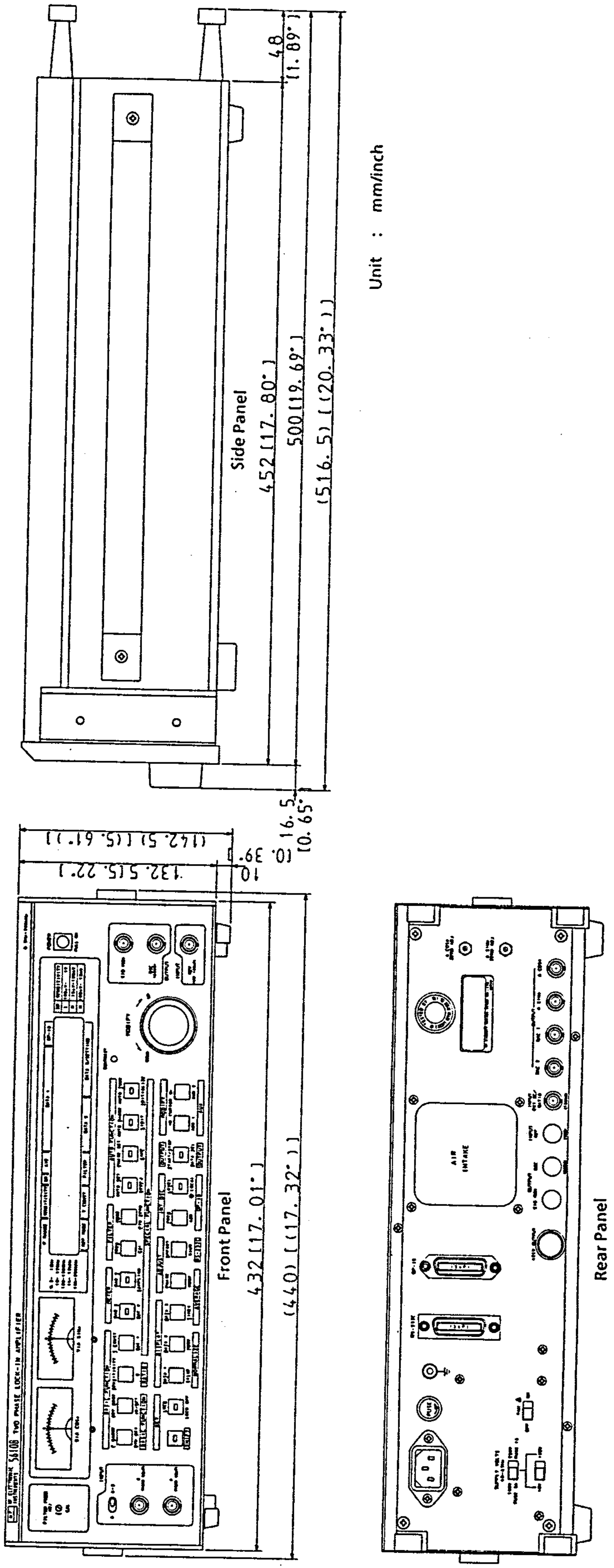


Fig. 1−3 Outer Dimensions

2 PREPARATIONS BEFORE USE

2.1 Outline

Please check the items below before using the unit.

Consideration should especially be given to the installation since it effects the life of the machine, its reliability, and safety.

In addition, care should be taken against dropping and shocks when moving the unit or when installing it in the rack mount.

2.2 Unpacking and Repacking

(1) Unpacking

After unpacking, first check that there has been no damage during shipping. Sufficient care has been giving to packing details before shipping, but please check all the accessories against the items in the Contents List below.

(2) Repacking

When repacking the unit for transport, use a cardboard box of appropriate strength and size which can sufficiently withstand the weight of the unit. Pack the unit so that it is sufficiently protected.

2.3 Contents

The contents of the package are listed Table 2-1.

Table 2-1 Contents List

Main unit	1
Instruction manual	1
Accessories	
Power cable	1
Fuse (5.2mm dia. ×20mm)	2
Signal cable (BNC-BNC)	2

2.4 Installation Location

(1) Setting Location

The authorized temperature and humidity range for this unit :

Operation	0 to 40 °C,	10 to 90% RH
Storage	– 10 to 50 °C,	10 to 80% RH

Choose a location for this unit which satisfies the temperature and humidity range, is exposed to little dust and vibration, and does not receive direct sunlight.

This unit is equipped with a line filter, but if there is equipment in the vicinity that generates pulse noise, a strong magnetic field, or a strong electric field, it may cause erroneous operation. By all means avoid using the unit near such equipment.

The rear guard located on the rear panel of the unit is for the protection of the connectors and the fan, it is not a stand for the unit. Do not use the unit in a standing orientation since it will easily fall over and is dangerous.

(2) Fan

This unit has been equipped with a fan to lower the temperature rise within the case when the power is supplied to the unit as well as shorten the time during which there is a temperature rise. Allow at least 10 cm between the air intake vent of the fan and a wall or other object to ensure proper air circulation.

The fan filter should be washed periodically with a neutral detergent since dust adhering to the filter may impede the air circulation and cause a breakdown.

If the noise of the fan becomes a hindrance to measurements, the fan can be switched off with the switch on the rear panel of the unit. When the fan has been switched off, articles which block the natural air circulation must not be placed on or beneath the case.

Note that when the power has been switched on, the time taken until the temperature within the case reaches steady a state is about 5 minutes with the fan on and about 1 hour with the fan off.

2.5 Power Supply and Ground

(1) Power Supply

This unit operates on a commercial power supply of 100, 120, 220, or 240V ±10% single phase, at 48 to 82Hz. The power consumption is approximately 55VA.

The power supply voltage is switch selectable, but is set to 100V at the time of shipping on a standard basis. When selecting the power supply voltage, first check the line voltage and disconnect the power cord before making any changes.

The fuse capacity will differ depending on the power supply voltage setting. Use a 2A fuse for 100V/120V and a 1A fuse for 220V/240V.

When the power is switched from an " On " state to " Off " and then " On " again, allow an interval of 15 seconds or more. In addition, when changing the various settings, allow an interval of 1 second or more following the operation before switching the power off.

CAUTION

- Check whether the power supply voltage setting is correct.
- Do not use a fuse which is outside of the specified rating.
- Be sure that the power plug has been disconnected before changing the power supply voltage setting.

(2) Ground

For the purposes of outside interference prevention and safety, be sure to ground the unit from the ground terminal on the rear panel.

This unit is equipped with a line filter, the circuit of which is shown in Fig.2-1. Since the leakage current is a maximum of 0.75mA rms at 250V, 80Hz an electric shock may be received when the case of the unit is touched. To ensure safety when using the unit, be sure to ground the ground terminal.

The units power input connector is a 3-pin type, but the plug on the supplied power cord is a 2-pin type which matches the domestic situation. A 3-pin cord including ground terminal is available. If required, contact the manufacturer or a sales agent.

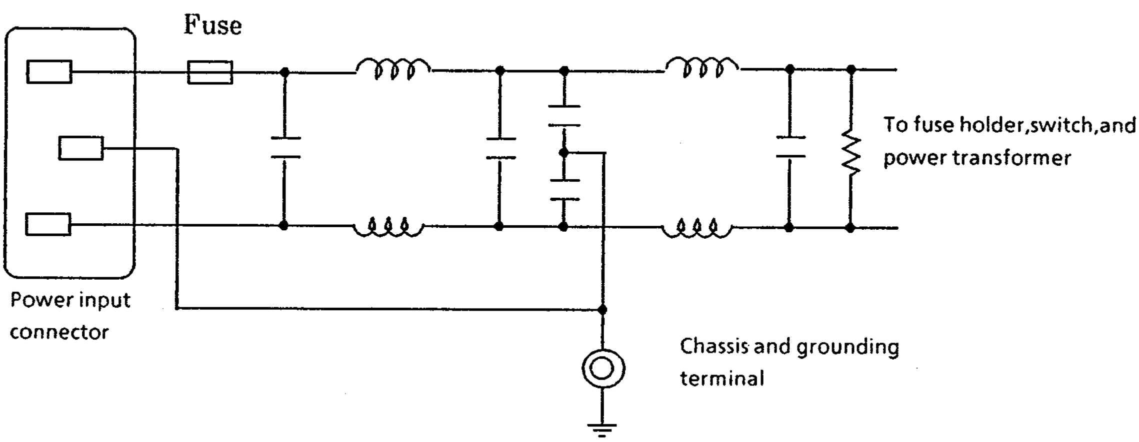


Fig.2-1 Line filter

2.6 Rack Mount (Optional)

By attaching the optional rack mount adapter and rails, the unit can be installed in an 18-inch IEC and EIA standard rack.

The method of installing the adapter and rails as well as the rack mounting procedure is shown below.

(1) Attaching the rails to the rack frame

Attach the two rails to the frame as shown in Fig.2−3.

(2) Attaching the rack mount adapter

Remove the nylon rivets from the decorative plates on both sides as shown in Fig.2−3 and attach the rack mount adapter with the screws after removing the decorative plates.

(3) Removing plastic feet

If the lower surface of the plastic feet contact the rail, remove the plastic feet.

Turn the unit upside down, remove the two screws of the bottom plate (rear panel side) and remove the bottom plate. Keep the plastic feet and screws after removal.

Perform the following procedure to attach the bottom plate.

- Insert the bottom plate into the grove of the lower back side of the front panel.
- Position the lower plate so that its holes are aligned with the screw holes on the side of the unit.
- Insert the two screws and tighten them alternately using a Philipps screwdriver.

(4) Installation of the unit into its rack

Referring to Fig.2−3, put the unit into the rack and fix the rack frame with screws.

(5) Precautions at the time of rack mounting

- Use a rack mount with an effective mounting depth of 600mm or greater.
- Allow 50mm or more of space above and below the unit for ventilation.

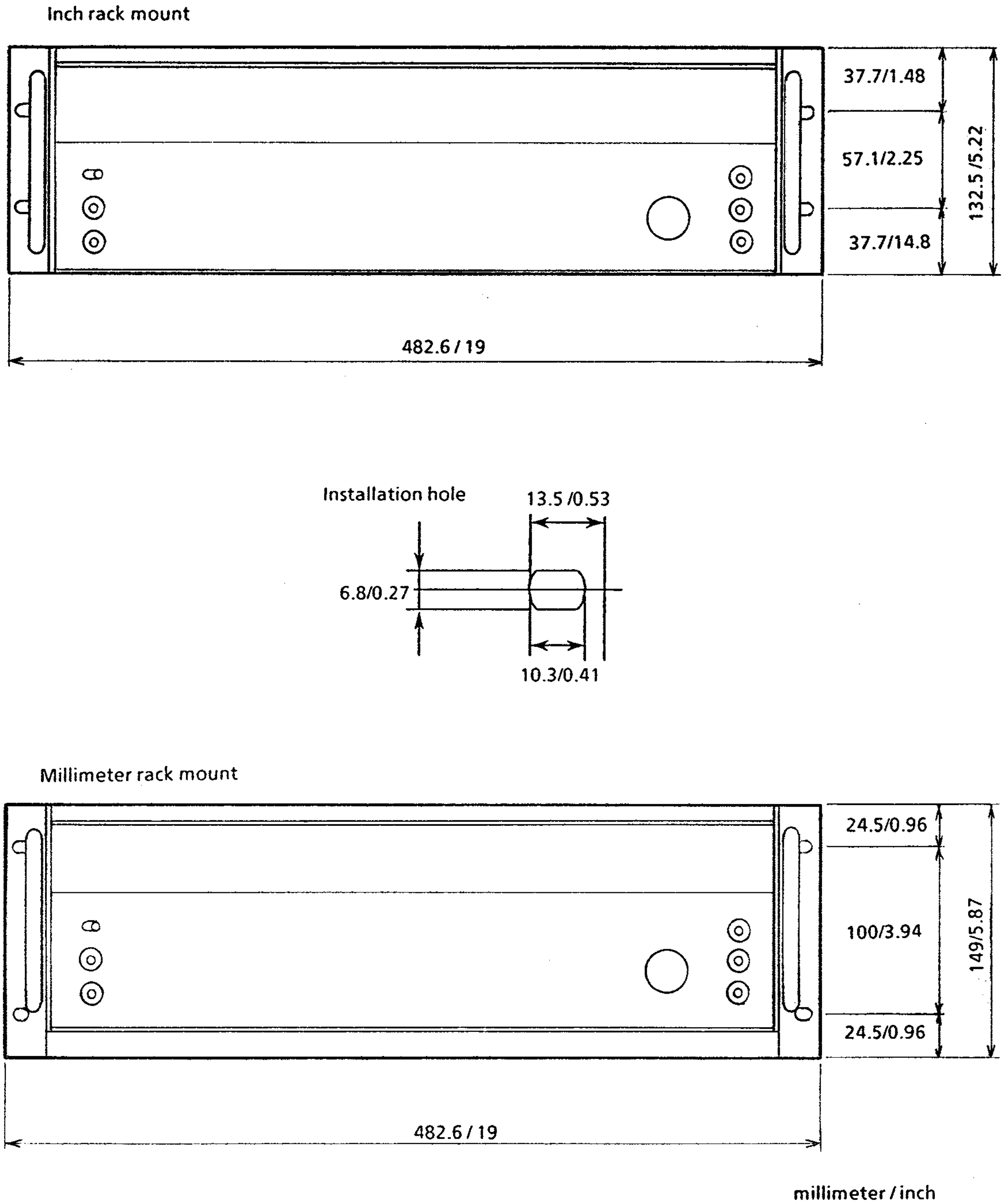
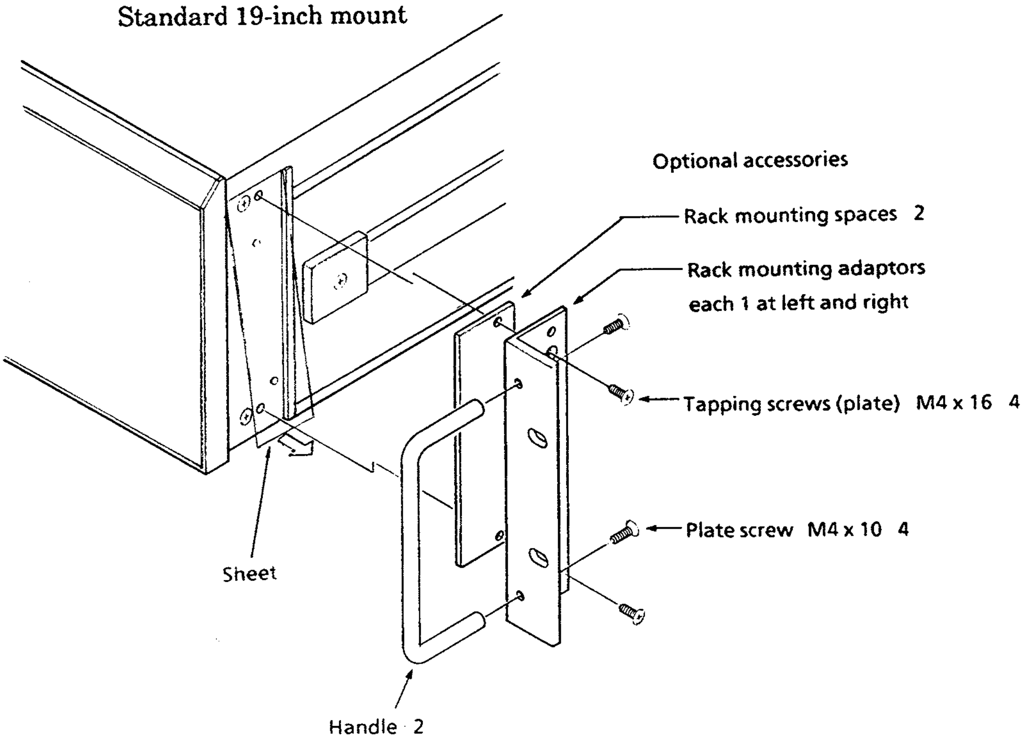


Fig.2-2 Rack Mount Dimensions

Standard 19-inch mount



Standard metric mount

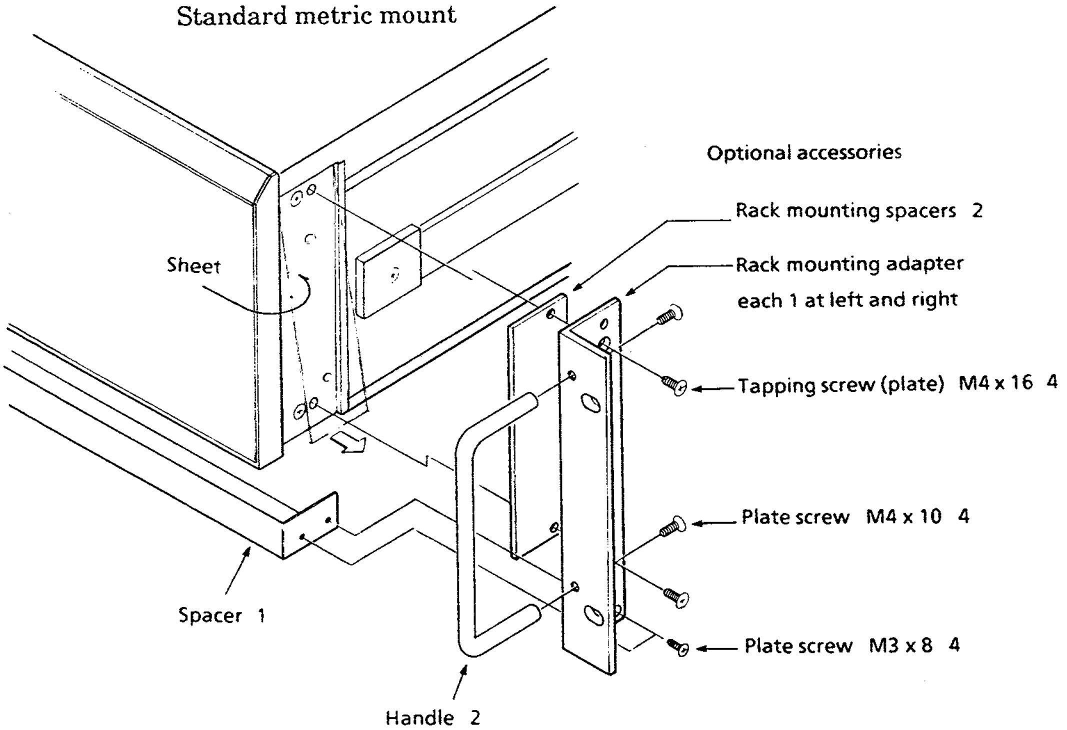


Fig.2-3 Rack Mount Adapter Installation

2.7 Installation of the Internal Oscillator (INT OSC) (Optional)

When the INT OSC (optional) has been purchased separately, install it according to the procedure below.

(1) Set the power switch to the OFF position.

(2) Remove the screws from the top plate. Hold the rear portion of the top plate and remove it.

(3) Insert the INT OSC printed circuit board (both sides of which are protected by shield board) into the slot labeled PB-5. As shown in the diagram below, arrange the parts side of the printed circuit board (PCB) to the right, insert both ends of the PCB into the PCB guide, and slowly press it in downward. Check that the PCB has been smoothly inserted into the PCB connectors.

(4) Attach connectors 14 and 15 into the top, front panel side of the PCB.

(5) Reattach the top plate as it was originally and tighten the screws. (The front panel side of the top plate is constructed to fit into the sash groove on the top of the front panel.)

(6) Set the power switch to ON and use according to the operation method of Section 3.4.5.

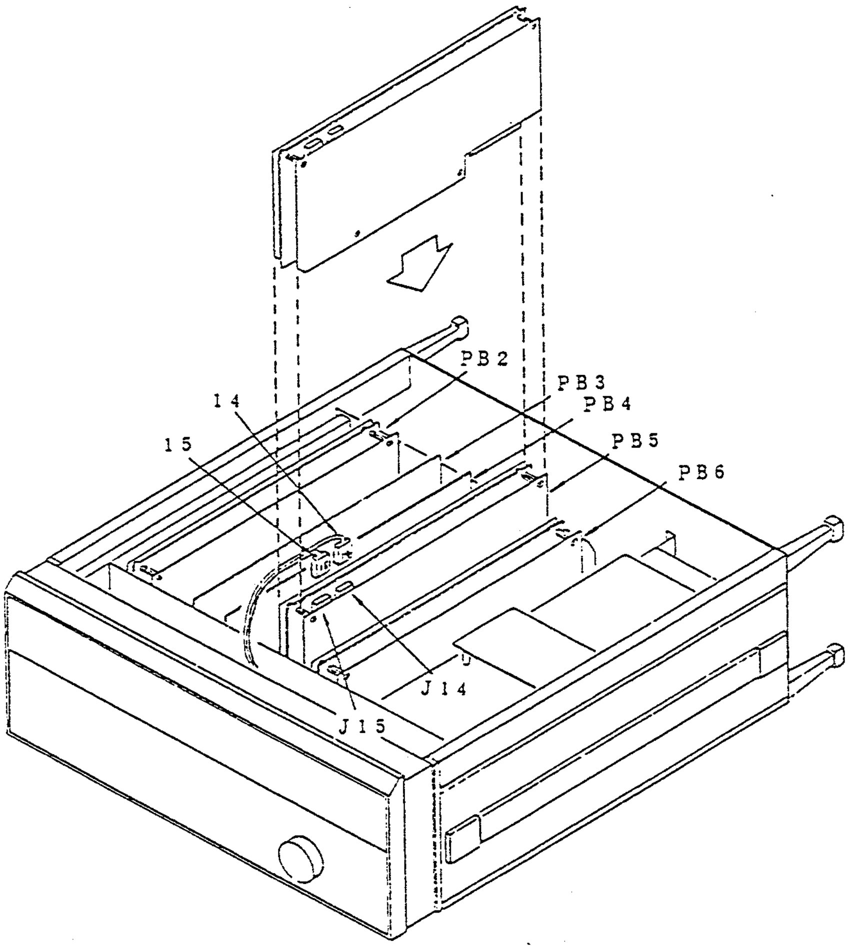


Fig.2-4 Installing the INT OSC

3. OPERATION

3.1 Outline

The front panel of the 5610B/A may be roughly divided into two sections : the display section at top and the operations section at bottom. The display section consists of a 40-character by 2-line liquid crystal display and a center-zero analog meter for the X (A cos ϕ) and Y (A sin ϕ) display. The operations section has 24 key switches one of which is the shift key. With the exception of the shift key, the key switches have two kinds of functions. One of these is the original function of the key (indicated on the upper side of the key), the other function is available when the shift key is depressed (and is indicated on the lower side of the key).

The rotary pulse switch offers the same feeling as conventional rotary switches and can be used for selecting the sensitivity and making the various settings. Functions which can be set by the rotary pulse switch are shown in a red color.

With the exception of special items, most of the setting contents are backed up by battery. When the power is switched on again, the previous contents will be set.

3.2 Name and Operation of Each Section

3.2.1 Description of the Front Panel (See Fig.3 - 15)

Depending on the type of key switch, the label [SHIFT], [MODIFY], or [CURSOR] may appear in the description of the name and operation of the section. The meaning of such labels is as follows :

[SHIFT]	Indicates that the shift key must be pressed. Press the shift key, then press the required key.
[MODIFY]	Indicates that a setting change is made by the rotary pulse switch (MODIFY). After pressing the required key, turn the rotary pulse switch. This operation is necessary for keys labeled in red on the frontpanel.
[MODIFY] [CURSOR]	Indicates that the digit is defined using the cursor function and that the setting of the number at that digit is changed with [MODIFY].

① FILTER FREQ ADJ (Filter Frequency Adjust)

This is a trimmer for adjusting the center or cutoff frequency of the input signal filter. It is used when making finer adjustment beyond the set resolution in cases where the Q is high or in the lowest frequency range. For one revolution, the variable range is twice the resolution.

Normally set this control at the CAL position by rotary it fully counterclockwise.

② X : A COS ϕ, and Y : A SIN ϕ (Meter for PSD output signal monitoring)

It is used to observe the fluctuation of the output signal or to detect the zero-point of Y (A sin ϕ) at the time of phase adjustment. When METER MAG ㉓ or ㉔, is pressed and the lamp is lit the output voltage of the PSD analog DC output ⑥⓪ and ⑥① will be ten times as high.

③ F RANGE (Frequency Range)

This section displays the analysis frequency ranges. There are five analysis frequency ranges which are set by ⑲ F RANGE and ㊸ MODIFY.

The display values and the ranges set are as follows :

0.5-	0.5Hz	to	12Hz
10-	10Hz	to	120Hz
100-	100Hz	to	1200Hz
1k-	1kHz	to	12.00kHz
10k-	10kHz	to	200kHz

④ REF MODE (Reference Mode)

The reference frequency can be supplied externally (EXT) or from the internal oscillator (INT) and the analysis can be made with respect to the fundamental frequency (1F) or the second harmonics (2F) of the reference signal.

The reference mode, therefore consists of these combination : EXT 1F, EXT 2F, INT 1F and INT.

Setting is done by the ⑳REF MODE key and each time the key is pressed, the following selection will be made : EXT 1F, EXT 2F, INT 1F, INT 2F. <u>When the optional oscillator has not been installed in the unit, the INT 1F and INT 2F settings will not be possible.</u>

⑤ SENSITIVITY

This section displays the sensitivity range. The sensitivity range is 100nV (1μV 5610A) to 1V in 1−3 sequence and in 15 ranges (13 ranges 5610A). The sensitivity range is set by ㉑ SENSITIVITY and ㊸ MODIFY.

⑥ T CONST (Time Constant)

This section displays the time constant. The time constant is 1 ms to 30s in 1−3 sequence and in 10 ranges. The time constant is set by ㉒ T CONST and ㊸ MODIFY.

⑦ DR (Dynamic Reserve)

This section displays the dynamic reserve. Dynamic reserve is expressed by the ratio of the allowable maximum noise voltage to the input sensitivity. This indicates the level of the degree of noise amplitude under which measurements can be made normally. In other words, the value expresses the amount of margin which exists with respect to the noise. For detailed values, see Table 1−1. The dynamic reserve is set by㉛ SHIFT and⑲ DYN RES. The dynamic reserve changes according to the sensitivity range. The ranges which can be set are shown below.

L (Low)	100μV	to	1V
M (Mid)	10μV	to	100mV
H (High)	100nV (1μV 5610A)	to	10mV

⑧ FILTER

This section displays the filter mode and the Q at the time of using the BPF. The filter has four modes : LPF (Low-pass filter), HPF (High-pass filter), BPF (Band-pass filter), and THRU (Through). There are three types of BPF (normal type, LP type, and HP type), each of which has a selectable Q of 1, 5, or 30 for a total of 9 kinds.

The filter mode is selected by ㉖ FILTER MODE and ㊸ MODIFY.

⑨ AVE (Average)

This section displays the averaging mode. There are three averaging modes : LIN (Linear : moving average), EXP (Exponential : exponent average), an no averaging (without display). The averaging modes are selected by ㉛ SHIFT and ㊱ AVERAGE MODE.

⑩ DATA 2

This is an indicator of measurement results. It displays either ϕ (phase) or Y (A sin ϕ). Switching is by the ㉒ DATA 2 key.

⑪ DATA 1

This is an indicator of measurement results. It displays either A (amplitude) or X (A cos ϕ). Switching is by the ㉑ DATA 1 key. A and X are both simultaneously displayed by voltage value and dB or %. Selection of dB and % is by ㉛ SHIFT and ㉞ NORMALIZE MODE.

The A or X character flashes on and off at the measurement processing interval.

⑫ DATA 3 / SETTING

This section displays the measurement results and the setting values of the various functions. The three kinds of measurement results, which are the reference signal frequency (REF), the external DC input voltage (EDC), and the ratio (RAT), can be selected with the ㉟ DATA 3 key.

The setting values of the various functions are displayed in this section when the pertinent key is pressed. At this time the three alphabetic characters at the left side indicate the header of the program code when using the GP-IB and RS-232C interfaces.

To return the display to the original measurement results, press the ㉟ DATA 3 key.

⑬ GP-IB

This section displays the various states of the GP-IB. The displayed symbols are shown below.

S : Indicates that SRQ is being sent from the unit.

L : Indicates that the unit is being designated as the listener by the controller.

T : Indicates that the unit is being designated as the talker by the controller.

⑭ CONTRAST

This is a trimmer for adjusting the contrast of the liquid crystal display. Turning it in the clockwise direction will darken the displayed characters.

⑮ POWER PULL ON

Pulling this units power switch toward you will switch on the power. When the power is on a red ring will appear on the switch bar and the lamp will light up below. The lamp will go off when the LAMP OFF setting is performed with ㉛ SHIFT and ㉘ LAMP.

⑯ A A−B (Input Mode)

This is the input selection switch. Setting the switch to the A side will provide a single ended input of only the A input, and setting it to the A−B side will provide a differential input with the non-inverted input at A and the inverted input at B.

⑰ B (Signal Input B)

This signal input BNC connector is used as the inverted input at the time of differential input (A−B). It will be open-circuited when switch ⑯ is set at the A side.

⑱ A (Signal Input A)

This signal input BNC connector is used as the non-inverted input at the time of single ended input (A) and differential input (A−B).

⑲ F RANGE (Frequency Range) [MODIFY]

This key is used for setting the analysis frequency range. The set range is displayed in ③ F RANGE. The following 5 frequency ranges are available :

0.5-	0.5Hz	to	12Hz
10-	10Hz	to	120Hz
100-	100Hz	to	1200Hz
1k-	1kHz	to	12.00kHz
10k-	10kHz	to	200kHz

⑲ DYN RES (Dynamic Reserve) [SHIFT]

This key is used for setting the dynamic reserve. The set value is shown in ⑦DR. The dynamic reserve is a value that indicates the level of the noise margin. For detailed values see Table 1−1. The dynamic reserve is limited by the sensitivity range. The range that can be set is as follows :

L (Low)	100μV	to	1V
M (Mid)	10μV	to	100mV
H (High)	100nV (1μV 5610A)	to	10mV

Between the sensitivity and the dynamic reserve, it is the sensitivity that has priority and when the sensitivity is selected outside of the setting range, the dynamic reserve will also be switched. In the opposite situation, even if the dynamic reserve is switched, the sensitivity will not change. A dynamic reserve which exceeds the sensitivity range cannot be set. (For example, when the sensitivity range is at 100 mV, the dynamic reserve can only be set to M or L.)

⑳ REF MODE (Reference Mode)

This key is used for setting the reference signal mode. The set value is shown in ④REF MODE. This key selects the source of the reference signal : an external signal (EXT), or signal from the internal oscillator and the mode of analysis : fundamental frequency (1F), or second harmonics (2F). The selection will change through the following items as the key is pressed successively : EXT 1F, EXT 2F, INT 1F, and INT 2F. When the optional oscillator has not been installed in the unit, the INT 1F and INT 2F settings will not be possible.

⑳ dB / oct [SHIFT] [MODIFY]

This key is used for setting the roll-off of the low-pass filter which determines the time constant. The set value is shown in ⑫DATA 3/SETTING by pressing this key after pressing the ㉛SHIFT key. There are two types of setting values : 6 dB/oct and 12 dB/oct.

㉑ SENSITIVITY [MODIFY]

This key is used for setting the sensitivity. The set value is shown in ⑤ SENSITIVITY. The setting range is 100nV (1 μV 5610A) to 1V in 1 – 3 sequence in 15 ranges (13 ranges 5610A).

㉑ RATIO K [SHIFT] [MODIFY] [CURSOR]

This key is used to set constant K which is used at the time of ratio measurements. The set value is shown in ⑫ DATA 3/SETTING by pressing this key after pressing the ㉛ SHIFT key. The setting range is from 0.100 to 9.999.

㉒ T CONST (Time Constant) [MODIFY]

This key is used for setting the time constant. The set value is shown in ⑥ T CONST. The time constant setting range is 1 ms to 30 s in 1 – 3 sequence in 10 ranges.

㉒ DAC 1 (Digital to Analog Converter) [SHIFT] [MODIFY]

This key selects the output to the BNC connector of the rear panel ㊾ OUTPUT DAC 1. One of the four outputs listed below may be selected : A or A dB/%, or X, or X dB/%.

The display is shown in ⑫ DATA 3/SETTING.

These signals are processed internally in the form of 12-bit digital data. These data are converted to analog data by the D – A converter and output from the ㊾ OUTPUT DAC 1 BNC connector. The sampling speed of the D – A converter is a value set by ㉛ SHIFT and ㉔ SAMPLING.

㉓ METER MAG X (Meter Magnify)

This switch multiplies by a factor of 10 the sensitivity of the ② X : A cos ϕ meter and the output voltage from the ⑥① OUTPUT A cos ϕ BNC connector. The lamp lights up when the gain is multiplied by 10.

㉓ DAC 2 (Digital to Analog Converter) [SHIFT] [MODIFY]

This key selects the data output to the BNC connector of the rear panel ⑤⑧ OUTPUT DAC 2. One of the five kinds of output listed below may be selected. The display is shown in ⑫ DATA 3/SETTING. Data output : ϕ (phase), or Y (A cos ϕ, or EXT DC (external DC voltage), or RATIO (K), or REF FREQ (reference signal frequency.)

㉔ METER MAG Y (Meter Magnify)

This switch multiplies by a factor of 10 the sensitivity of the ② X : A sin ϕ meter and the output voltage from the ⑥⓪ OUTPUT A sin ϕ BNC connector. The lamp lights up when the gain is multiplied by 10.

㉔ SAMPLING (Sampling) [SHIFT] [MODIFY] [CURSOR]

This key is used for setting the measurement processing interval and the transmission interval of the data. Pressing this key will display two groups of figures, two digits at a time. The setting contents are as shown below.

Right 2 digits : Measurement processing interval (Sampling time)

00 : Stop	01 : 100 ms	02 : 300 ms
03 : 1 s	04 : 3 s	05 : 10 s

Left 2 digits : Data transmission interval (The number of samples that will be taken for one output of the measurement process)

There will be one output for every 2^n measurement processes, the setting being determined by the value of n. The setting range for n is from 0 to 16. Therefore, the time of the data transmission interval will be $2^n \times$ (Measurement processing interval).

㉕ FILTER FREQ (Filter Frequency) [MODIFY] [CURSOR]

This key is used for setting the cutoff frequency of the filter and its center frequency. The setting range is from 0.5 Hz to 120 kHz, divided into the following four ranges : 0.5 Hz to 120 Hz, 100 Hz to 1200 Hz, 1 kHz to 12 kHz, and 10 kHz to 120 kHz.

The display is shown in ⑫ DATA 3/SETTING. The optional frequency is set by ㊶ and ㊷ CURSOR and ㊸ MODIFY.

㉕ CAL (Calibration) [SHIFT]

This key is used for calibrating the gain of the amplifier and the phase sensitive detector (PSD). See Section 3.4.13 (4) for the operation method.

㉖ FILTER MODE [MODIFY]

This key is used for selecting the filter type. Turning ㊸ MODIFY in the clockwise direction will provide settings as shown in the table below.

The set mode is displayed in ⑧ FILTER and ⑫ DATA 3/SETTING.

Mode			Function			Display	
THRU		(Through)	No filter (Passage through)			TURU	
HPF		(High Pass Filter)	Passage of the high region			HPF	
LPF		(Low Pass Filter)	Passage of the low region			LPF	
BPF	: 1	(Band Pass Filter 1)	BP	(Normal type)	Q=1	BPF	1
BPF	: 5	(Band Pass Filter 2)	BP	(Normal type)	Q=5	BPF	5
BPF	: 30	(Band Pass Filter 3)	BP	(Normal type)	Q=30	BPF	30
BPF	: L1	(Band Pass Filter 4)	BP	(Low-pass type)	Q=1	BPF	L1
BPF	: L5	(Band Pass Filter 5)	BP	(Low-pass type)	Q=5	BPF	L5
BPF	: L30	(Band Pass Filter 6)	BP	(Low-pass type)	Q=30	BPF	L30
BPF	: H1	(Band Pass Filter 7)	BP	(High-pass type)	Q=1	BPF	H1
BPF	: H5	(Band Pass Filter 8)	BP	(High-pass type)	Q=5	BPF	H5
BPF	: H30	(Band Pass Filter 9)	BP	(High-pass type)	Q=30	BPF	H30

12 varieties of mode including THRU are provided. It is important to choose a mode which matches the purpose of the measurement.

㉖ PSD ZERO [SHIFT]

This key is used for correcting the zero drift of the phase sensitive detector. When this key is pressed after the input has been short-circuited and the output has stabilized, the output will be corrected to zero. For details see Section3.4.13 (3).

㉗ AUTO SET

This key is used to start the automatic setting function. The lamp will be lighted during the setting. Before pressing the ㉗ AUTO SET key, it is necessary to set the ⑳ REF MODE and ㉕ FILTER MODE. The following parameters will be set automatically by inputting reference signal frequency and the amplitude of the input signal : Analysis frequency range, time constant, sensitivity, dynamic reserve, filter frequency, and the reference signal phase. For details, see Section 3.4.3 (1).

㉗ BEEP [SHIFT]

This key is used for switching on and off the beep sound function. With each press the function will be switched alternatively between on and off. When a beep sound is generated at the press of the key the on state is indicated. The beep sound will be generated at times of overload, unlocking, and misoperation.

㉘ PHASE SET

This key is used to perform an automatic adjustment of the offset phase of the reference signal. When this key is pressed the unit will automatically detect the phase difference of the input signal with respect to the reference signal and automatically set the phase of the reference signal. Accordingly, the value of ⑪ X : A cos ϕ after the phase setting has been performed will be the amplitude value of the input signal, and the phase (ϕ) shown in ⑩ DATA 2 will be the phase angle of the input signal with respect to the reference signal. For details see Section 3.4.3 (2).

㉘ LAMP [SHIFT]

This key switches all of the lamps on the front panel on and off. With each press the function will be switched alternately between on and off. When the power supply is switched on the function will be on (and the lamp will be lit).

㉙ AUTO RANGE

This key switches the automatic ranging function of the sensitivity range alternately on and off. With each press the function will be switched between on and off. The on state is indicated by a lit lamp. Auto-ranging function is limited to the range allowed by the set dynamic reserve.

The maximum sensitivity may be limited or the limit value can be cancelled (LIMIT OFF) by means of ㉛ SHIFT, ㉙ LIMIT, and ㊸ MODIFY. For details see Section 3.4.3 (3).

㉙ LIMIT (Auto Range Limit) [SHIFT] [MODIFY]

This key is used to set the limit of the maximum sensitivity at the time of the auto-ranging operation or to cancel the limit value (LIMIT OFF). The range which can be selected varies with the dynamic reserve and will be the same range as the sensitivity that may be set with each dynamic reserve. The initial setting when the power is switched on becomes LIMIT OFF. For details see Section 3.4.3 (3).

㉚ AUTO TUNE

This key switches on and off the automatic setting function of the analysis frequency range and the center frequency. With each press the function will be switched between on and off. The on state is indicated by a lit lamp. For details see Section 3.4.3 (4).

㉚ INITIALIZE [SHIFT]

This key is used to initialize the various functions and the setting values to fixed values. For details see Section 3.4.1.

㉛ SHIFT

This is the shift key. Press this key before the desired function key is pressed when setting the functions indicated beneath the keys ⑲ through ㊷. The lamp will light up at the time of the shift state.

㉜ LOCK

This key is used for inhibiting the operations on the panel. When this key is pressed the red lamp will light up and all of the key operations on the panel and the MODIFY operation will be inhibited. To get out this state perform the LOCK OFF operation of the following item.

㉜ LOCK OFF [SHIFT]

This key is used to get out of the state in which the panel functions are inhibited. When this key is pressed after pressing the shift key, the lamp will go off and operations from the panel will be possible. When the unit has been set to the remote state by the GP−IB controller, the operations of the panel will be inhibited even when this lamp is off.

㉝ DATA 1

This key is used to select which measurement results, either A (amplitude) or X (A cos ϕ) in ⑪ DATA 1 will be displayed. With each press of this key the selection will change between A and X.

㉝ NORMALIZE VALUE [SHIFT] [MODIFY] [CURSOR]

This key is used to set the reference value of the dB value or the % value which is shown in ⑪ DATA 1. The setting range is from 1.000 µV to 1.000 V. The setting value is shown in ⑫ DATA 3/SETTING.

㉞ DATA 2

This key is used to select which measurement results, either ϕ (phase) or Y (A sin ϕ) in ⑩ DATA 2 will be displayed. With each press of this key the selection will change between ϕ and Y.

㉞ NORMALIZE MODE [SHIFT]

Measurement results A/X which are shown in ⑪ DATA 1, may be simultaneously displayed as voltage values, dB values, or % values. This key selects dB or %.

㉟ DATA 3

This key is used for selecting any of the measurement results REF FREQ, EXT DC and RATIO to be displayed in the ⑫DATA 3 / SETTING. At the time of power on, the REF FREQ is displayed.

㉟ AVERAGE TIMES [SHIFT] [MODIFY]

This key is used to set the averaging times of the measurement results which are shown in ⑪ DATA 1. The setting range is arranged in ten ways from 2^0 (1) to 2^9 (512). For details on using this see Section 3.4.9.

㊱ ADJUST PHASE [MODIFY] [CURSOR]

This key is used to set the offset phase of the reference signal. The setting range is from −179.99° to +180.00° and the resolution is 0.01°. For details on the method of use see Section 3.4.4.

㊱ AVERAGE MODE [SHIFT]

This key sets the averaging mode of the measurement results which are shown in ⑪ DATA 1. The set mode is displayed in ⑨ AVE. There are three types of settings, LIN (movement average), EXP (exponent average), and no averaging, in which case nothing is displayed in ⑨ AVE.

㊲ ADJUST OFFSET [MODIFY] [CURSOR]

This key is used for setting the amount of offset to the data shown in ⑪ DATA 1. The setting range is from −3162 to +3162. Data displayed in dB will not change even when the offset is applied.

㊲ RS-232C BAUD [SHIFT] [MODIFY] [CURSOR]

This key is used for setting the Baud rate and functions of the RS-232C. Pressing this key will display two groups of figures, two digits at a time. The setting contents are as follows :

Right 2 digits : Baud rate

00 : 300   01 : 600   02 : 1.2k   03 : 2.4k   04 : 4.8k   05 : 9.6k

Left 2 digits : RS-232C functions and selection of the RS-232C and GP-IB

Stop bit	1 bit	0
	2 bits	8
Parity	OFF	0
	ON	4
	ODD	0
	EVEN	2
Character length	8 bits	0
	7 bits	1

Added values are displayed in decimal, the setting range is from 0 to 16, and when set to 16, the unit is under GP-IB control.

㊳ INT OSC FREQ [MODIFY] [CURSOR]

This key is used for setting the oscillation frequency of the internal oscillator (Optional). The setting range is from 0.5 Hz to 120 kHz, divided into the following four ranges :

0.5 Hz to 120 Hz   100 Hz to 1200 Hz   1 kHz to 12 kHz   10 kHz to 120 kHz

The internal oscillator is set to desired frequency by ㊶ ㊷ CURSOR and ㊸ MODIFY. When making a setting in excess of the range, the cursor is set at the third digit from the right.

When the cursor is set at the left edge digit, the range will be selected. When the cursor is set one or two digits from the right, setting is not possible in excess of the range.

In the case where the internal oscillator has not been installed and this key is pressed when ④ REF MODE is set to EXT, "OPR ERR" will be displayed (standing for Operation Error) and the setting will not be possible.

㊳ GP-IB ADR [SHIFT] [MODIFY] [CURSOR]

This key is used for setting the address and functions of the GP-IB. Pressing this key will display two groups of figures, two digits at a time. The setting contents are as shown below :

Right 2 digits : GP-IB address

Addresses from 0 to 30 are shown in decimal.

Left 2 digits : GP-IB function selection

Talk only		4
Header of send data (common with RS-232C)	Nil	0
	Present	2
Delimiter (RS-232C : send and receive common, GP-IB : send only)	CR/LF	0
	CR	1

Added values are displayed in decimal and the setting range is from 0 to 7.

㊴ INT OSC LEVEL [MODIFY] [CURSOR]

This key is used for setting the output amplitude of the internal oscillator (optional). The setting range is from 0 to 255, divided into the following three ranges : 0.0 mV to 25.5 mV, 0 mV to 255 mV, and 0.00 V to 2.55 V.

The oscillator is set to a desired output level by ㊶ ㊷ CURSOR and ㊸ MODIFY. The setting values are the values at the time of no load. Since the output impedance is 600Ω, when an 600Ω load is connected the output amplitude value will be half of the setting value.

In the case where the internal oscillator has not been installed and this key is pressed when ④ REF MODE is set to EXT, "OPR ERR" will be displayed (standing for Operation Error) and the setting will not be possible.

㊴ GP-IB LOCAL [SHIFT]

This is the GP-IB return-to-local key. When the GP-IB is in the local state, the lamp lights up and operation is possible from the panel. When the unit is set to the remote state by the GP-IB controller, the lamp will go off and operation from the panel will be inhibited. Pressing this key in this state will cause the lamp to light up and operation to be enabled from the panel again. This key will not be effective when the unit is set to local lock-out with the GP-IB controller.

㊵ START / STOP

This key is used for starting and stopping the sending of digital data. Pressing this key in the RS-232C mode or the GP-IB talk-only mode will cause the lamp to light up and the digital data set by ㉛ SHIFT and ㊵ DATA SEL to be sent at the ㉔ SAMPLING interval. One more press of the key will cause the lamp to go out and the data transmission to stop. When the power is switched on the stop state will be in effect.

When the GP-IB or RS-232C are not properly connected, the "NRDY ERR" (Not Ready Error) sign will be displayed and the data will not be sent.

㊵ DATA SEL [SHIFT] [MODIFY] [CURSOR]

This key is used for setting the data of the digital data transmission. Up to eight kinds of data can be selected from the table below and output will be in order from the data set at the left side. Each of the data codes are as shown in the table below.

First parameter		Second parameter	
Code	Data	Code	Data
0	No data	0	No data
1	Line number	1	Line number
2	A (Amplitude)	2	ϕ (Phase)
3	AdB /%	3	Y (A sin ϕ)
4	X (A cos ϕ)	4	EXT DC (External DC input voltage)
5	XdB /%	5	RATIO
6	ϕ (Phase)	6	REF FREQ(Reference signal frequency)
7	Y (A sin ϕ)	7	SENSITIVITY (Sensitivity range)
8	EXT DC (External DC input voltage)	8	Status
9	No data	9	No data

Since there are many kinds of data the data codes have been divided into first parameter and second parameter codes. Pressing this key will provide a display in ⑫ DATA 3/SETTING in the following form :

```
ODS    ␣␣␣␣    ␣␣␣␣
 |       |       |
 |       |       └─ Second parameter
 |       |
 └─ Header └─ First parameter
```

Choose the required output data and set the code using ㊶ ㊷ CURSOR and ㊸ MODIFY. For example, with a selection of A, ϕ, REF FREQ, and SENSITIVITY, the settings will be ODS00260067 or ODS26006700.

㊶ ◄ CURSOR

This key moves the cursor position of the setting value of display ⑫ DATA 3/SETTING to the left. The value of the digit at which the cursor is placed is changed by the rotary pulse switch of ㊸ MODIFY.

㊶ AUX 1 [SHIFT]

This is not used.

㊷ CURSOR ►

This key moves the cursor position of the setting value of display ⑫ DATA 3/SETTING to the right. The value of the digit at which the cursor is placed is changed by the rotary pulse switch of ㊸ MODIFY.

㊷ AUX 2 [SHIFT]

This is not used.

㊸ MODIFY

This rotary pulse switch is used for changing the setting values of the various functions. In numerical value settings, turning the switch in the clockwise direction will increase the setting value and turning it in the counterclockwise direction will reduce the setting value. Functions that may be set with this rotary pulse switch are those which are labeled in red on the panel.

㊹ SIG MON

This BNC connector is used for monitoring the input signal with an oscilloscope or other instrument. The AC signal applied to the phase sensitive detector passes through a buffer amp and is output.

㊺ OSC

This BNC connector is the output for the internal oscillator (optional). The output level is from 0 V to 2.55 Vrms and the output impedance is 600 Ω.

㊻ REF

This BNC connector is the input for the external reference signal. The input impedance is 1MΩ. In the case of basic operation, an external reference signal of 1V to 3 Vrms and a sine or a square wave are optimum.

3.2.2 Description of the Rear Panel

㊼ Power Input Connector

This connector is used for connecting the power cable to the unit. The power cable should be inserted firmly into the connector so that it doesnt come out easily. A 3-pin cord including ground terminal is available. If required, contact the manufacturer or a sales agent.

㊽ FUSE

This is the fuse holder. The cap may be removed by turning it in the counterclockwise direction with a Philipps screwdriver. Use a fuse with a capacity that suits the power supply voltage being used. A 2A fuse should be used for 100V /120V and a 1A fuse for 220V /240V. In either case use a fuse of the regular melting type sized 5.2 mm dia. × 20mm.

㊾ ⏚

This is the ground terminal which is connected to the unit case. Be sure to ground this terminal for user safety and prevention of outside interference.

㊿ RS-232C

This connector is for use with the RS-232C interface. For details see Section 8.

(51) GP-IB

This connector is for use with the GP-IB interface. The address, delimiter, etc. are set at the panel. For details see Section 7.

(52) Air Intake Vent

This air intake vent is used for cooling and quickly steadying the temperature in the frame. When placing the unit in position, allow a space of at least 10 cm to the rear of the fan. When the air filter has become dirty remove the filter and wash it in thin, neutral detergent. Note that the fan can be switched on and off with switch (55).

(53) A COS ϕ ZERO ADJ, A SIN ϕ ZERO ADJ

This is a one-revolution trimmer for the zero adjustment of the X (A cos ϕ) and Y (A sin ϕ) phase sensitive detector. For details see Section 3.4.13.

