MULTIFUNCTION
DIGITAL LOCK-IN AMPLIFIER

LI5640

INSTRUCTION MANUAL

NF Corporation

D:509993

LI5640

Multifunction

Digital Lock-in Amplifier

Instruction Manual

Introduction

Thank you very much for your purchase of Model LI 5640 Multifunction Digital Lock-in Amplifier.
Read "Safety Instructions" on the next page first to ensure safe and proper use of the Model LI5640 Multifunction Digital Lock-in Amplifier.

Warning indications used in this manual

This instruction manual uses the following signal words such as WARNING and CAUTION. Be sure to observe the instruction that follows such signal words for the safety of instrument users and for prevention of instrument damage.

⚠ WARNING

This indication gives information to avoid hazard in handling when the user is exposed to life or personal hazard such as electric shock.

⚠ CAUTION

This indication gives information to avoid instrument damage in handling.

Safety Instructions

For safe use of the instrument, be sure to observe the following signal words and instructions.
Please note that the NF Corporation will not be responsible for damage that occurred when the user neglected these signal words and instructions and will not indemnify the user for such damage.
This instrument belongs to Insulation Standard Class I Equipment (fitted with protective conductor terminals) as per JIS, IEC and other standards.

- **Be sure to observe the descriptions contained in the instruction manual.**

  The instruction manual contains instructions for safe use and operation of this instrument. Be sure to read the manual first before using the instrument.

  All warnings contained in the instruction manual aim at preventing hazard that leads to significant accident. They must be strictly observed.

- **Be sure to ground the instrument.**

  The instrument causes electric shock if it is not grounded.

  Be sure to positively ground the instrument so that the resistance to ground is 100 ohms or less for prevention of electric shock accident.

  Connect the three-poled power plug to a three-poled power receptacle that has a protective grounding contact, and the instrument will be automatically grounded.

  If a three-pole/two-pole converting adapter is used, be sure to connect the grounding line (green) of the converting adapter to the grounding terminal located close to the receptacle.

- **Confirm the power supply voltage.**

  This instrument operates at the power supply voltage given in Section 7.12 "Specifications". Check if the receptacle voltage is adequate to the rated power supply voltage of this instrument before connecting the power supply.

- **Observe the fuse rating.**

  Use of inadequate fuse may cause fire and other hazards. Use the fuse with rating specified in Section 7.12 "Specifications".

  Before replacing the fuse, be sure to unplug the power supply cord from the receptacle.

- **If any unusual sign is noticed:**

  Should the user notice smoke, odor, or noise from the instrument, immediately unplug the power cord and stop the operation.

  If any abnormality arises such as the above, keep the instrument inoperable until it is completely repaired and immediately contact the NF representatives.

- **Do not use the instrument in an atmosphere of combustible gases.**

  Otherwise, explosion and other hazards may be caused.

- **Do not detach the cover.**

  This instrument has high-voltage part inside. Never remove the cover.

  Internal inspection must be performed only by trained service technicians familiar with hazard prevention.

- **Do not modify the instrument.**

  Never execute any part replacement or modification that is not specified by the NF Corporation. Doing this may cause unexpected hazard and NF Corporation may not take requested repair.

- **Signal words and Safety Signs**

  Signs used on the instrument and in the instruction manual are generally defined as follows:

  ⚠ **Refer to Sign in the Instruction Manual**

  This sign informs the user of a potential hazard, and the signs are given on spots that require user's reference to the instruction manual.

⚠ **WARNING: Warning symbol**

This indication gives information to avoid hazard when the user is exposed to life or personal hazard such as electric shock in handling.

⚠ **CAUTION: Caution symbol**

This indication gives information to avoid instrument damage in handling.

| Indicates that the power switch is turned ON.

○ Indicates that the power switch is turned OFF.

 Indicates that the outer conductor of the connector is connected to the chassis.

 Indicates that the outer conductor of the connector is connected to the signal ground.

List of Contents

List of Figures

List of Tables

1. General

1.1 System overview

LI 5640 Multifunction Digital Lock-in Amplifier is a two-phase lock-in amplifier in which high stability is achieved through digital signal processing. The instrument has a basic capability for frequencies ranging from 1mHz to 100kHz and the voltage sensitivity ranging from 2nV to 1V in full scale. In addition, it has a diversity of functions such as measurement of current, higher harmonics and noise density as well as a function to lock to signal without reference signal.

1.2 Features

- **Various functions**

  It has diversity of functions such as measurement of current, higher harmonics and noise as well as a function to lock onto signal without reference signal.

- **High stability by digital signal processing**

  The instrument operates digitally in major sections such as phase sensitive detector. Therefore, the instrument is mostly free from effects of zero-drift, orthogonality errors and harmonics contained in the input, which are frequent problems in analog systems. It can offer high dynamic reserve (maximum 100dB) without using any analog filter that requires troublesome synchronizing operation and sometimes causes measurement error.

- **Digital signal processing supplies as smooth output as analog signal processing.**

  The amplitude resolution of output is 16 bits, and the highest data updating rate of X, Y, R and θ outputs is 256k samples/s. Stepwise changes are not so conspicuous as in analog output. The built-in data memory allows 16k samples/s recording.

- **Quick response**

  The shortest time constant is 10 μs, which allows the user to observe response of approximately 100 μs.

- **Frequencies as low as 1mHz can be measured**

  The instrument can analyze dilatory signals such as thermal response.

  Low frequency can be locked onto the reference signal within about two periods.

  Provides ripple-less high-speed response by means of a section-averaging filter with integer period.

- **Quick operation response**

  It locks onto the reference signal faster than analog systems in the entire frequency range.

  In addition, measurement quickly converges to an eventual value because the system responds by estimating the measurement in new setting when any of time constants, sensitivity and other setting is changed.

- **Simple operation panel**

  Since buttons are laid out by classified functions and automatic setting functions provide optimal adjustment according to measured signals, the system can be used easily.

- **Analog meters**

  Two analog meters help the user grasp the measurements intuitively.

- **External control**

  Incorporated GPIB and RS-232 interfaces permit combination with a computer to create an automatic measurement system.

2. Preparation before Use

2.1 Checking the appearance and accessories

Before use the instrument, read the "Safety Instructions" given in the beginning of the manual first.

Take out components from the package, then check each item.
If you find any abnormal flaw on the instrument visually, or if any part is missing, contact the NF representatives.
If you notice any unusual appearance of the package (scratches, dents etc.), immediately contact the NF representatives too.

- Appearance check

  Check the panel face, controls, connectors and others for scratches and dents.

- Accessory check

  Accessories of LI5640 are listed in Table 2-1 "Accessories". Check for missing, flaws and other defects.