(54) SUPPLY VOLTS

This is the power supply voltage selector which is set to match the line voltage. In the case of changing the setting, check the line voltage and disconnect the cable before making the setting.

(55) FAN

This switch is used for turning the (52) fan on and off. In case the noise of the fan interferes with the measurements, turn the fan off with this switch. If the fan has been switched off, avoid placement of the unit where the natural air circulation will be blocked as well as the placement of objects on top of the case.

After the power has been switched on, the time taken until the temperature within the frame becomes steady is about 5 minutes with the fan on and about 1 hour with the fan off.

In addition, in the instance where there is a short period of temperature fluctuation at the placement location, when the fan is switched off the time constant of the temperature fluctuation will increase and it will be more difficult for the unit to be affected by temperature fluctuation.

(56) ±24V OUTPUT

This is a DC power supply output which supplies power to external preamps, etc.

The current capacity is ±50mA. The wiring diagram is shown below.

The connector and cable are preamp accessories.

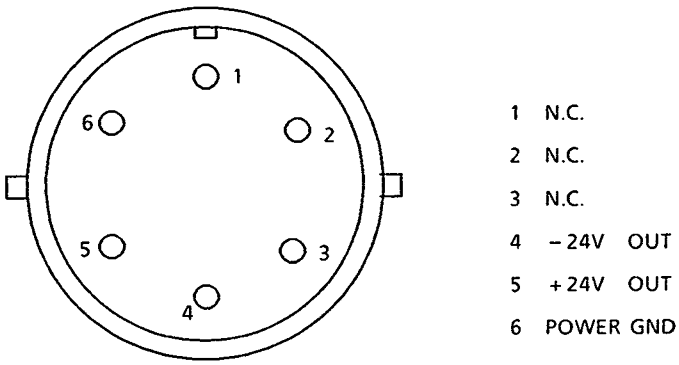


Fig.3-1 ±24V OUTPUT Connector Wiring Diagram

(57) INPUT EXT DC/RATIO

This BNC connector is the DC input for the ratio function. The input voltage range is from 0 to ±10V and the impedance is 100kΩ.

(58) OUTPUT DAC 2

This is the data analog output BNC connector which is selected by (31) SHIFT and (23) DAC 2. The output impedance is less than 1Ω and the maximum output current is ±5mA.

There are five kinds of data : ϕ, Y, EXT DC, RATIO, and REF FREQ.

(59) OUTPUT DAC 1

This is the data analog output BNC connector which is selected by (31) SHIFT and (22) DAC 2. The output impedance is less than 1Ω and the maximum output current is ± 5 mA.

There are four kinds of data : A, A dB / %, X, and X dB / %.

⑥⓪ OUTPUT A SIN ϕ

This is the analog output of the Y (A sin ϕ) phase detector. The output will be ± 10 V at fullscale for each range. The output impedance is less than 1Ω and the maximum output current is ± 5 mA.

When ㉔ METER MAG Y is pressed and the lamp lights up, the analog DC output voltage of this output is multiplied by a factor of 10.

⑥① OUTPUT A COS ϕ

This is the analog output of the X (A cos ϕ) phase sensitive detector. The output will be ± 10 V at fullscale for each range. The output impedance is less than 1 Ω and the maximum output current is ± 5 mA.

When ㉕ METER MAG Y is pressed and the lamp lights up, the analog DC output voltage of this output is multiplied by a factor of 10.

3.3 Input and Output Connections

(1) Input Connections

There are three types of input systems used in this unit, the signal system, the reference signal system, and the external DC voltage input system for use in ratio measurements. The equivalent circuit is shown in Fig. 3-2.

The permissible maximum input voltage for each of the input terminals is shown below. Attention must be paid to these values since the unit may be damaged if inputs in excess of these values are applied.

Permissible Maximum Input Voltages

Signal inputs A , B	DC ±200V (including AC component) ,	AC 30Vp-p
Reference signal input (REF)	DC ±200V (including AC component) ,	AC 50 Vp-p
EXT DC / RATIO	DC ±20V	

This unit will often be used in situations where the signal level is small and there is a lot of noise and so the connection method between the signal source and the unit must be decided on the basis of the conditions of the signal source. Care must be given especially to the coupling of the signal system and the reference signal system. Causes of noise mixing may be thought to be static coupling, electromagnetic induction, and common ground loops. Concerning asynchronous noise in the reference signal, it can be eliminated to the allowable limit of the units dynamic reserve. Note that indication errors result when synchronized noise mixes with the reference signal. Next, we will describe coupling methods which suit the conditions of the each of the signal sources.

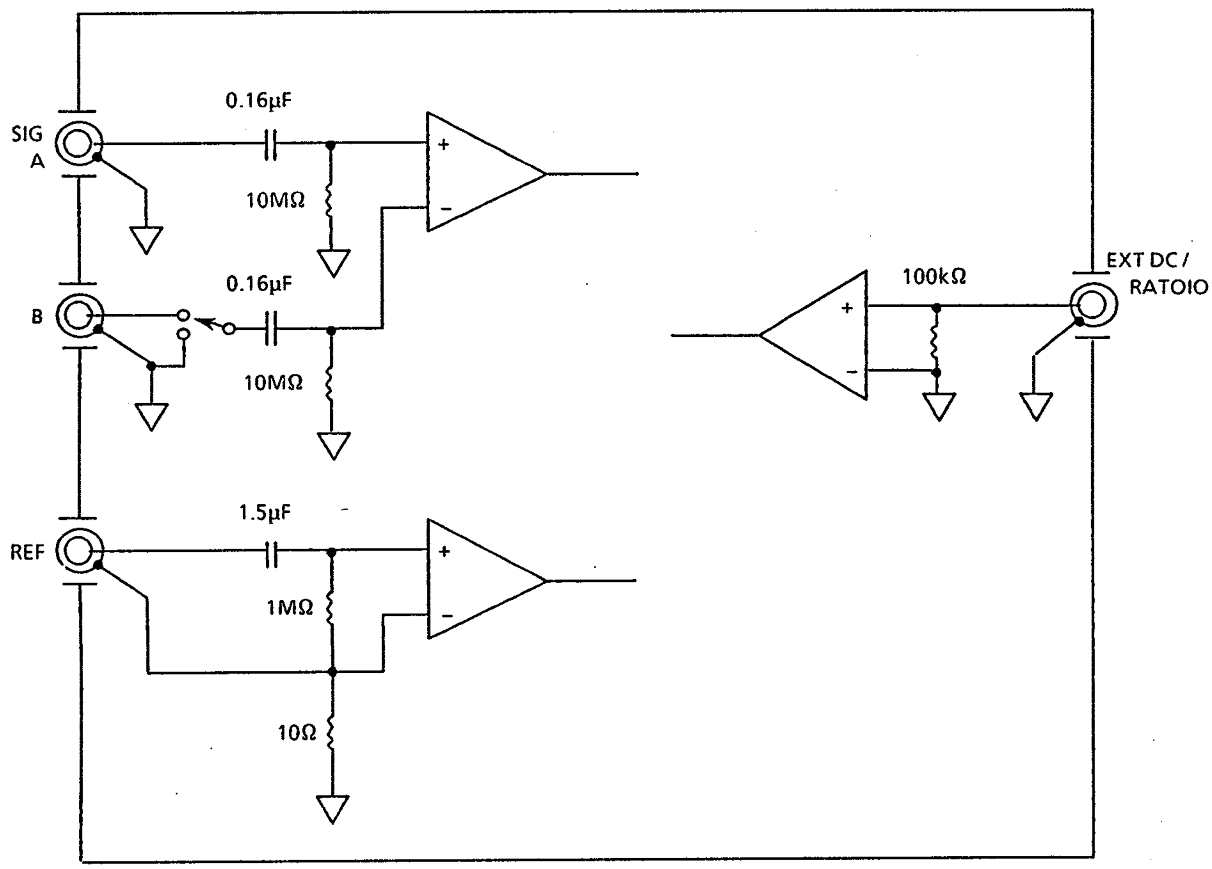


Fig.3-2 Input Section Equivalent Circuit

Fig.3-3 (A) shows an ideal signal source in which the signal source floats above ground and is separate from the reference signal. In this case, the input mode selection switch is set to the A side to provide a single ended input. Shielded cable is used so that electrostatic coupling does not occur between the signal system, reference signal system, and external noise source. The positioning should also be at a suitable interval and the ground terminal on the case should be grounded.

Fig.3-3 (B) shows an ideal signal source in which the signal sources have a parallel output. The input mode selection switch is set to the A-B side providing a differential input. At this time, if flux cuts between the two signal input cables a current will flow and noise will be produced. The two signal lines should be as close together as possible and twisted at a short pitch.

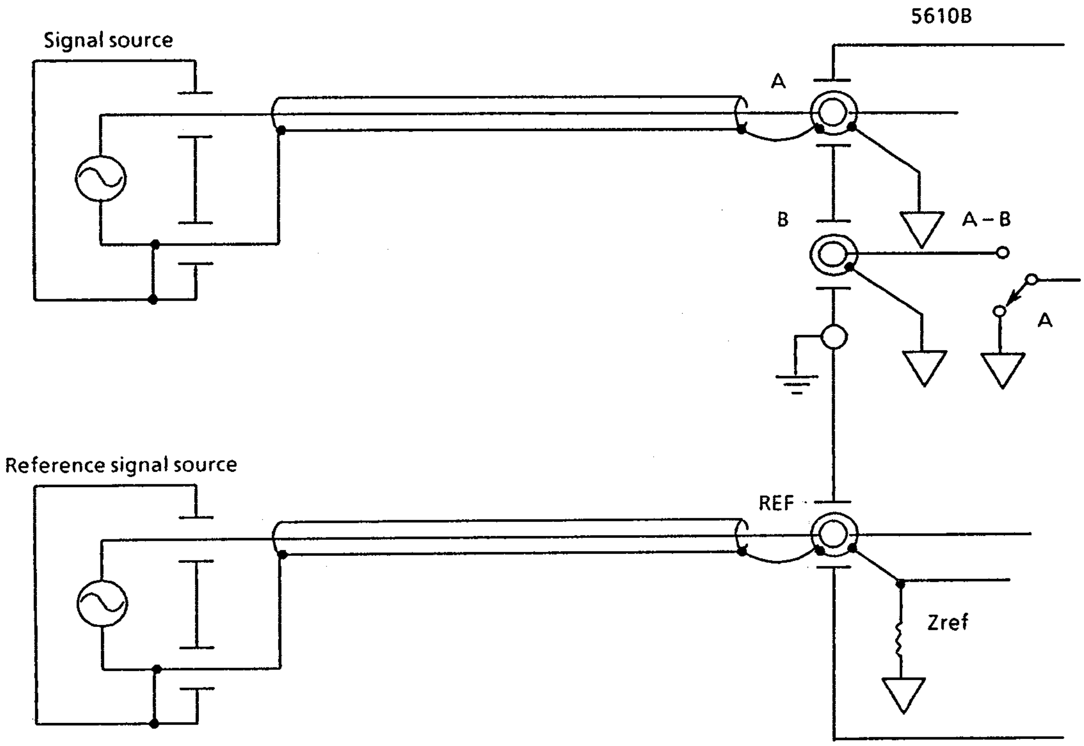


Fig.3－3(A)　Connections with the Signal Sources (A)

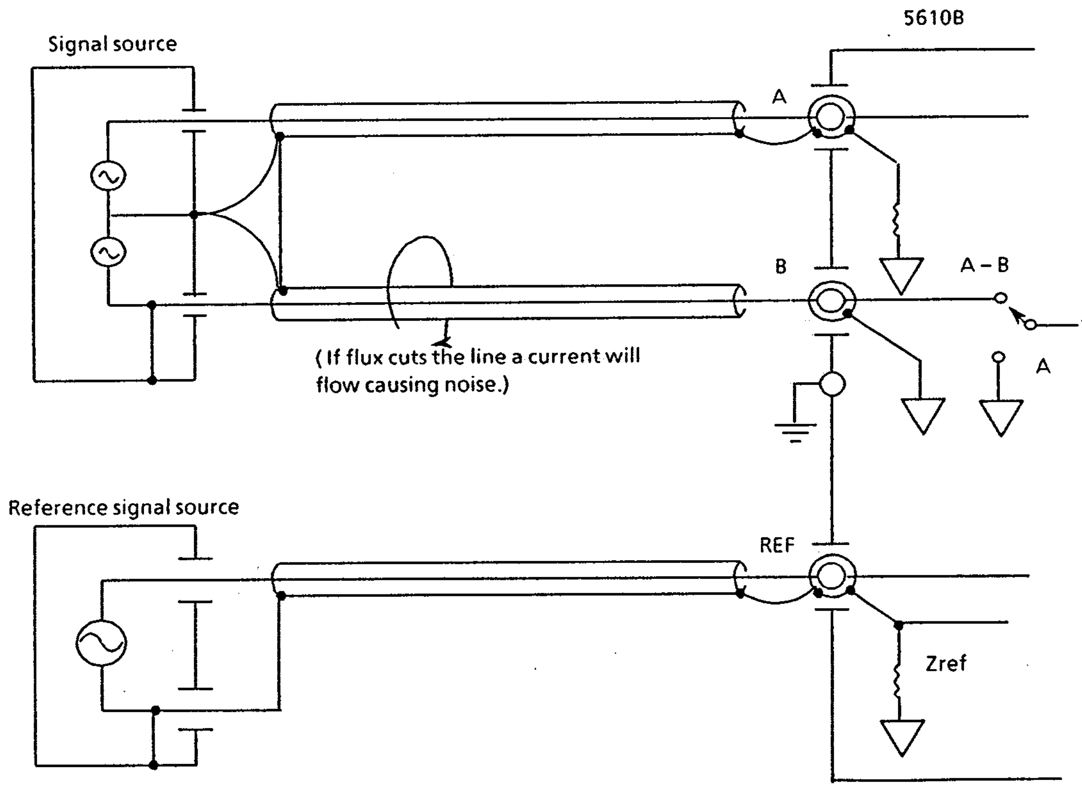
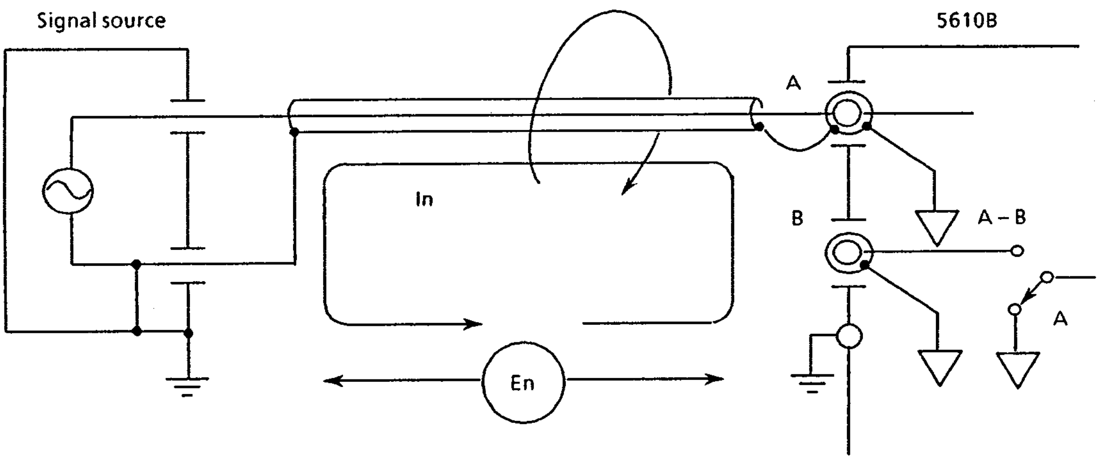


Fig.3－3(B)　Connections with the Signal Sources (B)

Fig.3-3 (C) shows the arrangement in which the signal source of Fig.3-3 (A) is grounded. (The grounding of this signal source does not only refer to the intentional grounding by the system designer, but also includes the instances where the insulation resistance is low or leakage current flows because of the floating capacitance. When considering grounding, not only is there an earth ground but also the common grounding of the case to the rack when the system is rack mounted.) Because the signal source is grounded a potential difference will occur between the signal source and the units case. In addition, flux that cuts the signal cables will cause a noise current to flow through them as shown in the diagram. A noise voltage will also arise because of the impedance of the signal cable (this is not only the DC resistance, but also the presence of inductance, which increases as the frequency becomes higher). In this case methods of removing the unit ground may be considered, but since the unit is operated by an AC power supply, there will be a ground path with the AC power supply via stray capacitance and so a complete floating condition is impossible. In addition, noise that is mixed from the AC power supply will increase because the ground has been removed and in the interest of insuring safety, it is necessary to ground the case.



Note : This connection method should not be used. Use the method shown in diagram

Fig.3-3(C) Connections with the Signal Source (C)

Fig.3-3 (D) shows a grounded arrangement with the same low impedance as (C), but the connection method is better. The input is arranged as a differential input and since the signal source and the unit are connected by a low impedance via the ground line, the outside conductor of the shielded line is not connected at the signal source side. Also in the case in which a preamp or other device is connected to the unit and uses the units DC power supply output, the arrangement will be suited to this connection method since the POWER GND of the power supply output is connected to the preamp or other device being used.

Fig.3−3 (E) shows the case in which grounding is by a relatively high impedance. Since the impedance is high, the current of the ground loop will be smaller. However, since there are cases where small voltage measurements cannot be ignored, the unit has been given a differential input which removes the influence of the noise voltage which appears on the outer conductor of the shielded line. The outer conductor of the shielded line is also connected at the signal source side.

Comparing this to the arrangement in Fig.3−3 (D), because the connection is by high impedance, the impedance seen from the units input side avoids an increase of only the Z_G portion. Since an increase of the signal source impedance invites an increase of heat noise and an increase of the effects of electrostatic coupling, considerations must be made to keep it as small as possible.

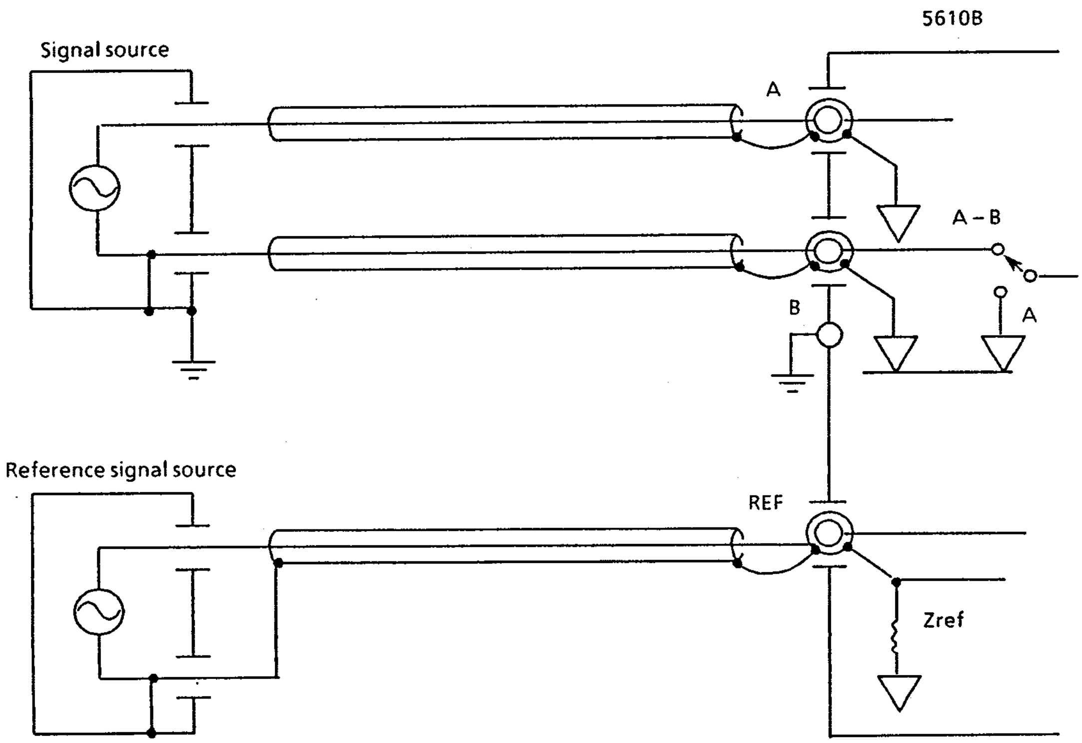


Fig.3−3(D) Connections with the Signal Source (D)

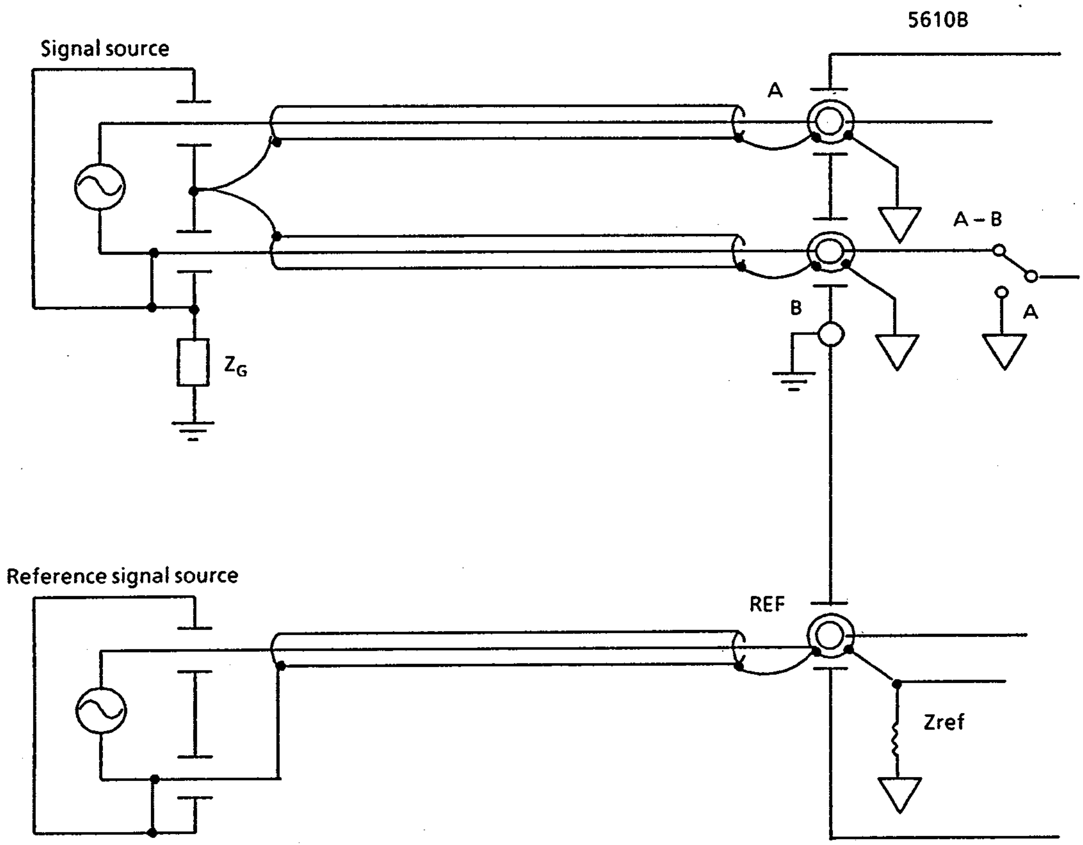


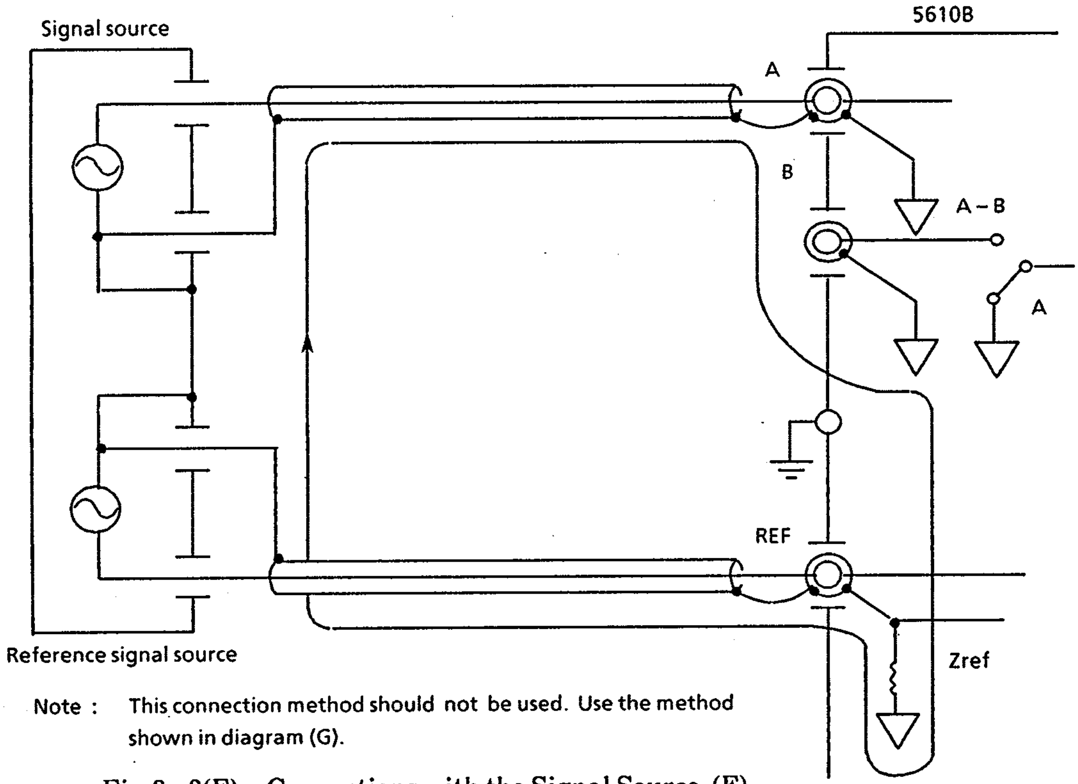
Fig.3−3(E) Connections with the Signal Source (E)

Fig.3−3 (F) shows the case where the signal source and the reference signal source are commonly connected. A loop such as the one in the diagram will be formed, however, since the units reference signal of 0V is connected with the case and Zref (10Ω), the bad influences of the loop will be reduced. Especially at the time of very small voltage measurements, cases which cannot be ignored will also occur and so at this time the connection method of Fig.3−3 (G) should be used providing a differential input which will remove the effects.

Explanations have been given to suit the conditions of the signal sources above, but when it comes to actual measurements, it is often not possible to prescribe the signal source in a clear form and so it is necessary to try various connection methods and find the best one.

For a check of the noise, connect the ㊹ SIG MON output of the front panel to an oscilloscope or another test instrument and find the connection method which offers the least noise. For a check of synchronous noise, make the same connections as for the measurement situation and then with the ground line in the same condition, disconnect only the output of the signal source and short the input terminal of the unit.

When at this time the measurement results are not zero and there is a value that cannot be ignored with respect to the expected measurement value, consideration must be given to the connection method.



Note : This connection method should not be used. Use the method shown in diagram (G).

Fig.3-3(F) Connections with the Signal Source (F)

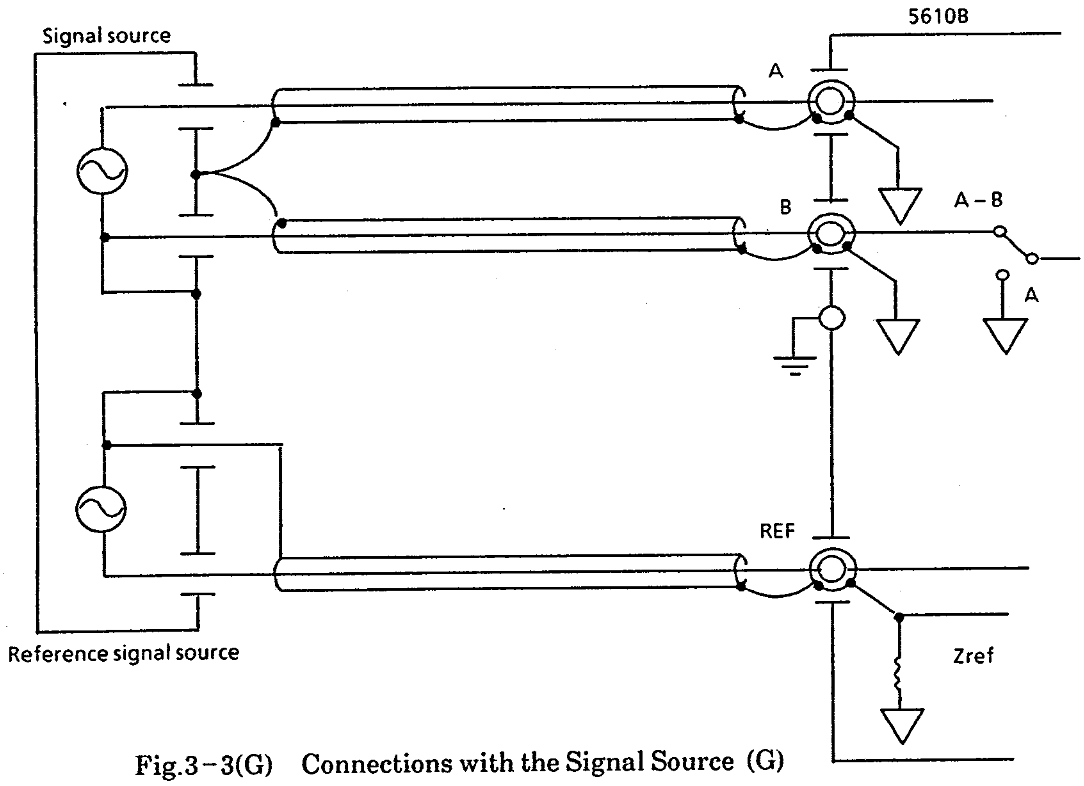


Fig.3-3(G) Connections with the Signal Source (G)

(2) Output

The unit has six kinds of signal outputs, the specifications of which are shown below. Be careful since the application of a signal to the output connector may result in damage to the unit.

SIG MON : This is the monitor output for the input signal. After passing through a filter, an AC signal will be output. Note that the full-scale signal output amplitude will vary depending on the dynamic reserve.

- Maximum output voltage : ± 10 V
- Maximum output current : ± 5 mA
- Output impedance : within 600 Ω ± 10%

Amplitude frequency response : 0.5 Hz to 200 kHz within ± 3 dB

Rated output (at the time of a full-scale sine wave input)

- DYN RES at L : 2 Vp-p (no load)
- DYN RES at M : 0.2 Vp-p (no load)
- DYN RES at H : 20 mVp-p (no load)

OSC OUT(optional) : This is the output of the internal oscillator. The internal oscillator is an option and when not installed, only the BNC connector is provided. If a function of the internal oscillator is set without the oscillator being installed, an error display will result.

- Maximum output voltage : 2.55Vrms (no load)
- Maximum output current : 5 mArms
- Output impedance : within 600Ω ±1%

OUTPUT A cos ϕ : This is the analog output of the phase detector (COS PSD). When an offset voltage is present, adjustments are made with (53) A COS ϕ ZERO ADJ on the rear panel. Front panel ㉛ ㉖ PSD ZERO does not have any bearing on this output since the zero adjustment is performed after conversion to a digital value. The same is true for ㉛ ㉕ CAL.

- Output voltage : 0 to ± 10 V
- Maximum output current : ± 5 mA
- Output impedance : Less than 1 Ω

OUTPUT A sin ϕ : This is the analog output of the phase detector (SIN PSD). When an offset voltage is present, adjustments are made with (53) A SIN ϕ ZERO ADJ on the rear panel. Front panel ㉛ ㉖ PSD ZERO does not have any bearing on this output since the zero adjustment is performed after conversion to a digital value. The same is true for ㉛ ㉕ CAL.

- Output voltage : 0 to ± 10 V
- Maximum output current : ± 5 mA
- Output impedance : Less than 1 Ω

OUTPUT DAC 1 : This is the analog output for which data selected by the ㉛ ㉒ DAC 1 key has undergone 12-bit D-A conversion. The sampling interval of the D-A conversion is a value set by ㉛ ㉔ SAMPLING.

Output voltage : 0 to ± 12 V
Maximum output current : ± 5 mA
Output impedance : Less than 1 Ω

OUTPUT DAC 2 : This is the analog output for which data selected by the ㉛ ㉒ DAC 2 key has undergone 12-bit D-A conversion. The sampling interval of the D-A conversion is a value set by ㉛ ㉔ SAMPLING.

Output voltage : 0 to ± 12 V
Maximum output current : ± 5 mA
Output impedance : Less than 1 Ω

The table below shows the output data :

OUTPUT DAC 1	OUTPUT DAC 2
A (amplitude)	ϕ (phase)
A dB or A%	Y (A sin ϕ)
X (A cos ϕ)	EXT DC
X dB or X%	RATIO
———	REF FREQ

The selection of dB or % is made by the ㉛ ㉞ NORMALIZE MODE.

3.4 Method of Use

3.4.1 Start up

(1) Check that the setting of the power supply voltage selector matches the line voltage in use. The unit may be used within a range of ± 10% of the set voltage value.

(2) Firmly insert the accompanying power cable into the power connector of the unit and insert the power plug into the AC outlet. Pulling the knob of the power switch toward you will put the unit into the operating condition.

(3) When the power is switched on the figures 1, 2, 3 will be displayed in order at the lower right portion of the liquid crystal display and about two seconds later the unit will enter the operating state at which time the measurement values and the setting values will be displayed on the liquid crystal display. When the power is switched on the initialized parameters will be as follows :

LAMP	:	ON
BEEP	:	OFF
DATA OUTPUT	:	STOP
GP-IB	:	LOCAL
KEY LOCK	:	OFF
PSD ZERO	:	0 (Zero drift correction value of the phase detector)
CAL	:	1 (Gain correction value of the phase detector)

(4) The following errors may be displayed when the power is switched on.

BACK UP MEMORY ERROR! PLEASE PRESS ANY KEY :

This will be displayed when there has been a sum check error in the data backed up by battery. This error occurs when the battery backing up the memory has discharged and the data can no longer be stored. The memory back-up period when the battery is completely charged is about 60 days, although the period may vary somewhat because of changes due to individual differences and ambient temperature. To bring a battery from a completely discharged state to full charge requires about 100 hours of charging. When the battery deteriorates, the back-up time becomes shorter. When the battery can no longer meet practical usage demands we will replace it at a charge.

If the power is switched off while some settings are being made, the sum check routine will not be completed and so the next time the power is switched on, an error will occur. Therefore, wait at least one second after changing the various setting values before switching off the power.

ROM ERROR !	:	There has been an error in the ROM being used.
RAM ERROR !	:	There has been an error in the RAM being used.

If ROM ERROR! or RAM ERROR! is displayed, switch off the power and contact us or our sales agent.

(5) After the power has been switched on, the time taken until the units internal temperature becomes steady is about 5 minutes with the fan on and about 1 hour with the fan off. When making exact measurements or when using the dynamic reserve at "H", take the measurements after a sufficient warm up.

Also, pay attention to changes in the ambient temperature.

(6) When the ④ REF MODE is set to EXT and the reference signal is not being applied to the unit, or the setting of the ③ F RANGE is not appropriate, "UNLOCK" will be displayed in the display section of the ⑪ DATA 1 measurement results. This indicates that measurement is impossible because the reference signal system is not synchronized. When a signal is applied to ㊻ REF INPUT or ④ REF MODE is set to INT (optional) and the setting of ③ F RANGE is performed, the "UNLOCK" characters will be deleted and the measurement results will be displayed. When the range of the analysis frequency is 0.5 to 12 Hz, it may take about 100 seconds until the "UNLOCK" characters are deleted.

(7) The ㉛ ㉚ INITIALIZE key has been provided for making initialization setting to the unit. This key is pressed after pressing the shift key. The various setting values are as shown below.

BASIC FUNCTION		
F RANGE	:	No initialization. (The previous setting values will be maintained. Same condition below.)
REF MODE	:	No intialization.
SENSITIVITY	:	1V
T CONST	:	100msec
DYN RES	:	L
dB / oct	:	12dB / oct
METER		
MAG X	:	OFF
MAG Y	:	OFF
FILTER		
FREQ	:	No initialization.
MODE	:	THRU
AUTO FUNCTION		
AUTO RANGE	:	OFF
AUTO TUNE	:	OFF
DISPLAY		
DATA 1	:	A
DATA 2	:	ϕ
DATA 3	:	REF FREQ
NORMALIZE		
MODE	:	dB
VALUE	:	1.000

ADJUST

PHASE	:	0°
OFFSET	:	0

AVERAGE

TIMES	:	64
MODE	:	OFF

INT OSC

FREQ	:	No initialization.
LEVEL	:	0.0mV

RS-232C

BAUD	:	No initialization.

GP-IB

ADR	:	No initialization.
LOCAL	:	No initialization.

OUTPUT

START / STOP	:	STOP
DATA SEL	:	No initialization.

RATIO

K	:	1

SPECIAL FUNCTION

DAC 1	:	No initialization.
DAC 2	:	No initialization.
SAMPLING	:	300ms 2^7(Outputs the digital data to the outside every 128 times.)
CAL	:	1 (Gain correction value of the phase detector.)
PSD ZERO	:	0 (Zero-drift correction value of the phase detector.)
BEEP	:	OFF
LAMP	:	ON
LIMIT	:	LIMIT OFF

3.4.2 Basic Operation Method

In this section we will describe the basic operation method for measuring the amplitude and phase of the input signal without using the automatic functions.

The basic function of the lock-in amp is to detect only the signal synchronized to the reference signal. Therefore, it is necessary to first consider from where the reference signal should be supplied. There are two methods : one being to supply the reference signal from outside (EXT) and the other being to use the units internal oscillator (INT), which is an option. For each of these methods we will give a description in order from when the power is switched on.

(1) Operation method using an external reference signal

The oscillator, device to be measured, and the 5610B/A are connected as shown in Fig.3-4. The arrows indicate the direction of the input and output of the signal. Since the signal is input with a single line ground in Fig.3-4, the ⑯" A " " A-B " switch is set to the A side. (For details on very small signals and input connections see Section 3.3.)

The oscillator output is connected to ㊻ REF INPUT as the reference signal. The conditions required of a reference signal are that it have a frequency between 0.5 Hz and 200 kHz and that the amplitude be from 0.3 V to 30 Vp-p in the form of either a sine wave or a square wave. An amplitude of 1 to 3 Vrms is desirable for the reference signal in view of the phase noise and the interference to the input signal.

The signal applied to ⑱ INPUT A must be less than 1 Vrms with a noise component of less than 28 Vp-p.

After checking the power supply voltage, pull the power switch ⑮ POWER toward you to switch the power on. The various setting values will be displayed on the liquid crystal display and the ⑮ POWER lamp will light to show that the power is on. The values of the various settings, which are backed up by battery, will be the same as when the unit was previously used. Pressing ㉛ SHIFT and then ㉚ INITIALIZE will set the initial values.

Press the ⑳ REF MODE key until the ④ REF MODE display becomes "EXT 1F". (Set "EXT 2F" when an analysis at twice the reference signal frequency is desired.)

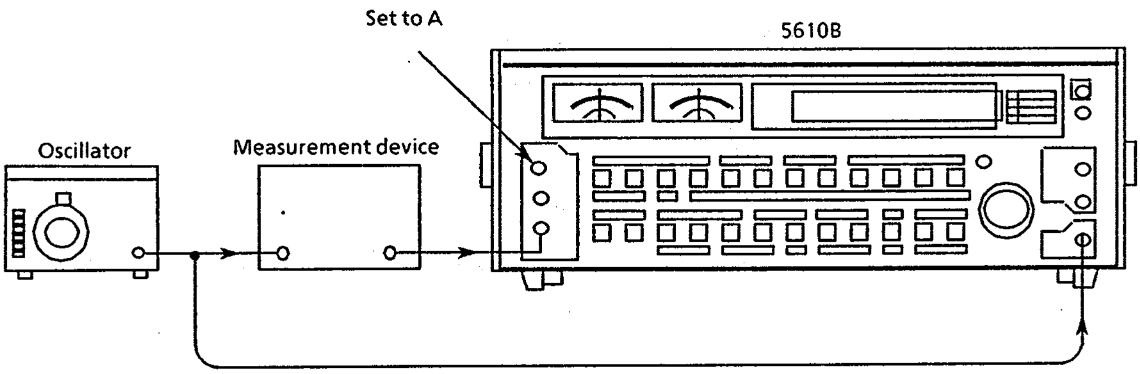


Fig.3-4 Connections using an External Reference Signal

When the ⑪ DATA 1 display shows " UNLOCK " it indicates that the setting range of the analysis frequency range is inappropriate with respect to the reference signal frequency. Press the ⑲ F RANGE key, then turn ㊸ MODIFY while observing the ⑫ DATA 3/SETTING display and set an analysis frequency range which suits the reference signal frequency. Check that the ⑪ DATA 1 display changes from " UNLOCK " to the measuring data. The lower the reference signal frequency, the longer the time until the " UNLOCK " display is deleted. (At 0.5 Hz, the longest it will take until the " UNLOCK " display is deleted is about 100 seconds and at 100 Hz or above the time will be about 1 second.)

Observe the ② X : A cos ϕ meter and the measurement results of ⑪ DATA 1. When the value of X : A cos ϕ is less than one-third of fullscale, the sensitivity range is inappropriate and should be changed. Press the ㉑ SENSITIVITY key and while observing the X : A cos ϕ meter and the measurement results of ⑪ DATA 1, slowly turn ㊸ MODIFY to the left one step at a time and set a sensitivity range that will provide a value of X which is one-third of fullscale or higher.

When the X : A cos ϕ meter and the measurement results of ⑪ DATA 1 are unsteady, the measurement frequency is low or there is a lot of noise, therefore, we will change the time constant. Press the ㉒ T CONST key and slowly turn ㊸ MODIFY to the right one step at a time, setting a time constant at which the wavering disappears.

The amplitude and phase of the input signal will be automatically measured and displayed, A (amplitude) at ⑪ DATA 1 and ϕ (phase) at ⑩ DATA 2.

The value of X (A cos ϕ) will be displayed at ⑪ DATA 1 when the ㉝ DATA 1 key is pressed. Similarly, the value of Y (A sin ϕ) will be displayed at ⑩ DATA 2 when the ㉞ DATA 2 key is pressed.

(2) Operation method using the internal oscillator (which is an option)

The device to be measured and the 5610B/A are connected as shown in Fig.3-5. The arrows indicate the direction of the input and output of the signal. Since the signal is input with a single line ground in Fig.3-5, the ⑯ " A " " A-B " switch is set to the A side. (For details on very small signals and input connections see Section 3.3.)

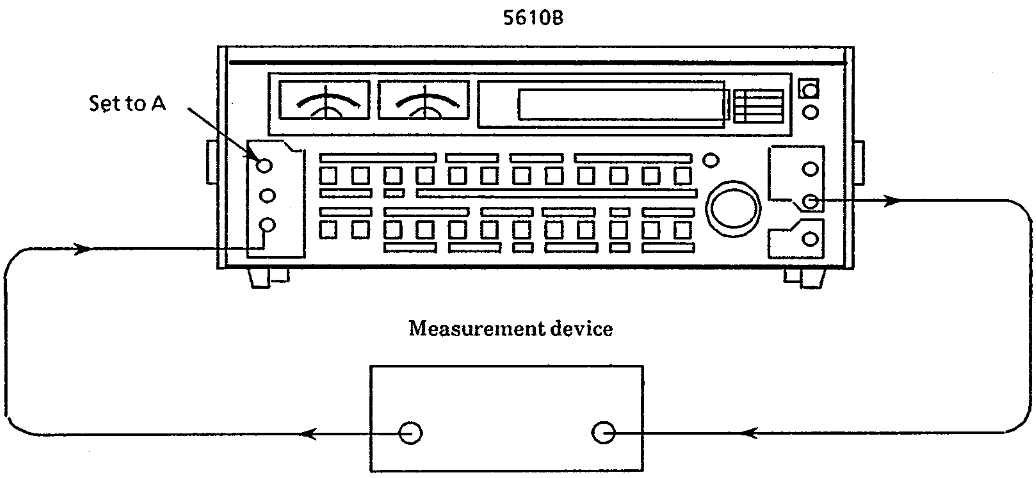


Fig.3-5 Connections using the Internal Oscillator

The signal applied to ⑱ INPUT A must be less than 1 Vrms with a noise component of less than 28 Vp-p. After checking the power supply voltage, pull the power switch ⑮ POWER toward you to switch the power on. The various setting values will be displayed on the liquid crystal display and the ⑮ POWER lamp will light to show that the power is on. The values of the various settings, which are backed up by battery, will be the same as when the unit was previously used. Pressing ㉛ SHIFT and then ㉚ INITIALIZE will set the initial values.

Press the ⑳ REF MODE key until the ④ REF MODE display becomes "INT 1F". (Set "INT 2F" when an analysis at twice the oscillation frequency of the internal oscillator is desired.)

When set to "INT" the reference signal will be automatically connected internally. If the optional internal oscillator has not been installed, the setting to "INT" will not be possible.

Next, we will set the frequency of the internal oscillator. Pressing the ㊳ FREQ key will display the setting value in ⑫ DATA 3/SETTING. Press the ㊶ CURSOR key twice and set the cursor at the left side. When ㊸ MODIFY is turned only the range of the oscillation frequency will change so the range to be used can be set. Press the ㊷ CURSOR key to set the digit to be changed and turn ㊸ MODIFY to set the frequency.

Next, we will set the output level of the internal oscillator. When the ㊴ LEVEL key is pressed, the present setting value will be displayed in ⑫ DATA 3/SETTING. (This displayed value is the value when the ㊺ OSC output is under no load and the output impedance is 600 Ω.)

Using ㊶ ㊷ CURSOR and ㊸ MODIFY, a 3-digit setting can be made from 0.0 mV to 2.55 Vrms. The setting values will change as shown below according to the setting position of the cursor and the rotation of ㊸ MODIFY.

Cursor position Third digit (farthest left)		Cursor position Second digit (center)	
MODIFY clockwise direction	MODIFY counterclockwise direction	MODIFY clockwise direction	MODIFY counterclockwise direction
_0.0mV	2.33V	0.0mV	2.46V
10.0mV	1.33V	1.0mV	2.36V
20.0mV	0.33mV	≀	≀
_30mV	_ 0mV	25.0mV	0.06mV
130mV	_0.0mV	26mV	_0mV
230mV		36mV	
0.33mV		≀	
1.33V		246mV	0.0mV
2.33V		0.26V	
		0.36V	
		2.46V	

3.4.3 Method of Using the Automatic Setting Function

(1) AUTO SET

This function makes the various complicated settings automatic and has been provided for the purpose of performing the settings when the units detailed method of use is not known.

The items which can be set automatically by this function are as follows :

- Analysis frequency range
- Sensitivity
- Time constant and roll-off (12 dB/oct fixed)
- Center frequency of the band-pass filter
- Offset phase of the reference signal (Phase setting of the auto function)
- Sampling period (300 ms fixed)
- Display of the measurement results : A (amplitude), ϕ (phase), and REF FREQ (reference signal frequency) Before operation of the AUTO SET, first set the following items :
- Reference signal mode ⑳ REF MODE)
- Filter mode ㉖ FILTER MODE) For details see the preparatory flow chart used at the time of AUTO SET in Fig.3-6. Next, we will describe the operation of AUTO SET.
- First, measure the frequency of the reference signal, then from that result, set the analysis frequency range, the time constant, and the center frequency of the band-pass filter.
- Next, set the dynamic reserve to L, the sensitivity range to 1 V, and measure the signal.
- When the measurement value is less than 30% of fullscale, increase the sensitivity in order and find the optimum range.

- The time required for switching the sensitivity range once is (Time constant × 3 + 600) ms. When the signal level is small or there is a lot of noise, it will take more time.
- When the signal level is fluctuating it may not be possible to find the optimum sensitivity range. In such an instance, cancel AUTO SET and make the measurement.
- When the setting of the optimum sensitivity range has been completed, detect the phase difference between the reference signal and the input signal, and set the offset phase of the reference signal.
- The operation of AUTO SET will be completed with the above and displayed as follows :
  The sensitivity ranges of 100nV and 300nV can be set only in manual setting or by external control. For the 5610B only.

⑩ ϕ	Phase with respect to the reference signal of the input signal
⑪ A	Amplitude value of the input signal
⑫ REF FREQ	Frequency of the reference signal

If the optimum sensitivity range cannot be found or if you wish to stop part way through, press the AUTO SET key once more and the auto set mode will be cancelled. In the auto set mode, the PSD zero offset and the correction value of the gain will not be cleared. In the case of first time use, press the INITIALIZE key and set to the initial values. The initial setting of the time constant by the reference signal frequency is as follows :

0.5Hz to 3Hz	3s	3Hz to 10Hz	1s
10Hz to 30Hz	300ms	30Hz to 200Hz	100ms

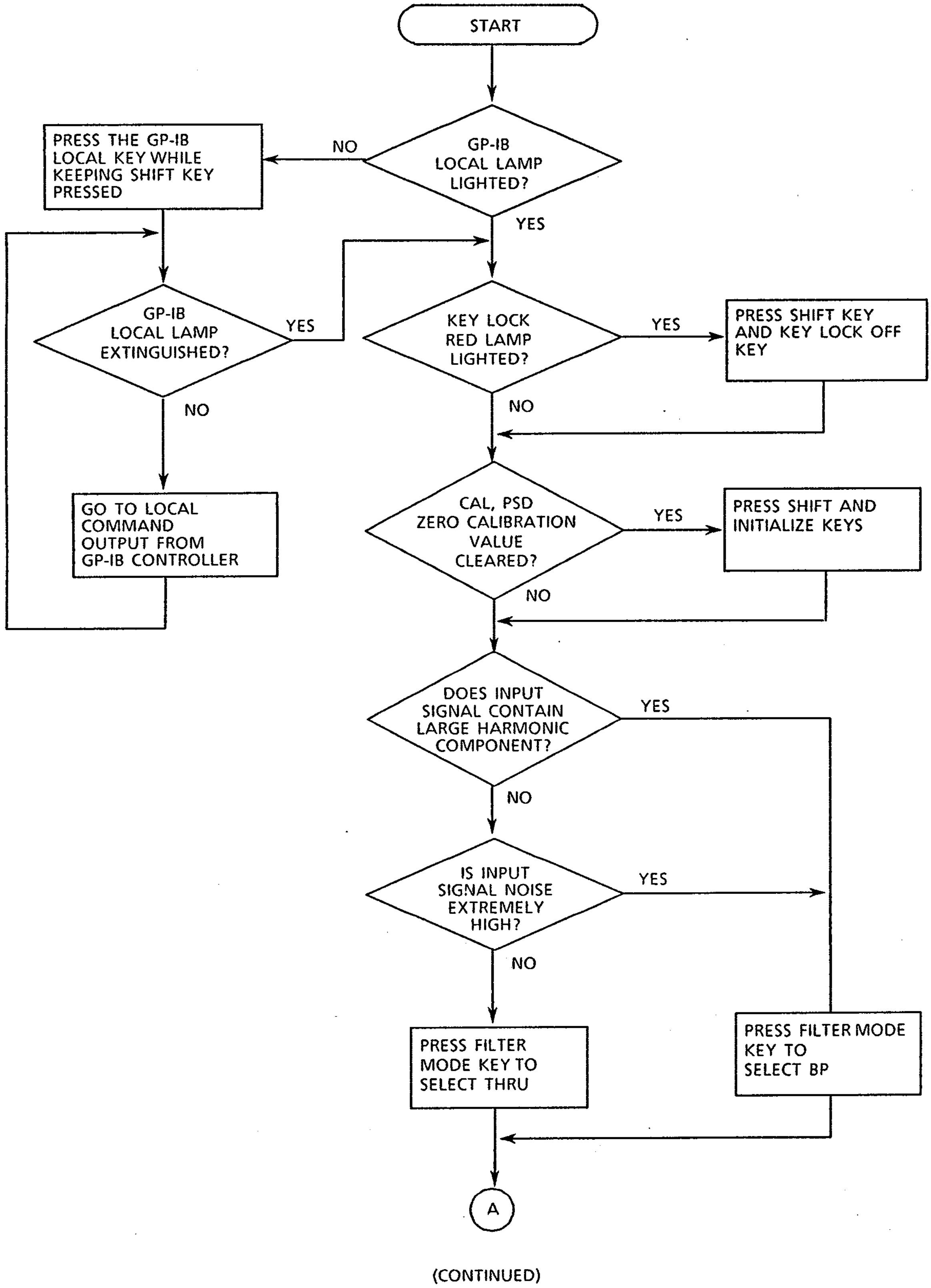


Fig.3－6　Preparations for AUTO SET Operation

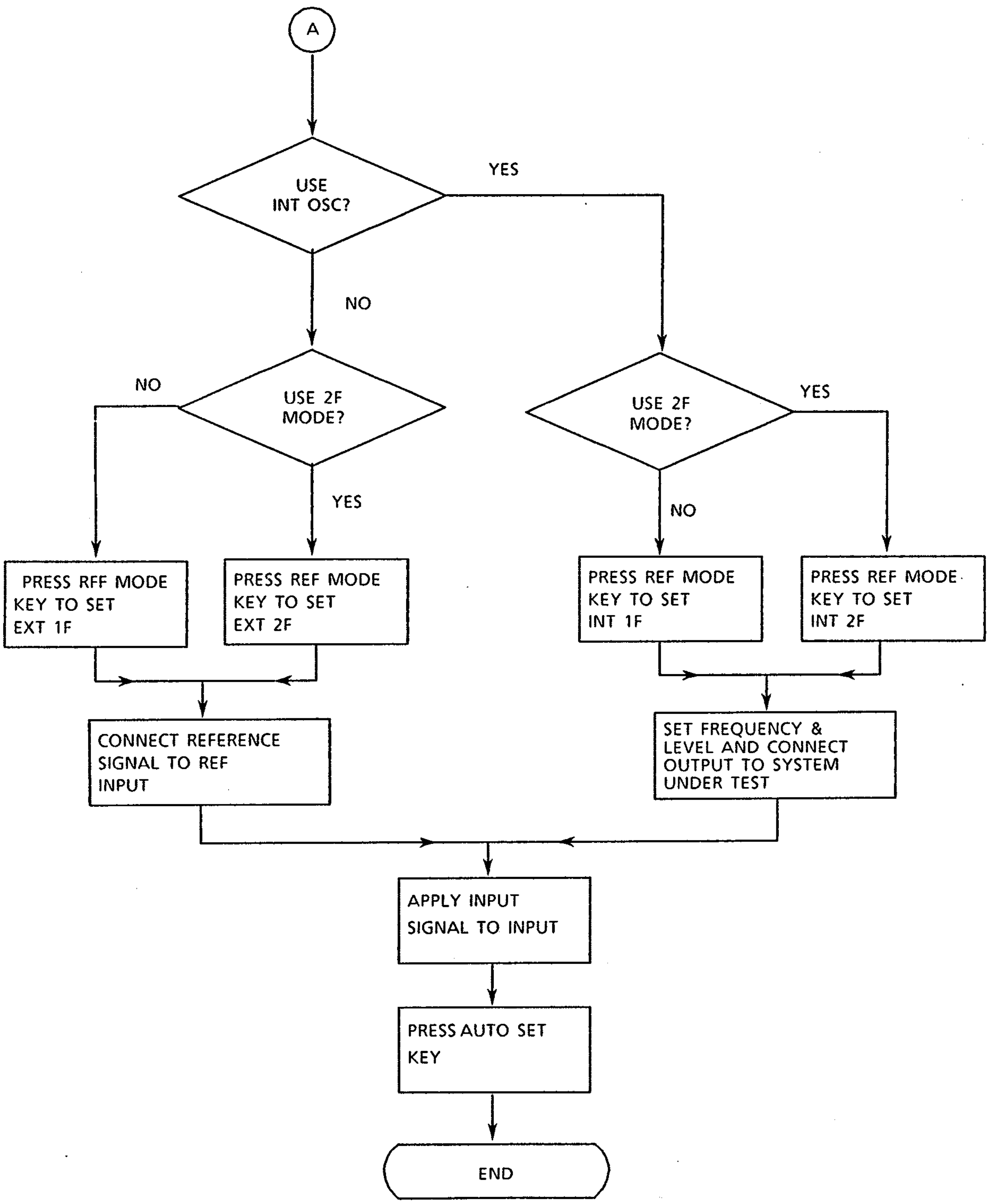


Fig.3-6 Preparations for AUTO SET Operation (continued)

㉗AUTO SET key is pressed the various setting values will be as follows :

BASIC FUNCTION
- F RANGE : Automatic setting
- REF MODE : Setting mode
- SENSITIVITY : Automatic setting
- T CONST : Determined by REF FREQ
- DYN RES : Corresponds to SENSITIVITY
- dB / oct : 12dB / oct

METER
- MAG X : OFF (×1)
- MAG Y : OFF (×1)

FILTER
- FREQ : Automatic setting
- MODE : Setting mode

AUTO FUNCTION
- AUTO RANGE: OFF
- AUTO TUNE : OFF

DISPLAY
- DATA 1 : A
- DATA 2 : ϕ
- DATA 3 : REF FREQ

NORMALIZE
- MODE : Setting mode
- VALUE : Setting value

ADJUST
- PHASE : 0°
- OFFSET : 0

AVERAGE
- TIMES : 64
- MODE : OFF

INT OSC
- FREQ : Setting value
- LEVEL : Setting value

RS-232C
- BAUD : Setting value

GP-IB
- ADR : Setting value
- LOCAL : Setting mode

OUTPUT
- START / STOP : STOP
- DATA SEL : Setting mode

RATIO
- K : 1

SPECIAL FUNCTION
- DAC 1 : Setting mode
- DAC 2 : Setting mode
- SAMPLING : 300ms, 2^7 (Every 128 times)

CAL : Does not clear
- PSD ZERO : Does not clear
- BEEP : Setting mode
- LAMP : Setting mode
- LIMIT : LIMIT OFF

(2) PHASE SET

This function performs an automatic setting of the phase. When the ㉘ PHASE SET key is pressed the phase offset of the reference signal will be set so that A sin ϕ becomes zero.

With the purpose of measuring the A (amplitude) and ϕ (phase) this function only corrects the units internal phase error, but it is mainly used in applications such as the following :

- When a high-speed change of the analog output of A is required

  Since this unit maintains the accuracy of vector computations, the value of A is calculated using digital computation. Because of this a change of A results in only a delay of the sampling time with respect to the output of X. And so the value of A is obtained from the X (A cos ϕ) output by means of phase adjustment to yield a maximum X (A cos ϕ) which is the direct output of COS PSD.

- When detection of a very small phase change is desired

The measurement of phase changes can be made more accurately in the vicinity of sin 0° rather than sin 90°. This is because since sin 0° = 0, the analog output of Y (A sin ϕ) is enlarged and read by a digital voltmeter. In addition, in the vicinity of sin 0°, the phase change and the Y (A sin ϕ) output change almost linearly and so the reading of the phase can be done easily.

For example, given an analog output of A at +5V, X (A cos ϕ) following the PHASE SET will also become +5V and Y (A sin ϕ) will become 0V. Here, when the phase changes 1°, the Y output will be

$$Y = 5 \times \sin 1° = 87.3 \text{ mV}.$$

On the other hand, given a change of 150mV,

$$\phi = \sin^{-1}(0.15 / 5) = 1.719°$$

As an approximation, since 87.3 mV = 1°, the computation 150 / 87.3 = 1.718° may be made. At less than 10°, as an approximate computation sin ϕ (degrees) = ϕ / 180 × π , measurement can be made with an error of about 0.5%. A little phase error exists between this units signal input and reference signal input.

This can be corrected by applying a standard signal without a phase difference (close to zero) between the input signal and the reference signal, and pressing the ㉘ PHASE SET key.

(3) AUTO RANGE

This function automatically sets the sensitivity range. The optimum sensitivity range is automatically set to correspond with the change of the signal. Range switching occurs when the signal exceeds 110% of fullscale or becomes less than 20% or fullscale. The time required for range switching is Time constant × 3 + Sampling interval × 2. "U-XX" will be displayed in ⑫ DATA 3/SETTING while the range is being changed. The figures XX show the code of the sensitivity range during the setting. The code is the same as the GP−IB parameter, being between 0 and 12 (1μV to 1 V).

100nV and 300nV ranges are out of the auto-ranging operations these range can be set only in manual setting or by external control.

The dynamic reserve is not switched in this function and so the range in which the sensitivity is automatically set will be the value of each dynamic reserve. These ranges are shown below.

Dynamic reserve L : 100μV to 1 V
Dynamic reserve M : 10μV to 100 mV
Dynamic reserve H : 1μV to 10 mV

There is also a function which limits the maximum sensitivity of the automatic setting ranges and a cancelling function (LIMIT OFF). This can be set by pressing the ㉛ SHIFT and the ㉙ LIMIT key. The initial value is LIMIT OFF. Pressing the ㉙ AUTO RANGE key will cause the lamp to light up indicating the auto range function. Pressing the key once more will switch off the lamp and cancel this mode.

(4) AUTO TUNE

Using the frequency of the reference signal, this function automatically sets the tuning frequency of the filter and the analysis frequency range to the same frequency when reference signal mode is 1F and to twice the frequency at the time of the 2F mode.

Note that when ㉚ AUTO TUNE is set in the HPF and LPF modes it will automatically select the THRU mode.

Also, when a signal is input that will yield a setting in which the frequency exceeds 120 kHz, the THRU mode will be set automatically.

When the filter mode is set to BPF and this key is pressed, the lamp will light up indicating the auto tune function, which will track the reference signal frequency and set the center frequency of the BPF. In addition, when the filter mode is set to THRU and the auto tune function is performed, only the analysis frequency range will be automatically set.

3.4.4 Setting the Reference Signal System

(1) Outline

The reference signal determines the units analysis frequency and plays an important role along with the input signal. The reference signal is converted to a square wave by the zero cross comparator inside the unit. A phase shift is performed from the input signal by only the value set with ㉔ ADJUST PHASE. Two square waves are generated with a phase difference of 0° and 90° from the shifted signal and they drive COS PSD and SIN PSD, respectively.

(2) Mode

Four kinds of modes are available in the reference signal mode with the combination of INT, EXT, 1F, and 2F. INT uses the built-in (optional) oscillator and analysis is performed at this oscillation frequency. When set to this mode, the oscillator output will be connected internally for use as the reference signal. Measurements are performed by connecting the oscillator output to the device being measured and applying the measurement signal obtained from here to the input of the unit. In the INT mode do not apply the signal to the reference signal input.

In the EXT mode analysis is performed with an external signal. A signal (external reference signal) which is synchronized to the analysis frequency is applied to ㊻ INPUT REF. The 1F and 2F modes set the frequency at which analysis is performed to the same frequency as the reference frequency or to twice the reference frequency. For instance, with a reference signal of 7 kHz the frequency at which analysis is performed will be 14 kHz with the 2F mode setting and the analysis frequency range will be 10 kHz to 200 kHz.

(3) Setting of the internal oscillator (INT mode)

See Section 3.4.5.

(4) External reference signal (EXT mode)

The external reference signal is connected to ㊻ INPUT REF. The input impedance is 1 M Ω and the maximum allowable input voltage is ± 200 V DC (including AC component) and 50 Vp-p AC. Attention should be given to the following points when making accurate phase measurements, detecting small phase changes, and measuring small voltages.

- Set the voltage value of the reference signal to 1 to 3 Vrms. If too small, phase errors and phase jitter's will increase. If too large, there may be bad effects on the input signal system.
- There should be no noise at the average value point of the signal. The DC component of the input signal is blocked by a capacitor and the signal is converted to a square wave by the zero cross comparator so that when there is noise at the average value point, the reference signal system may not function properly and phase jitters may increase.
- There should be no frequency fluctuation or phase jitters. When there is frequency fluctuation or phase jitters of the input signal, the measurement results will be unstable. Especially in the case where A sin ϕ has been phase-adjusted to zero for detecting phase change, the A sin ϕ output will be unstable and the noise will increase.

(5) UNLOCK

PPL (Phase Locked Loop) circuit is used in the reference system of this unit. When the reference signal is too small or the analysis frequency range is inappropriate the PLL circuit will not operate properly. Accordingly, the "UNLOCK" message will be displayed in the measurement data display section of ⑪ DATA 1. At this time, check the following points.

- Is the signal level of the reference signal in the range of 0.3 Vp-p to 30 Vp-p
- Is there a large frequency fluctuation or phase jitter in the reference signal
- Is there a lot of noise or pulse interference entering the reference signal
- In the case where the reference signal is a square wave, is the duty ratio within 10 : 1 and 1 : 10
- Are the frequency of the reference signal and the analysis frequency range appropriate
- Is the setting of the reference frequency range appropriate

(6) Phase adjustment

In the case of a single-phase lock-in amp, the phase difference between the input signal and the reference signal had to be adjusted to zero in order to measure the amplitude of the input signal. This unit is a 2-phase lock-in amp with two PSD so that simply measuring the amplitude will suffice without the need to make a phase adjustment. A phase adjustment is used in the following cases :

- Correction of the units phase error when measuring the phase in the vicinity of the lower and upper limits of the analysis frequency.
- When you wish to use the analog output of A cos ϕ as the amplitude value instead of A.
- When adjusting A sin ϕ to about zero in order to detect very small phase changes of the system being measured.

In the case of making phase adjustments, press the ㊱ ADJUST PHASE key located on the panel. Using ㊶ ㊷ MODIFY CURSOR and ㊸ MODIFY, phase adjustment will be possible from the minimum resolution of ± 0.01° step to ± 10° step. Correction of the phase error is performed as follows :

- Set the analysis frequency range, dynamic reserve, sensitivity, and time constant to the values that will actually be used. o Apply the reference signal and set the signal input connector so that there is no input (input shorted).

- When the measurement values of X and Y have stabilized and become fixed values, press the ㉛ PSD ZERO key. Check that the measurement values of X and Y have come close to zero.
- Apply the reference signal and a signal of the same phase to the input connector.
- Adjust the ㊱ ADJUST PHASE so that the value of Y becomes zero. Or press the ㉘ PHASE SET key. In case zero is not reached the first time, press the ㉘ PHASE SET key again.

When using the INT mode, do not apply the external reference signal to REF INPUT.

3.4.5 Setting the Internal Oscillator (INT OSC)

(1) Outline

The oscillator built into this unit (as an option) is a state variable type CR oscillator and the oscillation frequency and output level can be set digitally. For detailed specifications see Section 1.4.6. In case the oscillator option has been purchased at a later date, install it in the unit according to the method of Section 2.7.

Since this function is optional, the reference signal mode cannot be set to INT when the oscillator is not built in.

The setting of this function is performed when the reference signal mode is set to INT. When the reference signal mode is set to EXT, the oscillation is stopped and the output level is set to zero.

(2) Setting the oscillation frequency

The oscillation frequency range of the internal oscillator and the setting resolution are as follows :

0.5Hz to 120Hz	0.1Hz resolution
100Hz to 1200Hz	1Hz resolution
1kHz to 12kHz	10Hz resolution
10kHz to 120kHz	100Hz resolution

When setting the oscillation frequency, first check that the reference signal mode is set to INT and then set the analysis frequency range to be used. Pressing the ㊳ INT OSC FREQ key will display the set frequency in the display section of ⑫ DATA 3/SETTING. A change of the setting value is performed with ㊸ MODIFY. In addition, depending on the position of the cursor, there are three ways of operation. When the cursor is at the left edge only the frequency range will be switched and the numerical value will not change.

When the cursor is at the second position from the left edge, the setting of the numerical value and the range will be performed. Placing the cursor at the right edge and at the second position from the right edge will provide setting values which can only be changed within the range.

When the frequency has been set to less than 9.9 Hz, the frequency range will not change even if the cursor is set at the left edge. Range changes should be performed after the setting has been made at 10.0 Hz or higher. When the frequency setting value greatly exceeds the analysis frequency range the UNLOCK state will take effect and measurements will not be possible. Make a new setting since even if the oscillation frequency is changed, the analysis frequency range will not change.

(3) Setting the output level

The display of the output level is the value at the time of no load. Since the output impedance is 600 Ω, when the load is 600 Ω the output level will be half of the display value.

The output level range or the internal oscillator and the setting resolution are as follows :

0.0mV to 25.5mVrms	0.1mV resolution
0mV to 255mVrms	1mV resolution
0.00mV to 2.55mVrms	10mV resolution

When setting the output level, first check that the reference signal mode is set to INT and then press the ㊴ INT OSC LEVEL key display the setting value in the display section of ⑫ DATA 3/SETTING. Set the output level with ㊶ ㊷ CURSOR and ㊸ MODIFY. At this time if the setting value exceeds 255 there will be a shift to the next range above. There will not be a shift to a lower range, rather the setting value will become zero. Depending on the setting position of the cursor and the direction in which ㊸ MODIFY is turned, the setting value will change as shown below :

Cursor position First digit (farthest left)		Cursor position Second digit (center)	
MODIFY clockwise direction	MODIFY counterclockwise direction	MODIFY clockwise direction	MODIFY counterclockwise direction
_0.0mV	2.33V	0.0mV	2.46V
1.00mV	1.33V	1.0mV	2.36V
2.00mV	0.33mV	≀	≀
_30mV	_ 0mV	25.0mV	0.06mV
130mV	_0.0mV	26mV	_0mV
230mV		36mV	0.0mV
0.33mV		≀	
1.33V		246mV	
2.33V		0.26V	
		0.36V	
		2.46V	

3.4.6 Setting the Sensitivity and the Dynamic Reserve (SENSITIVITY, DYN RES)

(1) Dynamic reserve

Dynamic reserve is a specification peculiar to the lock-in amp. This is a figure which expresses to what extent noise can be superimposed with respect to the fullscale value of the input sensitivity and a normal measurement taken. A factor which limits the dynamic reserve is the clipping level of the AC amplifier with respect to the rated fullscale value as far as the phase detector. Accordingly, the definition of dynamic reserve is expressed in the formula below.

$$\text{Dynamic reserve} = \frac{\text{Maximum unclipped noise voltage (p-p)}}{\text{Input full scale sensitivity (rms)}}$$

As an example, with this unit the 1mV range has a dynamic reserve (H) of 70 dB (3160 times) and so there will be no clipping even when a signal of 3.16 Vp-p is applied to the input. In other words, the desired signal of 1mVrms can be detected from the input signal of (3.16 Vp-p noise + signal).

In the case of this unit, since the signal passes through a filter and then AC amplification, the dynamic reserve will be raised by only the portion blocked by the filter. For detailed dynamic reserve values see Section 1.4.3.

(2) Dynamic reserve and stability

Ways of increasing the dynamic reserve are to increase the clipping level of the AC amplifier prior to the PSD or to increase the gain of the DC amplifier following the PSD. In this unit the dynamic reserve is increased by the latter method. Because of this, when the dynamic reserve is increased the gain of the DC amplifier will increase and the stability will worsen as a result. Therefore, when the dynamic reserve is decreased within a range where input overload will not occur and measurements are taken, stable results may be obtained.

(3) Overflow

This unit monitors all of the clipping levels of the AC amplification section prior to the PSD and the DC amplification section following the PSD. When there is an overload at the AC amplification section, "I OVFL" will be displayed in the display section of ⑪ DATA 1 indicating such a situation and when there is an overload at the DC amplification section, "O OVFL" will be displayed indicating that there is an input signal overload.

Therefore, when there is an overload because of too much noise component in the input signal, "I OVFL" is displayed and when the desired signal component is larger than the setting sensitivity, "O OVFL" is displayed.

(4) Setting the sensitivity and dynamic reserve

The setting procedure for the sensitivity and the dynamic reserve is shown in Fig.3-7a. Set the reference signal system and make the settings after the "UNLOCK" message has been deleted.

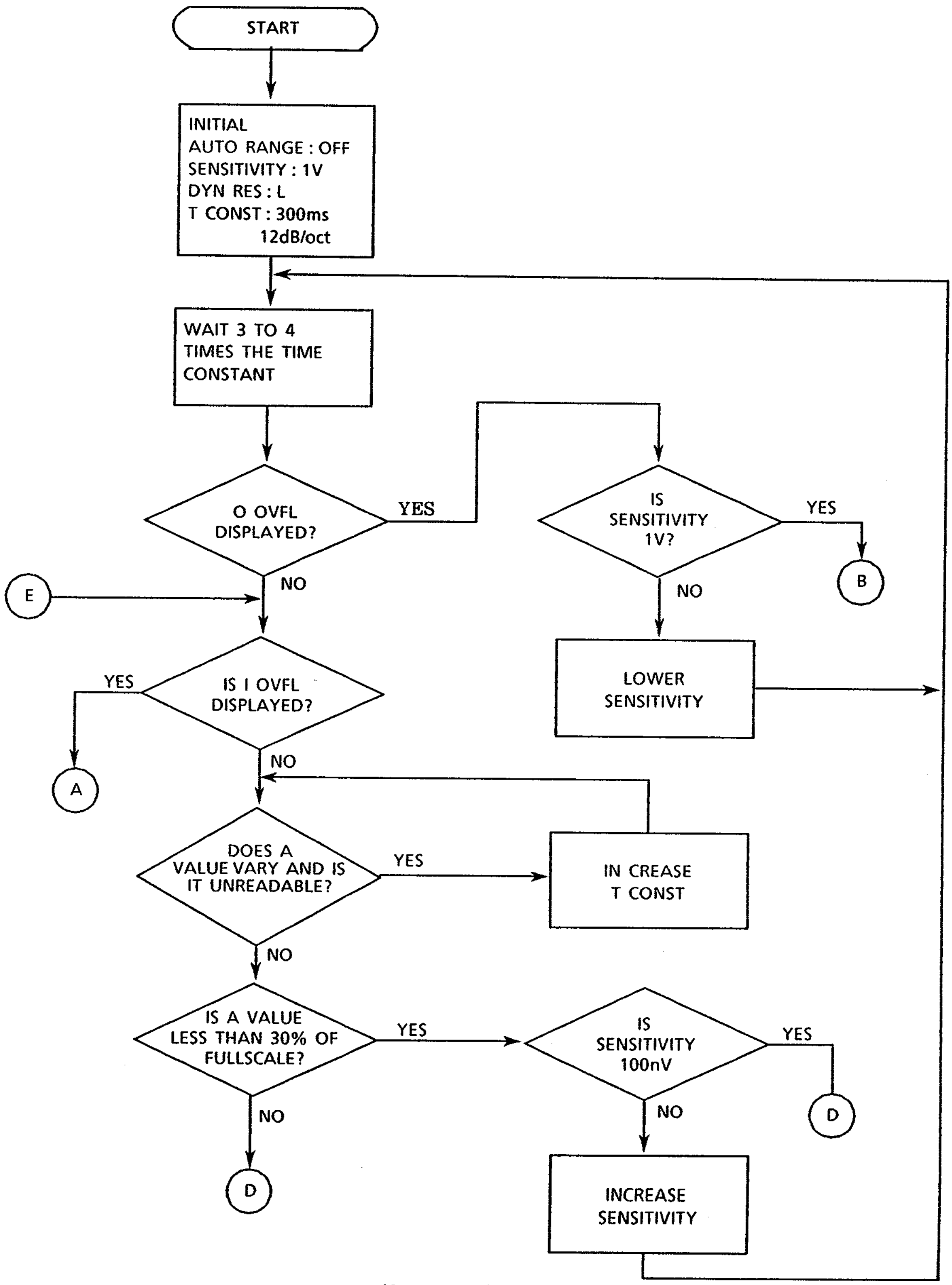


Fig.3-7a Setting Procedure for the Sensitivity and Dynamic Reserve (5610B)

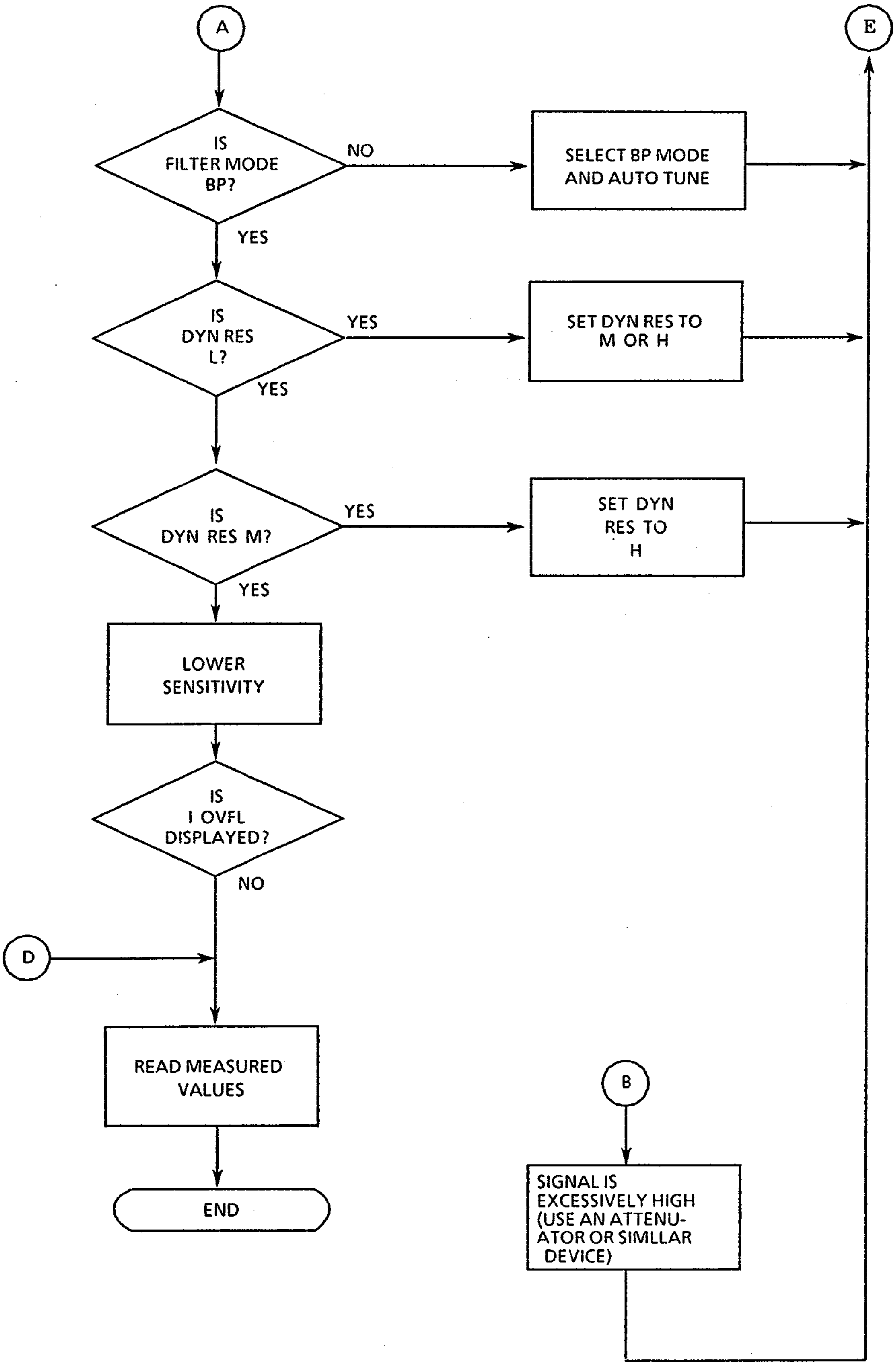
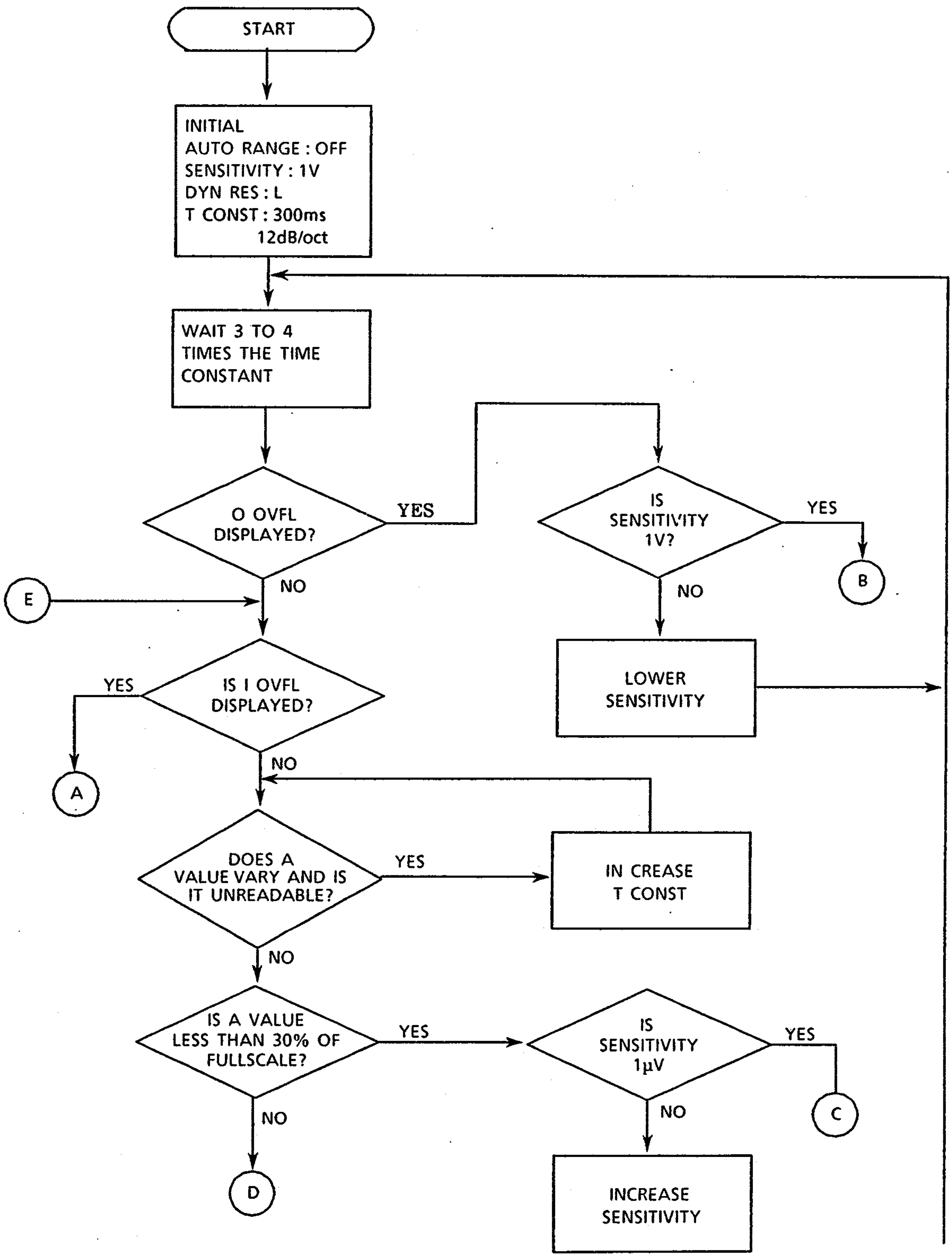


Fig.3－7a Setting Procedure for t Sensitivity and Dynamic Reserve (continued)



(CONTINUED)

Fig.3−7b Setting Procedure for the Sensitivity and Dynamic Reserve (5610A)

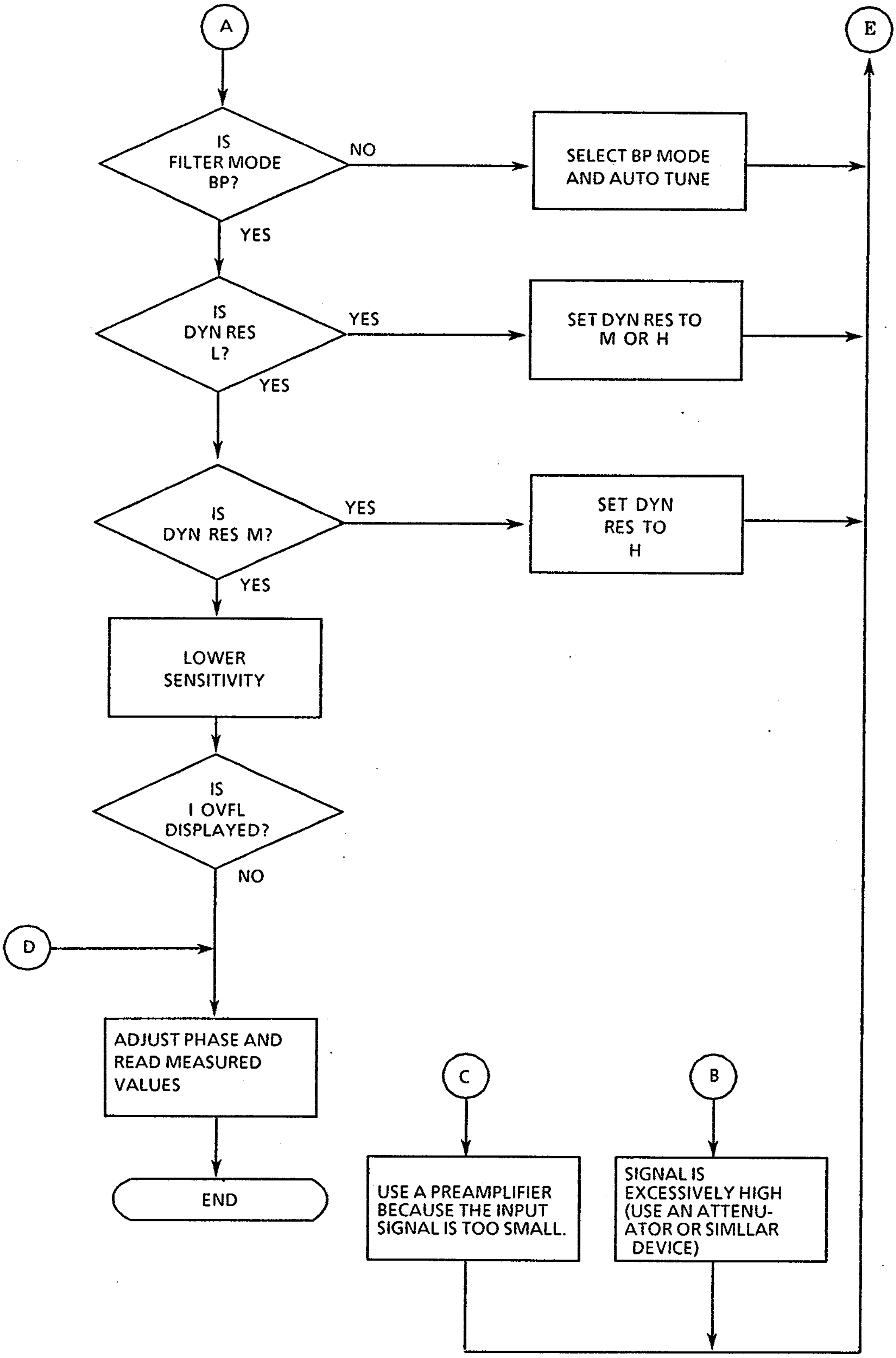


Fig.3−7b Setting Procedure for t Sensitivity and Dynamic Reserve (continued)

3.4.7 Setting the Time Constant (T CONST)

T CONST is the time constant of the low-pass filter which follows the phase detector. When the lock-in amp is thought of as being a band-pass filter with a center frequency at the reference signal frequency, T CONST determines the bandwidth. Therefore, the larger the noise of the signal or the lower the signal frequency, the larger the time constant must be and the equivalent bandwidth must be made narrower.

In actual use, T CONST is set to a degree at which the fluctuation of the displayed measurement value is not annoying. When the time constant has been set large, a wait of 4 to 5 times the length of the set time constant is until unit the data become stable.

Roll off of the low pass filter may be set 12dB /oct or 6 dB/oct,but usually at a setting of 12 dB/oct the response speed will be faster with respect to the same fluctuation of the data. When this unit is incorporated into a servo system, the 6 dB/oct setting may be used to stabilize the response of the servo system.

Switching is accomplished with the ㉛ ⑳ dB/oct key.

3.4.8 Setting of the Filter (FILTER)

(1) Outline

The filter used in this unit is a secondary-type state variable filter, the modes and frequency of which can be set by an external digital signal. The purposes for which the filter is used are as follows :

- Improvement of harmonic response : When a lot of odd harmonics are included in the input signal, measurement error will occur because the input signal is multiplied with a square wave in the phase detector. For this reason a filter is used to prevent harmonics from being added to the phase detector.
- Expansion of the dynamic reserve : Since the noise component is removed by the filter before AC amplification, the dynamic reserve will be expanded by only the noise portion which has been removed. For detailed values see Section 1.4.3.

  In summary, the filter is used when many harmonic components (e.g., square waves) are included in the input signal or when the AC amplifier becomes overloaded (I OVFL) due to noise of a specific frequency or pulse-type noise. For detailed filter specifications see Section 1.4.2.

(2) Features of each mode and method of use

This units filter offers the following modes :

HPF : High pass Filter (2-pole Butterworth)			Q : 0.7
LPF : Low Pass Filter (2-pole Butterworth)			Q : 0.7
BPF : Band pass Filter	Normal	type	Q : 1, 5, 30
	LPF	type	Q : 1, 5, 30
	HPF	type	Q : 1, 5, 30

- HPF : Provides the characteristics shown in Fig.3−8 offering 3 dB attenuation at the setting frequency with a slope of 12 dB/oct. The frequency is set lower than the signal frequency so as not to affect the gain of the signal. Since the pass band is flat, it is not necessary to change the setting frequency even if there is some fluctuation in the signal frequency. This filter is used when there is a lot of noise in the low-frequency components.
- LPF : Provides the characteristics shown in Fig.3−8 offering 3 dB attenuation at the setting frequency with a slope of 12 dB/oct. The frequency is set higher than the signal frequency so as not to affect the gain of the signal. Since the pass band is flat, it is not necessary to change the setting frequency even if there is some fluctuation in the signal frequency. This filter is used when there is a lot of noise in the high-frequency components.

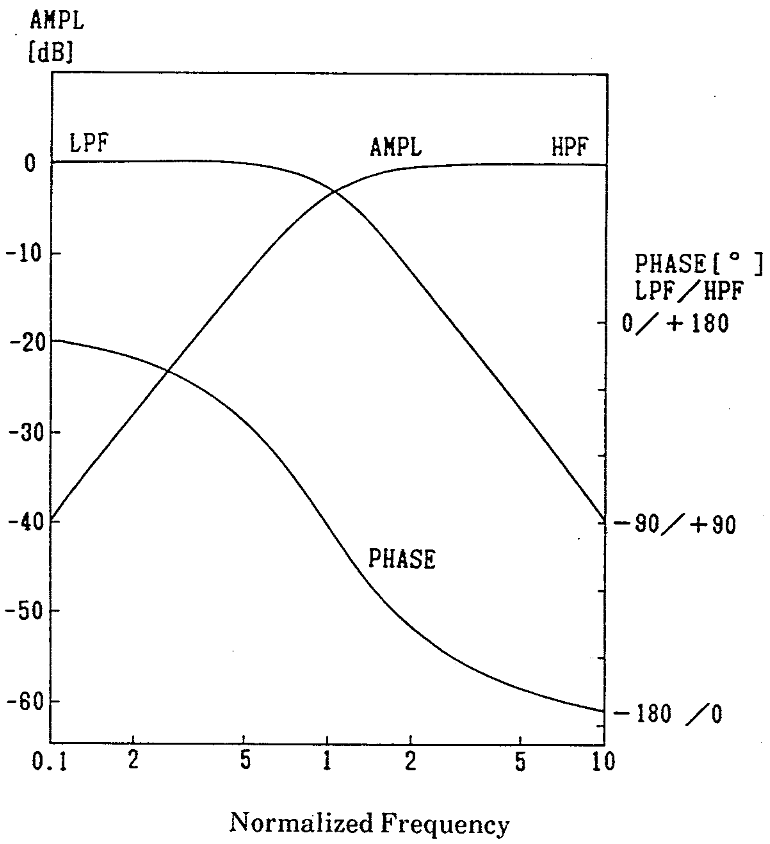


Fig.3−8 Signal System Filter (Normal type)

Three types of band-pass filter characteristics, normal. Low pass and high pass are available. For all three types, the gain at the set frequency is 1 and the AUTO TUNE function may be used.

- BPF (Normal) : As shown in Fig.3-10, the BPF (normal) filter has symmetrical high frequency and low frequency characteristics. The Q may be selected as 1, 5 or 30 and the rolloff at frequencies removed from the set frequency is 6dB / oct. Since the phase at the reference frequency is 0°, this filter characteristics is ideal for use in measuring the amplitude and phase of signals with high noise levels. Care should be taken as using a high Q will result in phase errors for even small frequency variance. This filter characteristics is also effective in minimizing harmonics.
- BPF (LPF Type) : As shown in Fig.3-17, the LPF type characteristics exhibit a peak, the gain at the peak being 1 and this peak being located at the set frequency. In contrast to the normal type characteristics, the high-end and rolloff is 12dB / oct, making these filter characteristics effective for signals exhibiting large high frequency component noise levels. The Q may be selected as 1, 5 or 30. It should be remembered that the phase at the set frequency is −90°. This filter characteristics is ideal in minimizing harmonics component.
- BPF(HPF Type) : As shown in Fig.3-11, the HP type characteristics exhibit a peak, the gain at the peak being 1 and this peak being located at the set frequency. In contrast to the normal type characteristics, the low end and rolloff is 12dB / oct, making these filter characteristics effective for signals exhibiting large low frequency component noise levels. The Q may be selected as 1 or 5. It should be remembered that the phase at the set frequency is 90°.

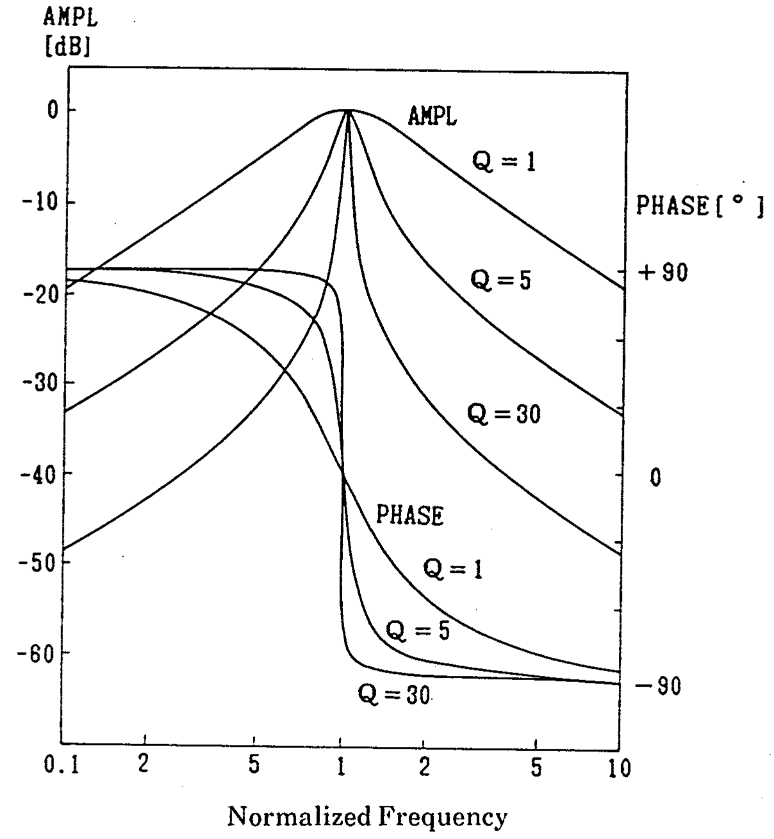


Fig.3−9 Signal System BPF Filter (Normal type) Characteristics

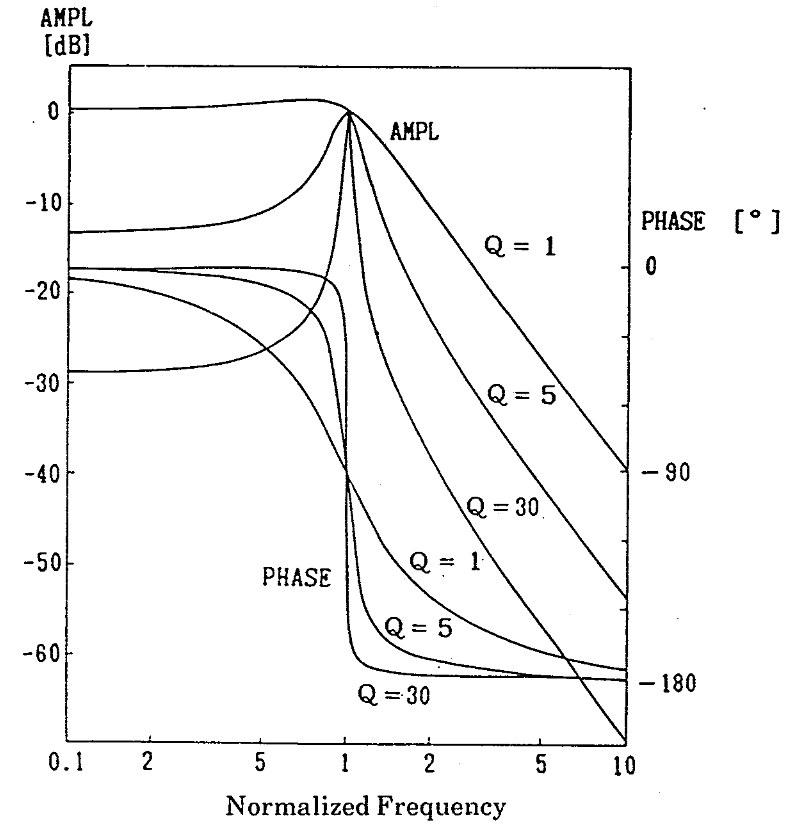
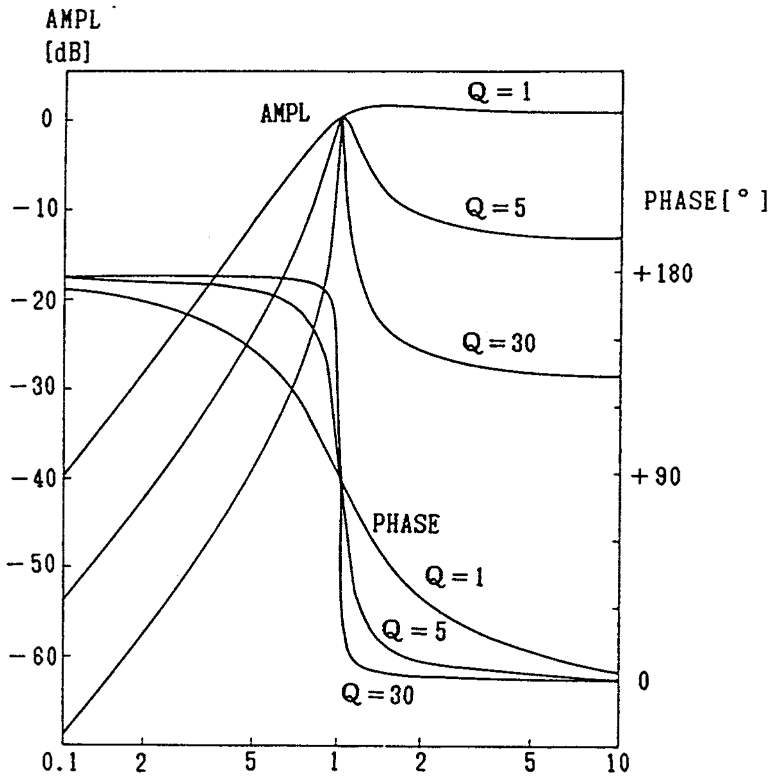


Fig.3−10 Signal System BPF Filter (LPF type) Characteristics



Normalized Frequency

Fig.3-11 Signal System BPF Filter (HPF type) Characteristics

(3) Mode setting method

The filter mode is set by pressing the ㉖ FILTER MODE key and turning ㊸ MODIFY in the clockwise direction at which time the mode will be set and displayed in the ⑧ FILTER display section in the following sequence :

"THRU" → "HPF" → "LPF"→ "BP1" → "BP5" → "BP30" → "BPL1" → "BPL5"→ "BPL30" → "BPH1" → "BPH5" → "BPH30" → "THRU".