Table 2-1 Accessories

Instruction manual (LI5640 Instruction Manual)	1
Power cord (7A/125V, 2 m, with three-pole plugs)	1
3-pole/2-pole converting adopter	1
Fuse (time lag, 1A/250V, 5.2 ϕ ×20mm)	1
Protection cap (for current input connector)	1

The supplied power cord, 3-pole/2-pole converting adapter and fuse can be used at power supply voltage of 100V or 120VAC in Japan. To use the unit at 230VAC, or outside Japan, consult the NF representatives.

To unpack the instrument for transfer or other purposes, place the instrument in a box having appropriate strength and allowance, and fill packing materials that can resist the weight to ensure sufficient protection of the instrument.

3. Panel Face and Basic Operations

3.1 Name and operation of panel parts

This section describes the part names, how to operate controls, and how the system responds in the order of the item numbers that appear in Fig. 3-1 "Front and Rear Panels".

3.1.1 Front panel

On the front panel some keys have two functions. The second function is activated when you press the SHIFT key and then press that key.

☞ For details ➡ Refer to Item ② SHIFT key.

The characters enclosed by a [ ] in the caption line indicate the name of the key.

① DATA1 and DATA2 Analog meters

The pointer indicates the same parameter as the parameter shown on the DATA1 or DATA2 digital indicator. When the digital indication is at 1V full scale, for example, the analog meter shows 10 full scale. Then, the analog output voltage of DATA1 and DATA2 will be +10V full scale. Since phase θ is not provided, take the meter full scale as $\pm 180^{\circ}$.

If the digital indication is at the full scale regardless of the setting, then the analog meter is also at the full scale.

② [SHIFT] Shift key

If the user presses the SHIFT key, the key lamp will light up, enabling the second function of each key. When the SHIFT key is pressed while the SHIFT lamp is lighting, the shift function is released, turning off the lamp.

The second function is shown in blue characters below the key. If the SHIFT lamp is lit, then press the key located above blue characters, for example "LAMP". In this instruction manual, the above operation is expressed: press the SHIFT + LAMP key.

The above operation enables the second function, and then the SHIFT lamp is turned off.

Pressing a key having no second function during the SHIFT lamp is lighting will result in only turning off the SHIFT lamp; the (first) function shown on the key will not be activated.

For further information on the second functions, see the description of each key.

NOTE : If a parameter other than phase offset, frequency, amplitude of OSC OUT or the order (nF) of the harmonics is shown on the REFERENCE indication section resulting from an operation such as pressing the SHIFT + FAN keys, then press ⑯ SHIFT + EXIT keys to return the indication to the previous one.

If you do not need to return the parameter on the REFERENCE indication to the previous state, then use the FREQ or other key to change the direct display. It is convenient as SHIFT operation is not required.

③ AUTO SET Automatic setting key

When the AUTO SET key is pressed, the following parameters will be automatically set and the system will be ready for a next measurement:

- Input coupling (AC/DC)
- Dynamic reserve (DYNAMIC RESERVE)
- Sensitivity (SENSITIVITY)
- Time constant (TIME CONSTANT)
- Synchronous filter (SYNC)
- Attenuation slope (SLOPE)
- Phase offset of reference signal (PHASE)
- Measurement parameter (DATA1 and DATA2)

While the system is engaged in automatic setting, "Auto" appears on the REFERENCE digital display. When a proper setting is defined, the automatic setting is completed. To discontinue the operation halfway, press the AUTO SET key once again. Pressing DYNAMIC RESERVE key or SENSITIVITY ▽ or △ key may also discontinue the operation. If the frequency is 1Hz or lower, automatic setting would take time; manual setting would be preferable.

☞ For details ➡ Refer to Section 3.4 "Basic operation" and Section 3.2.2 "Initial setting".

For selection of input signal (SIGNAL) and reference signal (SOURCE, EDGE), use manual operation.

③ SHIFT + INITIALIZE Initial setting key

Press the SHIFT + INITIALIZE keys to set measurement-related setting parameters to the initial values.

☞ For details ➡ Refer to Section 3.2.2 "Initial setting".

④ RATIO ON Ratio indication key and indication lamp

Once the key is pressed and the ON lamp is lit, X, Y and R measurements will be shown in proportion to the voltage supplied to AUX IN1 on the rear panel.

$$\text{Ratio} = K \times \frac{\text{Percentage of Y, Y and R to the sensitivity}}{|\text{AUX IN1}|\ [\text{V}] \times 10}$$

Indication range: ±2.4

☞ For K constant ➡ Refer to the description of ④ SHIFT + K key.

Supply a voltage as close to the full scale as possible to AUX IN1 in order to improve the accuracy.

☞ For details ➡ Refer to Section 4.9 "Ratio indication".

④ SHIFT + K K constant setting key

This function sets the proportional constant K used in ratio calculation.

Press these keys, and the K lamp of the REFERENCE indication section will light up, showing the K constant. An arbitrary value ranging from 0.1000 to 9.999 may be selected for K setting. Using the ◀ and ▶ keys to specify the digit, and make setting with the MODIFY dial. Press ⑯ SHIFT + EXIT keys to return to the previous indication.

⑤ DATA1 DISPLAY DATA1 display parameter switching key and indication lamp

By pressing this key, the user can select the parameter shown in DATA1 in the following order:

→ X → R → NOISE → AUX IN1→

X : The signal component of the same phase as the reference signal (= Rcos θ)

R : The magnitude of the signal (=$\sqrt{X^2+Y^2}$)

NOISE : The noise density of input signal

AUX IN1 : The DC voltage of the signal supplied to the AUX IN1 connector on the rear panel

If "R" is used, unlike using X or Y, we can obtain the signal magnitude without adjusting the phase offset.

☞ For details ➡ Refer to Section 4.8.2 "Selection of measurement parameters".

If NOISE is selected, AUX IN1 will be forced to appear on DATA2

To set the sensitivity for selected NOISE, use the noise density.

☞ For details ➡ Refer to Section 4.10 "Measurement of noise density (NOISE)".

⑥ SHIFT + LPF THRU Low-pass filter ON/OFF switching key

Press the key to toggle between enabling and or disabling the anti-aliasing filter that removes unnecessary components in the signal system. When ㉚ LPF THRU lamp is lighting, the filter is disabled. If you do not need quick response, keep the lamp unlit.

☞ For details ➡ Refer to Section 4.4 "Operation of anti-aliasing filter".

⑥ NORMALIZE Normalizing function switching key

Press the key and the display will change in the following order:

→ Initial value → dB → % →

The user can display the ratio of the measurement (X or R) to the standard value (STD) for reference in dB or %.

☞ For details ➡ Refer to the description of ⑥ SHIFT + STD.

If NOISE or AUX IN1 has been selected on DATA1, the previous measurement is displayed even when dB or % lamp is lighting.

dB : The displayed value = 20 LOG_{10} | X or R measurement/standard value |
Display range of ±120.00dB

% : The displayed value = (X or R measurement/standard value) × 100
Display range of ±199.99%

The values of 100 dB and 200% in the above two correspond to 10V of the DATA1 OUTPUT output voltage, respectively.

☞ For details ➡ Refer to Section 4.8.5 "Normalize (dB, %)".

⑥ SHIFT + STD Standard value setting key

This operation sets the standard value to be used when determining dB and % with the normalize function. Press these keys and a standard value will appear on the DATA1 digital display.

Voltage can be set in the range between 1.0000nV and 1.0000V and current between 1.0000fA and 1.0000 μA. Use the ◀ and ▶ keys to specify the digit and make setting with the MODIFY dial. If the user uses the ◀ and ▶ keys to blink the unit lamp, the value can be adjusted in ten-time units using the MODIFY dial. Press ⑯ SHIFT + EXIT keys to return to the previous indication.

DATA1	DATA2	REFERENCE
1.2345 μ	Std	

⑦ DATA1 Digital display

OVER: Over-level indication lamp

This display shows the measurement of the parameter selected by the DISPLAY key in numbers.

The OVER lamp lights up on the following conditions:

- Indication over-level : The range of measurement or indication is exceeded.
- Intermediate over-level : The range of band-limiting filter etc. is exceeded during processing.
- Input over-level : The range is exceeded in the first amplifier of SIGNAL INPUT.

A correct measurement is not available when the OVER lamp is lighting.

Intermediate stage or input over-level does not affect measurement of AUX IN1 and AUX IN2.

If the OVER lamp lights up in X or R, increase the sensitivity setting and/or dynamic reserve.

⑧ DATA1 OFFSET [ON] X output offset ON/OFF key

Pressing this key to light the ON lamp enables the user to cancel the X offset. Another press on the key will turn off the X offset.

☞ For details ➡ Refer to the description of ⑨ DATA1 OFFSET key.

⑧ [SHIFT] + [LINE] Power frequency specifying key

This key specifies the power frequency in order to eliminate the power frequency noise. Pressing this key will show the current set value on the REFERENCE digital display. Select 50 (Hz) or 60 (Hz) using the MODIFY dial. If the actual power frequency is different from the value specified here, sufficient noise attenuation cannot be achieved. Press ⑯ SHIFT + EXIT keys to return to the previous indication.

DATA1	DATA2	REFERENCE
	Lin	50

⑨ DATA1 OFFSET [MODIFY] X output offset modify key

Press this key to display and/or set the offset value to be subtracted from X.

When the key is pressed, the X OFFSET lamp of the REFERENCE indication section lights up and the X offset value appears on the REFERENCE digital display. The offset value is expressed in percentage in relation to the sensitivity full scale for 100%.

The offset can be set in the range of ±100.00% using the MODIFY dial. If the X offset is ON at the moment, X indication value immediately changes according to the change of the offset value. Therefore, the X value can be manually adjusted to zero easily

☞ For details ➡ Refer to Section 4.8.3 "X and Y offset".

⑨ [SHIFT] + [LAMP] Lamp ON/OFF key

Pressing the SHIFT + LAMP keys turns off all lamps and digital displays. This will prevent light of lamps from giving noise during optical measurement. Press the SHIFT + LAMP keys when all lamps are off to return to the previous lighting condition.

Buttons are operable even when the lamps are turned off.

⑩ DATA1 [EXPAND] X and R indication expand key

Press this key to light up the ×10 or ×100 lamp to increase the X and R effective sensitivity and resolution. For example, set the sensitivity to 100 μV and select ×10 in EXPAND, and the effective sensitivity (full scale) will be 10 μV. However, this function is not available to expand NOISE or AUX IN1.

To monitor small change, adjust OFFSET to decrease the displayed value first, then use EXPAND for enlarging.

⑩ SHIFT + FAN Fan ON/OFF key

Use this function to stop the cooling fan provided inside the rear panel. This will prevent the fan sound from giving noise during acoustic measurement.

When the SHIFT + FAN keys are pressed, the current setting appears on the REFERENCE digital display. Select ON or OFF using the MODIFY dial. Press ⑯ SHIFT + EXIT keys to return to the previous indication.

DATA1	DATA2	REFERENCE
	FAn	oFF

Do not keep the fan turned off for an extended time if the ambient temperature is higher than 30℃ because stopped fan will permit the internal temperature to rise.

⑪ DATA2 DISPLAY DATA2 indication parameter switching key

Pressing the key enables the user to select the parameter to be shown on the DATA2 display in the following order:

→ Y →θ→ AUX IN1→ AUX IN2→

Y : The signal component of the phase orthogonal to the reference signal (= R sin θ)

θ : The phase difference between the signal and the reference signal

AUX IN1 : DC voltage supplied to the AUX IN1 connector on the rear panel

AUX IN2 : DC voltage supplied to the AUX IN2 connector on the rear panel

☞ For details ➡ Refer to Section 4.8.2 "Selection of measurement parameter".

⑪ SHIFT + SPECIAL Special operation key

Use this key when to operate infrequently used functions or optional functions.

Follow the procedure below:

1) Press the SHIFT + SPECIAL keys.
2) Using the MODIFY dial, select the type of the parameter to be operated.
   Available types are external interface, noise measurement smoothing time constant, and spare control signal
3) Use the ▶ key to move to the value or selection item on the REFERENCE digital display. (Use the ◀ key to return to the type selection.)
4) Using the MODIFY dial, set or select the value.
5) Press ⑯ SHIFT + EXIT keys to return to the previous indication.

a) Selection of external interface

Select the external interface for use, either GPIB (GPib) or RS-232 (232). Both GPIB and RS-232 cannot be used at the same time.

DATA1	DATA2	REFERENCE
	intFc	Gpib
	Type	Selection item (or value)

b) Noise measurement-smoothing filter

Specify the response time constant for the smoothing filter used in measurement of noise density. Choose one out of 1, 4, 16 and 64. The factory default setting is "1". With this setting, the standard deviation will be 5% or so when measuring broadband white noise. The setting is based on an assumption that a recorder is used for data recording. Every four-time magnification of the value specified here will halve the dispersion of the measurement. However, the response time will be increased in proportion to the setting.

	noiSe	4

☞ For details ➡ Refer to Section 4.10.1 "Measurement of noise density (NOISE)".

c) Spare control signal

This function sets the spare control signal to be used for options or modification work by the manufacturer.

If this signal is operated during measurement, noise may be admitted. Therefore, do not operate this signal if the operation procedure is not contained in the instruction manual for the option or modification work.

	cnt00	2

⑫ DATA2 Digital display

OVER: Over-level indication lamp

The measurement of the parameter selected by the DISPLAY key will be shown in numbers.
The OVER lamp lights up on the following conditions:

- Indication over-level : The range of measurement or indication is exceeded.
- Intermediate over-level : The range of band-limiting filter etc. is exceeded during processing.
- Input over-level : The range is exceeded in the first amplifier of SIGNAL INPUT.