The numerical values 1, 5, and 30 express Q, the L of BPL indicates the low-pass mode of the band-pass filter, and the H of BPH indicates the high-pass mode of the band-pass filter.

(4) Frequency setting method

The range in which the filter may be set and the resolution are as follows :

0.5Hz to 120Hz	0.1Hz resolution
100Hz to 1200Hz	1Hz resolution
1kHz to 12kHz	10Hz resolution
10kHz to 120kHz	100Hz resolution

Pressing the ㉕ FILTER FREQ key will display the set frequency in the display section of ⑫ DATA 3/SETTING. A change of the setting value is performed with ㊸ MODIFY. In addition, depending on the position of the cursor, there are three ways of operation. When the cursor is at the left edge only the frequency range will be switched and the numerical value will not change. When the cursor is at the second position from the left edge, the setting of the numerical value and the range will be performed. Placing the cursor at the right edge and at the second position from the right edge will provide setting values which can be changed only within the range.

When the frequency has been set to less than 9.9 Hz, the frequency range will not change even if the cursor is set at the left edge. Range changes should be performed after the setting has been made at 10.0 Hz or higher.

When the Q has been set to 30 or when fine adjustments of the frequency, which has been set to less than 10.0 Hz, are desired, make the adjustments with the ① FILTER FREQ ADJ trimmer. When using AUTO TUNE, turn this trimmer fully in the counterclockwise direction setting it to CAL.

(5) AUTO TUNE

This function automatically tunes the center frequency of the filter to the reference signal frequency at the time of the BP mode setting. Concerning the operation, the reference signal is measured by the units internal frequency counter and the value is set to the filter.

Pressing the AUTO TUNE key will cause the lamp to light up and start the auto tune operation. One more press will switch off the lamp and stop the function. When this key is pressed in the LPF or HPF mode the filter will be switched to the THRU mode.

3.4.9 Setting of Averaging (AVERAGE)

(1) Outline

This unit has two averaging modes used to digitally average the measurement results and eliminate noise. In the case of the lock-in amp, noise removal is performed by the LPF following the phase detector, but when the time constant becomes very large the performance worsens and rather than using analog circuits it is advantageous to do the job digitally.

In averaging, it is necessary to pay attention to the time constant (T CONST) and the measurement processing interval (sampling) when making settings.

(2) LIN AVERAGE

This type of averaging is performed by the movement average method. The movement average method makes a simple addition of the past data of a specified frequency from the newest data. A dividing operation by this frequency is performed at each sampling. The S/N ratio will be improved by only the square root of the averaging frequency. With respect to the following EXP AVERAGE, this method has the advantage that there is a shorter time until the final value is determined.

The time constant (T CONST) is set the same as or slightly longer than the measurement processing interval and the averaging frequency is set so that the value (Measurement processing interval×Averaging frequency) becomes markedly larger than the time constant (T CONST).

(3) EXP AVERAGE

This averaging method is achieved by a digital computation of the CR response and expresses the same response as the primary low-pass filter, the time constant being (Measurement processing interval ×Averaging frequency).

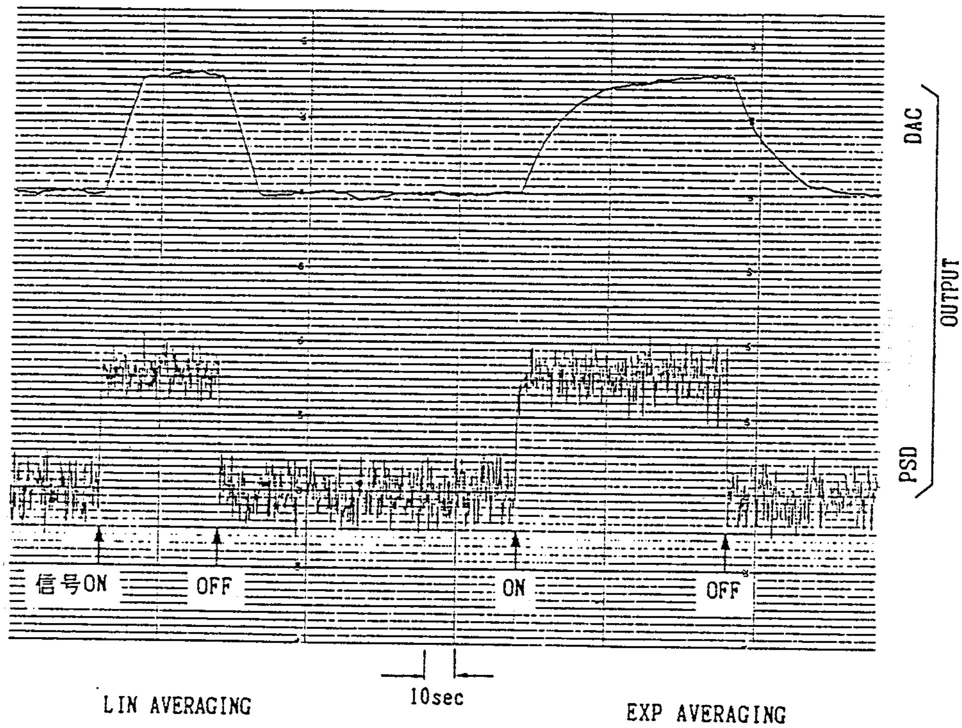
The time constant, the measurement processing interval, and the averaging frequency are set the same as in LIN AVERAGE.

The response waveform will be in combination with the time constant set by T CONST (at the LPF following the phase detector).

With the time constant (T CONST) there is a maximum of 30 seconds, but with EXP AVERAGE settings can be made to 10 seconds × 2^9 which is very effective when making the time constant larger. Used in combination with the time constant (T CONST), freer time constant settings may be made offerring a much wider application range.

(4) Usage notes

Concerning the sensitivity range, choose a range at which there will be no overflow due to instability of the data. The outputs of (61) A sin ϕ and (61) A cos ϕ will not be averaged. Also note that EXT DC will not be averaged. Fig.3-12 shows the response waveform at the time of switching on and off only the signal portion of a signal including noise.



Setting conditions

Measurement processing interval : 100 ms, averaging frequency : 128 times, time constant : 100 ms, 12 dB/oct, A

Fig.3-12 Effect of Averaging

3.4.10 Setting the Ratio

(1) Outline

The ratio function displays the ratio of the measured value and the DC voltage input from outside. The dual beam method (see part (3) below) is one of the main uses for this function. Here, by finding the ratio of the measurement results of two lock-in amps, the changes of the light sending and light receiving sections are cancelled and just the true changes of the device being measured become accurately measurable over a long period of time. The display value of the ratio is expressed as follows :

$$\text{RATIO} = K \times \frac{\text{X or Y percentage of range full scale}}{\text{Percentage of EXT DC full scale}} \qquad 0.1 \leqq K \leqq 9.999$$

The value at fullscale is 1.200 and at this time the analog output of ㊽ OUTPUT DAC 2 is ±12 V.

(2) Setting method

The fullscale value of the EXT DC measurement is ± 10 V and the resolution is 10 mV. An external DC voltage for comparison purposes is applied to the ㊼ EXT DC/RATIO BNC connector on the rear panel. The measurement resolution is best when a value close to fullscale but not exceeding fullscale is selected. When the display of ⑫ DATA 3/SETTING is set to "EDC :" with the ㉟ DATA 3 key, the EXT DC measurement value will be displayed.

The various settings will be performed so that the values of the ⑪ DATA 1 measurement results can be measured optimally. Read the measurement results of ⑪ DATA 1 and the EXT DC measurement value of ⑫ DATA 3/SETTING and compute a suitable value of K from the RATIO formula. Press the ㉛ ㉑ RATIO K switch and set with ㊸ MODIFY. The setting range is from 0.100 to 9.999.

When the display of ⑫ DATA 3/SETTING is set to "RAT :" with the ㉟ DATA 3 key, the RATIO measurement value will be displayed. The fullscale value of the ratio is 1.200 and at this time the ㊽ DAC 2 output will be +12 V when set to ratio. The display value of ⑫ DATA 3 / SETTING is calculated by internal digital values and displays up to ± 9.999. When a voltage exceeding ± 12 V is applied to EXT DC, "E OVFL" will be displayed in the display section of ⑪ DATA 1.

(3) Dual beam method

The connections of the general dual beam method are shown in Fig.3-13. A chopper of the type that simultaneously chop two different frequencies is selected. The beam from the light source is divided into two by a half mirror and is chopped by each of the differing frequencies.

The beam that does not pass through the sample (f_1) and the beam that passes through the sample (f_2) are made into one beam by the half mirror and are guided to the detector.

Because the output of the detector is connected to the input of two lock-in amps which are externally synchronized by, f_1 and f_2 and because this output is the change data (Y) of the light source and the detector are output to the output of the lock-in amp synchronized by f_1. The true changes of the sample and both the changes of the light source and the detector contained in data (X) are obtained in the output of the lock-in amp synchronized by f_2. The changes of the sample can be detected by taking the ratio of X to Y. By carrying out the X/Y calculation, the deviation of the light source and the detector contained in both denominator and numerator can be cancelled.

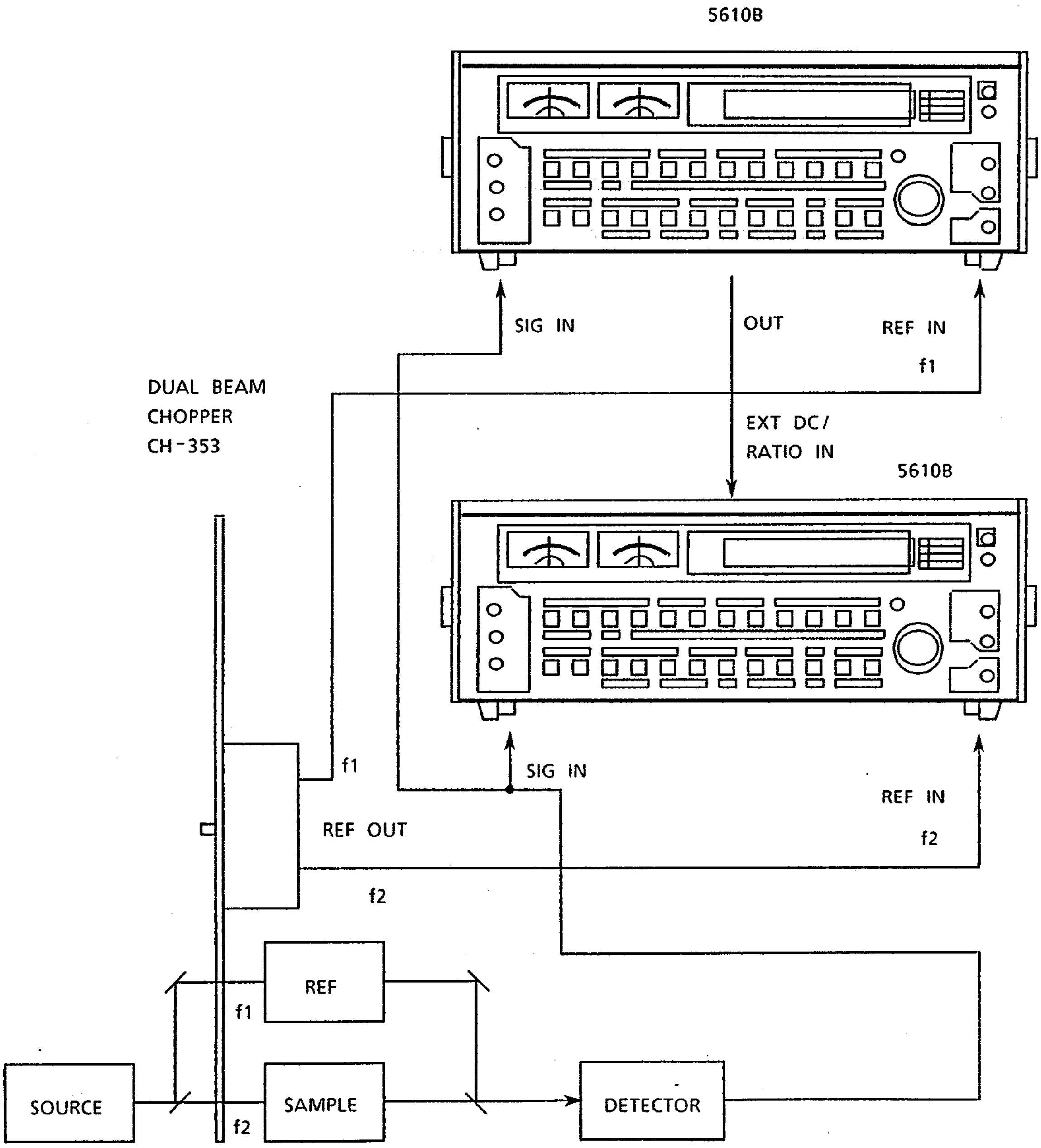


Fig.3-13 Dual Beam Method

3.4.11 Method of Data Output to the Printer

(1) Outline

This unit can output data directly to a printer equipped with a GP−IB interface (with a listen-only function) or an RS−232C interface. Data of the parameters to be printed and the speed can be set from the panel.

(2) Setting the output data

There are up to eight kinds of data from the table below which are output from this unit. This is accomplished by setting the data codes with the ㉛ ㊵ OUTPUT DATA SEL key on the front panel. Each data code is listed in the table below.

First parameter		Second parameter	
Code	Data	Code	Data
0	No data	0	No data
1	Line number	1	Line number
2	A (Amplitude)	2	ϕ (Phase)
3	AdB /%	3	Y (A sin ϕ)
4	X (A cos ϕ)	4	EXT DC (External DC input voltage)
5	XdB /%	5	RATIO (Ratio)
6	ϕ (Phase)	6	REF FREQ(Reference signal frequency)
7	Y (A sin ϕ)	7	SENSITIVITY (Sensitivity range)
8	EXT DC (External DC input voltage)	8	Status
9	No data	9	No data

Since there are many kinds of data the data codes have been divided into first parameter and second parameter codes. Pressing this key will provide a display in ⑫ DATA 3/SETTING in the following form :

```
ODS  ␣␣␣␣  ␣␣␣␣
 |    |     └─ Second parameter
 |    └─ First parameter
 └─ Header
```

Choose the required output data and set the code using ㊶ ㊷ CURSOR and ㊸ MODIFY. For example, with a selection of A, ϕ, REF FREQ, and SENSITIVITY, the settings will be ODS00260067 or ODS26006700.

The line number is used to indicate the elapsed time from the start of the measurement in the case of sending data out to the printer. When OUTPUT START is performed, the numerical value will start at 1 and be incremented by 1 until 9999 is reached, at which time the value will become zero and again start from 1. The passage of time is known from this numerical value and the data output interval.

(3) Setting the time of the data transmission interval

The time of the data transmission interval sets at what number of samples the data will be regularly output. This is expressed in the formula below :

Time of the data transmission interval = Sampling time × Data transmission interval (At what number of samples the measurement processing will be output once.)

The sampling time and the data transmission interval are set with the ㉔ SAMPLING key on the front panel. The data will be displayed as shown below when the ㉔ SAMPLING key is pressed while the ㉛ SHIFT key is held down.

Right 2 digits : Measurement processing interval (Sampling time)

00 : Stop 01 : 100 ms 02 : 300 ms 03 : 1 s 04 : 3 s 05 : 10 s

Left 2 digits : Data transmission interval

One output for 2 n times of measurement processing.

Set by the value of n. The setting range for n is 0 to 16.

(4) Printer with GP-IB interface

1When sending data directly to the printer with the GP-IB, set the unit to the talk-only mode and set the printer to the listen-only mode. Or set the unit to the GP-IB mode using the RS-232C BAUD key and press the OUTPUT START key to light the lamp and start the output of data. For detailed parameter settings see Section 7 on the GP-IB.

(5) Printer with RS-232C interface

When sending data directly to the printer with the RS-232C, set the unit to the RS-232C mode with the RS-232C BAUD key and set the parameters including the Baud rate and the stop bit to match the printer, then press the OUTPUT START key to light the lamp and start the output of data. For details on parameters and cable connections see Section 8 on the RS-232C.

3.4.12 Method of Using Special Functions

(1) BEEP

At times of overload, the UNLOCK condition, external control errors, and settings outside of the range, this unit may issue an alarm sound. This function is switched on and off by the ㉛ ㉗ BEEP key. When the key is pressed and the alarm sound is issued, the function is on, and when there is no sound the function is off. When the power is switched on the function will be off. Therefore, when the use of this function is desired, it must be switched on after the power is switched on.

(2) LAMP

A function has been included to switch off all of the lamp displays so that the light from the lamp displays does not cause interference when this unit is used in a dark room. This function is switched on and off with the ㉛ ㉘ LAMP key. When the power is switched on the function will be on. Note that when the function is off in a dark room situation and there is a momentary power failure during use, the lamps will light when the power comes on.

(3) KEY LOCK

The ㉜ KEY LOCK inhibits the setting operations of the panel. The red lamp will light during KEY LOCK. When the ㉜ KEY LOCK key is pressed after pressing the ㉛ SHIFT key, KEY LOCK will be cancelled, the lamp will go off, and the panel operations will be enabled.

(4) AUX

This key is not used with the present unit.

3.4.13 Method of Using the Calibration Function

(1) Outline

This unit has three calibration functions. One is with the PSD ZERO ADJ trimmer which calibrates the DC offset of the phase detector. The others are via the two keys, PSD ZERO and CAL which digitally process the correction of the zero drift and gain of the phase detector.

(2) Analog calibration of the phase detector DC offset

The phase detector converts and amplifies only the desired signal from within the input AC signal. In the dynamic reserve H mode, the DC gain is 1000 times and the zero point may drift due to temperature changes or a change with the passage of time. So with a change of placement or ambient temperature change, calibration will be necessary.

Calibration should be performed after checking that the ambient temperature change is small and allowing a sufficient warm-up period after switching on the power.

Short each of signal inputs A and B, perform the INITIALIZE function, and make the following settings :

F RANGE	: 100 to1.2kHz
REF MODE	: INT 1F (when the INT OSC option has not been installed, set EXT 1F and apply a reference signal in the vicinity of 400 Hz.)
SENSITIVITY	: 10mV
DYN RES	: H
T CONST	: 100ms, 12dB /oct
FILTER MODE	: THRU
All automatic functions	: OFF
INT OSC FREQ	: 400Hz
METER MAG	: ×10

㊼ A cos ϕ ZERO ADJ and A sin ϕ ZERO ADJ trimmers so that the value indicated on the ② X : A cos ϕ and Y : A sin ϕ meter becomes zero. Now, check that the meter indication is zero and that the measurement data of ⑪ DATA 1 is within ± 0.05 mV. If these values are greatly different, internal calibration is required.

(3) PSD ZERO

This function corrects the zero drift of the phase detector by a digital value and when compared with Step (2), can be used easily. Note, however, that this function will not correct the output signals of (60) A sin ϕ and (61) A cos ϕ.

Short each of signal inputs A and B, set all of the ranges to be used such as the analysis frequency range, the sensitivity, and the reference signal mode, then wait until the display becomes stable. When the display has become stable, press the (31) SHIFT key and then press the PSD ZERO key.

The value of the data of (11) DATA 1 will be corrected to zero and the correction values will be stored internally. These correction values will be cleared at the time of INITIALIZE and when the power is switched on.

When the displayed values, that is, the correction values are ± 30% of full scale or greater, correction will not be possible and an error will result with "CRCT ERR" being displayed in the display section of (12) DATA 3/SETTING.

(4) CAL

This function corrects the gain of the phase detector and the amplifier with a digital value. In making these corrections an accurate calibration signal is necessary.

After performing the correction of Step (3), set the display of (11) DATA 1 to X : cos ϕ and set all of the ranges that will be used such as the analysis frequency range, the sensitivity, and the reference signal mode, then apply a calibration signal, which is equivalent to sensitivity full scale, to the input. Perform the adjustment of the phase. The display value of (11) DATA 1 will become the input amplitude value. Check that this display value is within ± 10 of range full scale. Press the (31) SHIFT key and then when the (25) CAL key is pressed, the (11) DATA 1 display value will become the same value as range full scale and the correction value will be stored internally.

When the (11) DATA 1 display value prior to performing CAL is not within ± 10% of range full scale, "CRCT ERR" will be displayed in the (12) DATA 3/SETTING display section without correction being performed. The correction value will be cleared at the time of INITIALIZE and when the power is switched on.

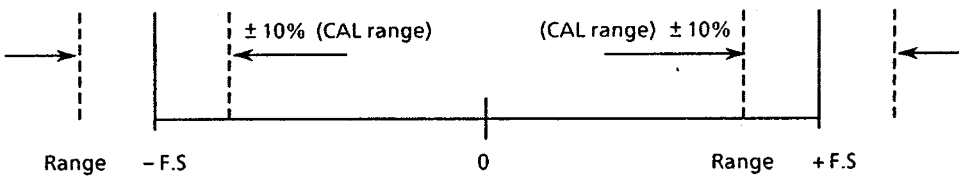


Fig.3-14 Explanatory Diagram of the CAL Range

3.4.14 Overload, Unlock, and Error Displays

(1) Overload display

There are three kinds of overload displays as shown below. They are displayed in the display section of ⑪ DATA 1. When BEEP is on the beep sound will be issued during the overload condition.

I OVFL (Over code 1)	:	When the input amplifier has become saturated due to too high a noise level with respect to the signal.
O OVFL (Over code 2)	:	When the signal is too large and has exceeded 120% of full scale.
E OVFL (Over code 4)	:	When the EXT DC input is ± 12 V or higher.

The over code is a code which responds when there is an overload inquiry of the GP-IB or other interface and when there is a simultaneous generation a summed value will result.

There is no special overload display at the time of ratio measurements and there will be a display of 9.999.

(2) Unlock

When the amplitude of the reference signal is too small or the reference signal circuit does not operate properly because the frequency is outside of the analysis frequency range, "UNLOCK" will be displayed in the display section of ⑪ DATA 1. If BEEP is on at this time, the BEEP sound will be issued.

(3) Error display

When the errors listed below occur, the error code is displayed in the display section of ⑫ DATA 3/SETTING and if the BEEP is on the BEEP sound will be issued once. The error code display will still be displayed after the error state has been cancelled and will not be deleted until another data display or function setting has been performed.

OPR ERR (Error code 1) : There has been an error in the key operation.

Example : When the INT OSC has been installed and the reference signal mode is set to EXT, the error will occur when an attempt is made to set the parameters of the INT OSC.

PRMTR ERR (Error code 2) : When there has been an attempt to set a parameter outside the specification range with a GP-IB, etc.

OPT ERR (Error code 3) : When there has been an attempt to make a setting of an optional function which is not included in the unit.

Example : Even though the INT OSC has not been installed there has been an attempt to set it.

PRGM ERR (Error code 4) : When there has been an error in the header of the program code of the GP-IB or RS-232C.

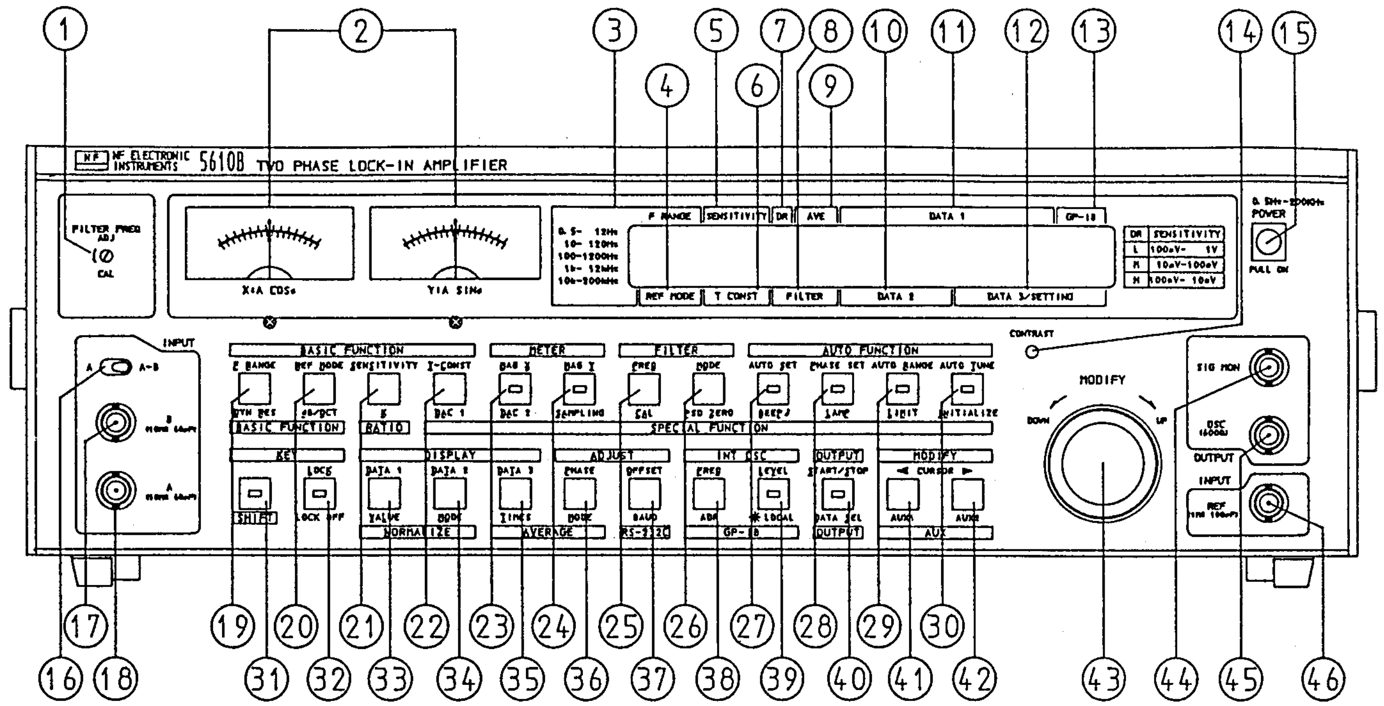
RS-232C ERR (Error code 5) : When there has been an error in the RS-232C.

Example : When there is a parity error or an overrun error.

NRDY ERR (Error code 6) : When the OUTPUT DATA START switch has been pressed but the external device is NOT READY.

REF ERR (Error code 7)	:	When the AUTO SET switch has been pressed but the reference frequency cannot be properly measured.
CRCT ERR (Error code 8)	:	When the CAL or PSD ZERO switch has been pressed but the data do not meet the conditions.
BACK UP MEMORY ERROR ! PLEASE PRESS ANY KEY	:	When there has been a sum check error in the data backed up by battery.
ROM ERROR !	:	When there has been an error in the ROM being used.
RAM ERROR !	:	When there has been an error in the RAM being used. If there has been a ROM error or a RAM error, switch off the power and contact us or our sales agent.

Front Panel



Rear Panel

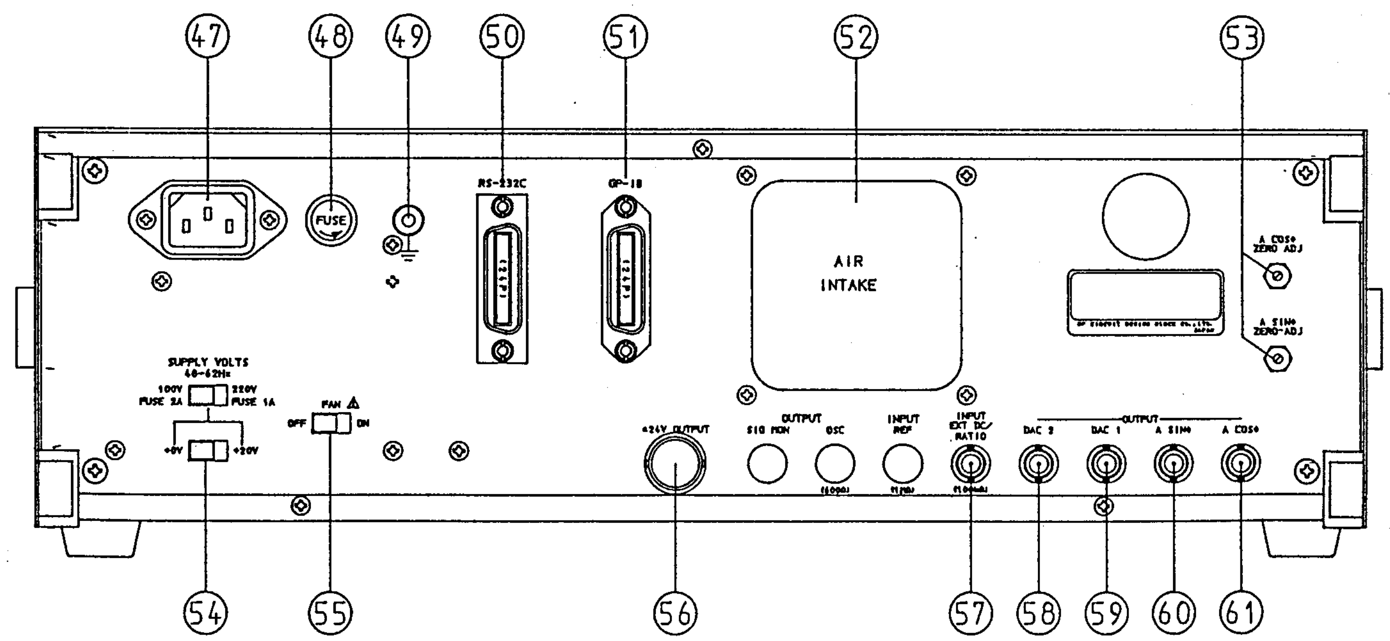
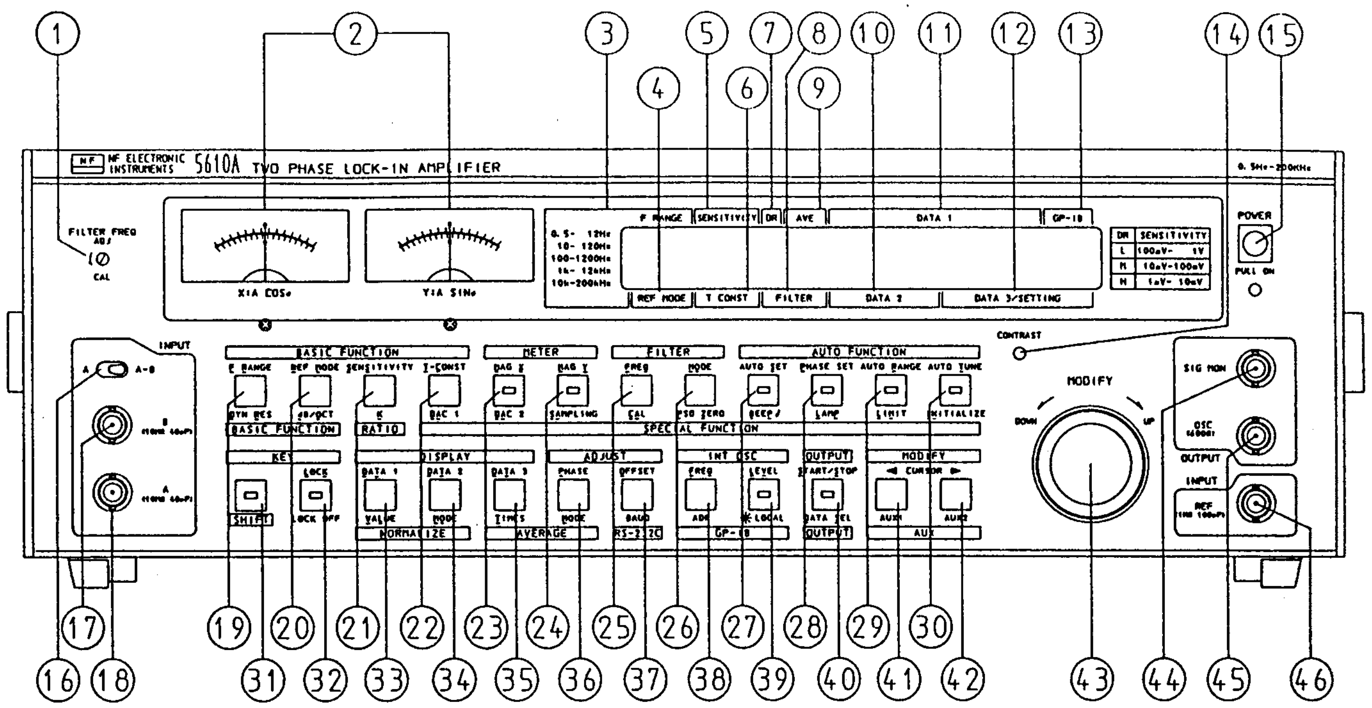


Fig.3-15a Front and Rear Panels (5610B)

Front Panel



Rear Panel

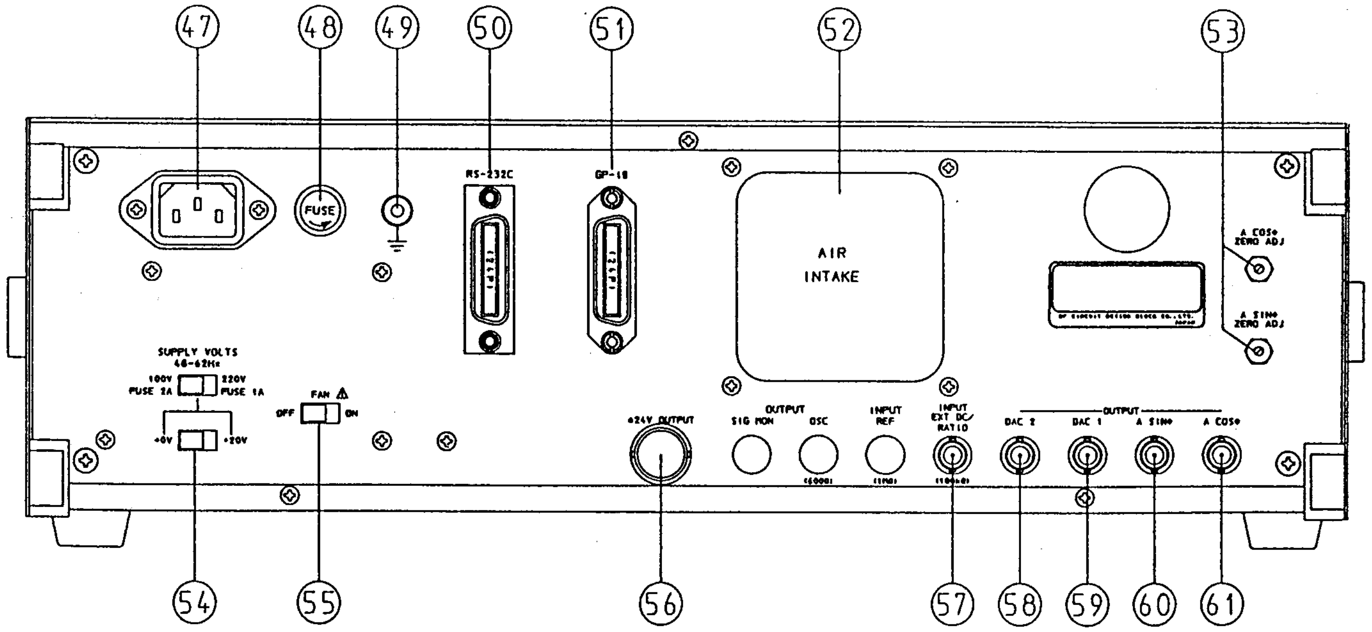


Fig.3-15b Front and Rear Panels (5610A)

4 OPERATING PRINCIPLES

4.1 Introduction

This section explains the basic operating principles of the 5610B/A. The basic lock-in amplifier is described first followed by the description of noise figure, equivalent noise bandwidth, step response and other aspects of lock-in amplifier operation.

The operating principle of the 5610B/A is explained using block diagrams.

4.2 Basic Lock-In Amplifier

The lock-in amplifier is based on the fact that the noise power is proportional to frequency bandwidth. If the frequency band is narrowed, noise is reduced and only the signal component can be extracted. To this end, it is essential to realize a highly stable band-pass filter capable of selectively amplifying only those frequency components existing very close to the frequency of the desired signal. One of the approaches provides the lock-in amplifier.

Fig.4-1 shows a block diagram of a basic lock-in amplifier. An input signal applied to the SIG INPUT is amplified by the AC AMPL, and applied to the PSD (phase sensitive detector).

Simultaneous with this, a reference signal applied at the REF INPUT is wave shaped and phase adjusted at the REF CIRCUIT and applied to the PSD as a square wave synchronized in phase with the signal to be detected. At the PSD, the input signal and reference signal are multiplied, converting these two signals to sum and difference frequencies. Therefore, the in-phase components are convereted to DC, while other frequency components (i.e., noise) are converted to AC. These AC components are eliminated by means of an LPF (low pass filter) leaving only the DC output corresponding to the measured signal components.

The low pass filter determines the bandwidth which essentially establishes the noise elimination capability of this system. The band-pass of the low pass filter may be made narrow without sacrificing stability, enabling the equivalent noise bandwidth to be made extremely narrow, so that virtually all noise can be eliminated.

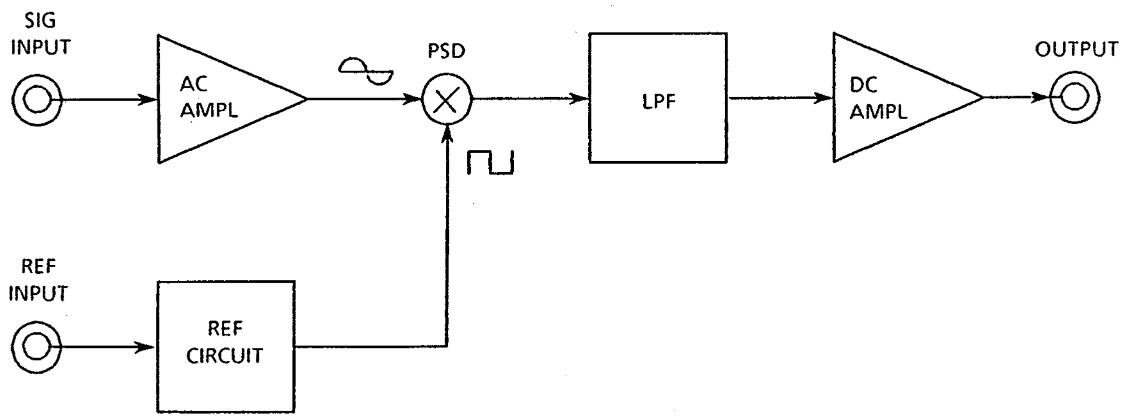


Fig.4-1 Basic Lock-in Amplifier

4.3 Noise Figure

While a lock-in amplifier can be used to greatly improve SN ratio as described in 4.2 above, this improvement is limited by lock-in amplifier internal noise (preamplifier noise). When the level of lock-in amplifier internal noise (preamplifier) is high, a large time constant is required to obtain the same SN ratio, resulting in longer measurement time. Thus, the level of the internal noise is one of significant parameters to indicate the performance of the lock-in amplifer.

The noise figure, which is used to express noise performance of lock-in ier. is the ratio of input referred noise voltage to the terminal noise voltage of the signal source.

$$\text{Noise figure (dB)} = \frac{\text{Input referred noise voltage}}{\text{Signal source thermal noise voltage}}$$

The signal source thermal noise voltage is an unavoidable source of noise for any signal source and is the minimum possible noise level, this being determined by temperature, signal source resistance and frequency bandwidth.

If, as shown in Fig.6−3, points of equal noise figure are connected, we derive what is known as the noise figure contour plot. The following is a brief description of how this plot is used.

(a) Determination of the Actual Input-Referred Noise Voltage

The noise figure is determined from the actual frequency bandwidth (B), signal source resistance (Rs), absolute temperature (T) and Boltzman's constant k (1.38×10^{-23}), as follows.

(Input-referred noise voltage) $\sqrt{4kTBRs}\times 10^{NF/20}$

From this equation, if the noise figure is below 3dB, it can be seen that the amount of noise increase over the ideal characteristics is 1.4 times max.

(b) Attaining the Optimum Noise Figure

The amount of noise may be reduced by reducing the signal source resistance, limiting the bandwidth and lowering the temperature. The noise figure indicates a rate of increase of noise under predetermined conditions. Therefore, lowering the noise figure could cause the absolute amount of noise increase to actually increase. If the signal source resistance is set so that the noise figure decreases, connecting a resistance in parallel or in series with the signal source will not improve SN ratio and even causes more deterioration of this ratio. If the signal source resistance is relatively low, the use of a step-up transformer can result in best noise characteristics. For details of this, refer to the instruction manual on catalog of " Input Transformer L1−771/771 " manufactured by us.

4.4 Equivalent Noise Bandwidth and Step Response

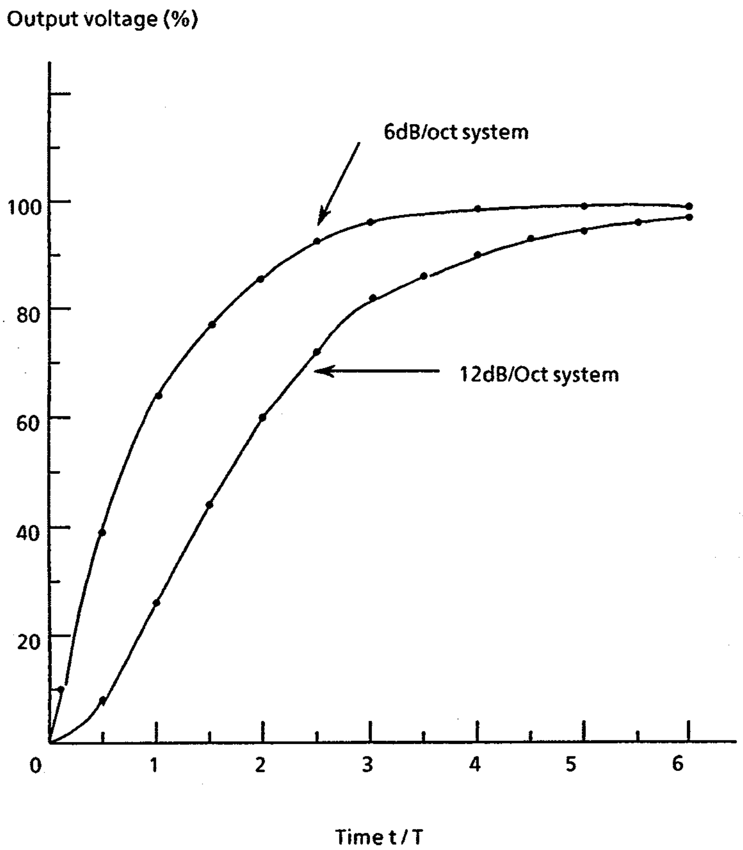
These system parameters are determined virtually entirely by the low pass filter characteristics. Mathematical description of these parameters will be omitted for simplification.

The equivalent noise bandwidth (ENB) is virtually entirely determined by the time constant (T CONST) of the low pass filter.

1/4T for T CONST 6dB/oct
1/ST for T CONST 12dB/oct The time constant (T)

The time step response characteristics are shown in Fig.4−2. From this figure, the amount of time required from the point at which a signal is applied to the lock-in amplifier until the final value is reached can be determined. If the time constant is 6dB/oct, this time is four to five times the time constant and for a time constant of 12dB/oct, this time is six to seven times the time constant.

The response time for a given equivalent noise bandwidth is approximately faster for 12dB/oct when compared with 6dB/oct. Therefore, in normal use, it is advantagenous to use the 12dB/oct setting. When using the 5610B/A as part of a servo system loop, 6dB/oct, however, should be used to assist loop stability problems.



	Output voltage (%)	
t / T	6dB/oct	12dB/oct
0.5	39.35	9.02
1.0	63.21	26.42
1.5	77.69	44.22
2.0	86.47	59.40
2.5	91.79	71.27
3.0	95.02	80.09
3.5	96.98	86.41
4.0	98.17	90.84
4.5	98.89	93.89
5.0	99.32	95.96
5.5	99.59	97.34
6.0	99.75	98.26

Fig.4−2 LPF Step Response

4.5 Block Diagram

The block diagram is shown in Fig.4−3

(1) Signal system

The signal system is a low-noise differential input selective amplifier comprised of A1, FILTER and A2. Four filter characteristics modes, HP, LP, BP and THRU may be selected. After passing through the filter, the input signal is amplified by amplifier A2, resulting in a dynamic reserve improvement equivalent to tne components blocked by the filter. Any overload conditions are detected at amplifiers A1 and A2 and the signal level.

The A1 and A2 gains and the filter parameters, and overload information as well are controlled by the CPU, through the data bus.

Fig.4−4 (a), (b) and (c) show the level diagrams for the signal system. The PSD gain is not the theoretical value but is circuit compensated to the value of 1. The voltages before the PSD are rms AC voltages and those following the PSD are indicated as DC voltages.

(2) PSD

The AC amplifier outputs are fed to a COS. PSD, a SIN PSD, and a monitor. At the PSD the AC amplifier output is multiplied with the square wave of the reference signal line output. Of the PSD outputs, the amplitude A which is inphase with the input signal voltage and the phase ϕ which is the difference in phase between the reference signal and the input signal are derived as the A COS (A SIN ϕ for Y, as shifted 90° on the reference signal line) DC signals, and to an AC signal representing asynchronous signals.

The AC signal representing asynchronous components is attenuated by the next low pass filter stage.

(3) Low Pass Filter and DC Amplifier

LPF is a low pass filter having a rolloff selectable as 6dB/oct or 12dB/oct. The time constant of this filter determines the equivalent noise bandwidth for signal detection and measurement (refer to Section 4.4).

The DC AMPL provides a DC signal level of ±10V fullscale which is fed to the PSD output connector as well as to the A−D converter section and meter.

(4) A−D and D−A Converters

The A COS Φ (A SIN Φ) DC signals are digitized by means of 13-bit A−D converters, and calculated, averaged and compensated by the CPU, to be displayed on LCD display and converted into the analog signal again by the D−A converter.

(5) Reference Signal System

After the reference signal passes through the input buffer, it is wave shaped to a rectangular waveform by a comparator and shifted the required amount with respect to the input signal by means of a phase shift circuit, and is fed to PSD.

(6) Internal Oscillator

A state-variable type internal oscillator is used with the oscillation frequency being digitally settable to 3.5 digits.

When the reference signal mode is set to INT, the oscillator output will be the reference signal and the signal will be output.

(7) CPU

The 5610B·A uses a high-performance 16-bit CPU with an 8-bit data bus to perform vector calculations, execute automatic functions, control panel functions and control the GP−1B and RS−232C interface as well as other functions. The memory consists of 64k bytes of ROM and 8k bytes of RAM, with the RAM contents being backed up by battery.