A correct measurement is not available when the OVER lamp is lighting.
Intermediate step or input over-level does not affect measurement of AUX IN1 and AUX IN2.
If the OVER lamp lights up in Y or θ, increase the sensitivity setting and/or dynamic reserve.

⑬ DATA2 OFFSET [ON] Y output offset ON/OFF key

Pressing this key to light the ON lamp enables the user to cancel the Y offset. Another press on the key will turn off the Y offset.

☞ For details ➡ Refer to the description of ⑭ DATA2 OFFSET key.

⑬ [SHIFT] + [BAUD] Baud rate setting key

This function sets the communication speed (baud rate) for performing RS-232 serial communication. Press the SHIFT + BAUD key, and the current baud rate setting will appear on the REFERENCE digital display. When to use RS-232, select the rate in the range between 1200 and 19200 using the MODIFY dial.

DATA1	DATA2	REFERENCE
	bAud	4800

⑭ DATA2 OFFSET [MODIFY] Y output offset modify key

Press this key to display and/or set the offset value to be subtracted from Y.

When the key is pressed, the Y OFFSET lamp of the REFERENCE indication section lights up and the Y offset value appears on the REFERENCE digital display. The offset value is expressed in percentage in relation to the sensitivity (full scale) for 100%.

The offset can be set in the range of ±100.00% using the MODIFY dial. If the Y offset is ON at the moment, Y indication value immediately changes according to the change of the offset value.

☞ For details ➡ Refer to Section 4.8.3 "X and Y offset".

⑭ [SHIFT] + [PARITY] Parity and character length setting key

This function sets the parity bit and the character length for RS-232 serial communication.

Follow the procedure below:

1) Change to RS-232 according to the description of ⑪ SHIFT + SPECIAL keys.
2) Press the SHIFT + PARITY keys.
3) Select one out of N/A (no), odd number (odd) and even number (Evn) for parity bit using the MODIFY dial.
4) Using the [▶] key, move to selection of character length.
5) Select the character length from 7 bits and 8 bits using the MODIFY dial.
6) Press ⑯ SHIFT + EXIT keys to return to the previous indication.

DATA1	DATA2	REFERENCE	If GPIB has been selected:
	Prt c	no 7	GPib will appear.

Parity — Character length

⑮ DATA2 OFFSET [AUTO X, Y] Automatic X and Y offset setting key

Pressing the AUTO X, Y key will automatically set the offset values for X and Y so that both X and Y indication values will be approximately zero, and X and Y offset will be turned on.

☞ For details ➡ Refer to Section 4.8.3 "X and Y offset".

⑮ [SHIFT] + [ADDRESS] Address and terminator setting key

This function specifies the address of this instrument and the message terminator for sending in GPIB.

Follow the procedure below:

1) Switch to GPIB according to the description of ⑪ SHIFT + SPECIAL keys.
2) Press the SHIFT + ADDRESS keys.
3) Set the address in the range between 0 to 30 using the MODIFY dial.
4) Using the [▶] key, move to selection of terminator.
5) Select one out of CR+LF (cL), CR (cr) and LF (LF) for sending terminator using the MODIFY dial. Any of these terminators works when LI5640 receives.
6) Press ⑯ SHIFT + EXIT keys to return to the previous indication.

DATA1	DATA2	REFERENCE	If RS-232 has been selected:
	Adr d	2 cL	232 will appear.

Address Terminator

⑯ DATA2 OFFSET [EXPAND] Y indication expand key

Press this key to light up the ×10 or ×100 lamp to increase the Y effective sensitivity and resolution. To monitor small change, first adjust OFFSET to decrease the displayed value, then use EXPAND for enlarging.

However, this function is not available to expand θ , AUX IN1, AUX IN2.

⑯ [SHIFT] + [EXIT] Return key

Press the SHIFT + EXIT keys to return indication of the previous frequency and measurement if the digital display was used in setting of K constant, GPIB address etc.

⑰ PHASE Phase offset display/setting key
AUTO Automatic phase offset setting key

Pressing the PHASE key will show the value of phase offset on the REFERENCE digital display. To achieve the desired value, move the θ measurement towards negative side by the specified value by shifting the ZERO phase point from the reference signal. Accordingly X and Y values will be changed.

The phase offset can be set in the range between -180.00° and +179.99° using the MODIFY dial.

When the AUTO key is pressed, phase offset is automatically set so that the θ and Y measurements will be zeroed.

If the UNLOCK lamp is lighting, automatic phase offset setting is not available because phase θ measurement is not obtained.

⑰ SHIFT + RECALL Call setting memory key

This function retrieves stored setting from the setting memory.

Follow the procedure below:

1) Press the SHIFT + RECALL keys.
2) Using the MODIFY dial, select the desired setting memory number in the range between 1 and 9.

   Selection of number 0 will return to the setting when power was turned off last.
3) Another press on the SHIFT and RECALL keys will call the setting.

   To abort the calling, press ⑯ SHIFT + EXIT keys.

DATA1	DATA2	REFERENCE	
	rcL	1	← Memory number

⑰ SHIFT + STORE Store setting memory key

This function stores the current setting values in the setting memory.

Follow the procedure below:

1) Press the SHIFT + STORE keys.
2) Using the MODIFY dial, select the desired setting memory number in the range between 1 and 9.
3) Another press on the SHIFT and STORE keys will store the setting values.

   To abort the storing, press ⑯ SHIFT + EXIT keys.

DATA1	DATA2	REFERENCE	
	Str	1	← Memory number

⑱ REFERENCE Reference system indication section (digital display and related indication lamp)

This section mainly displays reference system parameter settings selected by PHASE key etc. Additionally, X offset value, Y offset value, GPIB address and others are also displayed.

UNLOCK Out-of-step indication lamp

This UNLOCK lamp lights up when the system is not synchronized with the reference signal, or the frequency of the signal to be measured is out of the measurement range.

The following causes may be suspected as the reason for not being synchronous with the reference signal.

- The reference signal is not connected properly.
- The reference signal has too small amplitude.
- The waveform of the reference signal differs from the specification (SINE/TTL).
- The frequency is out of the measurement range.
  (If the nF setting is 2 or greater, determination will be made by the harmonics frequency.)
- Frequency or waveform of the reference signal is unstable.

X OFFSET X offset indication lamp

The lighting lamp indicates that the X offset is now displayed.

The offset is expressed in percentage to the sensitivity full scale.

Y OFFSET Y offset indication lamp

The lighting lamp indicates that the Y offset is now displayed.

The offset is expressed in percentage to the sensitivity full scale.

K K-constant indication lamp

The lighting lamp indicates that the K-constant in ratio indication is now displayed.

⑲ FREQ Frequency display/setting key

If the FREQ key is pressed, the frequency of the reference signal will appear on the REFERENCE digital display.

Display resolution is 4-1/2 digits (19999 max).

In harmonics measurement, the frequency of the fundamental wave is displayed.

Even if frequencies are out of synchronism, the frequency that is in action inside is displayed.

When the internal oscillator (INT OSC) is used, the set frequency is displayed. Setting can be made in the range from 0.0005Hz to 105.00kHz using the ◀ and ▶ keys and the MODIFY dial.

To keep synchronization with the measured signal input SIGNAL, first set the frequency near the signal frequency using the MODIFY dial. Once the set value comes near the signal frequency to a certain degree, then it will automatically approach the signal frequency until synchronization is achieved.

☞ For details ➡ Refer to Section 4.1.5 "Synchronization with measured signal (SIGNAL)".

⑲ SHIFT + AUX OUT1 Auxiliary output 1 setting key

This function sets a DC voltage (±10.000V) to be supplied to the AUX OUT1 connector on the rear panel.

Follow the procedure below:

1) Press the SHIFT and AUX OUT1 keys.
2) Using the ◀ and ▶ keys and the MODIFY dial, set the voltage.
3) Press the SHIFT + EXIT keys to return to the previous indication if necessary.

⑳ AMPTD Amplitude display/setting key

Pressing the AMPTD key will display the amplitude of sine wave reference signal output OSC OUT on the REFERENCE digital display. Amplitude setting is available in the range from 0.0000V to 5.00Vrms (up to 100kHz in no-load condition) using the ◀ and ▶ keys and the MODIFY dial.

Three ranges are provided: 5.00V, 0.500V and 0.0500V for full scale. The range can be selected manually. Using the ◀ and ▶ keys, move the blinking digit to the unit indication lamp V, and range selection is available with the MODIFY dial.

⑳ SHIFT + AUX OUT2 Auxiliary output 2 setting key

This function sets a DC voltage (±10.000V) to be supplied to the AUX OUT2 connector on the rear panel.

Follow the same procedure as that for SHIFT + AUX OUT1.

㉑ nF Harmonic order display/setting key

Pressing the nF key will display the order of the harmonic to be measured on the REFERENCE digital display. If the user wants to change the value, specify the desired value in the range from 1 to 19999 using the ◀ and ▶ keys and the MODIFY dial.

If "1" is set for the order, the component of the fundamental wave, or the reference signal frequency, will be measured.

If "2" or larger number is set for the order, the nF lamp blinks if the system is in any of the following states:

- Amplitude or other parameter than harmonic order is displayed (for evocative warning)
- SOURCE has been set in SIGNAL (Fundamental wave will be measured regardless of the set order.)

㉑ SHIFT + KEY LOCK Key lock operation key

This function locks key operation on the panel.

Pressing the SHIFT + KEY LOCK keys will toggle ON/OFF of the KEY LOCK lamp. When the KEY LOCK lamp is lighting, panel operation is disabled except SHIFT + KEY LOCK key operation.

㉒ KEY LOCK Key lock status indication lamp

When the KEY LOCK lamp is lighting, panel operation is disabled except SHIFT + KEY LOCK key operation. If the user wants to enable all operations, press the SHIFT + KEY LOCK keys to turn off this lamp.

㉒ REMOTE Remote status indication lamp

When the REMOTE lamp is lighting, panel operation is disabled except SHIFT + LOCAL key operation. Generally, if remote control is performed via GPIB, panel operation is disabled, turning on the REMOTE lamp.

Pressing the SHIFT + LOCAL keys will turn off the REMOTE lamp, bringing the system back to local control status. However, if the controller is demanding local lock out, SHIFT + LOCAL key operation will be invalid.

㉓ POWER Power switch

Press the top of this switch ("|" side), and the system will be energized. Press the bottom ("○" side), and the power will be turned off.

㉔ MONITOR OUT Monitor signal output connector

The subject signal, which is applied to the SIGNAL INPUT connector, will be amplified and supplied to the MONITOR OUT connector. To view the signal change, observe the monitor signal on an oscilloscope or other device.

Monitor output is isolated from the signal input system and the signal ground is connected to the chassis.

☞ For details ➡ Refer to Section 4.1.3 "Monitor output".

㉕ I, A, B Signal input connectors ⚠

These connectors are used to supply measured signals.

Signal ground is isolated from the chassis in the range of ±1V.

The GROUND key may be used to switch the impedance between the connector and the chassis if necessary.

⚠CAUTION

If a voltage exceeding ±1V is applied between the signal ground and the chassis, a high current will flow, breaking the internal circuit.

- I: Current input connector

Connecting a signal with remarkably high signal source impedance such as current output and charge output to the voltage input connector may cause signal attenuation, or deterioration of frequency characteristics due to connection cable and other capacitance (or electrostatic capacity). In such cases, it is better to connect them to the current input connector.

If current input is not used, attach the supplied protection cap to the current input connector.

⚠CAUTION

If any instrument with low output impedance that can supply high current is connected to the current input connector, excessive current will flow, damaging the current input section. Voltage output instrument, such as general oscillator, should not be connected directly.

- A: Voltage input connector

To connect a signal source and LI5640 with a single coaxial cable, select A with the SIGNAL key and connect the signal to this connector.

- B: Voltage input connector (reverse input)

If the ground potential fluctuates between the signal source and LI5640, affecting the measurement, then select A-B (differential) with the SIGNAL key and connect the reference potential to B connector and the measured signal to A connector. Inverse A/B connection will reverse the phase.

㉖ SIGNAL Signal selection key and indication lamp

This key switches between current input and voltage input, and also specifies current-voltage conversion gain of the current input.

Pressing the SIGNAL key will select in the following order:

→ I (10^6) → I (10^8) → A → A-B →

Setting should be made together with the connection to the signal input connector.

- I (10^6) : Current input; conversion gain 10^6 V/A, sensitivity 50fA to 1 μArms, frequency band up to 50kHz
- I (10^8) : Current input; conversion gain 10^8V/A, sensitivity 5fA to 10nArms, frequency band up to 500Hz
- A : Voltage input; single end, sensitivity 2nV to 1Vrms, frequency band up to 100kHz
- A-B : Voltage input; differential.

㉗ COUPLING Input coupling selection key and indication lamp

Pressing the COUPLING key enables the user to change AC and DC of input coupling.

- AC (AC coupling)

Elimination of the DC components amplifies subtle AC signal sufficiently to ensure high accuracy measurement.

AC is used for frequencies of approximately 1Hz and greater. Since lower frequency would cause measurement error to increase, select DC for 0.1Hz or lower frequencies.

The current/voltage converting section for current input is DC coupling. Since it changes to AC coupling after conversion to voltage, saturation with DC components may occur even if AC setting is selected.

- DC (DC coupling)

Even low frequency does not cause signal attenuation or increase of phase error.

DC is used in frequencies of approximately 1Hz or lower.

DC components are also taken as noise. If the DC components are high, dynamic reserve and sensitivity setting should be increased.