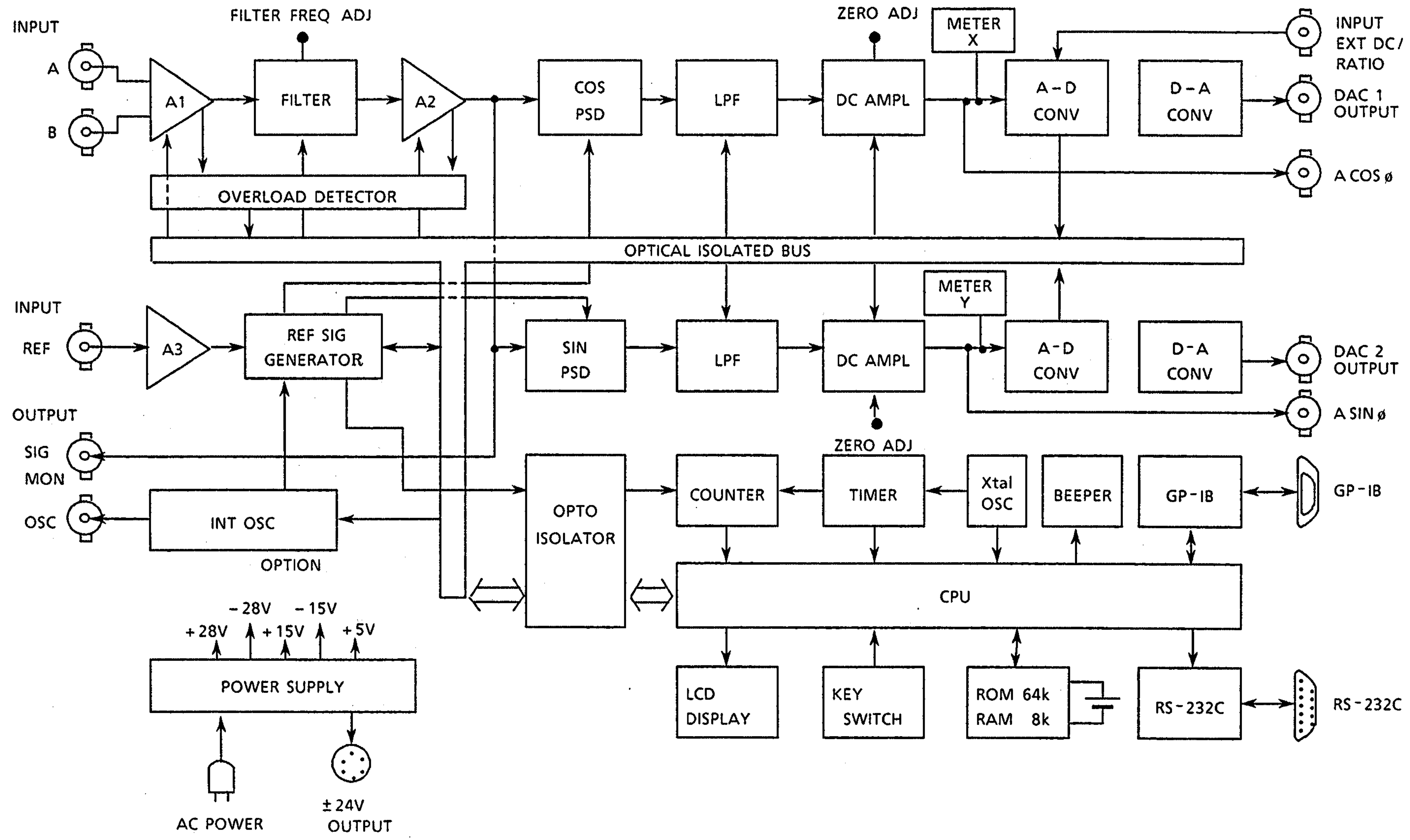


Fig.4-3 5610B/A Two Phase Lock-in Amplifier Block Diagram

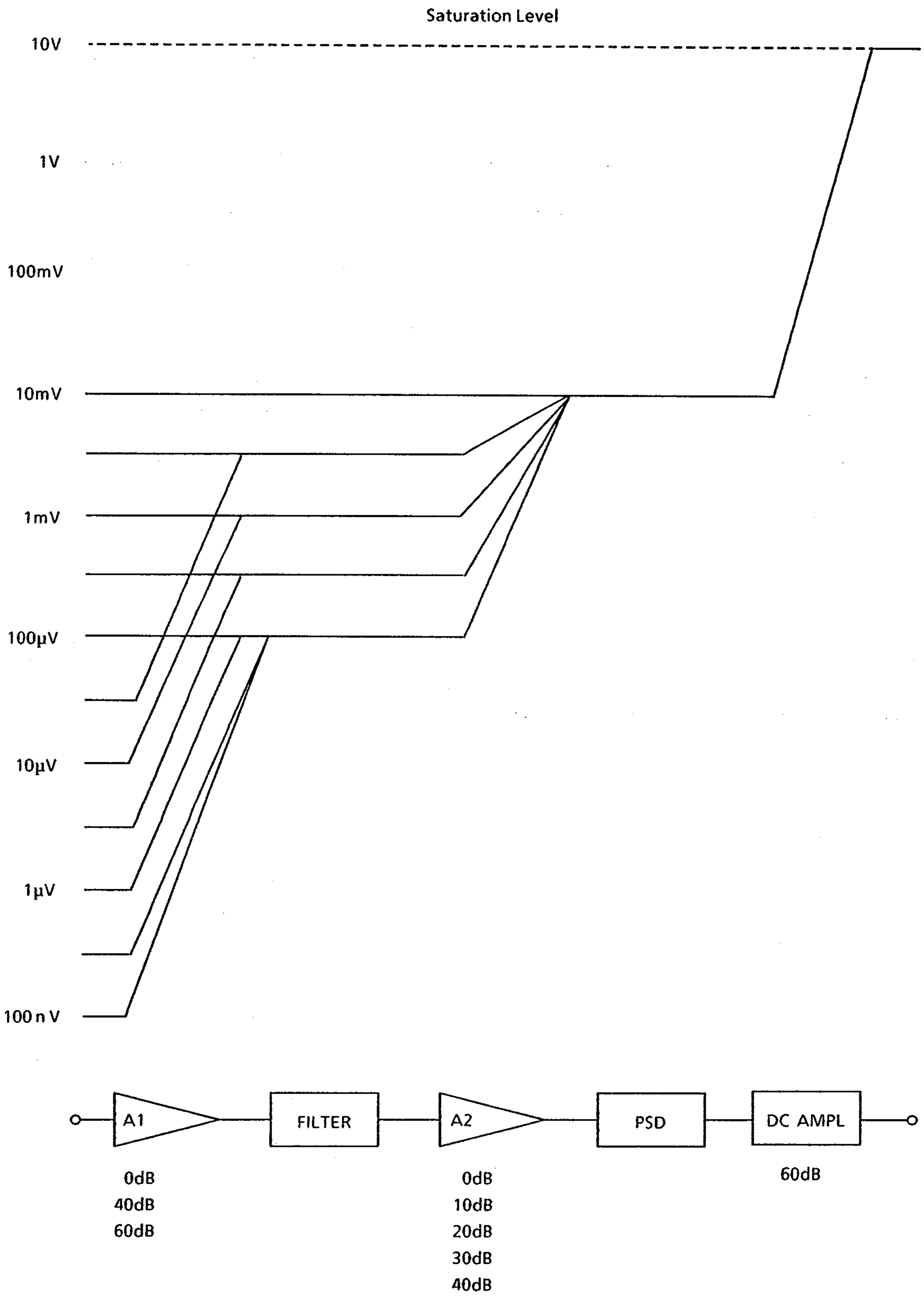


Fig.4－4(a)　Level Diagram at Dynamic Reserve H (5610B)

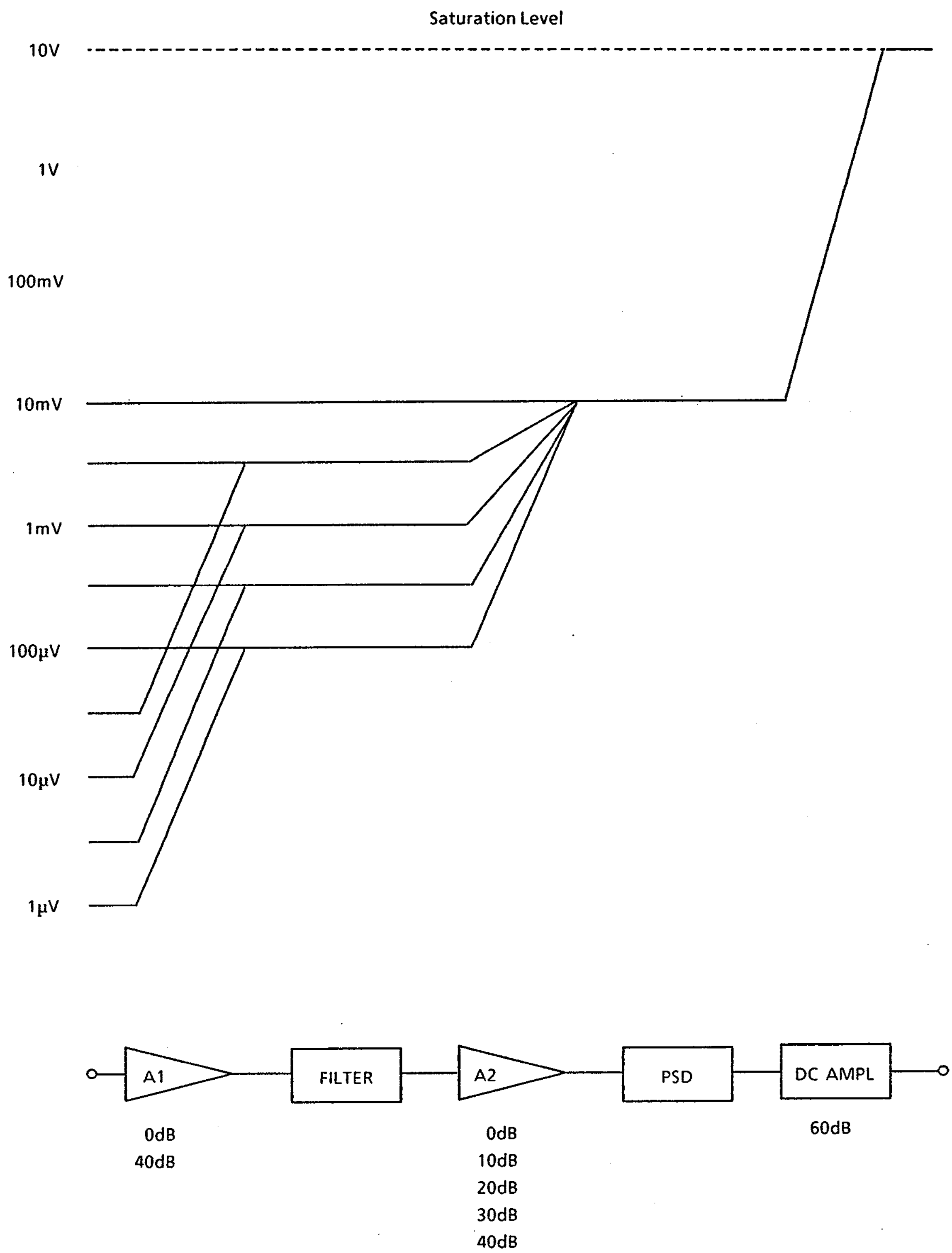


Fig.4−4(a) Level Diagram at Dynamic Reserve H (5610A)

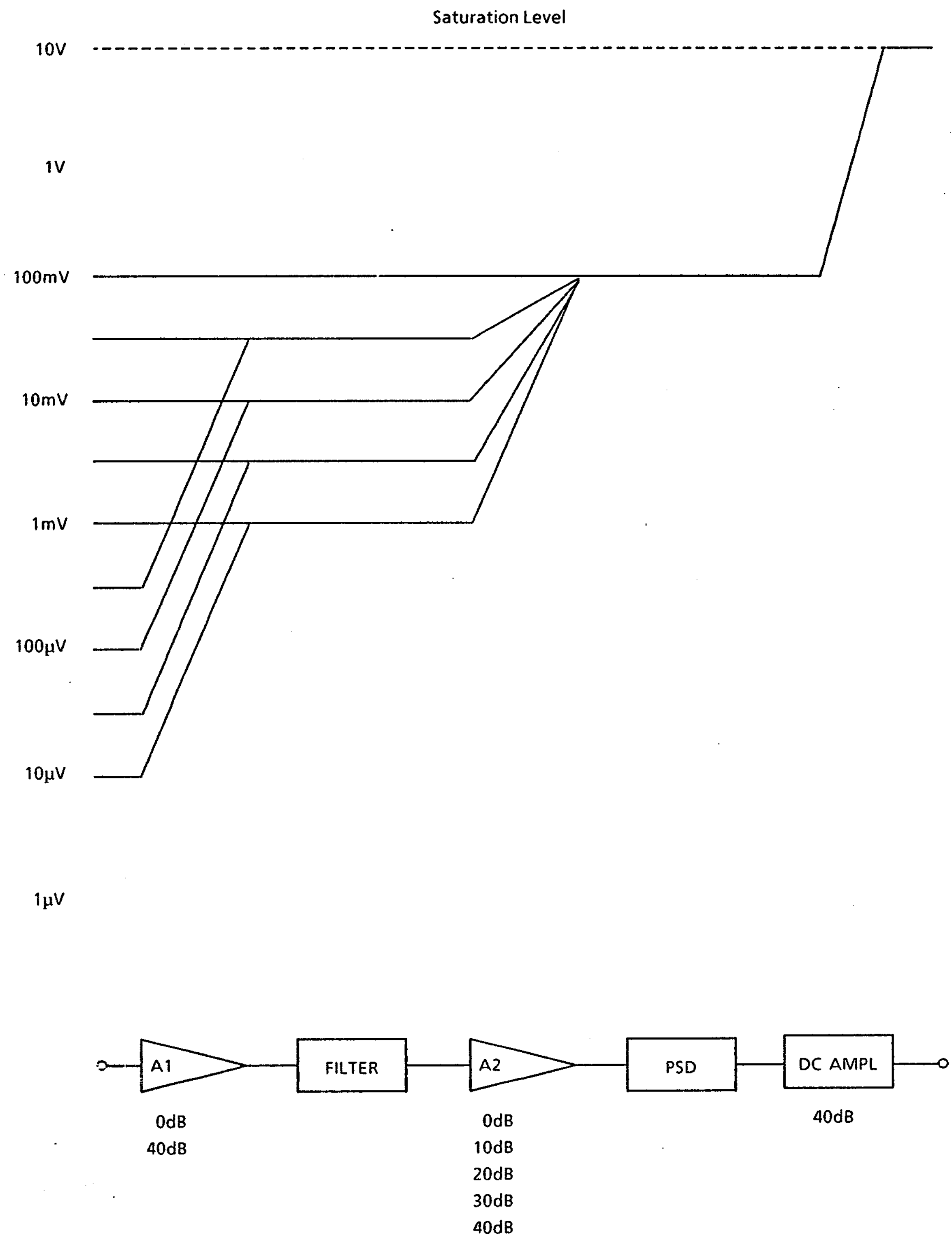


Fig.4-4(b) Level Diagram at Dynamic Reserve M

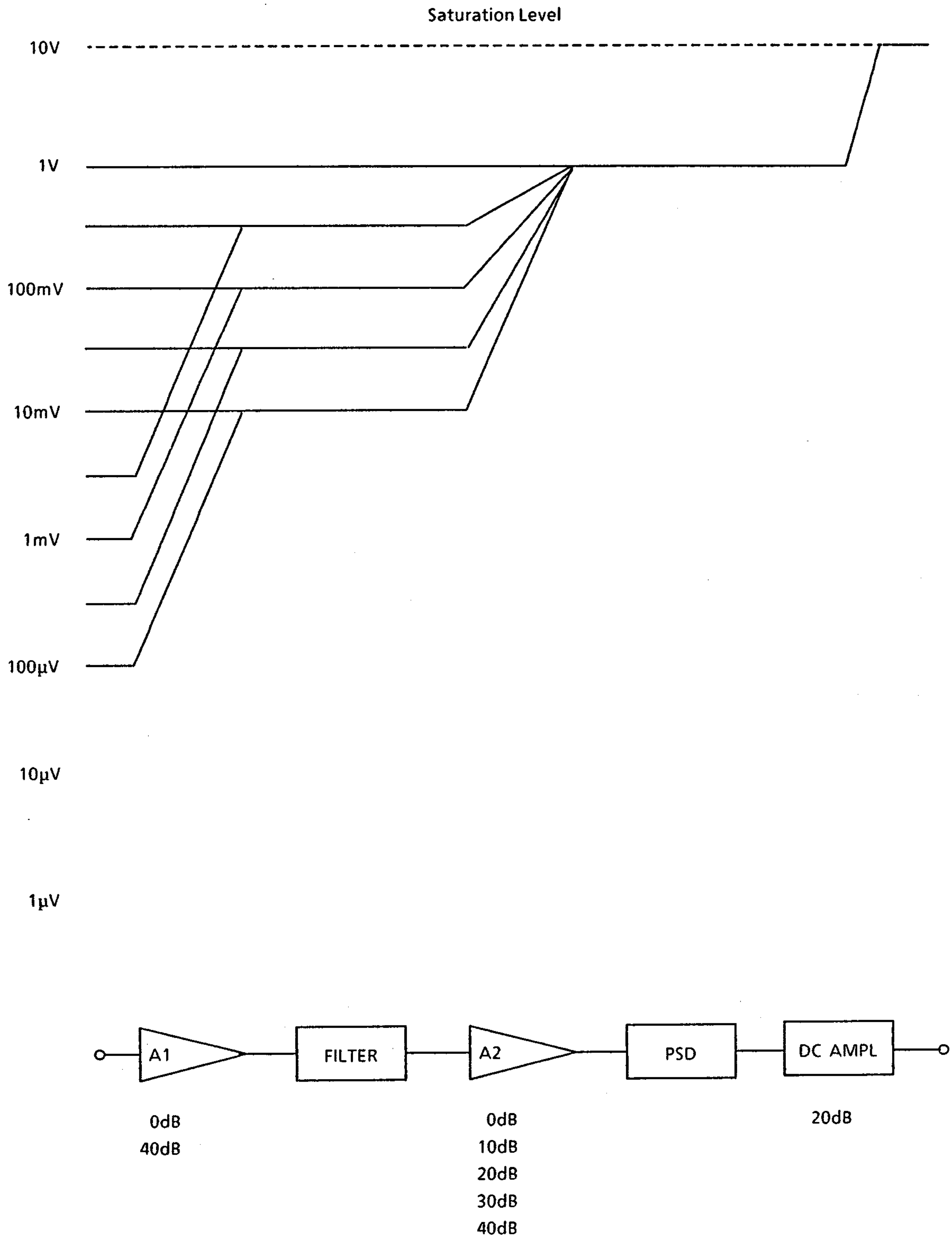


Fig.4−4(c) Level Diagram at Dynamic Reserve L

5 MAINTENANCE

5.1 Introduction

To maintain the 5610B/A in optimum operating condition, proper maintenance is required. This includes the following types of maintenance.

- Operational Inspection
  Check that the instrument is operating properly and meets its published specifications.
- Adjustment and Calibration
  Adjustment and Calibration If the instrument is not satisfying its specifications, perform the appropriate adjustment or calibration to restore its original performance.
- Troubleshooting
  If the above steps still do not correct the trouble, troubleshoot the 5610B/A to determine the cause of failure.
- Repair

The following measuring instruments are required in performing operational inspection, adjustments and calibration.

Oscilloscope	Bandwidth	: 10MHz or greater
Oscillator	Oscillation frequency	: 0.5Hz to 200kHz
	Output voltage	: 1Vrms or greater when terminated
	Output impedance	: 75Ω (50Ω)
Attenuator	Impedance	: 75Ω (50Ω)
	Attenuation	: 0 to 120dB in 1dB steps
	ttenuation accuracy	: ±0.05dB
RMS type AC Voltmeter	Accuracy	: ±0.1% or better
	Frequency response	: 200kHz or greater
DC Voltmeter	Accuracy	: ±0.1% or better
Frequency counter	Accuracy	: 1×10^{-6} or better
Distortion meter	0.1% fullscale	
Terminator	75Ω (50Ω) ±0.1%	
DC Standard voltage generator	0 to ±10V ±0.1%	
Personal computer	Must be equipped with GP-IB and RS-232C interface	

5.2 Power On

The 5610B/A goes through a memory check procedure when power is first applied and, if no abnormality is detected, parameters are automatically set from the battery backed up memory, and the measuring operation starts.

If the memory check reveals an error, the following error messages will appear.

BACK UP MEMORY ERROR! PLEASE PRESS ANY KEY : Memory back up has failed
ROM ERROR : Error has occurred on ROM
RAM ERROR : error has occurred on RAM

When ROM ERROR! or RAM ERROR! is displayed, turn off the power switch and contact us or our sales representative.

5.3 Memory Backup Battery

The nickel cadmium battery used for memory backup is trickle charged whenever the unit is powered on.

The memory backup capacity on a fully charged battery is normally approximately 60days, although this will vary depending upon ambient temperature and differences between individual batteries.

Approximately 100 hours of charging operation is required to fully charge discharged batteries. After this, the fully charged condition will be maintained if the instrument is operated for 20hours or more each week. Continuous power supplying does not risk overcharging the battery.

If the battery deteriorates, the backup capacity will drop. If it drops significantly, have the battery replaced by your sales representative (this will be performed at a charge).

Battery life is greatly influenced by operating conditions (e.g., charging conditions, ambient temperature and humidity), so that it cannot be strictly predicted. However, if the fully charged condition is maintained, about three to five years in a reasonable expectation of battery life.

If the instrument is stored in the unused condition for six months or longer, the battery life may be greatly shortened. For this reason, it is recommended that the instrument be powered on occasionally.

5.4 Operating Inspection

5.4.1 Checking prior to operating inspection

- Is the line voltage within the rated value?
- Is ambient temperature within the range of 18° to 28 °C
- Is ambient relative humidity within the range of 20% to 70% RH

5.4.2 BASIC FUNCTION Check

- Is the analysis frequency range properly set?
- Is the reference signal mode properly set?
- (Remember that if the INT OSC optional is not installed, the INT modes may not be selected.)
- Is sensitivity properly set?
- Is the time constant properly set?
- Is the time constant rolloff properly set?
- Is the dynamic reserve properly set?

5.4.3 FILTER Check

- Is the cutoff frequency properly set?
- Is the mode properly set?

5.4.4 AUTO FUNCTION Check

- Is AUTO SET operating properly?
- Is PHASE SET operating properly?
- Is AUTO RANGE operating properly? (Pay particular care with ARL and dynamic reserve.)
- Is AUTO TUNE operating properly? (The reference frequency should be in the range 0.5Hz to 200kHz.)

5.4.5 KEY Function Check

- Does the SHIFT key operate properly?
- Do the KEY LOCK and KEY LOCK OFF operate properly?

5.4.6 DISPLAY Function Check

- If DATA1 is switched properly.
- If DATA2 is switched properly.
- If DATA2 is switched properly.

5.4.7 NORMALIZE Function Check

- Is the NORMALIZE MODE switched properly?
- Can reference numerical values be set properly?

5.4.8 ADJUST Function Check

- Does the reference signal phase setting operate properly?
- Is the offset setting operating properly?

5.4.9 INT OSC (Optional) Check

- Is the oscillator frequency properly set?
- Is the output amplitude value properly set?

5.4.10 Digital data OUTPUT Check

- Do the data output START and STOP signals operate properly?
- Is the type of output data selected properly?

5.4.11 RATIO Function Check

- Can the RATIO K value be set properly?

5.4.12 SPECIAL FUNCTION Check

- Can the DA output data be set properly?
- Can the measurement processing interval be properly set?
- Can the digital data output interval be properly set?
- Does the CAL function operate properly?
- Does the PSD ZERO function operate properly?
- Does the BEEP on/off setting operate properly?
- Does the lamp on/off setting operate properly?
- Does the auto-range sensitivity limit control (LIMIT) setting operate properly?
- Does the INITIALIZE function operate properly?

5.4.13 AVERAGE Function Check

- Can the number of averages (times) be set properly?
- Can the averaging MODE be set properly?

5.4.14 RS-232C Check

- Can the RS-232C baud rate and parameters be properly set?
- Is the RS-232C interface operating properly?

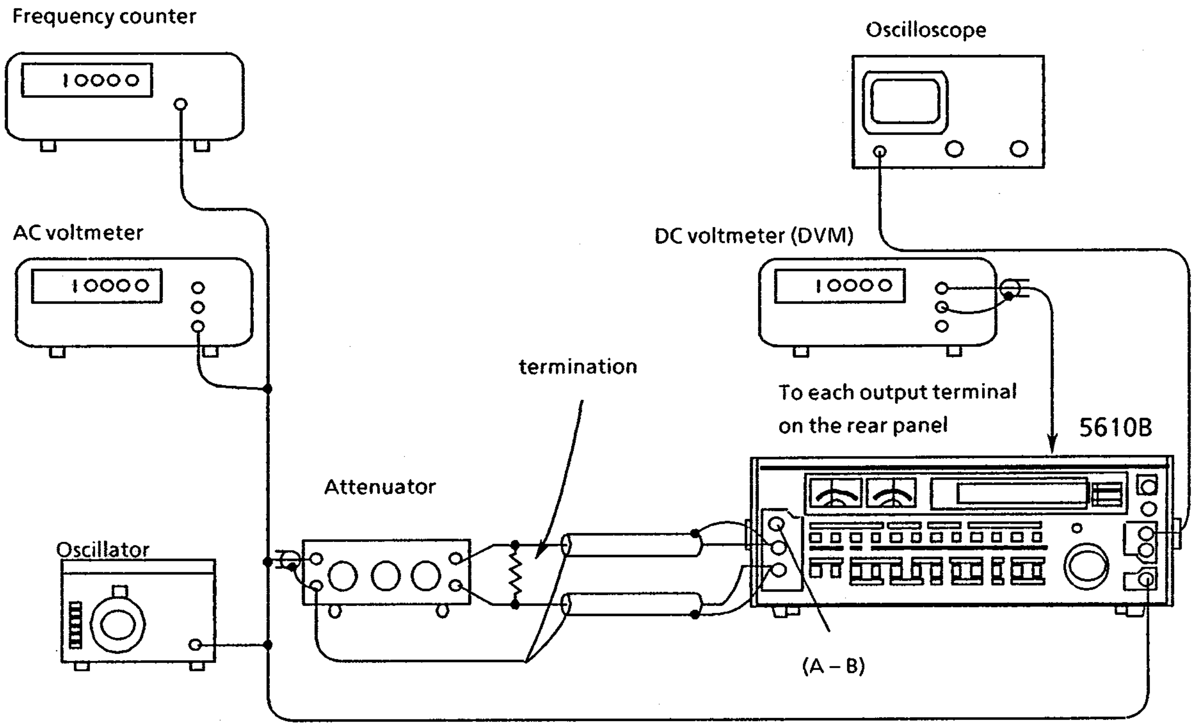
5.4.15 GP-IB Check

- Can the GP-IB address (ADR) and parameters be properly set?
- Does the GP-IB return to local (LOCAL) key operate properly?

5.5 Performance Check

5.5.1 Preparations Before Check

- Is the line voltage within the rated value?
- Is ambient temperature within the range of 18° to 28 °C?
- Is the ambient relative humidity within the range of 20% to 70% RH?
- The internal temperature in the enclosure stablizes after five minutes when the fan is on and after 1hour when off. Assure sufficient warming up time and conduct performance test.
- Perform a phase detector DC offset calibration by following the procedure of Section 3.4.13 (2).



Note : Separate the wirings of input signal and reference signal systems as far as possible.

Fig.5 – 1 Basic Connection diagram

5.5.2 Sensitivity (Accuracy Between Ranges) Check

Connect the measuring instruments as shown in Fig.5-1.

Set the oscillator output voltage to 1Vrms and the oscillation frequency to 1kHz.

Set up the 5610B/A controls as follows.

INITIALIZE		
F RANGE	:	1kHz to 12kHz
REF MODE	:	EXT 1F
T CONST	:	100ms, 12dB/oct
FILTER MODE	:	THRU

Vary the attenuator over the range 0 to 120dB and read the indication at each fullscale value. The sensitivity specification (accuracy between ranges) should be within ±2%.

5.5.3 Amplitude vs. Frequency Characteristics Check

Connect the 5610B/A and other measuring instruments and make settings as described in Section 5.5.2.

Vary the oscillator frequency and 5610B/A F RANGE from 0.5Hz through 20kHz and read the display, while adjusting phase. This should be ±3dB with respect to 1kHz as a reference.

5.5.4 Phase vs. Frequency Characteristics Check

Make the same connection and setting for each measurement device as for 5.5.2. Read the phase indication on the display.

The specifications for phase are as follows :

±1° (TYP) 0.5Hz to 10kHz

±5° (TYP) 10Hz to 100kHz

5.5.5 CMRR vs. Frequency Characteristics Check

Connect the measuring instruments and establish settings as described in Section 5.5.2.

Set the attenuator to 0dB and verify that the 5610B/A indication is 1V.

Next, disconnect the line from input B and connect the A and B inputs together. By making this connection, the common-mode signal is 1V with the difference signal being 0. Gradually increase the sensitivity and read the indication of amplitude for ranges from 1μV through 30μV. When the amplitude reading is 1μV, it will be CMRR 120dB. Use the same operation to make a similar check at other frequencies.

Rating should be 1μV range 110dB or more in the range of 100Hz to 1kHz.

5.5.6 Filter Characteristics Check

Connect measuring instruments and establish settings as described in Section 5.5.2.

Set the oscillator fequency to 1kHz and the attenuator to 0dB.

Verify that the 5610B/A amplitude display value is 1V and change the filter mode from THRU to the BPF mode, setting the Q to 5 (BPF 5 is displayed). Adjust the filter center frequency so that the amplitude is maximum. For correct adjustment of the filter center frequency, set so that the highest value is obtained for X display and zero for Y display.

Ratings are as follows.

Within ±1% (100Hz to 10kHz)

Within ±5% (0.5Hz to 100Hz, 10kHz to 120kHz)

Passband gain error

Q=1, 5

Within ±0.2dB (100Hz to 10kHz)

Within ±1dB (0.5Hz to 100Hz, 10kHz to 120kHz)

Q=30

Within ±1dB (100Hz to 10kHz)

Within ±3dB (0.5Hz to 100Hz, 10kHz to 120kHz)

5.5.7 External DC Input and Ratio Measurement DC Input Measurement Accuracy Check

Apply the output of a DC reference voltage generator to the rear panel EXT DC/RATIO connector.

Set up DATA3/SETTING to indicate ED and vary the voltage value over the range 0 through ±10, reading the displayed value over this range.

The rating calls for a reading of within ±(1%+1 digit) of fullscale.

5.5.8 Internal Oscillator (Optional) Check

Connect a frequency counter and AC voltmeter to the front panel OSC connector.

Verify that the internal oscillator has been installed in the 5610B/A and select the reference signal mode INT 1F.

Set the internal oscillator output amplitude to 2.00Vrms and vary the oscillation frequency over the range 10Hz to 100kHz, reading the oscillation frequency and output amplitude from the frequency counter and AC voltmeter, respectively. Next, set the oscillation frequency to 1kHz and vary the output amplitude value over the range 0 to 2.55Vrms, reading the output amplitude value from the AC voltmeter.

The specifications are as follows.

Oscillation frequency accuracy ±1%

Output amplitude accuracy ±1% of fullscale (1kHz, 2.55Vrms range)

5.6 Adjustment and Calibration

5.6.1 Necessary Checks before Adjustment and Calibration

This section describes how to make adjustments or calibration using half-fixed resistor, when the rated value cannot be obtained in 5.5. Never touch controls other than specified one. See Fig.5−2 for removing the top and side panels and Fig.5−3 for the locations of each resistor.

Do the same checking as for 5.5.1 before making adjustments.

5.6.2 Sensitivity Adjustment

The following resistors are used for sensitivity adjustment :

PB1 · RV2 : To adjust again when 40dB is selected as a preamplifier gain.
PB2 · PV1 : To adjust again when switching 0dB and 10dB gains on mid-amplifier.
PB3 · R204 : To adjust COS PSD gain.
PB4 · R204 : To adjust SIN PSD gain.

Connect measuring instruments as shown in Fig.5−1.

Adjust the output voltage of the oscillator to 1Vrms and set the oscillator requency to 1kHz and the attenuator to 10dB.

Set up the 5610B/A as follows.

INITIALIZE
F RANGE : 1k to 12kHz
REF MODE : EXT 1F
SENSITIVITY : 316.2 mV
T CONST : 100ms, 12dB/oct
FILTER MODE : THRU
DATA DISPLAY : X

Adjust the reference signal phase so that X : A COS Φ will indicate an input signal amplitude. Adjust PB3s R204 so that measured results of X : A COS Φ will be 316.2mV. A value of Y : A sin ϕ by shifting 90° the ADJUST PHASE. Set the ADJUST PHASE to 0° the SENSITIVITY to 1V, and the attenuator to 0dB. Adjust RV1 on PB2 so that the measured result will be 1.000V. Set the attenuator to 50dB and SENSITIVITY to 3.162mVrms (leaving the dynamic reserve set at L). Adjust RV2 on PB1 so that the X value is 3.162mVrms.

5.6.3 Phase Adjustment

The following controls are used to adjut phase.

PB6 R201 : To adjust the DC offset of the comparator provided to convert the input reference signal into square wave.

PB6 R205 : To adjust phase offset.

PB6 R204 : To adjust phase setting continuity.

PB6 R202 : To adjust high band frequency phase offset compensation.

Connect the measuring instruments as shown in Fig.5-1.

Set the output voltage of the oscillator to 1Vrms, the oscillator frequency to 1kHz and the attenuator to 0dB.

Set up the 5610B/A as follows.

INITIALIZE

REF MODE : EXT 1F

SENSITIVITY : 1V

TO CONST : 100ms, 12dB/oct

FILTER MODE : THRU

DATA 2 : Y

Make sure that an input signal value is 1V and set the reference signal offset phase to 0°. Adjust R205 so that Y : SIN Φ becomes zero. Vary only the reference signal from 1V to 100mV and adjust R201 so that Y : A SIN Φ is kept zero. Repeat the adjustment of RV205 and R201 two or three times. Again, set the reference signal to 1V and the reference signal offset phase of 0° to +0.01°. Adjust R204 so that Y : A SIN Φ value does not change.

Set the analysis frequency range to 10kHz to 200kHz and the reference signal offset phase to 0°. Gradually sweep oscillator oscillation frequencies from 10kHz to 200kHz. Adjust R202 so that a deviation of Y : A SIN Φ value from zero is minimized.

5.6.4 Internal Oscillator (Optional) Adjustment

The controls used to make the internal oscillator adjustment are as follows.

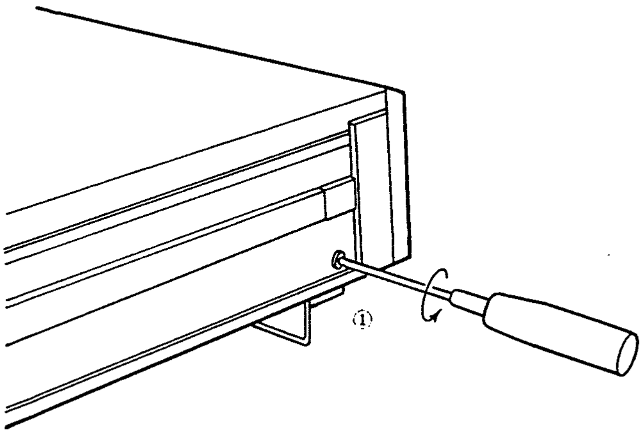
RV1 on PB5 : Output DC offset adjustment

RV2 on PB5 : Output amplitude value adjustment

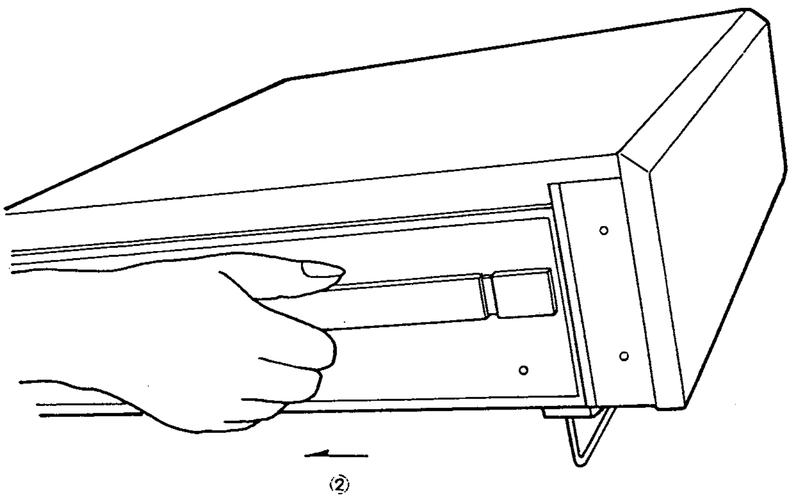
Connect the 5610B/A OSC output connector to a DC voltmeter and AC voltmeter. Select the INTF reference signal mode.

Set the INT OSC FREQ to 1kHz and set LEVEL to 0.00V. Adjust RV1 on PB5 so that the reading on the DC voltmeter is ±1mV.

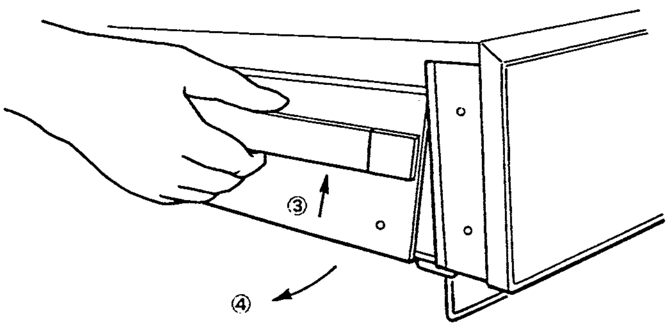
Next, set LEVEL to 2.00Vrms and adjust RV2 on PB5 so that the reading on the AC voltmeter is 2.00Vrms.



① Unscrew front and rear screws on the side cover

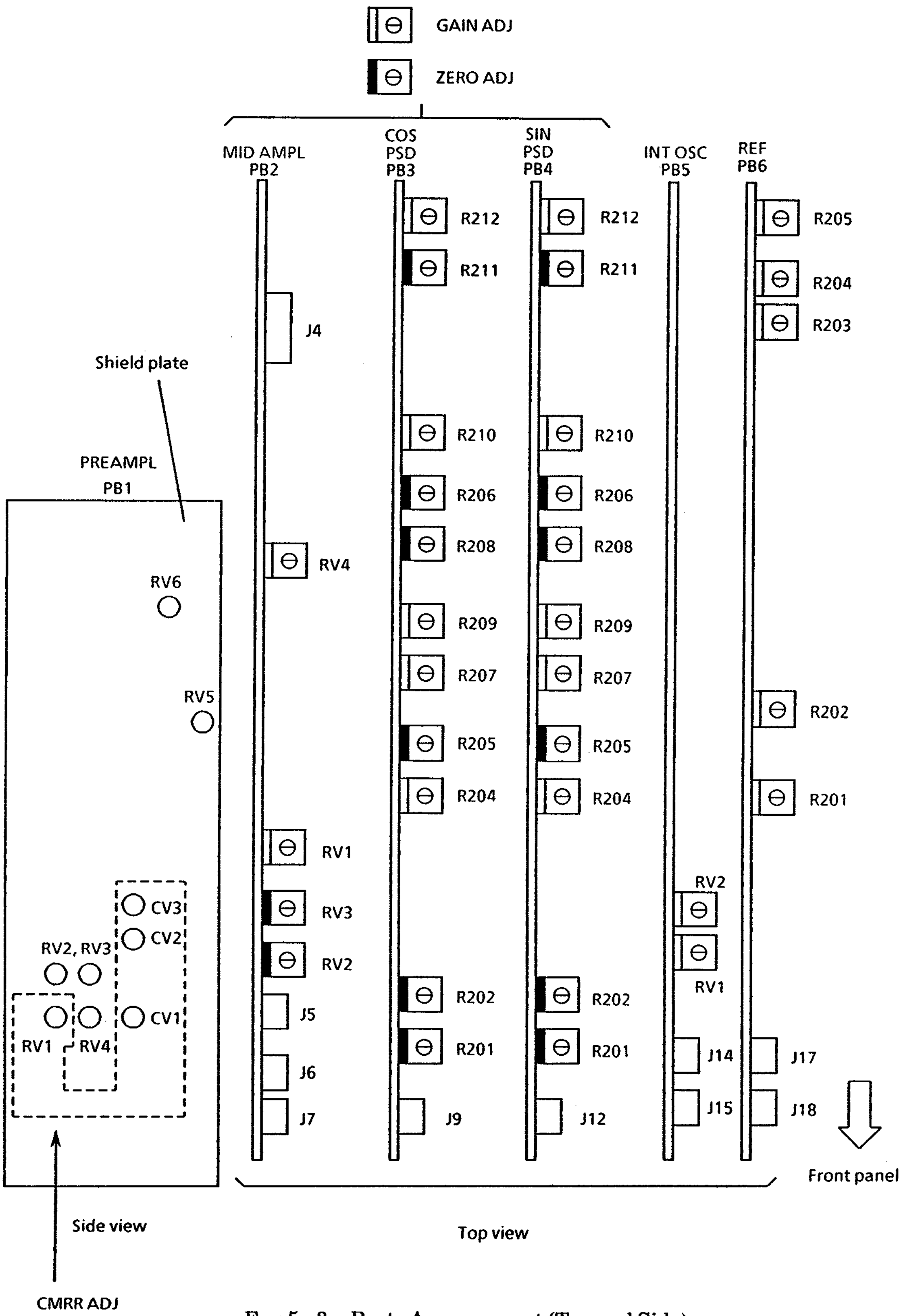


② Hold the handle of the cover and move back about 5mm



③ Move the side cover upward and remove it from the bottom
④ Open the lower part of the side cover and remove it from the top.

Fig.5−2 Removing Side Covers



Feg.5-3 Parts Arrangement (Top and Side)

6. TYPICAL DATA

6.1 Notes on Typical Data

Typical data has been provided with respect to the performance of the 5610B/A. One of the major quality control efforts being made at NF Electronics is in the area of minimizing the variation with respect to such typ performance data.

The data provided represents the values which would be obtained in averaging the performance of a number of instruments and, therefore, while the customers instrument may not be exactly the same as indicated in this data, we feel confident that as a result of a strict testing program, every instrument meets its required specifications at the time of shipment.

6.2 Typical Data Curves

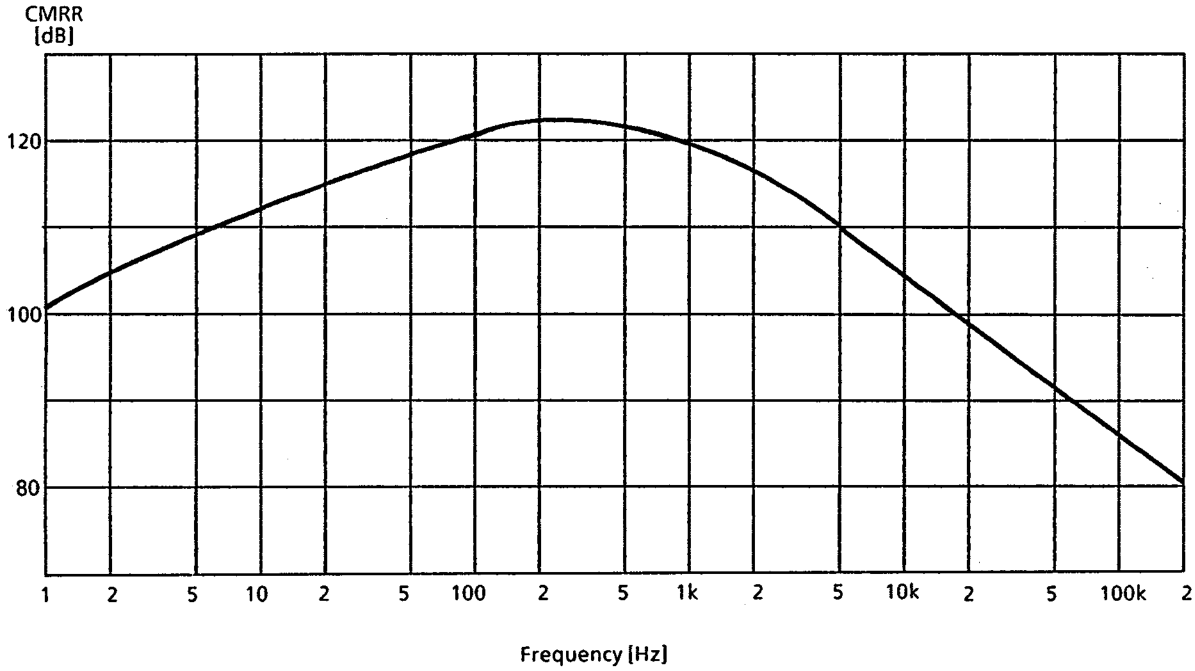


Fig.6－1　CMRR vs. Frequency Characteristics

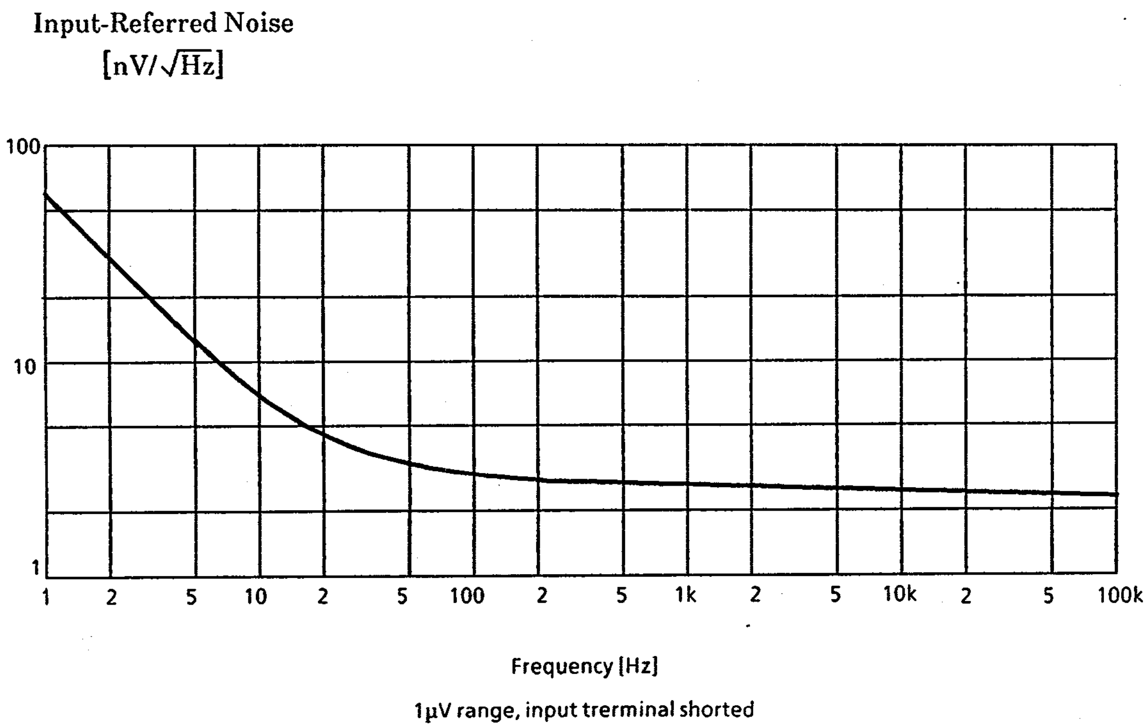


Fig.6－2　Input-Referred Noise vs. Frequency Characteristics

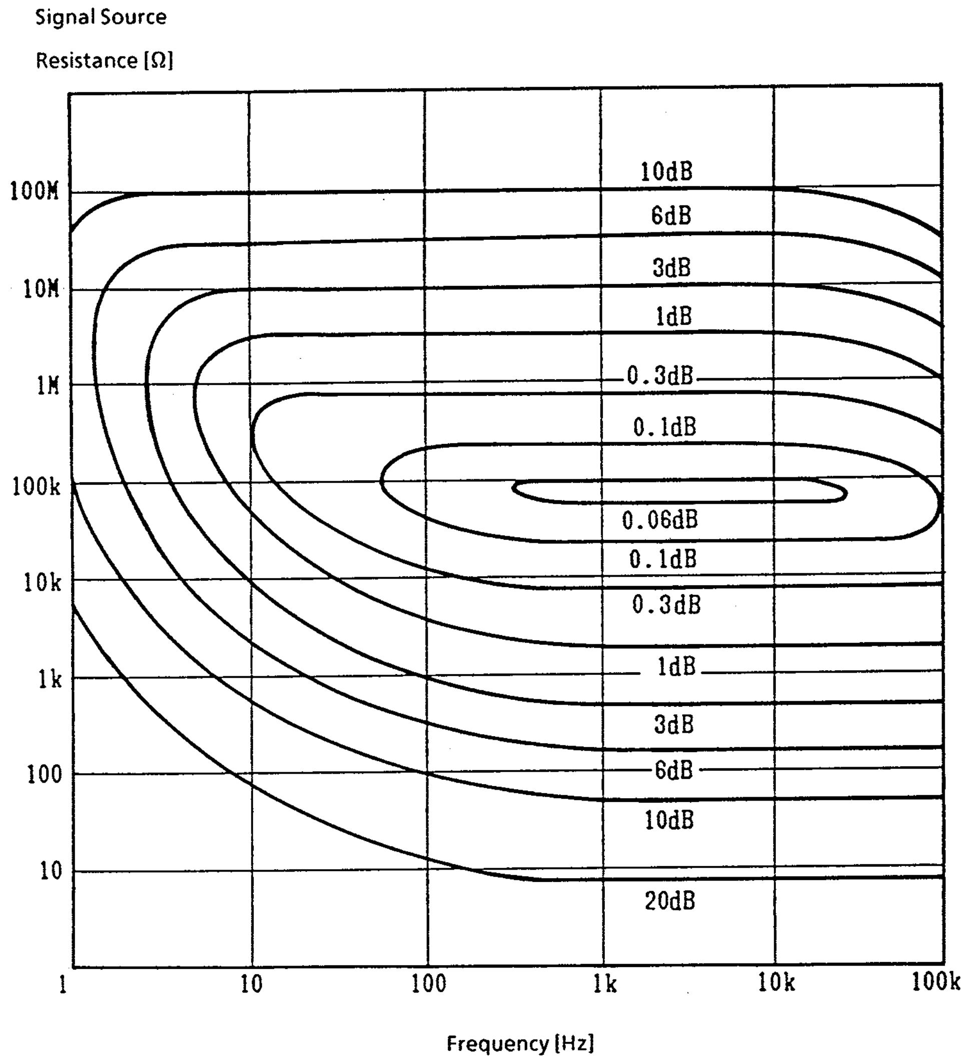


Fig.6-3 Noise Figure Contours (at a temperature of 290k)

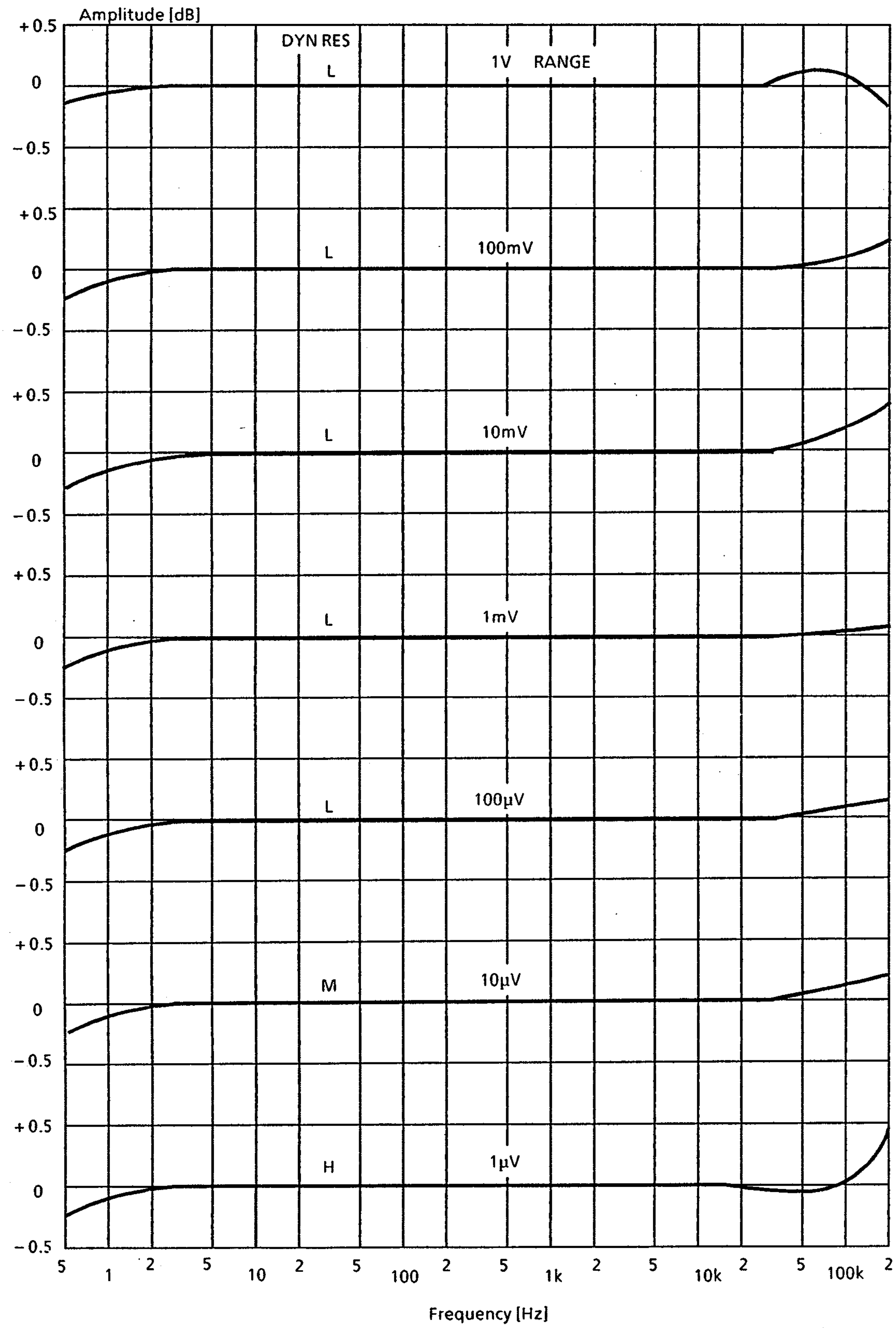


Fig.6-4 Amplitude vs. Frequency Characteristics

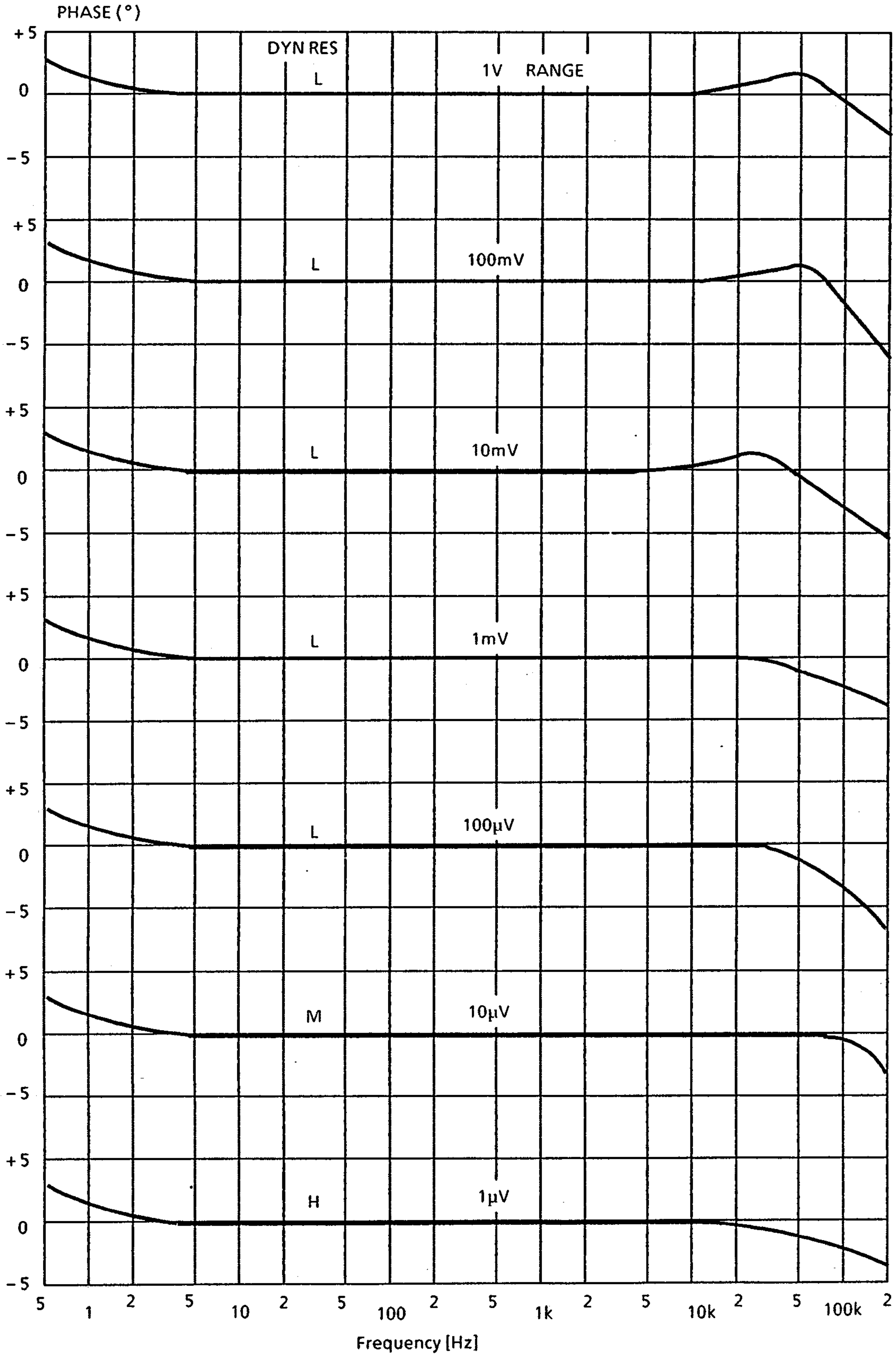
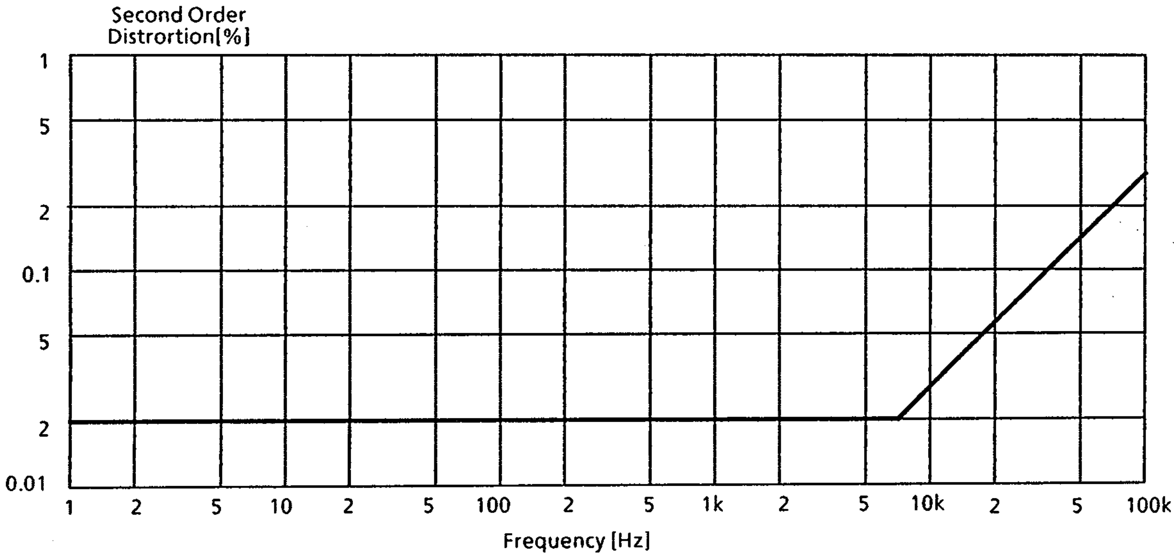


Fig.6-5 Phase Error vs. Frequency Characteristics



DYN RES	:	M
SENSITIVITY	:	10mV
REF MODE	:	EXT 2F
FILTER	:	THRU
Signal input Frequency	:	F
Signal input Voltage	:	1Vrms

Fig.6−6 Second Order Distortion vs. Frequency Characteristics

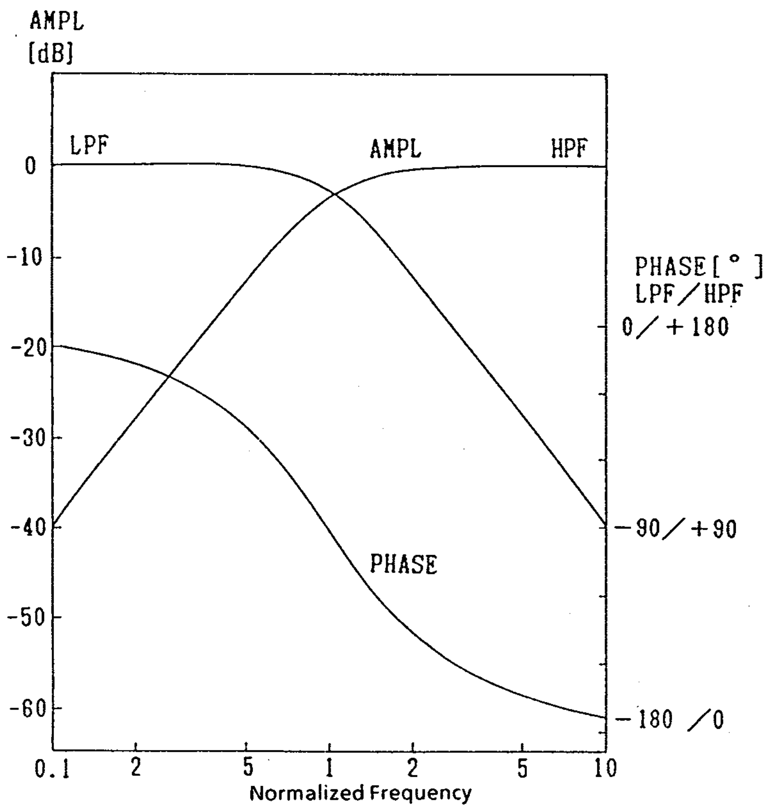


Fig.6−7 Signal System Filter HPF/LPF Characteristics

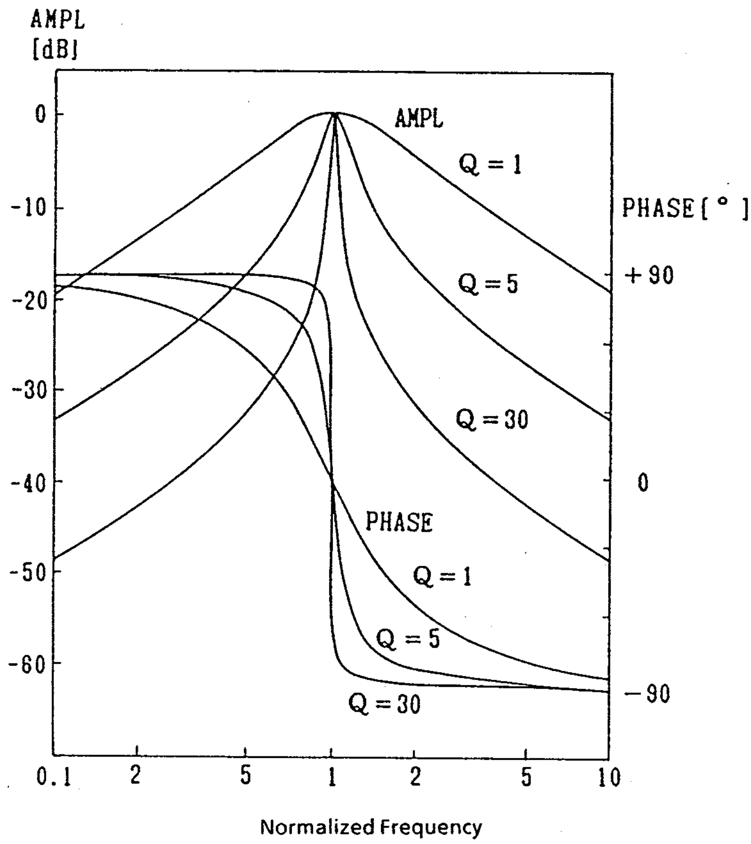


Fig.6−8 Signal System Filter BPF (Normal type) Characteristics

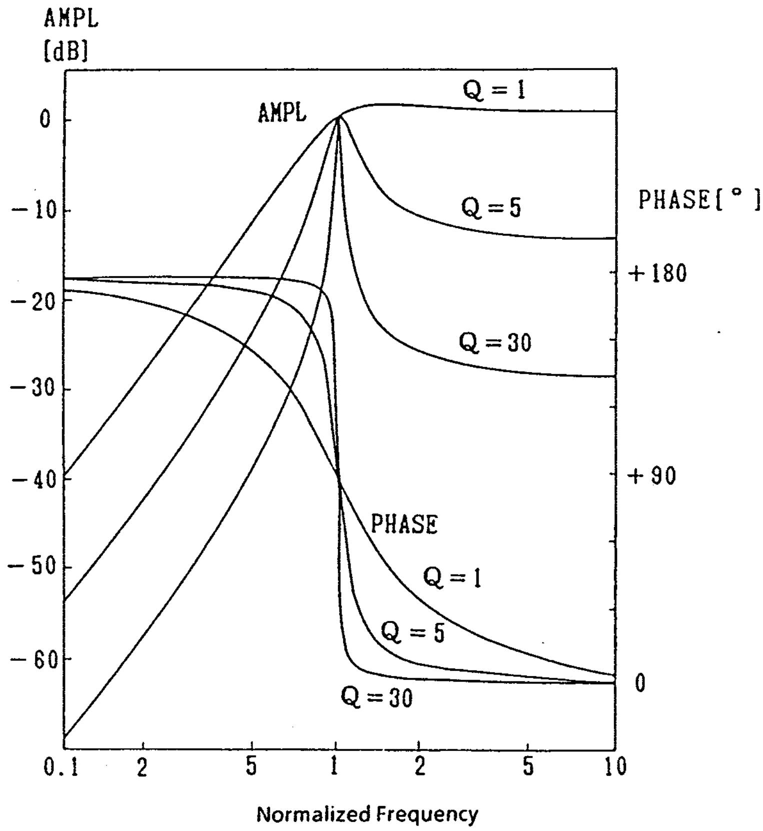


Fig.6−9 Signal System Filter BPF (HPF type) Characteristics

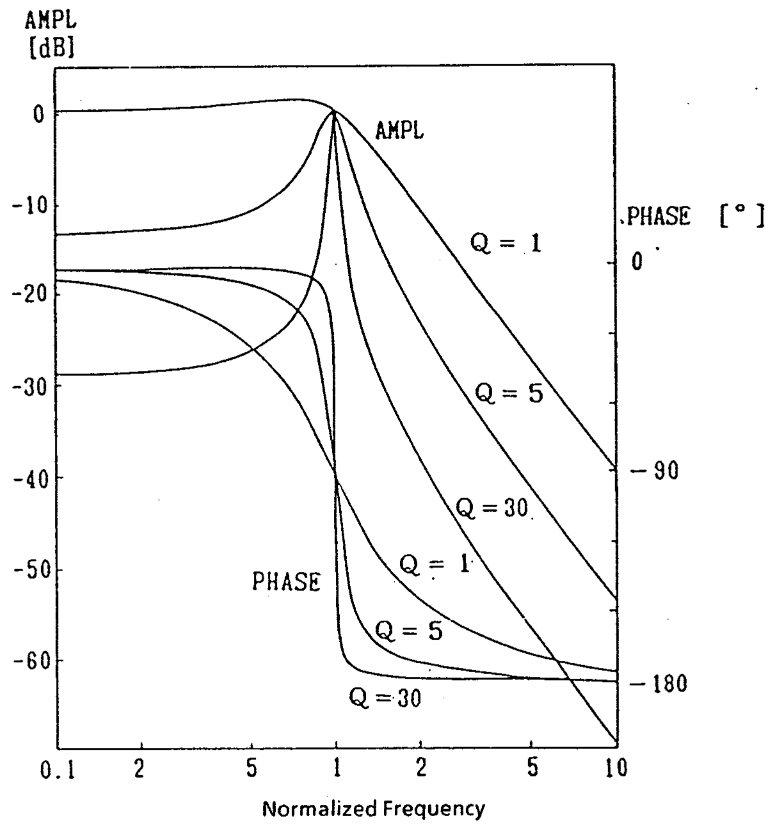


Fig.6−10 Signal System Filter BPF (HPF type) Characteristics

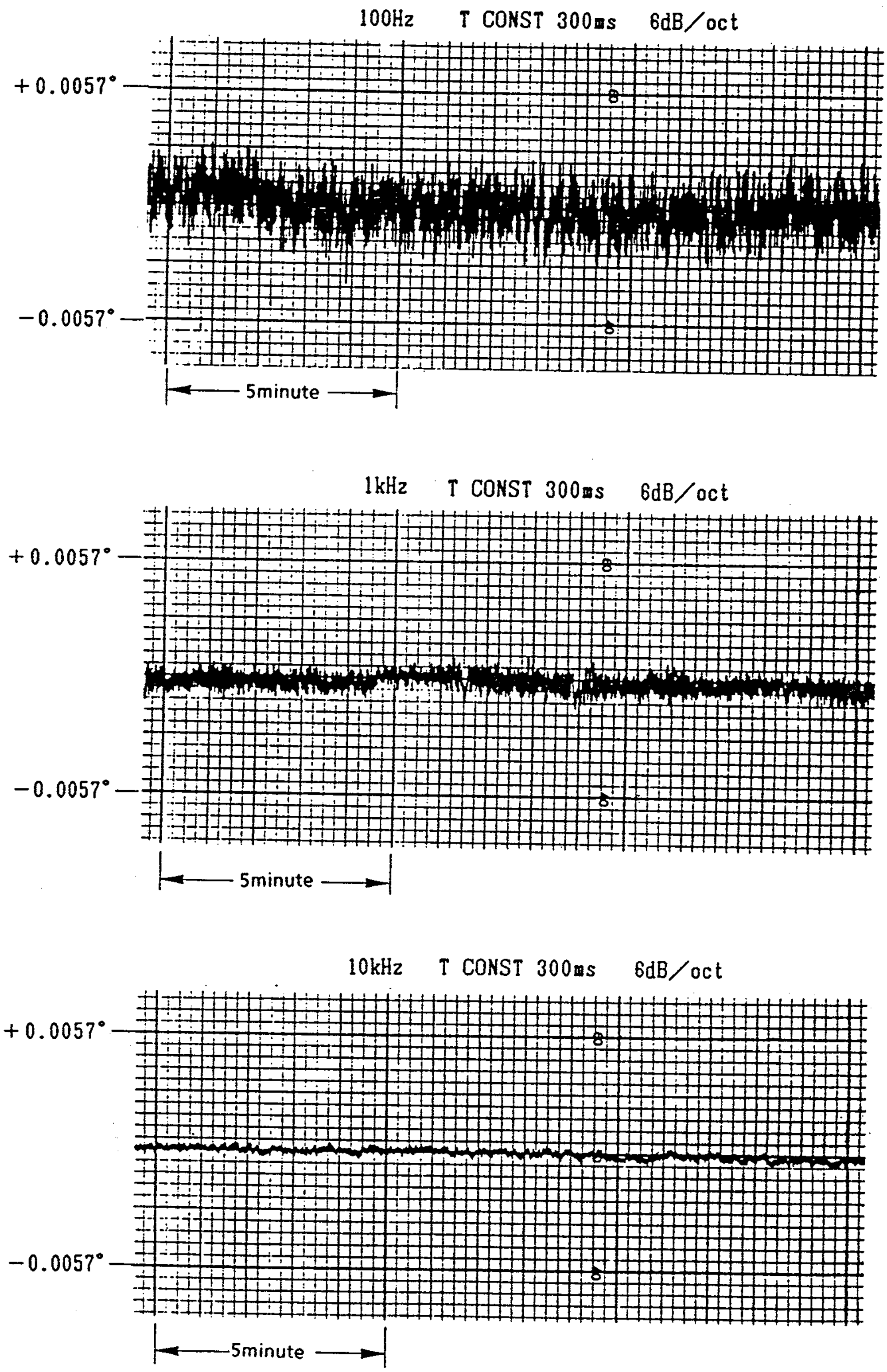


Fig.6−11 Phase Noise Characteristics

※ Response of internal oscillator when the reference signal is mode to fluctuate suddenly

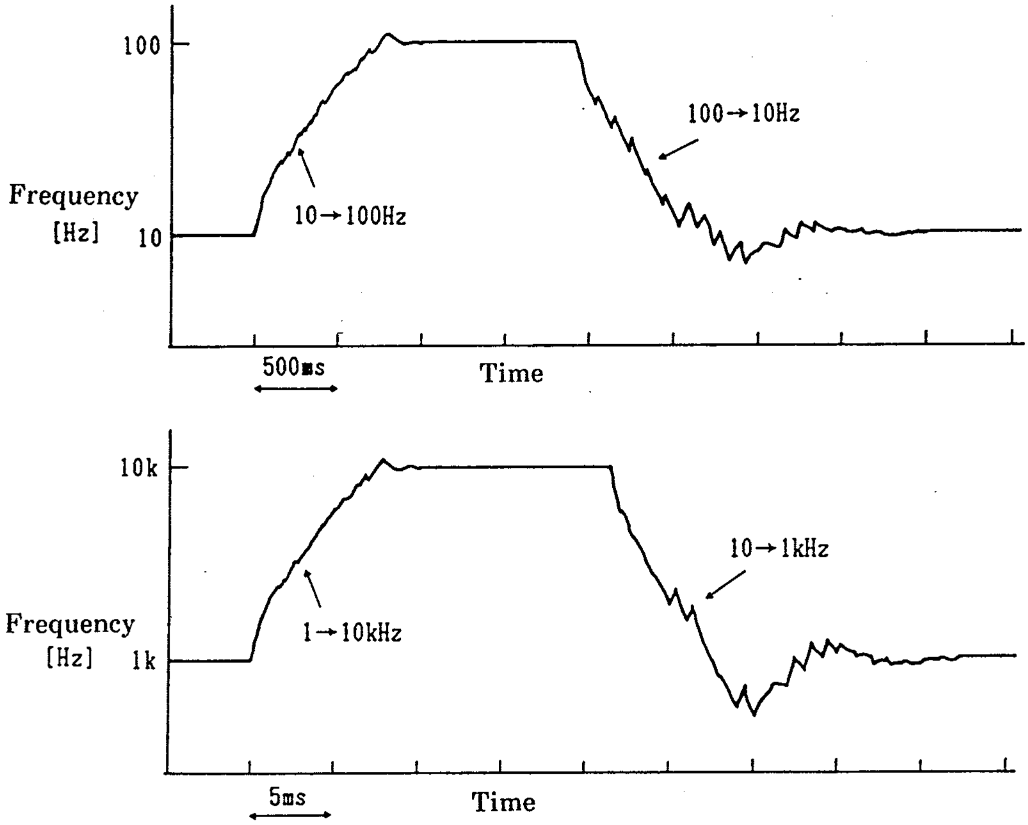


Fig.6－12　Reference Signal System Locking Time ※

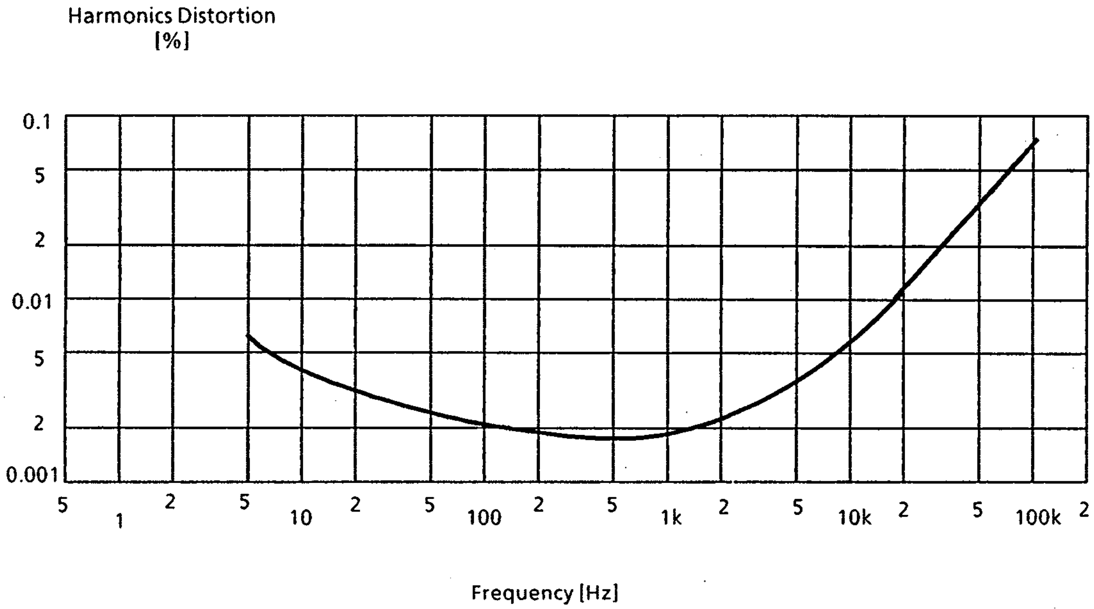


Fig.6-13 Internal Oscillator (Optional) Harmonics Distortion vs. Frequency Characteristics

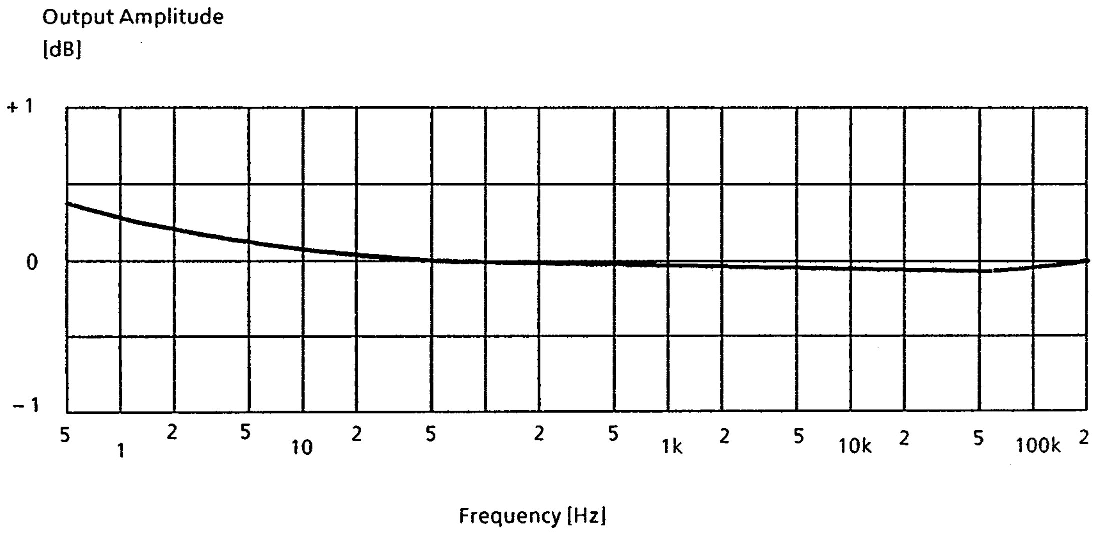


Fig.6-14 Internal Oscillator (Optional) Output Amplitude vs. Frequency Characteristic

7. GP-IB INTERFACE

7.1 Introduction

7.1.1 Outline

The GP-IB Interface is a general-purpose interface bus system recognized by the IEEE (Institute of Electrical and Electronics Engineers) in 1975 in the U. S. and is a method of standardizing the data input / output transfer between measuring instruments and peripherals including remote control functions.

By building each controller and peripheral device into an interface conforming to this standard, it is possible to establish complete hardware compatibility at the interface connectors of each device.

Up to 15 devices may be connected to a single interface bus and data transfer is performed by three handshake lines,enabling reliable data transfer between data senders and receivers having differing data transfer rates.

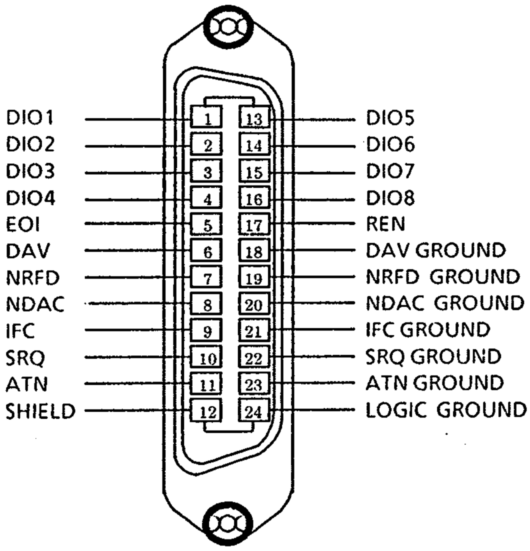
Various names have been applied to the GP-IB, including IEEE-IB, IEEE-488 bus, HP-IB, standard interface bus and byte serial bus. The official name, however, is the " IEEE Std 488-1978 : IEEE Standard Digital Interface for Programmable Instrumentation. "

It has virtually the same specifications as the IEC bus, although the connector differs,making it usable with this bus by means of connector adaptors.

7.1.2 Major GP-IB Specifications

(1)	Overall cable length	20m max.
(2)	Cable lengths between devices	4m max.
(3)	Number of devices connectable (including a controller)	15 max.
(4)	Transfer method	3 Lines handshake
(5)	Transfer rate	1M bytes / s (max.)
(6)	Data transfer	8 Bits parallel
(7)	Signal lines ● Data bus	8 Lines
	● Control bus (including DAV, NRFD, and NDAC handshake lines and ATN, REN, IFC, SRQ and EOI control lines)	8 Lines
	● Signal / system grounds	8 Lines
(8)	Signal logic	Negative
	● True (low-level)	0.8V max.
	● False (high-level)	2.0V min

(9) Interface Connector



IEEE-488

Fig.7-1 Interface Connector

7.1.3 Bus Line Signals and Operations

The GP-IB bus line consists of 24 lines, including 8 data lines, 8 control lines and 8 signal / system ground lines.

(1) Data Bus (DIO1 to 8)

These are the data input/output lines which are also used to input and output both address and command information, the type of data present on these lines being distinguishable by means of the ATN line. DIO1 is the least significant bit (LSB).

(2) Handshake Bus (DAV, NRFD, NDAC)

These three lines are handshake lines used to ensure reliable data transfer.

- DAV (DAta Valid)

  This line indicates that the data on the DIO lines sent from a talker or the controller are valid.

- NRFD (Not Ready For Data)

  This line indicates the condition of readiness of listeners to accept data on the DIO lines.

- NDAC (Not Data ACcepted)

  This line indicates the condition of acceptance of data by listeners.

(3) Control Bus (ATN, REN, IFC, SRQ, EOI)

- ATN (ATteNtion)
  This line is an output line from the controller which indicates whether the signals on the DIO bus are data signals or commands.
- REN (Remote ENable)
  This output line from the controller switches devices between remote control and local control.
- IFC (InterFace Clear)
  This output line from the controller clears the interface of devices.
- SRQ (Service ReQuest)
  This control line is used to call the controller from a talker or a listener. The controller detects this signal and excutes a serial or parallel poll operation.
- EOI (End Or Identify)
  This is used to indicate the end of a multiple bytes transfer sequence or, in conjunction with ATN, to execute a parallel poll.

7.1.4 GP-IB Handshaking

GP-IB handshaking is performed by checking the status of all the listeners and inhibiting the next data transfer until all listeners have completed the reception of data, so that the slowest device on the bus can perform data transfer reliably. The handshaking operations are executed by the following status signals.

NRFD	=High level	All listeners are ready for accepting data.
DAV	=Low level	A talker is outputting valid data to the data bus.
NDAC	=High level	All listeners have completed data reception.

The handshaking timing diagram is shown below.

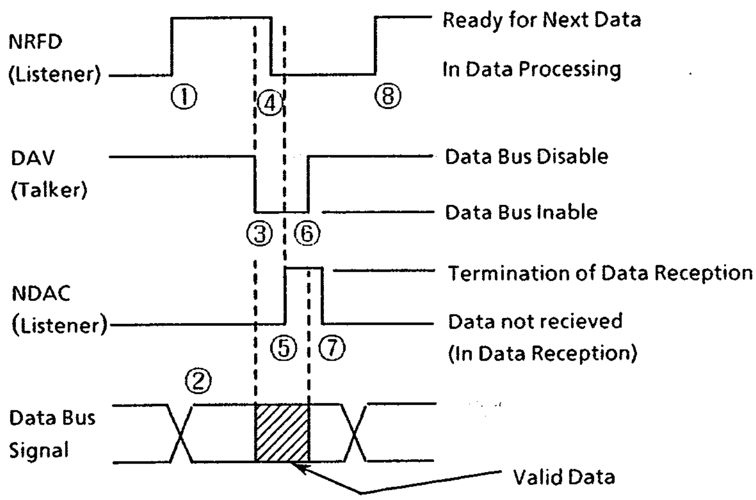


Fig. 7-2 Handshake Timing Diagram

① Indicates that all listeners are waiting for data.

② The talker outputs data to be sent to the data lines. May hay already occured.

③ The talker checks NRFD and if high, DAV is set to low to indicate to the listener that data is valid.

④ When the DAV changes to low level, the listener reads data and NRFD is set to low, indicating to the talker that data processing is in progress. Each listener sets NDAC to high at the completion of data input. The NDAC of the bus is the OR function of the NDACs from each listener.

⑤ When all listeners have completed receiving data, NDAC goes high (result of the OR output) indicating to the talker that data reception has been completed.

⑥ The talker sets DAV to high indicating to the listener that the data on the bus is not valid data.

⑦ The listener checks whether the DAV is high and sets NDAC to low, completing the handshake.

⑧ Indicates that all listeners have completed data processing and the next data is being waited for.

7.1.5 Data Transfer Example

The following is a data transfer example using the three-line handshake process.
In this example, the data "ABC" is sent, followed by the delimiter "CR/LF".

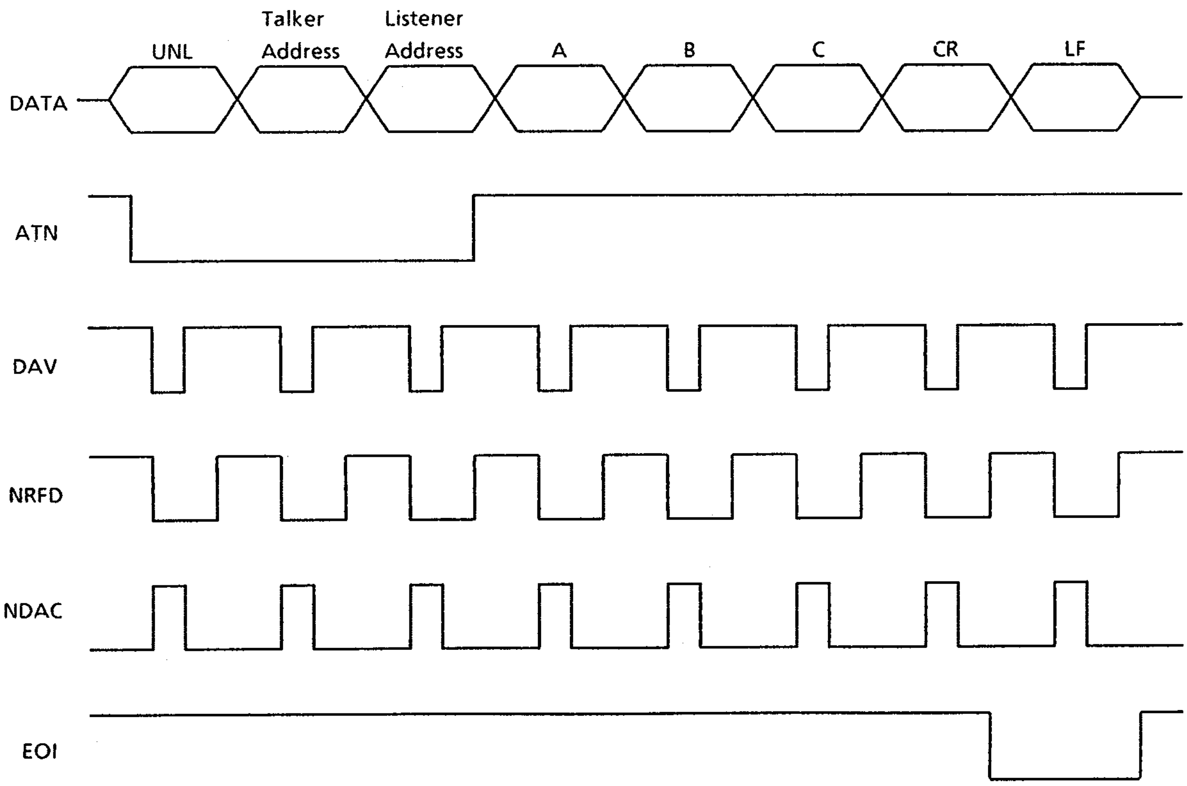


Fig.7-3 Data Transfer Example

7.1.6 Basic Talker Functions

- Only one talker may exist on the GP-IB at any time.
- When the controller ATN signal is high, data is sent to listeners.
- Source handshaking is performed automatically.
- A service request (SRQ) is sent to the controller.
- The talker function is enabled for both the local and remote modes.
- The talker function is canceled by any of the following.

  Whenever the talker address of an other device is received.

  Whenever the device is specified as a listener.

  Whenever untalk (UNT) is received.

  Whenever IFC is received.

7.1.7 Basic Listener Functions

- Two or more listeners may exist on the GP-IB at any time.
- When the controller ATN signal is high, data is received from a talker.
- Acceptor handshake is performed.
- The listener function is canceled by any of the following.

  Whenever the device is specified as a talker.

  Whenever unlisted (UNL) is received.

  Whenever IFC is received.

7.1.8 Basic Controller Functions

- Only one controller can be active on GP-IB.
- Sets the ATN signal to L to control the listner and talker specification and transmission of commands such as device clear.
- Outputs IFC and REN signals.

7.1.9 Multi-Line Interface Message

The multi-line interface message is the data output from the controller when the ATN signal is at low level.

This is shown in " Table 7-1 " .

Table 7-1 Multi-Line Interface Message

b7					0	① MSG	0	MSG	0	MSG	0	MSG	1	MSG	1	MSG	1	MSG	1	MSG
b6					0		0		1		1		0		0		1		1	
b5					0		1		0		1		0		1		0		1	
② b4	b3	b2	b1	COLUMN / ROW	0		1		2		3		4		5		6		7	
0	0	0	0	0	NUL		DLE		SP	LISTENER ADDRESSES ASSIGNED TO DEVICES	0	LISTENER ADDRESSES ASSIGNED TO DEVICES	@	TALKER ADDRESSES ASSIGNED TO DEVICES	P	TALKER ADDRESSES ASSIGNED TO DEVICES	`	MEANING DEFINED BY PCG	p	MEANING DEFINED BY PCG
0	0	0	1	1	SOH	GTL	DC1	LLO	!		1		A		Q		a		q	
0	0	1	0	2	STX		DC2		"		2		B		R		b		r	
0	0	1	1	3	ETX		DC3		#		3		C		S		c		s	
0	1	0	0	4	EOT	SDC	DC4	DCL	$		4		D		T		d		t	
0	1	0	1	5	ENQ	PPC③	NAK	PPU	%		5		E		U		e		u	
0	1	1	0	6	ACK		SYN		&		6		F		V		f		v	
0	1	1	1	7	BEL		ETB		'		7		G		W		g		w	
1	0	0	0	8	BS	GET	CAN	SPE	(		8		H		X		h		x	
1	0	0	1	9	HT	TCT	EM	SPD	)		9		I		Y		i		y	
1	0	1	0	10	LF		SUB		*		:		J		Z		j		z	
1	0	1	1	11	VT		ESC		+		;		K		[		k		{	
1	1	0	0	12	FF		FS		,		<		L		\		l		|	
1	1	0	1	13	CR		GS		–		=		M		]		m		}	
1	1	1	0	14	SO		RS		.		>		N		^		n		~	
1	1	1	1	15	SI		US		/		?	UNL	O		_	UNT	o		DEL	

Columns 0 and ① MSG: ADDRESS COMMAND GROUP (ACG)
Columns 1 and MSG: UNIVERSAL COMMAND GROUP (UCG)
Columns 2–3 with MSG: LISTENER ADDRESS GROUP (LAG)
Columns 4–5 with MSG: TALKER ADDRESS GROUP (TAG)
Columns 0–5: PRIMARY COMMAND GROUP (P C G)
Columns 6–7: SECONDARY COMMAND GROUP (S C G)

NOTES
1 MSG IS THE INTERFACE MESSAGE
2 b_1=DIO1 ... b_2=DIO7; DIO8 IS NOT USED
3 HAS SECONDARY COMMAND

GTL…Go to Local
SDC…Selected Device Clear
PPC…Parallel Poll Configure
GET…Group Execute Trigger
TCT…Take Control

LLO…Local Lockout
DCL…Device Clear
PPU…Parallel Poll Unconfigure
SPE…Serial Poll Enable
SPD…Serial Poll Disable
UNL…Unlisten
UNT…Untalk

7.2 5610B/A GP-IB Interface Description

7.2.1 Introduction

The 5610B/A GP-IB Interface has a full range of interface functions and enables remote control of virtually any parameter setting that is possible from the front panel. In addition the data and conditions, once set, may be transferred to an external device, greatly faciliating the implementation of an automated measuring system.

Measurement data is transferred to a controller or other device specified in the listener mode in ASCII character format.

RS-232C may also be used, but not simultaneously with the GP-IB.

7.2.2 Specifications

(1) Interface Functions

The 5610B/A interface is provided with the following functions.

Table 7-2 Interface Functions

Function	Description
SH1	Has all send handshake functions.
AH1	Has all receive handshake functions.
T5	Has basic talker functions, serial poll, talker only mode, cancellation of talker by MLA.
L4	Has basic listener functions, cancellation of listener by MTA.
SR1	Has all service request functions.
RL1	Has all remote / local functions.
PP0	Has no parallel poll function.
DC1	Has all device clear functions.
DT0	Has no device trigger functions.
C0	Has no controller function.

(2) Bus Driver

The 5610B/A bus drive specifications are as follows.

Table 7-3 Bus Driver

DIO 1 to 8 NDAC NRFD SRQ	Open-collector
DAV EOI	Three-state

(3) Code Used

The code used by the 5610B/A interface in the listener is the ISO 7-bit code (ASCII), and if the parity is included as the MSB (most significant bit), this will be ignored. There is no distinction made between lower case and upper case characters and either will be interpreted and executed properly. Space (20H) and tab (09H) are ignored.

Transmitted codes in the talker mode are ISO 7-bit code (ASCII) with no parity. All alphabetics are sent as upper case characters.

(4) Address

The address of the 5610B/A is set from the front panel and this set value is stored in memory backed up by battery even when the power is switched off. Refer to Section 7.3.1 for the setting method. At the time of shipment, the address setting is "2".

(5) Delimiters

The delimiter code used for a code string received by a listener is CR, LF, or EOI signal or combinations of these.

The delimiter for codes sent by a talker is determined at the 5610B/A rear panel switch setting as either CR, LF or EOI. The EOI signal is output simultaneously with this delimiter. For details on the setting method, refer to Section 7.3.1.

(6) Interface Message Responses

IFC	:	Initialize GP-IB interface. Cancel Listener / talker
DCL and SDC	:	Clear GP-IB input and output buffers. Clear error status. Cancel the SRQ. (Main frame functions not changed)
LLO	:	Disable the panel LOCAL key.
GTL	:	Enable the local mode.

(7) Program Codes

Program codes which make various 5610B/A settings temporarily stored in the 5610B/As input buffer and, when a delimiter is received, these are interpreted in the same sequence as input.

The input buffer capacity is 128 characters (bytes), with codes for delimiters, spaces and tabs not stored in the input buffer. If program codes are received which exceed 128 characters, the input buffer overflows, is cleared and the program codes are not executed.

During program code interpretation, if an undefined code is encountered, the input buffer is cleared and the program codes are not executed. When an undefined parameter is encountered, only that program code is cleared.

Upon completion of interpretation and execution of codes, the input buffer is cleared and the next input is possible.

Program codes are divided into headers and parameters and it is possible (within the input buffer character capacity) to continuously send codes. The program code transmission syntax is shown in Fig.7－4.

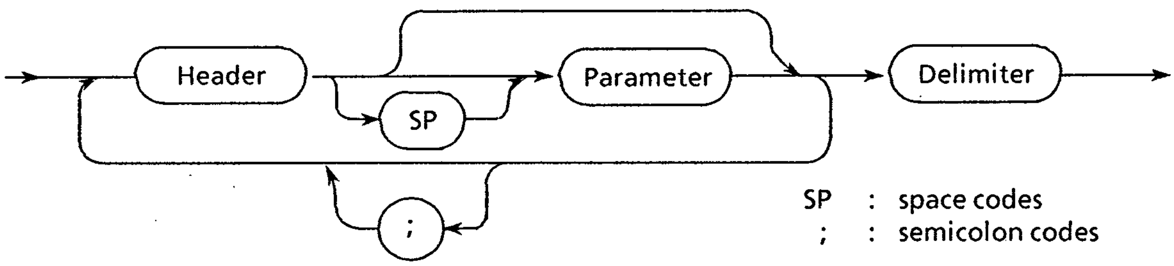
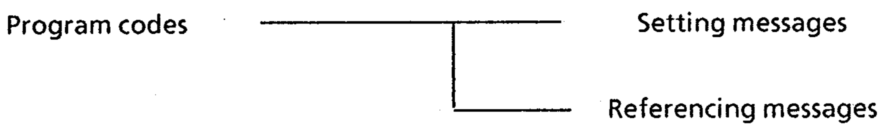


Fig.7－4 Program Code Syntax

If program codes are sent continously, spaces or semicolons may be used to divide them to make them more readable. The program codes used with the 5610B/A may be the divided into setting messages used for settings or operational commands and referencing messages which inquire as to status or settings.



The basic setting message format is as follows. (In this example, the ADJUST OFFSET is set to +234 and the FILTER F RANGE is set to 1k to 12.00kHz.)

ADO	_	+1234	_	;	_	FFR	_	3	_	;
a	b	c	b	d	b	a	b	c	b	d

a : Header section. consisting of three leters. Both upper case and lower case letters will be accepted.

b : These spaces are inserted to enhance readability but can be left out altogether.

c : This is the parameter section. Parameter values begin with a sign (+, −) and then are followed by a value. If the specified range is exceeded, the setting will not be made. If the parameter is left out for a parameter having a polarity, the plus sign is assumed.

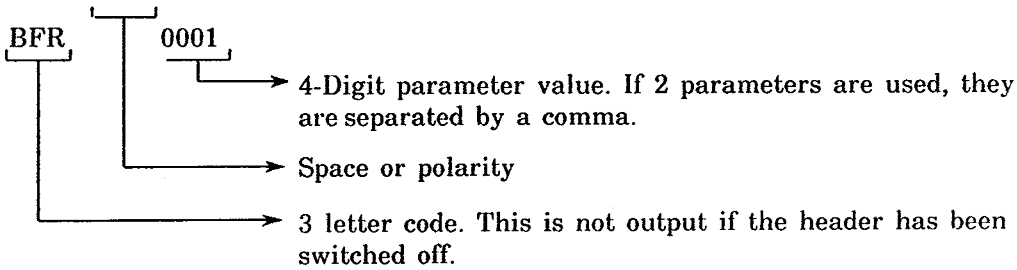
d : These semicolons are added to separate program codes and enhance readability or may e inserted or left out altogether.

With the exception of reference messages and special codes, a setting message header is suffixed by the question mark and no parameter is waited for with respect to a setting message. Only one type of reference message may be transmitted at a time and when the 5610B/A receives a reference message, the response data is transmitted the next time a talker specification is made. The following table 9−1 indicate the program code formats.

The parameter settings for the GP−IB and RS−232C interfaces may not be made by external control and are possible only from the front panel.

(8) Data Output Format

Data format with respect to a referencing message is as follows.