㉘ GROUND Signal ground selection key and indication lamp

Press the GROUND key, and the impedance between the signal ground and the chassis will be changed as follows:

- FLOAT

This mode isolates between the signal ground and the chassis with high impedance (about 10kΩ).
If grounding is made on the signal source side, noise interference due to ground loop may be avoided by setting the LI5640 side to FLOAT.

- GROUND

This mode connects between the signal ground and the chassis with low impedance (about 10Ω).
If the signal source is not grounded, set the LI5640 side to GROUND in order to stabilize the signal ground potential, which will assure little noise interference. At the same time, shield the signal source with the signal ground to produce more effects.

㉙ (SIGNAL INPUT) OVER Input over-level indication lamp

This lamp lights up if the first voltage amplifier or the current/voltage converter is saturated with signal peak. If this happens, try the following operations to manage avoidance.

- Increase the dynamic reserve (→ MEDIUM → HIGH).
- Increase the sensitivity setting.
- Change to I (10^6) if I (10^8) is used.

If the OVER lamp persists lighting even if the above measures are taken to the limit, then it is because the maximum LI5640 allowable input voltage (or current) is exceeded. Reduce the input signal.

㉚ FILTER

LPF THRU Low-pass filter indication lamp

It the anti-aliasing filter to eliminate unnecessary high frequency components in the signal system is disabled and not used, the LPF THRU lamp lights up.
To switch between "to use" or "not to use", press the SHIFT + LPF THRU keys.
If the user needs especially high response with less noise, quick response can be ensured by not using the anti-aliasing filter.
This lamp should usually be turned off because high noise increases measurement error.

LINE/LINE×2 Power frequency noise elimination filter ON/OFF key and indication lamp

Pressing the LINE/LINE×2 will change the notch filter that eliminates the power frequency (LINE) and its twofold frequency (LINE×2) noise in the following order, turning on the lamp of the valid filter.

→ Invalid (Lamp unlit) → LINE → LINE×2 → LINE and LINE×2 →

Noise can be attenuated by 20dB or more at the center frequency of each notch filter. However, around the center frequency, the very signal to be measured is also attenuated.
The power frequency (50Hz/60Hz) should be set in advance.

☞ For details ➡ Refer to the description of ⑧ SHIFT + LINE keys.

㉛ DYNAMIC RESERVE HIGH MEDIUM LOW

Dynamic reserve selection key and indication lamp

The dynamic reserve is an allowance against noise, indicating the level of the greatest noise in relation to the sensitivity full scale where measurement is still possible with that noise.

Pressing the DYNAMIC RESERVE key changes the level in the following order, which is indicated by the lamp:

→ HIGH → MEDIUM → LOW →

☞ For the actual value (in dB) of dynamic reserve ➡ Refer to Table 4-2 "Actual value of Dynamic Reserve".

Unnecessarily increasing the dynamic reserve would deteriorates measurement stability and accuracy. Minimum dynamic reserve should be selected for better operation.

㉜ SENSITIVITY ▽ △ Sensitivity selection keys and indication lamps

Select voltage and current sensitivity (full scale) with these keys. Sensitivity of voltage and that of current are independent of each other. Setting is available in the following range:

Voltage: 2 nV to 1Vrms (1-2-5 sequence)

Current: 5 fA to 1 μArms (1-2-5 sequence)

In measurement of noise density (NOISE), specify the value in the units of $V/\sqrt{Hz}$ and $A/\sqrt{Hz}$. Read V and A as $V/\sqrt{Hz}$ and $A/\sqrt{Hz}$, respectively because "$/\sqrt{Hz}$ " is not shown on the panel.

When either of thee keys is pressed, automatic sensitivity setting process will end halfway.

㉝ (SENSITIVITY) OVER Intermediate step over-level indication lamp

This OVER lamp lights up if signal is too high and any of the LI5640 amplifiers except the first one, phase sensitive detector and subsequent band-limiting filters, and noise measurement system experiences an over-level condition. When this lamp is lighting, proper measurements cannot be obtained. Try to increase sensitivity setting or dynamic reserve in order to prevent saturation with high noise, or to increase the time constant in order to reduce the noise.

☞ For details ➡ Refer to Section 4.6 "Sensitivity operation (SENSITIVITY)".

㉞ SENSITIVITY [AUTO] Automatic sensitivity setting key and indication lamp

Pressing this AUTO key will automatically adjust the sensitivity and dynamic reserve according to the magnitude of the signal. This lamp keep lighting during automatic setting process.

When any adequate setting is found, the automatic setting is completed.

During automatic sensitivity setting, the user may abort the setting by pressing any key such as this AUTO key. If abortion is made with another key than AUTO, the function of that key works as well.

Dynamic reserve will be adjusted to the minimum necessary level.

If signals sharply fluctuate or noise cannot be eliminated sufficiently, or otherwise if the signal is too small, automatic setting will be forced to end after repeating increasing/decreasing the sensitivity. In such occasions, try to manage manual setting.

☞ For details ➡ Refer to Section 4.6 "Sensitivity operation (SENSITIVITY)".

㉟ TIME CONSTATNT [▽] [△] Time constant selection key and indication lamp

With these keys, select the time constant for the low-pass filter that eliminates noise after phase sensitive detector..

Setting is available in the range from 10 μs to 30ks.

As the longer is the time constant, the smaller the equivalent noise bandwidth becomes and thus noise will be eliminated. However, response will be slower.

☞ For details ➡ Refer to Section 4.7.3 "Equivalent noise bandwidth" and Section 4.7.4 "Response time".

㊱ TIME CONSTNT [AUTO] Automatic time constant setting ON/OFF key and indication lamp

Pressing this key will adjust the time constant and synchronous filter (SYNC) setting according to the frequency when the key is pressed.

- Attenuation slope will be set to 24dB/oct.
- The time constant will be set to such a value that the ripple due to the signal frequency will be sufficiently attenuated.
- Synchronous filter turns on at the frequency of approximately 200Hz or lower and turns off at the frequency or higher.

If the noise is high, the time constant by automatic setting may be too short. In such cases, increase the time constant manually.

The AUTO lamp usually looks unlit, which is normal.

㊲ SYNC Synchronous filter ON/OFF key and indication lamp

Pressing the SYNC key and the toggles between ON and OFF of the synchronous filter. Press the key to enable the filter, turning on the lamp, and the control will take the moving average of signal for the integer period. This reduces the ripples that emerge in the output even if a short time constant has been set at a low frequency. If noise is low and a long time constant is not necessary, the user may have a remarkably reduced response time.

☞ For details ➡ Refer to Section 4.7.5 "Synchronous filter (SYNC)".

In measurement of noise density, operation progresses in a state of synchronous filter being off in practice even if "Turn on the synchronous filter" has been specified. The SYNC lamp blinks for evocative warning.

㊳ SLOPE Attenuation slope selection key and indication lamp

This SLOPE key enables the user to select the attenuation slope for the low-pass filter that eliminates noise after phase sensitive detector. Every press on this key switches the slope in the following order, which is indicated by the lamp:

→ 6dB → 12dB → 18dB → 24dB →

The value indicates the attenuation per octave.

Compared with the same equivalent noise bandwidth, the greater the attenuation slope is, the quicker response will be obtained. Therefore, select 24dB/oct for attenuation slope and a shorter time constant if the user's measurement is significant.

To integrate a LI5640 unit in an automatic control loop, the user sometimes has to select 6dB/oct for attenuation slope in order to maintain stability of the control system.

㊴ DATA1 OUT, DATA2 OUT Measurement analog output connector

This connector supplies parameters being shown on the DATA1 display/setting section and DATA2 display/setting section in current voltage with the full scale being ±10V.

OFFSET, EXPAND, RATIO and NORMALIZE are also effective for analog output.

The highest data updating rate is 256k samples/s for X, Y, R and θ and 16k samples/s for other parameters. Amplitude resolution is approximately 16 bits equivalent.

㊵ EDGE Reference signal synchronous edge selection key and indication lamp

Pressing the EDGE key switches the synchronous edge of external reference signal REF IN in the following order:

→ SINE POS → TTL POS → TTL NEG →

SINE POS : Takes the time point at which the average value is crossed upward from below as 0° .

TTL POS : Takes the rising edge of TTL level logic signal as 0° .

TTL NEG : Takes the falling edge of TTL level logic signal as 0° .

With SINE POS, low-frequency signal will be attenuated because REF IN becomes AC coupling. Therefore, use TTL level for approximately 1Hz or lower frequencies. Although the amplitude of sine wave that works properly is 0.3 to 30Vp-p, a sine wave of 2Vrms or so, or a square wave is preferable from the stability viewpoint.

㊶ [◀] Modify digit left shift key

Press this key, and the blinking digit on the indication section moves to the left. Then, in the case of a number, turning the MODIFY dial will increase or decrease the number in the blinking digit and upper.

㊶ [SHIFT] + [CLEAR] Right clear key

When the user is setting a number, pressing this key will zero the number in the digits right to the blinking digit (lower digits excluding the blinking one).

㊷ MODIFY Modify dial

The user can specify a number or select a parameter by turning this dial. The blinking portion is changeable. Turning the dial adds 1 to or subtracts 1 from the figure in the blinking digit, increasing or decreasing the number in that digit and higher. The blinking digit can be moved with the [◀] and [▶] keys.

㊸ [▶] Modify digit right shift key

Press this key, and the blinking digit on the indication section moves to the right. Then, in the case of a number, turning the MODIFY dial will increase or decrease the number in the blinking digit and upper.

㊸ [SHIFT] + [LOCAL] Local key

When the system is in a remote control state operated by GPIB, the user can return the system to a local control state for panel operation by pressing this key. However, if the system is in a local lockout state, this operation cannot return the system to local.

When the system is in a remote control state, the REMOTE lamp keeps lighting.

㊹ SOURCE Reference signal selection key and indication lamp

This key selects the reference signal that plays the role of reference for frequency and phase. Pressing the SOURCE key changes the reference signal source in the following order, which is indicated by the lamp:

→ REF IN → INT OSC → SIGNAL →

- REF IN (external reference signal):
  Takes the signal supplied to the REF IN connector as the reference signal.
- INT OSC (internal oscillator):
  Takes the output of the internal oscillator as the reference signal.
- SIGNAL (measured signal input):
  Takes the measured signal supplied to the SIGNAL INPUT connector as the reference signal.

☞ For details ➡ Refer to Section 4.1.5 "Synchronization with measured signal (SIGNAL)".

㊺ REF IN External reference signal input connector ⚠

If external signals are used, connect to this connector.

A 0.3 to 30 Vp-p sine wave or square wave, and a TTL level square wave are available for reference signal. Using the EDGE key, select the synchronous edge for the reference signal according to the signal type.

If the noise is too high, normal synchronization may not be ensured.

㊻ OSC OUT Internal oscillator output connector ⚠

A sine wave reference signal can be taken from this connector.

If internal oscillator "INT OSC" is selected for reference signal source "SOURCE", the output of the internal oscillator is available from this connector.

If external reference signal input "REF IN" or measured signal input "SIGNAL" is selected for reference signal source, a sine wave signal synchronous with the reference signal is available. If out of synchronization, it will be the internal frequency at the moment.

When harmonics are under measurement, fundamental wave signal will be supplied.

☞ For amplitude setting ➡ Refer to the description of ⑳ AMPTD key.

3.1.2 Rear panel

㊼ ~ LINE Power supply inlet

Use the supplied power cord to supply power to the unit.

☞ For details ➡ Refer to Section 7.12 "Specifications".

㊽ FUSE Power supply fuse ⚠

Use the supplied power supply fuse. Never use nonstandard fuses, which may cause electric shock or fire.

1 A time lag for 100/120 V AC,

0.8 A time lag for 230 VAC,

☞ For details ➡ Refer to Section 7.12 "Specifications".

㊾ VOLTAGE SELECTOR Power supply voltage selector ⚠

Select a setting that meets your power supply voltage.

Securely make setting so that the central line of the slide control will come just to the position of 100/120/230 V indication line.

☞ For details ➡ Refer to Section 7.12 "Specifications".

㊿ Cooling fan

This is the suction port of the cooling fan. If the filter is found to be dirty, remove the fan guard and clean the dust.

☞ For fan ON/OFF ➡ Refer to the description of ⑩ SHIFT + FAN key.

(51) REF OUT Reference signal output connector

This connector supplies a TTL-level square signal synchronous with the reference signal. The rising edge of this signal approximately corresponds to the 0° (synchronous edge) of the reference signal. The signal can be used as the square wave output of the internal oscillator or the trigger signal for the oscilloscope.

(52) X OUT/Y OUT X output, Y output connectors

X signal and Y signal are supplied at these connectors regardless of selection of DATA1 and DATA2 parameters. OFFSET, EXPAND, RATIO and NORMALIZE are also effective for these outputs.

If the measurement is sensitivity full scale, output voltage is ±10V, and data updating rate is 16k samples/s. Amplitude resolution is approximately 16 bits equivalent.

(53) AUX OUT1/AUX OUT2 Auxiliary output connectors 1 and 2 ⚠

The user may supply output of arbitrary DC voltage in the range of ±10.000V at these connectors. Press SHIFT + AUX OUT1 keys or SHIFT + AUX OUT2 keys to display voltage of auxiliary output on the REFERENCE digital display, and the voltage will be ready for change using the MODIFY dial.

⑭ AUX IN1/AUX IN2 Auxiliary input connectors 1 and 2 ⚠

The user may supply input of arbitrary DC voltage in the range of ±12V to these connectors for measurement.