Measurement Data

A (Amplitude)	␣A␣±123.4E−3
A dB or A%	␣LA␣123.4␣␣␣/␣%A␣100.0␣␣␣
X (A cos ϕ)	␣X␣±123.4E−3
X dB or X%	␣LX␣123.4␣␣␣/␣%X␣100.0␣␣␣
ϕ	␣P␣±123.4E−5
Y (A sin ϕ)	␣Y␣±123.4E−3
Ext DC	␣ED±10.00␣␣␣
Ratio	␣RT±1.234␣␣␣
Ref.Frequency	␣RF␣1.234E+3
Sensitivity	␣SS␣12␣␣␣␣␣␣
Over Status	␣ST␣7␣␣␣␣␣␣␣
Line Number	␣NO␣1234␣␣␣␣

If the header has been switched off, the 3-character code including a space is not transferred. Data values are separated by commas.

During the measurement, "Sensitivity SS 12" has the same meaning of the setting range of SENSITIVITY in the program code table (Table 9 - 1). "Over status ST 7" is the as "Over Code" in the same table.

(9) Service Request

The service request (SRQ) is a function which interrupts the controller from the 5610B/A under the following conditions. When the bus line SRQ goes low, the front panel LCD ⑬ will indicate "S".

The service request is made when :

- Overflow has occurred in signal and EXT DC inputs.
- The range has been changed in the auto range operation.
- An error has occurred. (For the type of error, see 3.4.14 (3))
- Data is ready for output.

Data gets ready for output when :

1. Data for the inquiry message (? ODT, ? BFR, etc.) is obtained.
   The Ready-for-output is set up independently of the measurement data on the code representing 5610B/As internal setting.
2. Data is obtained with the START / STOP switch set to START (OSS1).
3. The program code header has an error.
   The output data then is "ERR 0004", or "10004" when the output data without header is set. Under this condition, the output is "10004" when no header is specified for "ERR 0004" output data.

- UNLOCK is set.

The controller senses the SRQ and performs a serial poll, at which point the following status byte is sent to the controller from the 5610B/A and the SRQ line returns to high.

Status Byte

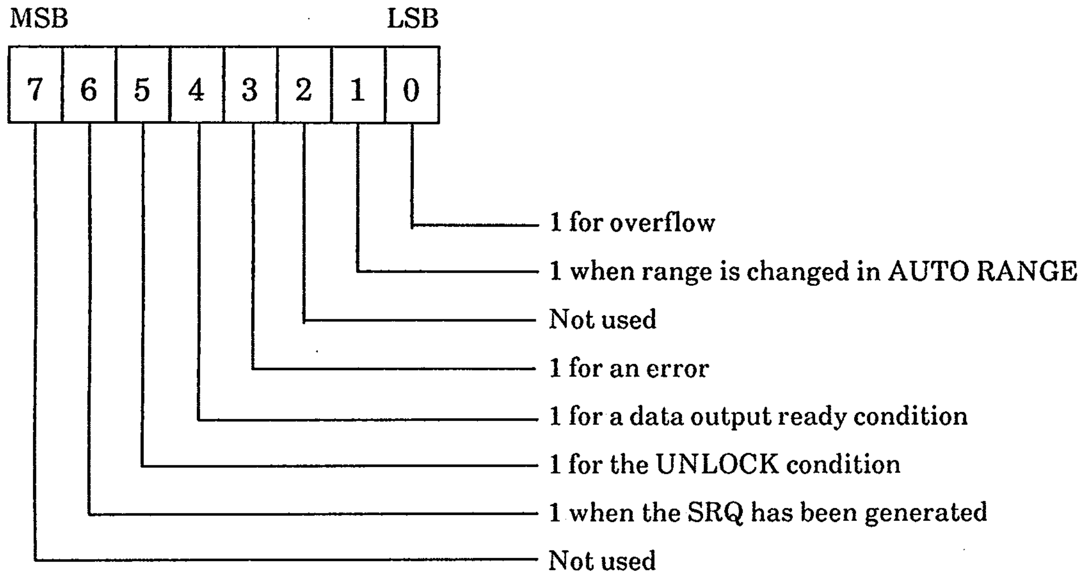


Fig.7-5 Status Byte

The items to be used for the service request may be selected by setting the factor as the decimal sum of the binary weights shown above. For example, for the UNLOCK and error conditions, the value would be $2^5 + 2^3$ 40 so that the setting SRQ 40 is made.

The service request is cancelled under the following conditions.

- After the status byte is output using a serial poll.
- When the device clear (SDC or DCL) is received.
- When masked by means of the SRQ 0 setting.

(10) Over Codes

When overflow occurs, the over code is transmitted as a response to the inquiry command "OVR". For details on over codes, refer to Section 3.4.14.

(11) Error Codes

When an error condition occurs, the error code is transmitted as a response to the inquiry command "ERR". For details on error codes, refer to Section 3.4.14.

7.3 GP−IB Operation

7.3.1 Switching Between the RS−232C and GP−IB

Interface and GP−IB Interface The 5610B/A has two interfaces, the GP−IB and the RS−232C, although these may not be used simultaneously and one must be explicitly selected. This selection is made by means of the front panel RS−232C BAUD key. Press this key while holding the SHIFT key down and the following codes will be indicated on DATA 3/SETTING display / ⑫.

Rightmost 2 digits : Baud rate code (0 to 5)

Leftmost 2 digits : GP−IB / RS−232C switching and RS−232C parameter settings

If the MODIFY switch is used to set the leftmost code to 16, the GP−IB interface will be selected for remote control.

7.3.2 Address and Function Settings

The 5610B/A requires that its GP−IB and parameter settings be made from the front panel, these settings being retained in memory backed up by battery even when the power is switched off.

These settings are made by means of the GP−IB ADR key on the front panel (note that setting of these functions is only possible from the front panel and not via the GP−IB itself).

If this key is pressed after the SHIFT key is held down, the following codes appear on display / ⑫.

Rightmost 2 digits : GP−IB Address

Decimal value in the range 0 to 30

Leftmost 2 digits : Function setting

Talk only		4	The given value is a decimal number in te range 0 to 7.
Transmitted data header (used also for RS-232C)	Disabled	0	
	Enabled	2	
Delimiter (used in common for the RS-232C receive	CR LF	0	
and send and for GP-IB send data only)	CR	1	

Function setting is made by using the MODIFY switch. The displayed value is instantly read in so that if a change is made during GP−IB control, there is a danger of the GP−IB bus locking up and this should be avoided.

The talk only function is used when outputting data directly to a printer having the GP−IB function without requiring the intervention of a controller. For details, refer to Section 3.4.11.

The header is an alphabetic string which indicates the type of transmitted data and is set off when performing such operations as substitutions of this data into numerical variables inside the program.

The delimiter for transmitting data is set depending upon the specifications of the listener and controller used.

7.3.3 Remote/Local Operation

Using the GP-IB, the remote/local specification is used to indicate whether or not a peripheral device is being controlled by the controller.

If the 5610B/A is set into the remote condition from the controller, the GP-IB REMOTE lamp on the front panel will be extinguished and front panel operations will be inhibited.

To return the front panel to its normal (local lockout) condition from a controller, even the GP-IB LOCAL key on the front panel will become inoperative. At this time, the remote / local mode of the Model is completely under control by the controller. To escape from the local lockout condition, set the underline message REN to high (false).

The figure that follows describes the remote/local operation.

Talker operation has no relationship to remote/local mode setting.

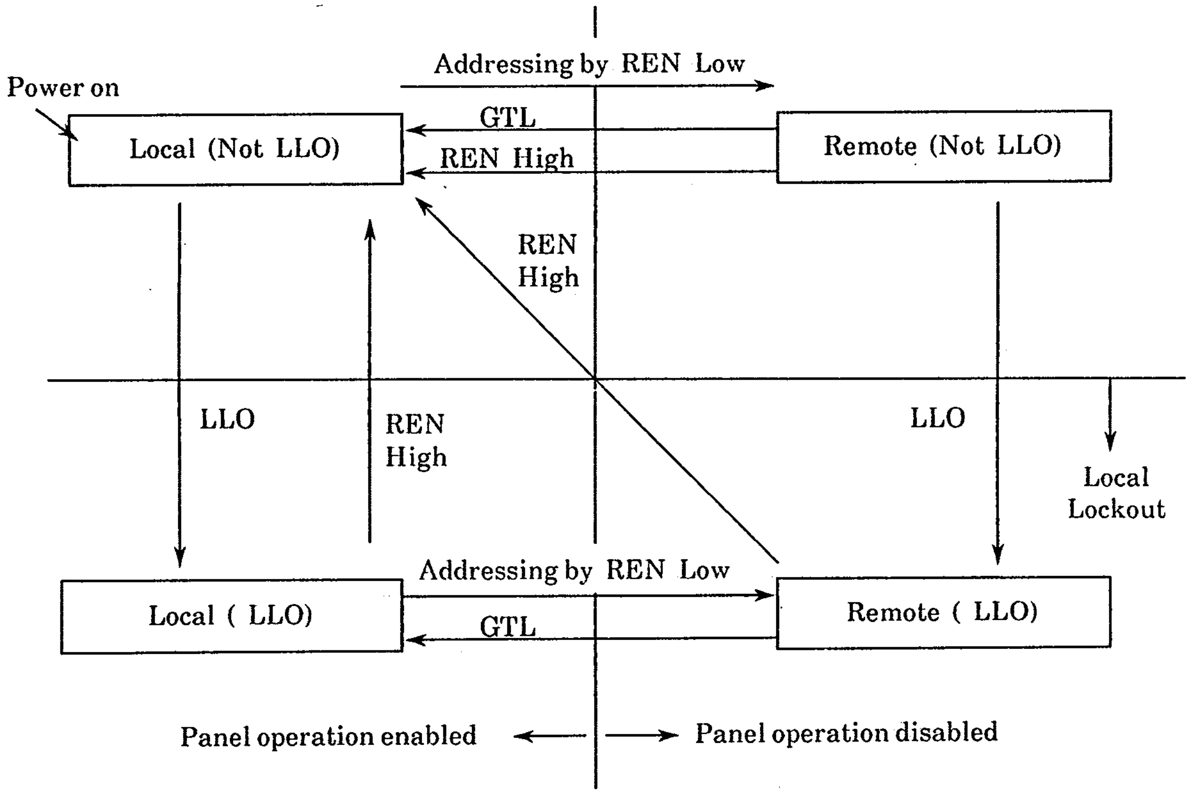


Fig. 7-6 Remote and Local Operations

7.3.4 Program Code Settings

All program codes used by the 5610B/Aare ISO 7-bit (ASCII) codes and both upper case and lower case characters are accepted. The delimiter is CR, LF, EOI or any combination of these. However, if there is no delimiter, the code will be received and stop made.

For detailed specifications of program codes, see Section 7.2.2 (7).

The following functions may not be set using the GP-IB.

- Power on/off
- INPUT A, A-B switching
- GP-IB ADR (address) setting
- RS-232C BAUD rate setting
- MODIFY, COARSE and FINE operations
- FILTER FREQ ADJ adjustments

7.3.5 Data Output

The data output by the 5610B/A consists of two types, one being data sent in response to inquiry messages which request setting values and the other consisting of measurement results.

For data given in response to inquiry messages, when the 5610B/A is specified as a listener and an inquiry message received, the response is prepared and transferred the next time the 5610B/A is specified as a talker. The format for the various inquiry messages is the same for the corresponding setting message. For details, refer to Section 7.2.2(7). Remember that an inquiry message can specify only one type of data at a time.

Measurement result data specified by ㉛ SHIFT and ㊵ OUTPUT DATA SEL are output at once. Data selection is described in Section 7.2.2(8).

Data is transmitted by either specifying the data inquiry message "ODT" to transfer data or by using the service request (SRQ).

The method of transferring data which uses the service request is employed by setting the data transfer interval using SAMPLING (refer to Section 3.2.1). Setting the SRQ mask and data output ready bits (refer to Sections 7.2.2(9)) and specifying the OUTPUT START "OSSI", at which point the 5610B/A generates an SRQ at the specified data transfer interval and indicates to the controller that the data output ready condition has been reached. After the controller performs a serial poll, the 5610B/A is specified as a talker and data is received.

7.3.6 Talk Only Mode

The talk only mode is used to output data directly to such devices as printers having the listen only function without having to use a system controller. For the talk only mode, it is not necessary, therefore, to connect a controller at all. For details, refer to Section 7.3.2 and 3.4.11.

7.3.7 Precautions for Use of the GP-IB Interface

(1) The number of devices which are connectable to the GP-IB including the controller is 15. The maximum cable length is limited as follows.

A) The overall cable length is 2m x (no. of devices) or 20m, whichever is shorter.

B) The maximum length of any single cable is 4m.

(2) The GP-IB connector should only be removed when the power of the 5610B/A has been switched off. If other devices are connected to the bus, the power supplies of these devices should be switched off as well.

(3) When using the GP-IB, be sure to turn on the power of all devices connected to the bus.

(4) The GP-IB address setting should be checked before operation. In particular, be sure that there is no more than one device in the system having the same talk address as this type of condition can result in damage to such devices.

(5) Take sufficient care with the setting of the delimiter characters. If the delimiter is not uniformly set within a system, trouble may occur.

(6) If there is an error in the header section which is part of a program code string send to the 5610B/A, none of the associated program codes in the string will be executed. If an error exists in the parameter section, the associated program code will not be executed.

(7) If the 5610B/A is specified as talker without actually requesting data output (i.e., without sending an inquiry message), there is a danger of locking up the GP-IB bus.

(8) Since the GP-IB is designed for use as an interface under relatively good environmental conditions, care should be taken to avoid power supply variations and noise.

(9) The measurement data maximum transfer speed should be equivalent to a 500ms interval.

(2) Sample Program HP-2

This program is a basic program used to obtain measurement data. It inputs eight types of character data and outputs this data to the printer.

Line 70	:	HDR1 is the program code that adds a header indicating the data type. ODS2345 and ODS2367 are the program codes indicating the type of data to be output. The meanings of the parameters are as follows :
2	:	A (amplitude) value
3	:	A in decibel (if an appropriate mode is selected, A in % may be output.)
4	:	X (A cos ϕ) value
5	:	X in decibel (may be output in % value, if an appropriate mode is selected.)
2	:	Phase
3	:	Y (A sin ϕ) value
6	:	Reference signal frequency
7	:	Sensitivity range
Line 90	:	Outputs in enquiry command " ?ODT " to request the data.
Line 100	:	Inputs the data from the device of the talk address " 2 " , in the form of a train of characters.
Line 110	:	Outputs the input data as it is, to the printer.
Execution results	:	The measurement data with the header are printed out in the order of A, LA, X, LX, P, Y, RF and SS.

These data have the following meanings :

A	1.028E-3	:	A (ampliude) value is 1.028mV
LA	-59.8	:	A is -58.8dB for 1V
X	1.028E-3	:	X (A cos ϕ) value is 1.028mV
LX	-59.8	:	X is -58.8dB for 1V
P	0.05	:	Phase difference of input signal and the reference signal is +0.05°.
Y	0.001E-3	:	Y (A sin ϕ) value is 1μV.
RF	3.45E +3	:	The reference signal frequency is 3450Hz.
SS	0007	:	The sensitivity range has been set to 3mV.

Sample Program HP-2 and Execution Results

```
10 ! □ SAMPLE PROGRAM 2
20 !     FILE NAME "□_HO2"
30 !
40 ABORT 7
41 CLEAR 7
42 REMOTE 702
50 DIM A$[100]
60 !
70 OUTPUT 702;"HDR1 ODS2345,2367"
80 !
90 OUTPUT 702;"?ODT"
100 ENTER 702;A$
110 PRINT A$
120 END
```

```
A  1.028E-3, LA -59.8   , X  1.028E-3, LX -59.8   ,
P     0.05, Y  0.001E-3, RF  3.45E+3, SS 0007
```

7.4 Sample Programs

The model name of 5610A or 5610B is output at [   ].

7.4.1 Sample Programs Using the 9816 (Hewlett-Packard)

These sample programs are intended for use with the 9816 acting as a controller. For these programs, the 5610B/A address is set to 2 and the delimiter is set to CR/LF. (Make the 00 02 setting using the ADR key.) The GP-IB / RS-232C mode switching is set to GP-IB (16 XX setting using the RS-S232C BAUD key).

(1) Sample Program HP-1

This very basic program sets the analysis frequency range, reference signal mode, sensitivity, time constant, time constant rolloff and dynamic reserve.

Line 40 to 42 : The "REN" goes low and the "IFC" message is transmitted.

Line 60 : The ASCII data inside the parentheses and a CR/LF sequence are sent to the device having the listener address 2. The ASCII codes inside the quotation marks mean the following.

- BFR1 : Analysis frequency range set to 10Hz to 120Hz
- BRM2 : Reference signal mode set to EXT 1F
- BSS10 : Sensitivity set to 100mV fullscale
- BTC5 : Time constant set to 300ms
- BDO1 : Time constant rolloff set to 12dB / oct
- BDR2 : Dynamic reserve set to L

Sample Program HP-1 Listing

```
10 ! [    ]    SAMPLE PROGRAM 1
20 !           FILE NAME "[    ]_H01"
30 !
40 ABORT 7
41 CLEAR 7
42 REMOTE 702
50 !
60 OUTPUT 702;"BFR1 BRM2 BSS10 BTC5 BDO1 BDR2"
70 END
100 !
```

(3) Sample Program HP−3

This program reads measurement data into the controller as nume rical variables and performs calculations on the input measurement data.

Line 60 : Since appending a header to data will prevent substitution as numerical variable, the program code "HDRO" is used to turn the header off. Send the program codes "ODS 2345 and ODS 2367" to set the type of data to be output.

Line 80 : Send the reference command "ODT" which requests data.

Line 90 : The eight types of output data are separated by commas so that they are substituted into variables in the output sequence.

Line 110 to 180 : Output the input data to the printer.

Sample Program HP−3 and Execution Results

```
10 ! □ SAMPLE PROGRAM 3
20 !         FILE NAME "□_H03"
30 !
40 ABORT 7
41 CLEAR 7
42 REMOTE 702
50 !
60 OUTPUT 702;"HDRO ODS2345,2367"
70 !
80 OUTPUT 702;"?ODT"
90 ENTER 702;A,B,C,D,E,F,G,H
100 !
110 PRINT "AMPLITUDE      ",A
120 PRINT "AMP dB         ",B
130 PRINT "A COS P        ",C
140 PRINT "A COS dB       ",D
150 PRINT "PHASE          ",E
160 PRINT "A SIN P        ",F
170 PRINT "REF FREQ       ",G
180 PRINT "SENSITIVITY    ",H
190 END
```

```
AMPLITUDE              .001028
AMP dB                 .1
A COS P                .001028
A COS dB               .1
PHASE                  0
A SIN P                0
REF FREQ               3440
SENSITIVITY            7
```

(4) Sample Program HP−4

This program uses the timer interrupt capabilities of the 9816 to input data at a fixed time interval.

Line 60	:	Set header off and output data to XCA and EXT DC.
Line 90	:	Generate a timer interrupt every 3000ms and when a timer interrupt is generated, declare a jump to line 140.
Line 100	:	Terminate when five measurement data have been obtained.
Line 140 to 180	:	In the interrupt processing program, data is requested at line 140 and input at line 150, data is output at line 160, output is sent to the printer. When the interrupt processing is completed, looping is done between lines 100 and 110.

Sample Program HP−4 and Execution Results

```
10 ! [    ] SAMPLE PROGRAM 4
20 !        FILE NAME ":[    ]_H04"
30 !
40 ABORT 7
41 CLEAR 7
42 REMOTE 702
50 !
60 OUTPUT 702;"OSS1 HDR0 ODS4,4 SRQ16"
70 !
80 I=0
90 ON CYCLE 3 GOSUB 140
100 IF I=5 THEN 120
110 GOTO 100
120 OUTPUT 702;"OSS0 SRQ0"
130 STOP
140 OUTPUT 702;"?ODT"
150 ENTER 702;A,B
160 PRINT USING "6A,S4DE,11A,S4DE";"AcosP",A,"     EXT DC ",B
170 I=I+1
180 RETURN
190 END
```

```
AcosP +1029E-06    EXT DC -2150E-03
AcosP +1030E-06    EXT DC -1920E-03
AcosP +1029E-06    EXT DC -1620E-03
AcosP +1029E-06    EXT DC -1260E-03
AcosP +1027E-06    EXT DC -8600E-04
```

(5) Sample Program HP−5

This program uses the 5610B/As service request to input data at a fixed interval.

Line 80	:	Header and the output data settings and program code "SSA5, 1" are used to output one data consisting of 2 5 32 samples every interval with a sample interval of 100ms. Therefore, one data is transmitted every 3.2s.
Line 110	:	By "OSS1" the data output is started, and "SRQ16" is used to allow the service request of data output ready completion to be used.
Line 120	:	When the service request interrupt is generated, declare a jump to line 200.
Line 130	:	Permits the operation of the interrupt function of the 9816.
Line 140	:	Terminates when five measurement data have been obtained.
Line 150	:	When the interrupt processing is completed, looping is done between lines 140 and 150.
Line 170	:	"SRQ0" is used to pro\ the service request of the 5610B/A "OSS0" stops the data outputing, ending the measurement.
Line 200	:	Since the service request is generated, the serial poll is performed and the status byte is set to "S".
Line 210	:	The beeper is generated, to show the generation of the service request.
Line 220	:	Input the measurement data.
Line 230	:	The input data is output to the printer.
Line 250	:	Permit again the service request interrupt of the 9816.

Sample Program HP-5 Listing and Execution Results

```
10 !          SAMPLE PROGRAM 5
20 !          FILE NAME "      _H05"
30 !
40 ABORT 7
50 CLEAR 7
60 REMOTE 702
70 !
80 OUTPUT 702;"HDRO ODS4,4 SSA5,1"
90 !
100 I=0
110 OUTPUT 702;"OSS1 SRQ16"
120 ON INTR 7 GOSUB 200
130 ENABLE INTR 7;2
140 IF I=5 THEN 170
150 GOTO 140
160 !
170 OUTPUT 702;"OSSO SRQO"
180 STOP
190 !
200 S=SPOLL(702)
210 BEEP
220 ENTER 702;A,B
230 PRINT USING "6A,S4DE,11A,S2D.2D";"AcosP",A,"          EXT DC",B
240 I=I+1
250 ENABLE INTR 7;2
260 RETURN
270 END
```

```
AcosP +1028E-06     EXT DC  -.34
AcosP +1028E-06     EXT DC  -.91
AcosP +1028E-06     EXT DC -1.34
AcosP +1030E-06     EXT DC -1.72
AcosP +1029E-06     EXT DC -2.03
```

(6) Sample Program HP-6

This program uses inquiry commands to input setting values of the 5610B/A.

Line 60 : Send the program code which adds a header to indicate the type of data.

Line 80 : Send the command which inquires the analysis frequency range. Since an inquiry command is effected for only one data transfer at a time, a program such as this needs six repititions of inputing and outputing of data, to obtain six types of setting data.

Line 90 : Input the data which is a response to the inquiry command "BFR".

Sample Program HP-6 and Execution Results

```
10 ! [    ] SAMPLE PROGRAM 6
20 !        FILE NAME "[    ]_H06"
30 !
40 ABORT 7
41 CLEAR 7
42 REMOTE 702
50 !
60 OUTPUT 702;"HDR1"
70 !
80 OUTPUT 702;"?BFR"
90 ENTER 702;A$
100 OUTPUT 702;"?BRM"
110 ENTER 702;B$
120 OUTPUT 702;"?BSS"
130 ENTER 702;C$
140 OUTPUT 702;"?BTC"
150 ENTER 702;D$
160 OUTPUT 702;"?BDO"
170 ENTER 702;E$
180 OUTPUT 702;"?BDR"
190 ENTER 702;F$
200 !
210 PRINT "F.RANGE     ",A$
220 PRINT "REF MODE    ",B$
230 PRINT "SENSITIVITY",C$
240 PRINT "TIME CONST ",D$
250 PRINT "T.C. SLOPE ",E$
260 PRINT "DYN.RES.    ",F$
270 END
```

```
F.RANGE              BFR 0003
REF MODE             BRM 0002
SENSITIVITY          BSS 0007
TIME CONST           BTC 0004
T.C. SLOPE           BDO 0001
DYN.RES.             BDR 0002
```

(7) Sample Program HP-7

This program is used to demonstrate the use of the 5610B/A remote/local operation.

Line 60	:	The 5610B/A is specified as a listener and the ASCII code "BFR 1" is sent to the 5610B/A. Since the 5610B/A is a listener, it goes into the remote mode, the GP-IB LOCAL lamp goes off and the frequency analysis range is set to 10Hz to 120Hz. Since it is now in the remote mode, settings from the panel become inoperative. To return it to the local mode, press the LOCAL key while holding down the SHIFT key. This will cause the GP-IB LOCAL lamp to be light up enabling settings to be made from the panel once again.
Line 80	:	This command is inserted to cause a temporary program halt. It is possible at this point to proceed to the next step by pressing the [END LINE] key.
Line 100	:	This specifies the 5610B/A once again as a listener, placing it into the remote mode.
Line 110	:	The local lockout command is sent to the 5610B/A and the 5610B/A enters the remote (local lockout) mode. In this condition, panel settings become inoperative and even the LOCAL key is ignored. The local lockout condition is, therefore, the condition under which the LOCAL key used normally to return the 5610B/A to local becomes inoperative.
Line 130	:	Proceed to the next step by pressing the [END LINE] key.
Line 150	:	This command is used to set the 5610B/A into the local mode, with the 5610B/A specified as a listener. The GTL multiline message is output and the 5610B/A enters the local mode. This is the local lockout condition, under which the GP-IB LOCAL lamp is illuminated and panel settings become possible.
Line 170	:	Proceed to the next step by pressing the [END LINE] key.
Line 190	:	The "BSS10" program code is sent to the 5610B/A to place it in the remote condition once again and enable the local lockout condition.
Line 210	:	Proceed to the next step by pressing the [END LINE] key.
Line 230	:	By means of this command, the "REN" line goes high and the 5610B/A enters the local condition and local lockout is canceled.
Line 250	:	Proceed to the next step by pressing the [END LINE] key.
Line 270	:	The "BTC5" program code is sent to the 5610B/A but since the "REN" line is high, the 5610B/A is only capable of receiving data and setting is not performed.

Sample Program HP-7 Listing

```
10 ! [      ]  SAMPLE PROGRAM 7
20 !           FILE NAME "[      ]_H07"
30 !
40 ABORT 7
41 CLEAR 7
42 REMOTE 702
50 !
60 OUTPUT 702;"BFR1"
70 !
80 INPUT A$
90 !
100 OUTPUT 702;"BRM2"
110 LOCAL LOCKOUT 7
120 !
130 INPUT A$
140 !
150 LOCAL 702
160 !
170 INPUT A$
180 !
190 OUTPUT 702;"BSS10"
200 !
210 INPUT A$
220 !
230 LOCAL 7
240 !
250 INPUT A$
260 !
270 OUTPUT 702;"BTC5"
280 !
290 INPUT A$
300 !
310 END
```

(8) Sample program HP−8

This program is used to measure the amplitude and phase of input signals using the AUTO SET function. the AUTO SET processing time extends as the input signal and noise levels rise. Create the program taking into account the state of an input signal.

Line 60	:	Has no header, start the output data, and sets output data and service request.
Line 90	:	Sets a timer interrupt to perform measurements in increments of 30 seconds.
Line 100	:	Ends measurement after performing measurements five times.
Line 160	:	Set up the AUTO SET mode. If the AUTO SET processing is terminated within 20 seconds, it is forcibly terminated.
Line 170	:	Execute the pocessings A Lines 150 to 320.
Line 190	:	A service request has been generated. Inputs status byte to "S" by serial pole.
Line 210	:	Input measurement data.
Line 230 to 260	:	Output the input data to the printer.

Sample Program HP−8 Listing and Execution Results

```
10 ! [      ] SAMPLE PROGRAM 8
20 !          FILE NAME "[      ]_H08"
30 !
40 ABORT 7
41 CLEAR 7
42 REMOTE 702
50 !
60 OUTPUT 702;"OSS1 HDRO  ODS26,6 SRQ16"
70 !
80 I=0
90 ON CYCLE 30 GOSUB 150
100 IF I=5 THEN 120
110 GOTO 100
120 OUTPUT 702;"OSSO SRQ0"
130 STOP
140 !
150 J=0
160 OUTPUT 702;"AUS20 ?ODT"
170 GOTO 190
180 !
190 S=SPOLL(702)
200 BEEP
210 ENTER 702;A,B,C
220 OUTPUT 702;"SRQ0"
230 PRINT "AMPLITUDE",A
240 PRINT "PHASE    ",B
250 PRINT "FREQUENCY",C
260 PRINT
270 OUTPUT 702;"SRQ16"
280 I=I+1
290 J=1
300 OUTPUT 702;"SRQ16"
310 ENABLE INTR 7;2
320 RETURN
330 END
340 !
```

```
AMPLITUDE  .00103
PHASE      .05
FREQUENCY  3440

AMPLITUDE  .00103
PHASE      .05
FREQUENCY  3440

AMPLITUDE  .001028
PHASE      .05
FREQUENCY  3440

AMPLITUDE  .001028
PHASE      0
FREQUENCY  3440

AMPLITUDE  .001029
PHASE      0
FREQUENCY  3440
```

7.4.2 Sample Program for the PC-9801 (NEC)

The following sample programs were intended for use with the PC-9801 acting as a controller. The 5610B·A address is set at 2 and the delimiter set up as CR/LF (00   02 setting by means of the GP-IB ADR key). The GP-IB / RS-232C switching is set to GP-IB (16   XX setting using the BAUD key). Since the program content corresponds to the programs given in Section 7.4.1 only those parts which differ are described below. Read the Section 7.4.1 first.

(1) Sample Program PC-1 This program has the same content as the sample program HP-1.

Line 130	:	The controller sends the message "IFC" declaring that it is the controller.
Line 140	:	The "REN" line is made Low.
Line 150	:	The data input/output delimiter is set up as CR/LF.
Line 270	:	The ASCII data in quotation marks and a CR/LF sequence are sent to the device with the listener address 2.

Sample Program PC-1 Listing

```
100 ' □ Sample Program 1
110 '          File Name "□.001"
120 '
130 ISET IFC
140 ISET REN
150·CMD DELIM=0
160 '
170 PRINT@ 2;"BFR1 BRM2 BSS10 BTC5 BD01 BDR2"
180 '
190 END
```

(2) Sample Program PC-2

The contents of this program are the same as the sample program HP-2.

Line 200 : The PC-9801 "INPUT @ " command reads data only up until a comma is encountered. In this example, when all data values which include commas are input, the "LINE INPUT @ " command is used.

Sample Program PC-2 Listing and Execution Results

```
100 ' [    ] Sample Program 2
110 '          File Name "[    ].002"
120 '
130 ISET IFC
140 ISET REN
150 CMD DELIM=0
160 '
170 PRINT@ 2;"HDR1 ODS2345,2367"
180 '
190 PRINT@ 2;"?ODT"
200 LINE INPUT@ 2; A$
210 LPRINT A$
220 '
230 END
```

```
A  1.029E-3, %A    0.1    , X  1.029E-3, %X    0.1    ,
P   -0.16, Y -0.003E-3, RF  1.005E+3, SS 0007
```

```
A  1.030E-3, LA -59.7    , X  1.030E-3, LX -59.7    ,
P   -0.16, Y -0.003E-3, RF  1.005E+3, SS 0007
```

(3) Sample Program PC−3

The contents of this program are the same as for sample program HP−3. At line 200, the numerical variables A, B, C, D, E, F, G and H are read in as data.

Sample Program PC−3 Listing and Execution Results

```
100 ' [    ] Sample Program 3
110 '           File Name "[    ].003"
120 '
130 ISET IFC
140 ISET REN
150 CMD DELIM=0
160 '
170 PRINT@ 2;"HDRO ODS2345,2367"
180 '
190 PRINT@ 2;"?ODT"
200 INPUT@ 2; A,B,C,D,E,F,G,H
210 '
220 LPRINT "AMPLITUDE          ",A
230 LPRINT "AMPLITUDE dB       ",B
240 LPRINT "A COS P            ",C
250 LPRINT "A COS P   dB       ",D
260 LPRINT "PHASE     °        ",E
270 LPRINT "A SIN P            ",F
280 LPRINT "REF FREQ  Hz       ",G
290 LPRINT "SENSITIVITY RANGE  ",H
300 '
310 END
```

```
AMPLITUDE                    .001028
AMPLITUDE dB                -59.8
A COS P                      .001028
A COS P   dB                -59.8
PHASE     °                 -.22
A SIN P                     -.000004
REF FREQ  Hz                 1006
SENSITIVITY RANGE            7
```

(4) Sample Program PC-4

The PC-9801 has no timer interrupt function which enables interupts at a fixed interval. In place of this approach, this program uses pressing the function key to generate an interrupt and process data.

Line 190 : Declaration is made that a function key will be pressed to generate an interrupt and line 280 is declared as the jump destination as the interrupt occurs.

Line 200 : The function key [F·1] is set as the interrupt key. When this program is run, each time the [F·1] key is pressed, measurement data is taken and then sent to the printer. When five data have been input, the program stops.

Sample Program PC-4 Listing and Execution Results

```
100 ' □ Sample Program 4
110 '        File Name "□.004"
120 '
130 ISET IFC
140 ISET REN
150 CMD DELIM=0
160 '
170 PRINT@ 2;"HDRO ODS48,"
180 '
190 ON KEY GOSUB *DATAIN
200 KEY(1) ON
210 IF I=5 THEN *FINISH
220 GOTO 210
230 '
240 *FINISH
250   KEY(1) OFF
260 END
270 '
280 *DATAIN
290   PRINT@ 2;"?ODT"
300   INPUT@ 2; A,B
310   LPRINT "AcosP      ";
320   LPRINT USING "+#.###^^^^";A;
330   LPRINT "    EXT DC ";
340   LPRINT USING "+##.##";B
350   I=I+1
360 RETURN
```

```
AcosP      +1.030E-03    EXT DC   +1.58
AcosP      +1.030E-03    EXT DC   +2.08
AcosP      +1.031E-03    EXT DC   +2.44
AcosP      +1.031E-03    EXT DC   +2.55
AcosP      +1.030E-03    EXT DC   +2.65
```

(5) Sample Program PC-5

The contents of this program are the same as for sample program HP-5.

Line 160 : Initializes SRQ flag in PC-9801

Line 220 : Use the service request interrupt Declare to jump to line 320 when an interrupt occurs.

Line 240 : The service request interrupt is enabled.

Line 330 : A serial poll is performed and "S" is substituted as the status byte.

Sample Program PC-5 Listing and Execution Results

```
100 ' □ Sample Program 5
110 '         File Name "□.005"
120 '
130 ISET IFC
140 ISET REN
150 CMD DELIM=0
160 POLL 2,S
170 '
180 PRINT@ 2;"HDRO ODS26, SSA5,1"
190 '
200 I=0
210 PRINT@ 2;"OSS1 SRQ16"
220 ON SRQ GOSUB *DATAIN
230 IF I=5 THEN *FINISH
240 SRQ ON
250 GOTO 230
260 '
270 *FINISH
280   PRINT@ 2;"OSSO SRQO"
290   SRQ OFF
300 END
310 '
320 *DATAIN
330   POLL 2,S
340   LPRINT "Status Byte =",S
350   BEEP
360   INPUT@ 2; A,B
370   LPRINT "AMPL   ";
380   LPRINT USING "+#.###^^^^";A;
390   LPRINT "     PHASE   ";
400   LPRINT USING "+##.##";B
410   I=I+1
420 RETURN
```

```
Status Byte =  80
AMPL   +1.031E-03     PHASE    -0.22
Status Byte =  80
AMPL   +1.028E-03     PHASE    -0.16
Status Byte =  80
AMPL   +1.030E-03     PHASE    -0.16
Status Byte =  80
AMPL   +1.029E-03     PHASE    -0.16
Status Byte =  80
AMPL   +1.030E-03     PHASE    -0.22
```

(6) Sample program PC-6

Contents are the same as for HP-6 sample program. Only one inquiry command is valid per transfer. Therefore, data output and input should be repeated six times.

Sample Program PC-6 Listing and Execution Results

```
100 ' □ Sample Program 6
110 '         File Name "□.006"
120 '
130 ISET IFC
140 ISET REN
150 CMD DELIM=0
160 '
170 PRINT@ 2;"HDR1"
180 PRINT@ 2;"?BFR"
190 INPUT@ 2;A$
200 PRINT@ 2;"?BRM"
210 INPUT@ 2;B$
220 PRINT@ 2;"?BSS"
230 INPUT@ 2;C$
240 PRINT@ 2;"?BTC"
250 INPUT@ 2;D$
260 PRINT@ 2;"?BDO"
270 INPUT@ 2;E$
280 PRINT@ 2;"?BDR"
290 INPUT@ 2;F$
300 '
310 LPRINT "F.Range",A$
320 LPRINT "REF.Mode",B$
330 LPRINT "Sensitivity",C$
340 LPRINT "Time Constant",D$
350 LPRINT "T.C. Slope",E$
360 LPRINT "DYN.RES.",F$
370 '
380 END
```

```
F.Range       BFR 0002
REF.Mode      BRM 0002
Sensitivity   BSS 0007
Time Constant BTC 0004
T.C. Slope    BDO 0001
DYN.RES.      BDR 0002
```

(7) Sample program PC−7

Contents are the same as for HP−7 sample program.

Line 220 : Instruction to transfer local lock out. "&H5C", "&H22" and "&H11" are multi line message codes for the talker address, listener address and LLO respectively. " ; " following them sets the ATN line in the high level.

Line 260 : Instruction to set the 5610B/A in the local mode. "&H5C", "&H22" and "&H1" are multi line message codes for the talker address, listener address and GTL respectively. " ; " following them sets the ATN line in the high level.

Line 340 : Instruction to set the "REN" line in the high level.

Sample Program PC−7

```
100 ' [    ] Sample Program 7
110 '           File Name "[    ].007"
120 '
130 ISET IFC
140 ISET REN
150 CMD DELIM=0
160 '
170 PRINT@ 2;"BFR1"
180 '
190 INPUT A$
200 '
210 PRINT@ 2;"BRM2"
220 WBYTE &H5C,&H22,&H11;    'MTA,LA,LLO
230 '
240 INPUT A$
250 '
260 WBYTE &H5C,&H22,&H1;    'MTA,LA,GTL
270 '
280 INPUT A$
290 '
300 PRINT@ 2;"BSS10"
310 '
320 INPUT A$
330 '
340 IRESET REN
350 '
360 INPUT A$
370 '
380 PRINT@ 2;"BTC5"
390 '
400 INPUT A$
410 '
420 END
```

(8) Sample program PC-8

Contents are the same as for HP-8 sample program.

Line 250	:	Constantly read timer values. Perform measurements when second values become "00". This means one measurement is performed per minute.
Line 340 to 400	:	Set up the AUTO SET mode. Perform processings from 420 to 590 when the data output ready service request is generated upon the completion of the AUTO SET operation.
Line 420 to 590	:	Perform serial pole and data input by interrupt routine. Flag J which indicates the completion of interruption is set to 1.

Sample Program PC-8 and Measurement Results i n the high level.

```
100 ' □ Sample Program 8
110 '           File Name "□.008"
120 '
130 ISET IFC
140 ISET REN
150 CMD DELIM=0
160 POLL 2,S
170 '
180 PRINT@ 2;"HDRO ODS26,6 SRQ16"
190 '
200 I=0
210 '
220 *LOOP
230   T$=RIGHT$(TIME$,2)
240   PRINT T$
250   IF T$="00" THEN GOSUB *MEASURE
260   IF I=5 THEN *FINE
270   GOTO *LOOP
280 '
290 *FINE
300   PRINT@ 2;"SRQ0"
310   SRQ OFF
320 END
330 '
340 *MEASURE
350   J=0
360   PRINT@ 2;"AUS20 ?ODT"
370   ON SRQ GOSUB *DATAIN
380   IF J=1 THEN RETURN
390   SRQ ON
400   GOTO 380
410 '
420 *DATAIN
430   POLL 2,S
440   LPRINT "Status Byte =",S
450   BEEP
460   INPUT@ 2; A,B,C
470   LPRINT "Amplitude ";
480   LPRINT USING "+#.###^^^^";A;
490   LPRINT "    Phase ";
500   LPRINT USING "###.##";B;
510   LPRINT "    REF. FREQ. ";
520   LPRINT USING "#####^^^^";C
530   PRINT@ 2;"SRQ16"
540   I=I+1
550   J=1
560   RETURN
```

```
Status Byte =  80
Amplitude +1.030E-03    Phase  -0.16    REF. FREQ.   1005E+00
Status Byte =  80
Amplitude +1.029E-03    Phase  -0.16    REF. FREQ.   1005E+00
Status Byte =  80
Amplitude +1.029E-03    Phase  -0.22    REF. FREQ.   1005E+00
Status Byte =  80
Amplitude +1.030E-03    Phase  -0.22    REF. FREQ.   1005E+00
Status Byte =  80
Amplitude +1.030E-03    Phase  -0.22    REF. FREQ.   1005E+00
```

8. RS-232C INTERFACE

8.1 RS232C Overview

8.1.1 Introduction

RS-232C is a standard which describes an interface used with modems and similar devices in performing data transfer between computers and data terminal equipment. This is the standard prescribed by JIS C 6361 (Interface Between Modems and Communications Control Equipment and Data Terminal Equipment) and by EIA (US) standards.

Since serial data transfer developed in the communications field, a widely used technique in long-distance transfer employs a device known as a modem to modulate signals to be transmitted and demodulate received signals. The RS-232C is the standard which describes the interface with this modem. Therefore, both the data terminal and modem specifications conform to this standard and are connected as shown in Fig.8-1.

The RS-232C interface is used in personal computers and this has led to use in interfacing to measuring instruments. When interfacing a computer to measuring instruments using the RS-232C, since long-distance data transfer is seldom required, the modem is often eliminated, with direct connection being made between the computer and measuring instruments. Since this scheme differs from the originally intended connection method of the RS-232C, if devices at both ends of the interface are either computers or data terminals, interface problems may occur. To overcome these problems, both sides can be made to conform to modem specifications, with input-to-output and output-to-input connections made using an interface cable known as a cross cable or null modem cable. Fig.8-2 shows an example of connections made using such a cable.

Since the use of the RS-232C in this manner is rather " unconventional " , before using the interface, a thorough check should be made of the specifications of the devices to be connected, the proper cable should be prepared and the appropriate driver program developed.

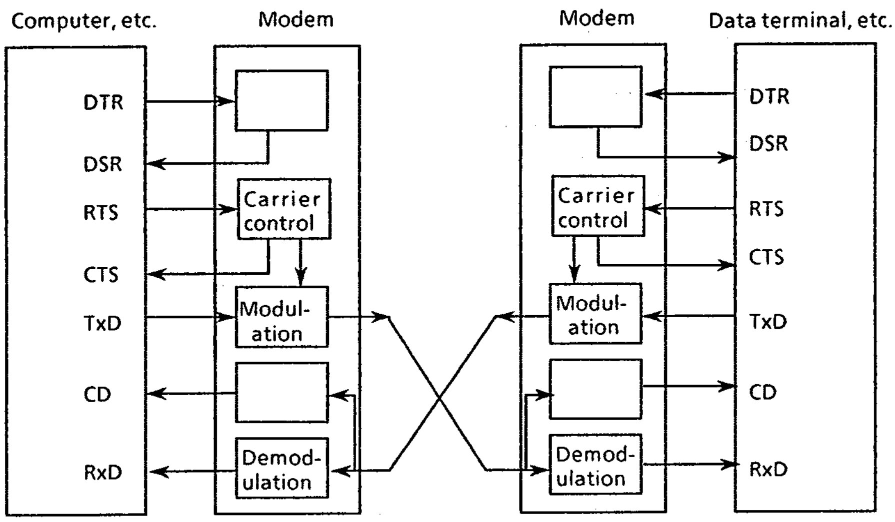
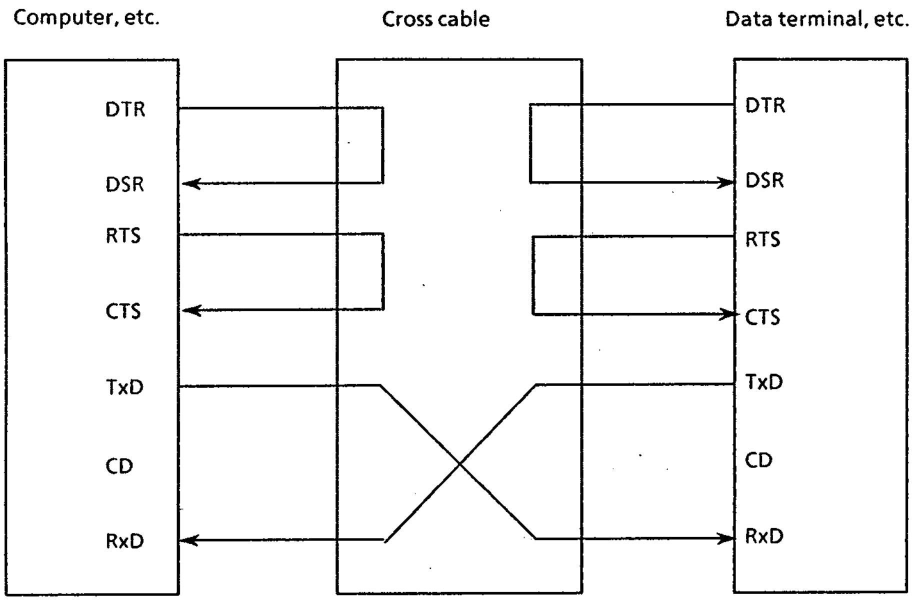


Fig.8-1 RS-232C Connections Using a Modem



Abbreviations

CD : Carrier Detect

CTS : Clear To Send

DSR : Data Set Ready

DTR : Data Terminal Ready

RTS : Reqyest To Send

RxD : Received Data

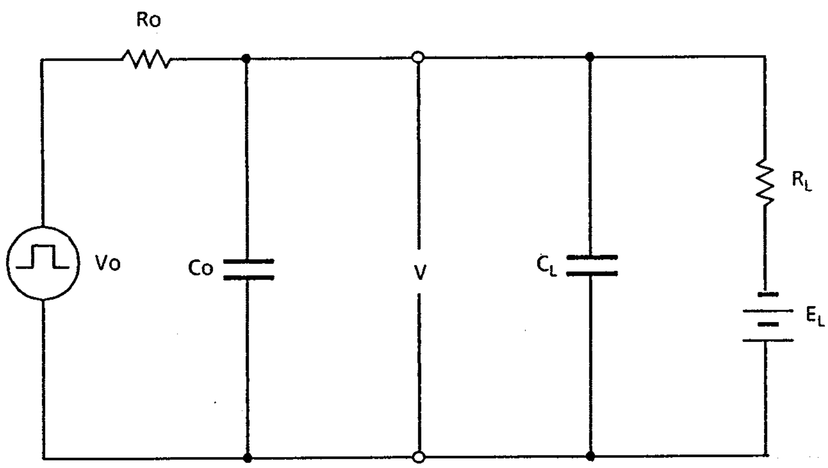
TxD : Transmitted Data

Fig.8-2 RS-232C Connections without Using a Modem

8.1.2 RS-232C Major Specifications

(1) Equivalent Interconnection Circuit

Fig.8-3 shows the equivalent circuit of the RS-232C interconnections.



Vo : Open-circuit voltage

Ro : Internal circuit DC resistance

Co : Overall capacitance including cable capacitance measured at the connection point

V : Voltage at the connection point

C_L : Effective load capacitance measured a the connection point

R_L : Terminating resistance

E_L : Open-circuit load voltage

Fig.8-3 Equivalent Circuit

(2) Receivers

Input impedance (R_L)	: 3kΩ to 7kΩ (with 3 to 25V applied)
Effective load capacitance (C_L)	: 2500 pF max.
Signal 1 threshold voltage	: −3V max.
Signal 0 threshold voltage	: +3V min.
Open-circuit voltage (E_L)	: 2V max.

(3) Drivers

Maximum open-circuit voltage	: ±25V
Maximum output current when shorted	: ±0.5A max.
Logic 1 output level	: −15V to −5V
Logic 0 output level	: +15V to +5V
Output impedance	: 300Ω min.

(4) Connector

Fig.8−4 shows the connector used at the data terminal end.

8.2 5610B/A RS−232C Interface

8.2.1 Introduction

The RS−232C interface of the 5610B/A as approximately the same functions as the GP−IB and enables the setting of parameter values and the transfer of parameter values and data. By using the digital data output function, it is possible to perform automatic printing on an RS−232C equipped printer, enabling the simple rintout of measurement results.

8.2.2 Specifications

The RS−232C interface of the 5610B/A conforms to JIS (Japanese Industrial Standard) C 6361 data terminal equipment specification standard for slow-speed, asynchronous modems.

Communications mode	: Asynchronous
Baud rate	: 300, 600, 1200, 2400, 4800 and 9600, selectable
Data bit length	: 7/8 bits, selectable
Number of stop bits	: 1/2 bits, selectable
Parity	: Even, odd or none, selectable
Output signals	: ±12V, SN75188N or equivalent drivers
Input signals	: Maximum ±30V, SN75189AN or equivalent receivers (Simultaneous input and output is not possible.)

8.2.3 Connector and Signal Lines

Fig.8－5 shows the pin arrangement of the RS－232C connector (as seen from the rear panel). The connector is held in place by M2.6 screws.

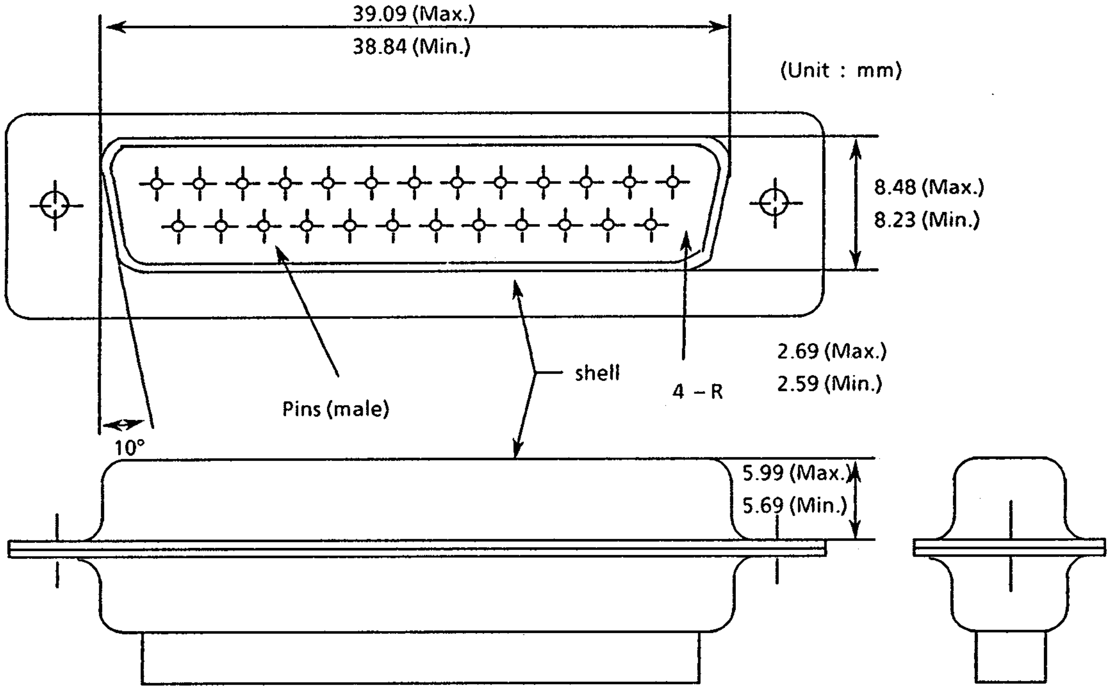


Fig.8－4 Connector on the Connection Cable Side

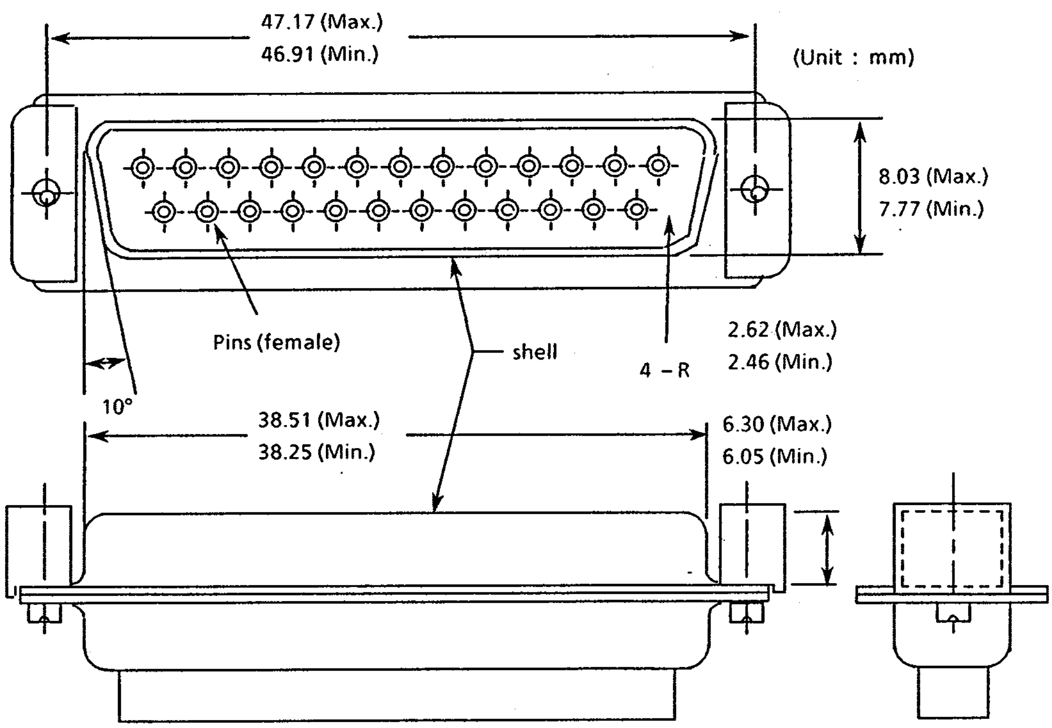


Fig.8－5 Connector on Data Terminal Side

Table 8-1 RS-232C Signal Line Types and Functions

Pin no	Signal name	Symbol	Function	Direction
1	Frame Ground	FG		
2	Transmitted Data	TxD	Transmits data from the 5600B/A4.	Output
3	Received Data	RxD	Used to receive data at the 5600B/A.	Input
4	Request To Send	RTS	When data transfer from the 5600B/A begins, this line goes high and when the data transfer is completed, it returns to low.	Output
5	Clear To Send	CTS	When set to high, output of data from the 5600B/A is enabled. The normal protocol is to return a high level to CTS from the modem or other device as a response to RTS. If no wait for response is needed from the receive side, however, CTS should be directly connected to RTS. This line may also be used as the receive side BUSY.	Input
6	Data Set Ready	DSR	When set to high, output of data from the 5600B/A is enabled. When set to low and the 5600B/A is set up to send, an "Er6" condition occurs. If this input is not required, it should be connected to DTR.	Input
7	Signal Ground	SG		
20	Data Terminal Ready	DTR	Goes to high when the 5600A is in the RS-232C mode and is low when the 5600B/A is in the GP-IB mode.	Output

8.2.4 Difference with Respect to the GP-IB

The 5610B/A has a GP-IB interface as a standard feature and the RS-232C differs from the GP-IB in the following points. All the settable parameters and data output are the same those for the GP-IB, however. These two interfaces may not be used simultaneously.

- Parallel connection of devices is not possible.
- Since a " one-by-one " data transfer is performed, there is no need for designating the address.
- There is no service request function.
- There are no functions corresponding to the GP-IB address command and universal command.
- There are no remote /local functions.
- Unless the measurement is stopped, data transfer is not possible, except at OUTPUT START.

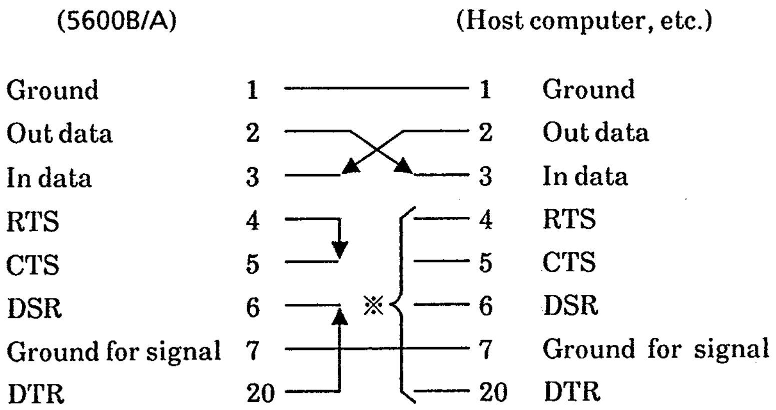
8.3 Operation

8.3.1 Making Connectins

When the RS-232C interface is used without modems, there is no standard cable such as specified for the GP-IB, making it necessary to make connections depending on the specifications of the devices to be used.

The sections below describe the connection methods at the 5610B/A (terminal-like device) and data terminal sides. The actual connections made require careful consideration of individual device specifications. Refer also to Section 8.4.1.

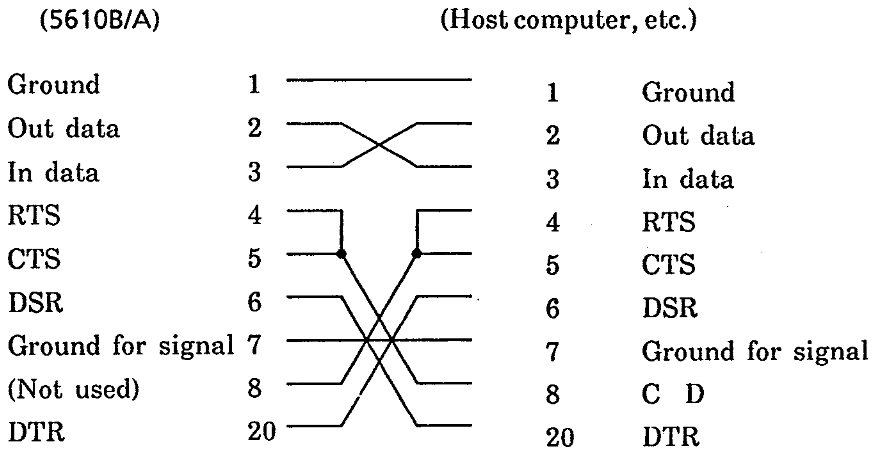
(1) Minimum connection



※ Make connections depending on analyzer's specifications and programs, etc.

In the 5600B/A, grounds 1 and 7 are not separated.

(2) To check mutual connection



In the 5610B/A, grounds 1 and 7 are not separated.

8.3.2 Parameter Setting Method

When controlling the 5610B/A using the RS-232C, the following parameters must be set (or verified) from the front panel.

(1) GP-IB/RS-232C Interface Selection and RS-232C Function Setting

If the RS-232C BAUD key is pressed while holding the SHIFT key down, the following data will appear on display DATA 3/SETTING ⑫.

Rightmost 2 Digits : boud rate

00 : 300 01 : 600 02 : 1.2k 03 : 2.4k

04 : 4.8k 05 : 9.6k

Leftmost 2 Digits : RS-232C Functions and RS-232C/GP-IB Selection

Stop bits	1 bit	0
	2 bits	8
Parity	Unused	0
	Used	4
	Odd	0
	EVEN	2
Character length	8 bits	0
	7 bits	1

The value given is the decimal number corresponding to the sum of the binary weighted values shown and is in the range 0 to 16. If 16 is set, GP-IB control is performed and control by means of the RS-232C is inhibited.

(Example) To set the number of stop bits to 2, the parity on and to odd and the character length to 8 bits, the setting value would be 8+4+0+0=12, so that the left two digits would be set to 12.

(2) Delimiter and Header Settings

While the header may be externally controlled, the delimiter setting can only be made from the front panel.

For received data strings, the 5610B/A can accept <CR>, <LF >and <CR LF> as a delimiter.

For data strings transmitted by the 5610B/A, the delimiter sent may be selected, this setting being used as the GP-IB delimiter setting as well. The same is true of the data header.

If the GP-IB ADR key is pressed while the SHIFT key is held down, the following data will appear on display DATA 3/SETTING ⑫.

Rightmost 2 digits : GP-IB Address (unrelated to RS-232C)

Leftmost 2 digits :	Talk onlyThe value given (unrelated to is the decimal RS-232C)	Used	4	The value given is the decimal number corresponding to the sum of the binary weights shown above. The setting range is 0 to 7.
	Send data header	Unused	0	
		Used	2	
	Delimiter (Used for RS-232C send/receive and GP-IB send only)	<CR> <LF>	0	
		<CR>	1	

(3) Transmitted Data Type Setting

These settings may be made frm an external device but are made from the front panel when data is to be sent to a printer equipped with an RS-232C interface.

If the OUTPUT DATA SEL key is pressed after the SHIFT key is held, a value will appear on display DATA 3/SETTING ⑫ tha is the code indicating the type of data currently selected. Data are sequentially transmitted starting from the left digit. For the data codes, see Section 7.2.2 8).

If a zero setting is made, data is not output and both ! 0123 " and " 1230 " settings have the same effect, with data being output in the same sequences A, A(dB) and Ext DC.

The line number setting is used when outputting data on the printer or similar device and causes line numbers from 1 through 9999 to be assigned starting at OUTPUT START and incrementing by 1 for each output. When 9999 is reached, the sequence repeats from 1. From the line number and the output interval, it is possible to determine for any given data, how much time had elapsed from the beginning of measurements.

(4) Transfer Interval Settings

These settings may be made from an external device but is made from the front panel when data is to be sent to a printer equipped with an RS-232C interface.

If the SAMPLING key is pressed after the SHIFT key is pressed, the following data will appear on display ⑫.

Rightmost 2 digits : Measurement processing interval (sampling time)

00 : Stopped	01 : 100ms	02 : 300ms	03 : 1s
04 : 3s	05 : 10s		

Leftmost 2 digits : Digital data transfer interval

One output is made every 2^n times and the value of n is set in the range 0 to 16.

If the setting " 0403 " is made, for example, the measurement processing interval would be 1s and the output interval would be 2^4, so that one data would be output every 16s.

(5) Starting Data Transfer

This setting may be made from an external device but is made from the front panel when data is to be sent to a printer equipped with an RS−232C interface.

If the OUTPUT START/STOP key is pressed, the orange lamp will light up and digital data transfer will begin. If pressed once again, the lamp will be extinguished and digital data transfer will stop. When power is first turned on, data transfer is forced into the stopped condition.

8.3.3 Control Using the RS−232C

(1) Program Code Settings

The program codes used on the 5610B/As RS−232C interface are all ISO 7−bit (ASCII) codes, and both upper and lower case characters are accepted. The delimiter may be set from the front panel to <CR> <LF> or <CR>, this setting being made simultaneously for transmission reception.

Program codes are the same as used with the GP−IB. For details refer to Section 7.2.2 7. For the RS−232C, the BOS command has been added for use in re-starting measurement.

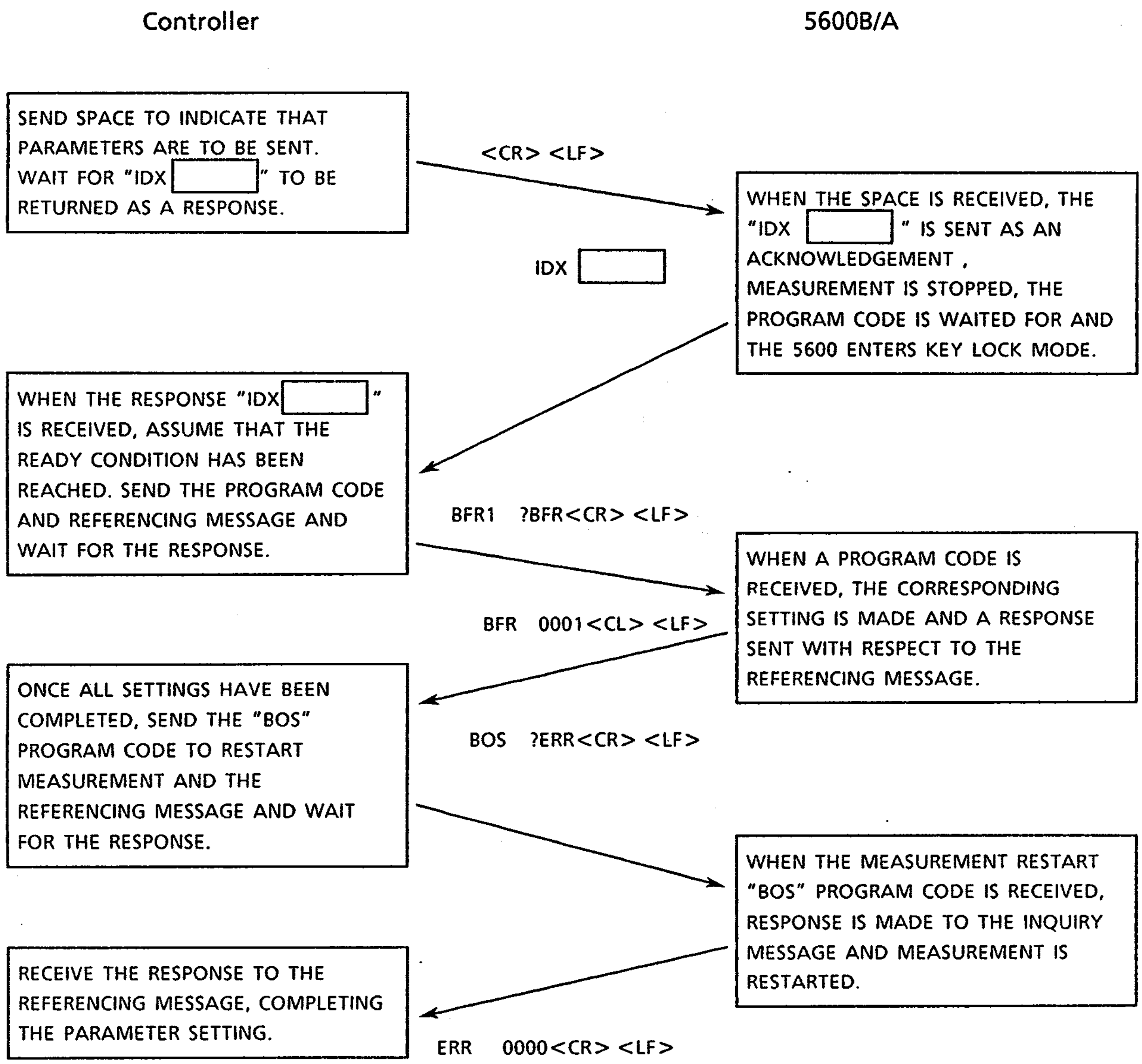
Using the RS−232C, since there are no hardware handshakes such as used with the GP−IB, verification must be made while sending and receiving program codes. Therefore, when controlling the 5610B/A, always use in inquiry code after a setting code and proceed to the next step only after waiting for the response from the 5610B/A.

It should be remembered that the 5610B/A cannot make a measurement during RS−232C data transfer. Before sending a program code, send a space to the 5610B/A, wait for the "␣ IDX 5610B/A " response from the 5610B/A (which indicates that the measurement is interrupted and that the 5610B/A is ready to receive a command) before proceeding to set the program code. When the 5610B/A receives data from the RS−232C, it enters the KEY LOCK mode, in which front panel controls are inoperative. When the RS−232C transfer is completed, to restart measurement, send the program code " BOS " to the 5610B/A (see the next page).

(2) Measurement Data Output

As is the case for GP−IB, two methods can be used to output measurement data. One is similar to the parameter inquiry message and consists of using the " ODT " message which references measurement data and the other consists of using DATA OUTPUT START to output data from the 5610B/A periodically.

In the external control mode using the RS−232C, the communication between 5610B/A and the controller is illustrated on the next page.



Note
- In this example, the header for data output from the 5610B/A has been switched on.
- The model name of 5610A or 5610B is output at [ ].

8.4 Sample Programs

The model name of 5610A or 5610B is output at ☐.

8.4.1 PC-9801 (NEC) Sample Programs

These sample programs are intended for use with the PC-9801 acting as the controller.

A cable having the connection shown in Section 8.3.1(b) is used and the RS-232C parameters are set as follows :

Baud rate	:	1200
Data bit length	:	8 bits
Number of stop bits	:	1 bit
Parity	:	None
Delimiter	:	< CR>,< LF>

The PC-9801 baud rate is 1200 but the monitor should be checked with respect to this setting. This can be done by keying in the sequence MON ↵ SSW2 ↵.

If the monitor returns " 05- " , the baud rate is 1200. If the results are different, set the monitor to 05. Set up the 5610B/A as follows :

RS-232C BAUD	:	0802
GP-IB ADR	:	0002

Program operation is the same as described in Section 7.4.1.

(1) Sample Program PC−RS1

This program is a very basic type of program which sets the analysis frequency range, reference signal mode, sensitivity, time constant, time constant rolloff and dynamic reserve.

Line 160 : The RS−232C port is opened and RS−232C parameters set as follows :
- N : No parity check
- 8 : 8 bit data length
- 1 : 1stop bit length
- N : No flow control of received data
- N : Kana (the Japanese syllabary) is not used

Line 170 : Before making parameter settings " ␣ " is sent to the 5610B/A to stop measurement and have it wait for RS−232C data input.

Line 180 : Receive character string " □ " which indicates that the 5610B/A is ready for data input.

Line 190 : Display the character string "□" indicating the ready completion on the CRT.

Line 210 : Send program data and error referencing messages.

Line 220 : Receive error code.

Line 230 : Display error code on the CRT.

Line 250 : When parameter settings are completed, send the KEY LOCK OFF and " BOS " command which restarts measurement.

Line 290 : Close the RS−232C port.

Sample Program PC−RS1 Listing

```
100 ' □ RS-232C Sample Program 1
110 '         File Name "□.RS1"
120 '
130 '(Set baudrate 1200
140 '     mon(cr) ssw2(cr) 05(cr) (ctrl)b
150 '
160 OPEN "COM1:N81NN" AS #1
170 PRINT# 1," "
180 INPUT# 1,Q$
190 PRINT Q$
200 '
210 PRINT# 1,"BFR1 BRM2 BSS10 BTC5 BDO1 BDR2 DDT226 ?ERR"
220 INPUT# 1,Q$
230 PRINT Q$
240 '
250 PRINT# 1,"KLKO BOS ?ERR"
260 INPUT# 1,Q$
270 PRINT Q$
280 '
290 CLOSE #1
300 END
```

(2) Sample Program PC-RS2

This program is a simple program that can be used to receive measurement data from the 5610B/A over the RS-232C. It inputs five types of character data at once and outputs them to a printer.

Line 160 to 190	:	As was done in sample program PC-RS1, these lines make preparation for use of the RS- 232C control functions. They stop 5610B/A measurement and place the 5610B/A in the KEY LOCK mode.
Line 210	:	Output program code uses to select the type of data to be output. (Upon this setting, the data are output in the order of A, LA(%A), X, LX(%X), P, ED, RT and RF.)
Line 250	:	Send the " ODT " message which references measurement data.
Line 260	:	Input measurement data as a character string.
Line 270	:	Print the input measurement as is on the printer.
Line 290	:	Since the input of the measurement data is completed, cancel the KEY LOCK condition and restart measurement. Sample Program PC-RS2 Listing

Sample Program PC-RS2 Execution Results

```
100 ' [      ] RS-232C Sample Program 2
110 '          File Name "[      ].RS2"
120 '
130 '(Set baudrate 1200
140 '      mon(cr) ssw2(cr) 05(cr) (ctrl)b
150 '
160 OPEN "COM1:N81NN" AS #1
170 PRINT# 1," "
180 INPUT# 1,Q$
190 LPRINT Q$
200 '
210 PRINT# 1,"HDR1 ODS2345,2456 ?ERR"
220 INPUT# 1,Q$
230 LPRINT Q$
240 '
250 PRINT# 1,"?ODT"
260 LINE INPUT# 1,A$
270 LPRINT A$
280 '
290 PRINT# 1,"KLKO BOS ?ERR"
300 INPUT# 1,Q$
310 LPRINT Q$
320 '
330 CLOSE #1
340 END
```

```
IDX [      ]
ERR 0000
 A  1.030E-3, LA -59.7    , X  1.030E-3, LX -59.7    , P    -0.16, ED  0.00    , RT
9.999    , RF 1.005E+3
ERR 0000
```

(3) Sample Program PC-RS3

This program substitutes measurement data into numerical values, enabling calculations to be performed on input measurement data.

Lines 160 to 190	:	Preparation for RS-232C control.
Line 210	:	Since the appendage of a data heder would prevent input as numerical variables, the " HDR0 " command is used to switch the header off and the output data types are selected.
Line 250	:	The " ODT " measurement data referencing message is sent.
Line 260	:	Input the measurement data as the numerical variables A, B and C.
Line 270 to 310	:	Output the input measurement data to the printer.
Lines 330 to 370	:	Perform operations to terminate RS-232C control.

Sample Program PC-RS3 Listing and Execution Results

```
100 ' □ RS-232C Sample Program 3
110 '        File Name "□RS3"
120 '
130 '(Set baudrate 1200
140 '      mon(cr) ssw2(cr) 05(cr) (ctrl)b
150 '
160 OPEN "COM1:N81NN" AS #1
170 PRINT# 1," "
180 INPUT# 1,Q$
190 LPRINT Q$
200 '
210 PRINT# 1,"HDRO ODS48,6 ?ERR"
220 INPUT# 1,Q$
230 LPRINT Q$
240 '
250 PRINT# 1,"?ODT"
260 INPUT# 1,A,B,C
270 LPRINT "AcosP     ",A
280 LPRINT "EXT DC    ",B
290 LPRINT "Frequency",C
320 '
330 PRINT# 1,"KLKO BOS ?ERR"
340 INPUT# 1,Q$
350 LPRINT Q$
360 '
370 CLOSE #1
380 END
```

```
□
0000
AcosP          .001029
EXT DC         0
Frequency      1006
0000
```

(4) Sample Program PC-RS4

This program makes use of the PC-9801 function key interrupt capability, so that each time the [F-1] function key is pressed data is transferred from the 5610B/A and sent to the printer.

Lines 160 to 190	:	Preparation for RS-232C control.
Line 210	:	The header is switched (7) Sample program PC-RS7 The contents are the same as for HP-8.
Line 150 to 230	:	Routine for setting initialization.
Line 270 to 320	:	Reads timer every time. Performs measurements by AUTO SET when second becomes " 00 " .
Line 340 to 430	:	Routine to end measurement.
Line 450 to 640	:	Measurement routine by AUTO SET. Feeds space by line 460 before AUTO SET 490 to be ready for receiving commands.

Sample Program PC-RS4

```
100 ' [    ] RS-232C Sample Program 4
110 '          File Name "[    ].RS4"
120 '
130 '(Set baudrate 1200
140 '      mon(cr) ssw2(cr) 05(cr) (ctrl)b
150 '
160 OPEN "COM1:N81NN" AS #1
170 PRINT# 1," "
180 INPUT# 1,Q$
190 LPRINT Q$
200 '
210 PRINT# 1,"HDRO ODS48, BOS ?ERR"
220 INPUT# 1,Q$
230 LPRINT Q$
240 '
250 '
260 ON KEY GOSUB *DATAIN
270 KEY(1) ON
280 IF I=5 THEN *FINISH
290 GOTO 280
300 '
310 *FINISH
320   PRINT# 1,"KLKO BOS ?ERR"
330   INPUT# 1,Q$
340   LPRINT Q$
350   KEY(1) OFF
360   CLOSE #1
370 END
380 '
390 *DATAIN
400   PRINT# 1," "
410   INPUT# 1,Q$
420   LPRINT Q$
430 '
440   PRINT# 1,"?ODT"
450   INPUT# 1,A,B
460   LPRINT "AcosP ";
470   LPRINT USING "+####^^^^";A;
480   LPRINT "    EXT DC ";
490   LPRINT USING "+##.##";B
500 '
510   PRINT# 1,"BOS ?ERR"
520   INPUT# 1,Q$
530   LPRINT Q$
540   I=I+1
550 '
560 RETURN
```

Sample Program PC-RS4 (contd) and Execution Results

```
0000
AcosP  +1028E-06     EXT  DC   +0.00
0000
AcosP  +1030E-06     EXT  DC   +0.00
0000
AcosP  +1029E-06     EXT  DC   +0.00
0000
AcosP  +1028E-06     EXT  DC   +0.00
0000
AcosP  +1029E-06     EXT  DC   +0.00
0000
0000
```

(5) Sample program PC-RS5

Using the PC-9801 RS-232C input interrupt function, this program periodically input measurement data output periodically by the 5610B/A and output this data to the printer. Press the function key to end the measurement.

Lines 160 to 200 : Preparation for RS-232C control.

Line 210 : The header is switched on, the types of data to be output are selected, the measurement processing interval and output data interval are set and data output is started. In this example, the measurement processing interval is 300ms and data output interval is $2^5 = 32$, so that one data is output every 9.6s.

Lines 250 to 260 : Declaration of the timer interrupt which will terminate measurements after one minute.

Lines 280 to 290 : Declaration of the RS-232C input interrupt.

Lines 300 to 310 : When the interrupt processing has been completed, this routine is executed in a loop.

Lines 330 to 480 : Operations to complete measurement. Lines 360 and 380 comprise a wait routine used to establish the proper timing.

Lines 500 to 550 : Routine to input measurement data by using an RS-232C input interrupt. For details, refer to the PC-9801 instruction manual.

Sample Program PC-RS5 Listing

```
100 '        RS-232C Sample Program 5
110 '              File Name "       RS5"
120 '
130 '(Set baudrate 1200
140 '      mon(cr) ssw2(cr) 05(cr) (ctrl)b
150 '
160 OPEN "COM1:N81NN" AS #1
170 '
180 PRINT# 1," "
190 INPUT# 1,A$
200 LPRINT A$
210 PRINT# 1,"HDR1 ODS48,6 SSA5,2 OSS1 ?ERR"
220 INPUT# 1,Q$
230 LPRINT Q$
240 '
250 ON KEY GOSUB *FINISH
260 KEY(1) ON
270 '
280 ON COM GOSUB *DATAIN
290 COM ON
300 PRINT TIME$ ; "   " ;
310 GOTO 300
320 '
330 *FINISH
340   BEEP
350   KEY(1) OFF
360   FOR I=1 TO 2000 : NEXT I
370   COM OFF
380   FOR I=1 TO 2000 : NEXT I
390 '
400   PRINT# 1," "
410   INPUT# 1,Q$
420   LPRINT Q$
430   PRINT# 1,"KLKO OSSO BOS ?ERR"
440   INPUT# 1,Q$
450   LPRINT Q$
460 '
470   CLOSE #1
480 END
490 '
500 *DATAIN
510   TIME$ STOP
520   IF LOC(#1)=0 THEN RETURN
530   LPRINT INPUT$(LOC(1),#1);
540   TIME$ ON
550 RETURN
```

Sample Program PC-RS5 (Cont'd) and Execution Results.

```
ERR 0000
 X  1.029E-3, ED  0.00   , RF 1.006E+3
 X  1.029E-3, ED  0.00   , RF 1.006E+3
 X  1.029E-3, ED  0.00   , RF 1.006E+3
 X  1.028E-3, ED  0.00   , RF 1.006E+3
 X  1.029E-3, ED  0.00   , RF 1.006E+3
 X  1.030E-3, ED  0.00   , RF 1.006E+3
 X  1.029E-3, ED  0.00   , RF 1.006E+3
 X  1.030E-3, ED  0.00   , RF 1.006E+3
```

(6) Sample Program PC-RS6

This program uses referencing messages to input the 5610B/A setting values.

Lines 160 to 190	:	Preparation for RS-232C control.
Line 210	:	Set the header on.
Lines 250 to 360	:	Send inquiry messages for various settings and input the corresponding data responses from the 5610B/A. Since an inquiry message is capable of transferring only one data at a time, as shown in this example, it is necessary to repeat the data output and input sequence 6 times to obtain the sending of six data.
Lines 380 to 430	:	Output the input data to the printer.
Lines 450 to 500	:	Operations to end RS-232C control.

Sample Program PC-RS6 Listing

```
100 ' [    ] RS-232C Sample Program 6
110 '           File Name "[    ].RS6"
120 '
130 '(Set baudrate 1200
140 '      mon(cr) ssw2(cr) 05(cr) (ctrl)b
150 '
160 OPEN "COM1:N81NN" AS #1
170 PRINT# 1," "
180 INPUT# 1,Q$
190 LPRINT Q$
200 '
210 PRINT# 1,"HDR1 ?ERR"
220 INPUT# 1,Q$
230 LPRINT Q$
240 '
250 PRINT# 1,"?BFR"
260 INPUT# 1,A$
270 PRINT# 1,"?BRM"
280 INPUT# 1,B$
290 PRINT# 1,"?BSS"
300 INPUT# 1,C$
310 PRINT# 1,"?BTC"
320 INPUT# 1,D$
330 PRINT# 1,"?BDO"
340 INPUT# 1,E$
350 PRINT# 1,"?BDR"
360 INPUT# 1,F$
370 '
380 LPRINT "F.Range",A$
390 LPRINT "REF.Mode",B$
400 LPRINT "Sensitivity",C$
410 LPRINT "Time Constant",D$
420 LPRINT "T.C.Slope",E$
430 LPRINT "DYN.RES.",F$
440 '
450 PRINT# 1,"KLKO BOS ?ERR"
460 INPUT# 1,A$
470 LPRINT A$
480 '
490 CLOSE #1
500 END
```

Sample Program PC-RS6 Listing (Cont'd) and Execution Results

```
[     ]
ERR 0000
F.Range         BFR 0002
REF.Mode        BRM 0002
Sensitivity     BSS 0007
Time Constant   BTC 0004
T.C.Slope       BDO 0001
DYN.RES.        BDR 0002
ERR 0000
```

(7) Sample program PC-RS7

The contents are the same as for HP-8.

Line 150 to 230 : Routine for setting initialization.

Line 270 to 320 : Reads timer every time. Performs measurements by AUTO SET when second becomes " 00 " .

Line 340 to 430 : Routine to end measurement.

Line 450 to 640 : Measurement routine by AUTO SET. Feeds space by line 460 before AUTO SET 490 to be ready for receiving commands.

Sample Program PC-RS7

```
100 ' □ RS-232C Sample Program 7
110 '          File Name "□.RS7"
120 '
130 '(Set baudrate 1200
140 '      mon(cr) ssw2(cr) 05(cr) (ctrl)b
150 '
160 OPEN "COM1:N81NN" AS #1
170 '
180 PRINT# 1," "
190 INPUT# 1,A$
200 LPRINT A$
210 PRINT# 1,"HDRO ODS26,6 ?ERR"
220 INPUT# 1,Q$
230 LPRINT Q$
240 '
250 I=0
260 '
270 *LOOP
280   T$=RIGHT$(TIME$,2)
290   PRINT T$ ; "  " ;
300   IF T$="00" THEN GOSUB *MEASURE
310   IF I=5 THEN *FINISH
320   GOTO *LOOP
330 '
340 *FINISH
350   PRINT# 1," "
360   INPUT# 1,Q$
370   LPRINT Q$
380   PRINT# 1,"KLKO OSSO BOS ?ERR"
390   INPUT# 1,Q$
400   LPRINT Q$
410 '
420   CLOSE #1
430 END
440 '
450 *MEASURE
460   PRINT# 1," "
470   INPUT# 1,A$
480   LPRINT A$
490   PRINT# 1,"AUS20 ?ODT"
500   INPUT# 1,A,B,C
510   LPRINT "Amplitude ";
520   LPRINT USING "+#.###^^^^";A;
530   LPRINT "    Phase ";
540   LPRINT USING "###.##";B;
550   LPRINT "    REF. FREQ. ";
560   LPRINT USING "#####^^^^";C
570   PRINT# 1,"BOS ?ERR"
580   INPUT# 1,Q$
590   LPRINT Q$
600   I=I+1
610 RETURN
```

```
□
0000
□
Amplitude +1.008E-03     Phase  -0.16     REF. FREQ.   1005E+00
0000
□
Amplitude +1.010E-03     Phase  -0.22     REF. FREQ.   1005E+00
0000
□
Amplitude +1.008E-03     Phase  -0.28     REF. FREQ.   1005E+00
0000
□
Amplitude +1.009E-03     Phase  -0.28     REF. FREQ.   1005E+00
0000
□
Amplitude +1.008E-03     Phase  -0.22     REF. FREQ.   1005E+00
0000
□
0000
```

8.4.2 Outputting Measurement Data to a Printer

This section describes in detail the procedure for outputting measurement data to the equipped with an RS-232C optional.

Use a connection cable as described in Section 8.3.1(b).

The following RS-232C parameters are used :

Baud rate	1200
Data length	7 bits
No. of stop bits	2 bits
Parity	None

Set the 5610B/A as follows :

RS-232C BAUD	09 02
GP-IB ADR	02 02
OUTPUT DATA SEL	01260700
SAMPLING	05 02
AUTO RANGE	ON

Once the 5610B/A is ready for measurements, press the START/STOP key.

The results of execution, shown below, ae that one set of values is printed every 9.6s.

Data Output Sample

```
*NO 0001     , A   10.13E-6, P    -2.14, SS 0003
 NO 0002     , A   10.11E-6, P    -3.05, SS 0003
 NO 0003     , A   10.20E-6, P    -0.50, SS 0003
 NO 0004     , A   10.21E-6, P    -2.07, SS 0003
 NO 0005     , A   10.13E-6, P    -2.76, SS 0003
 NO 0006     , A   10.09E-6, P     0.16, SS 0003
 NO 0007     , A   10.33E-6, P    -2.38, SS 0003
 NO 0008     , A   10.40E-6, P    -0.49, SS 0003
 NO 0009     , A   10.56E-6, P    -1.41, SS 0003
 NO 0010     , A   10.66E-6, P    -4.84, SS 0003
 NO 0011     , A    8.75E-6, P    -2.81, SS 0003
 NO 0012     , A   10.38E-6, P    -1.65, SS 0003
 NO 0013     , A   10.95E-6, P    -4.45, SS 0003
 NO 0014     , A   10.59E-6, P    -3.08, SS 0003
 NO 0015     , A    9.87E-6, P   -10.86, SS 0003
 NO 0016     , A   10.19E-6, P    -4.72, SS 0003
 NO 0017     , A    9.90E-6, P    -2.89, SS 0003
 NO 0018     , A   10.15E-6, P    -0.62, SS 0003
 NO 0019     , A   10.55E-6, P    -1.95, SS 0003
 NO 0020     , A    9.89E-6, P    -4.23, SS 0003
 NO 0021     , A   10.48E-6, P     1.09, SS 0003
 NO 0022     , A   10.59E-6, P    -2.59, SS 0003
 NO 0023     , A   10.13E-6, P    -0.34, SS 0003
 NO 0024     , A   10.28E-6, P    -3.17, SS 0003
 NO 0025     , A   10.20E-6, P    -1.18, SS 0003
 NO 0026     , A    9.84E-6, P    -0.46, SS 0003
 NO 0027     , A   10.23E-6, P    -3.59, SS 0003
 NO 0028     , A   104.0E-6, P    -1.54, SS 0005
 NO 0029     , A   103.1E-6, P    -1.55, SS 0005
 NO 0030     , A   102.7E-6, P    -1.61, SS 0005
 NO 0031     , A   103.0E-6, P    -1.50, SS 0005
 NO 0032     , A   102.7E-6, P    -1.61, SS 0005
 NO 0033     , A   102.5E-6, P    -1.56, SS 0005
 NO 0034     , A   103.0E-6, P    -1.50, SS 0005
 NO 0035     , A   102.6E-6, P    -1.67, SS 0005
 NO 0036     , A   102.8E-6, P    -1.33, SS 0005
 NO 0037     , A   102.8E-6, P    -1.56, SS 0005
```

Table 9-1 Program Codes Lists

BASIC FUNCTION

Panel marking	Header	Operation & setting range	Reference message exists	Initialize value	Example
F RANGE	BFR	Analysis frequency range (Hz) setting 0: 0.5 to 12 1: 10 to 120 2: 100 to 1.2k 3: 1k to 12k 4: 10k to 200k	YES	None	BFR1
REF MODE	BRM	Reference mode setting 0: INT F 1: INT 2F 2: EXT F 3: EXT 2F	YES	None	BRM2
SENSITIVITY	BSS	Input sensitivity setting (V) −2 : 100n 6 : 1m −1 : 300n 7 : 3m 0 : 1μ 8 : 10m 1 : 3μ 9 : 30m 2 : 10μ 10 : 100m 3 : 30μ 11 : 300m 4 : 100μ 12 : 1 5 : 300μ *5610B	YES	1V	BSS10
SENSITIVITY	BSS	Input sensitivity setting (V) 0: 1μ 6 : 1m 1: 3μ 7 : 3m 2: 10μ 8 : 10m 3: 30μ 9 : 30m 4: 100μ 10 : 100m 5: 300μ 11 : 300m 12 : 1 *5610A	YES	1V	BSS10
T CONST	BTC	Time constant setting (s) 0: 1m 5 : 300m 1: 3m 6 : 1 2: 10m 7 : 3 3: 30m 8 : 10 4: 100m 9 : 30	YES	100ms	BTC5
dB/OCT	BDO	Time constant rolloff setting 0: 6dB/oct 1: 12dB/oct	YES	12dB/oct	BDO1
DYN RES	BDR	Dynamic reserve mode setting 0: H 1: M 2: L	YES	L	BDR1

FILTER

Panel marking	Header	Operation & setting range	Reference message exists	Initialize value	Example
FREQ	FFQ	Cutoff frequency value setting 100 to 1200 5 to 1200 only for 0.5Hz to 120Hz Cutoff frequency range setting 1: 0.5 to 120.0Hz 2: 100 to 1200Hz 3: 1kHz to 12.00kHz 4: 10kHz to 120.0kHz	YES	None	FFQ123,2
MODE	FMO	0: THRU 1: HPF 2: LPF Band-pass filter Q and mode setting 30: Nomal Q1 31: Nomal Q5 32: Nomal Q30 33: LPF Type Q1 34: LPF Type Q5 35: LPF Type Q30 36: HPF Type Q1 37: HPF Type Q5 38: HPF Type Q30	YES	THRU	FMO33

AUTO FUNCTION

Panel marking	Header	Operation & setting range	Reference message exists	Initialize value	Example
AUTO SET	AUS	Automatic setting: Setting is made with the forced stopping time parameter in the range 1 to 9999 in second.	NO	None	AUS30
PHASE SET	AUP	Phase setting	NO	None	AUP
AUTO RANGE	AUR	Auto-ranging 0: Auto-ranging off 1: Auto-ranging on	YES	OFF	AUR1
AUTO TUNE	AUT	Auto-tuning 0: Auto-tuning off 1: Auto-tuning on	YES	OFF	AUTO

DISPLAY

Panel marking	Header	Operation & setting range	Reference message exists	Initialize value	Example
DATA 1	DDT	DDT ␣␣␣ (1st digit) 2 : A & AdB/A% 4 : X & XdB/X%	YES FORMAT DDT 0224	A	DDT 244 Designated Simultane -ously No abbreviation
DATA 2		DDT ␣␣␣ (2nd digit) 2 : Φ 4 : Y		Φ	
DATA 3		DDT ␣␣␣ (3rd digit) 4 : EXT DC 5 : RATIO 6 : REF FREQ		REF FREQ	

NORMALIZE

Panel marking	Header	Operation & setting range	Reference message exists	Initialize value	Example
VALUE Note : Setting to 100nV or 300nV range is not possible	NVL	Setting of the reference values in dB or %. 1 to 999 (100 or 3162 coincides with the fullscale value of each range) Setting of lthe range of reference values in dB or %(V) 0 : 1μ 6 : 1m 1 : 3μ 7 : 3m 2 : 10μ 8 : 10m 3 : 30μ 9 : 30m 4 : 100μ 10 : 100m 5 : 300μ 11 : 300m 12 : 1	YES	1V	NVL512,4
MODE	NMO	Select the unit for the ratio of the measuring value to the reference value 0 : dB 1 : %	YES	dB	NMO1

ADJUST

Panel marking	Header	Operation & setting range	Reference message exists	Initialization value	Example
PHASE	ADP	Reference phase offset value setting −17999 to +18000. (−179.99 deg to +180.00 deg)	YES	0°	ADP9000
OFFSET	ADO	Set offset to the value displayed on A/A COSϕ neglecting a decimal point. −3162 to +3162	YES	0	ADO-316

AVERAGE

Panel marking	Header	Operation & setting range	Reference message exists	Initialization value	Example
TIMES	AVT	Number of averages setting. Set as n (0 to 9) for 2^n averages.	YES	2^6 (64)	AVT5
MODE	AVM	Averaging mode setting. 0: No averaging 1: LIN 2: EXP	YES	0	AVM1

INT OSC

Panel marking	Header	Operation & setting range	Reference message exists	Initialize value	Example
FREQ	OFQ	Oscillator frequency value setting 100 to 1200 (5 to 1200 only in 0.5Hz to 120Hz range) Oscillator frequency range setting 1 : 0.5 to 120.0Hz 2 : 100 to 1200Hz 3 : 1kHz to 12.00kHz 4 : 10kHz to 120.0kHz	YES	None	OFQ100,3
LEVEL	OLV	Oscillator output level value setting 0 to 255 Oscillator output level range setting 0 : 0 to 25.5mV 1 : 0 to 255mV 2 : 0 to 2.55V	YES	0.0mV	OLV100,1

METER

Panel marking	Header	Operation & setting range	Reference message exists	Initialize value	Example
MAG X	MMG	Meter sensitivity setting 0 : ×1 1 : ×10	YES	×1	MMX1
MAG Y	MMY	Meter sensitivity setting 0 : ×1 1 : ×10	YES	×1	MMY1

RATIO

Panel marking	Header	Operation & setting range	Reference message exists	Initialize value	Example
K	RAK	Setting factor value for RATIO function 0.100 to 9.999	YES	1.000	RAK 0.25

KEY

Panel marking	Header	Operation & setting range	Reference message exists	Initialize value	Example
LOCK	KLK	Setting panel setting disable function 0 : Enables setting 1 : Disables setting	YES	–	KLK1

OUTPUT

Panel marking	Header	Operation & setting range	Reference message exists	Initialize value	Example
START / STOP	OSS	Starts / stops external output data 0 : Stop 1 : Start	YES	STOP	OSS1
DATA SEL	ODS	Setting external output digital data ODS ␣␣␣␣ , ␣␣␣␣ 1st parameter → 2nd parameter 0 : No data 1 : Line Number 2 : A 3 : AdB / A% 4 : X (A COS Φ) 5 : XdB / X% 6 : Φ 7 : Y (A sin Φ) 8 : Ext DC 9 : No data → 0 : No data 1 : Line Number 2 : ø 3 : Y (A sinø) 4 : Ext DC 5 : RATIO 6 : REF FREQ 7 : SENSITIVITY 8 : STATUS 9 : No data	YES	None	ODS12,245

SPECIAL FUNCTION

Panel marking	Header	Operation & setting range	Reference message exists	Initialize value	Example
DAC	SDA	Setting D−A converter analog output data SDA ␣ ␣ 2 : A 3 : AdB / A% 4 : X (A COS Φ) 5 : XdB / X% DAC 1 OUT 2 : Φ 3 : Y (A SINϕ) 4 : Ext DC 5 : RATIO 6 : REF FREQ DAC 2 OUT	YES	None	SDA3
SAMPLING	SSA	Sampling interval and digital data external output interval setting SSAN_1, N_2 N_1 : Digital data external output interval (set as n (0 to 16) for 2^n). N_2 : Measuring processing interval (Sampling interval) 0 : Stop 1 : 100ms 2 : 300ms 3 : 1s 4 : 3s 5 : 10s	YES	N_1 : 2^7 N_2 : 300ms	SSA4, 1
CAL	SCA	Beeper function ON / OFF 0 : Beeper off 1 : Beeper on	NO	1	SCA
PSD ZERO	SPZ	LED lamp on / off 0 : Lamp off 1 : Lamp on	NO	0	SPZ

SPECIAL FUNCTION (continued)

Panel marking	Header	Operation & setting range	Reference message exists	Initialize value	Example
BEEP	SBP	BEEP ON/OFF 0 : Beep OFF 1 : Beep ON	YES	OFF	SBP1
LAMP	SLP	LED lamp ON/OFF 0 : lamp OFF 1 : lamp ON	YES	ON	SLP0
LIMIT	SLM	Setting max, sensilivity limit in AUTO RANGE mode (V) 0 : 1μ 6 : 1m 1 : 3μ 7 : 3m 2 : 10μ 8 : 10m 3 : 30μ 9 : 30m 4 : 100μ 10 : 100m 5 : 300μ 11 : 300m 12 : 1 13 : OFF	YES	OFF	SLM5
INITIALIZE	SIN	No initialize parameter for setting panel	No	–	SIN

GP-IB

Panel marking	Header	Operation & setting range	Reference message exists	Initialize value	Example
ADR (only for header)	HDR	Availability of header for output data 0 : NO 1 : YES	YES	None	HDR1

Other functions

Panel marking	Header	Operation & setting range	Reference message exists	Initialize value	Example
OUTPUT DATA	ODT	Measurement data output request command, no parameter	YES (No setting)	-	?ODT
Beginning of Sample	BOS	Instruction to start measurement after controlling with RS-232C (only for RS-232C)	No	-	BOS
SRQ Mask	SRQ	Setting service request factor. Set by decimal value added with the numerical value of factor used. 1 : Overflow 2 : Range switch 8 : Error 16 : Output ready 32 : Unlock	YES	None	SRQ17 (SRQ is sent by 1+16 when only for overflow and output ready)
Status	STS	Status (status byte to be sent when header is SRQ) inquiry command, no parameter. Responded by a decimal value added with the numerical value of a factor. 1 : Overflow 2 : Range switch 8 : Error 32 : Unlock	YES (No setting)	-	?STS
Over Code	OVR	Overcode inquiry command, no parameter. Responded by a decimal value added with the numerical value of a factor. 1 : Input over 2 : Output over 4 : Ext DC over	YES (No setting)	-	?OVR
Error Code	ERR	Error code inquiry command, no parameter. See 3.4.14 for error code.	YES (No setting)	-	?ERR
Model name	IDX	Command for model name inquiry, sending "5610B/A". Used to check the operation of the 5600B/A and check GP-IB adders.	YES (No setting)	-	?IDX

WARRANTY

NF CORPORATION certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory.

ALL ***NF*** products are warranted against defects in materials and workmanship. Obligations under this warranty are limited to replacing, or repairing of any instrument returned to our factory for that purpose within one year of delivery to the original purchaser. No other warranty is expressed or implied. ***NF*** does not assume liability for installation or for incidental or consequential damages.

NF CORPORATION

3-20 Tsunashima Higashi 6-chome, Kohoku-ku, Yokohama-shi
223, JAPAN
Phone(045)545-8111 Fax(045)545-8191 Telex 3823-297

WA：58996

5610B／A INSTRUCTION MANUAL

NF CORPORATION

3-20 Tsunashima Higashi 6-chome, Kohoku-ku,
Yokohama-shi, 223, JAPAN
Phone(045)545-8111

http://www.nfcorp.co.jp/

NF Corporation
6-3-20, Tsunashima-higashi, Kohoku-ku,Yokohama 223-8508 JAPAN