The voltage of AUX IN1 can be viewed on DATA1 or DATA2 and the voltage of AUX IN2 on DATA2. Frequency bandwidth is about 130 Hz, and data updating rate is 16k samples/s.

AUX IN1 is also used as the reference input for ratio indication.

☞ For details ➡ Refer to Section 4.9 "Ratio indication".

⑮ ⏚ Grounding terminal for guard (chassis ground)

Use this terminal in order to shield the signal source etc. by using the chassis potential of lock-in amplifier as the reference potential.

⑯ ±24V OUT ±24V power supply output connector ⚠

This power output connector supplies power to external preamplifier etc. The ground (0V line) of this power supply is connected to the SIGNAL INPUT I, A, B connector's ground.

⚠CAUTION

Do not apply a voltage that exceeds ±1V between the power supply ground and the chassis. This would cause continuity through the diode that limit the ground-to-ground voltage, allowing great current to flow and LI5640 and connected devices may be damaged.

⑰ TRIG IN Trigger signal input connector

To this TRIG IN connector, provide TTL-level signal that defines the timing of recording data in the data memory. The timing will be defined by the falling edge of this signal. The data memory can be operated only by external interface.

⑱ GPIB GPIB connector

This connector is a 24-pin connector for GPIB interface stipulated in the IEEE-488.1 standard. This connector can be overlaid for use in multistage coupling. However, limit the number of stages to three because it may be damaged by great load.

☞ For details ➡ Refer to Section 5. "GPIB Interface".

⑲ RS-232 Serial communication connector

This connector is a 9-pin female connector for RS-232 serial communication.

☞ For details ➡ Refer to Section 6. "RS-232 Interface".

3.1 Name and operation of panel parts

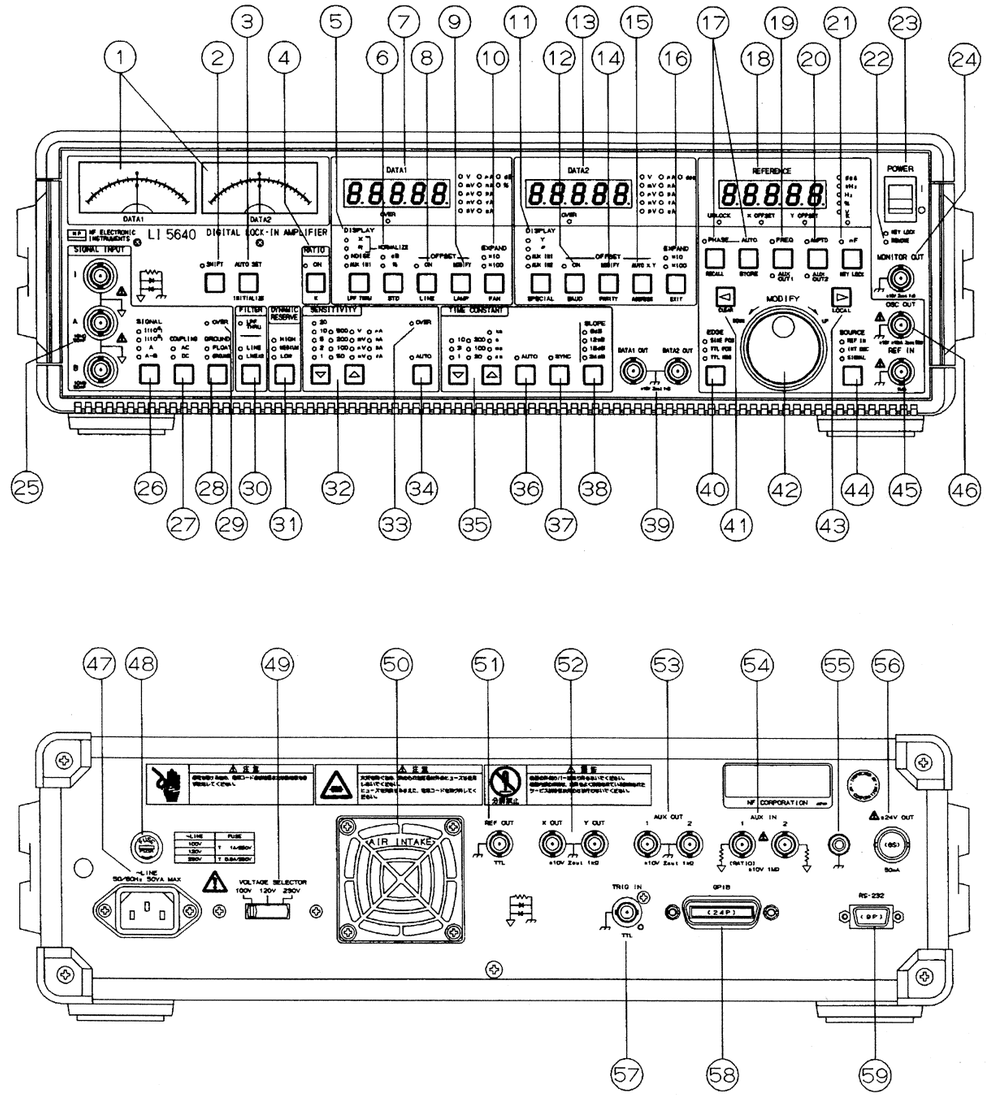


Fig. 3-1 Front and Rear Panels

3.2 Operation at power on and initial setting

3.2.1 Startup

First, make preparation for use according to Section 2 "Preparation before Use".
Turn on the power switch and the system will execute self check. If the check is successful, the system returns to the setting of last power off, or to a specific setting.

☞ For details ➡ Refer to "Automatic resetting" in Table 3-2 "List of Initial Values".

During the self check, the version number of the installed software appears on the REFERENCE digital display.

If any of backed-up settings or contents of setting memory is found to be lost, backup error E 3 appears on the REFERENCE digital display. The user can press the key EXIT with blue characters at the bottom to release the error indication in order to start the system. However, the factory default settings will be used.

☞ For details ➡ Refer to "Factory default settings" in Table 3-2 "List of Initial Values".

Other error indications than E 3 cannot be released, disabling further operation.

If it is the first use of this instrument, please make setting or confirmation of power supply frequency.

☞ Refer to Section 3.2.3 "Setting of power supply frequency".

Table 3-1 Operation at Power ON

Operations	Indications				Error indication on REFERENCE
	DATA1	DATA2	REFERENCE	Other lamps	
All lamp lighting check	All lit	All lit	All lit	All lit	
ROM check	1	Unlit	Version No.	Unlit	E1
RAM check	2	Unlit	Version No.	Unlit	E2
Backup check	3	Unlit	Version No.	Unlit	E3
Internal initialization	4	Unlit	Version No.	Unlit	E4
Internal initialization (continued)	5	Unlit	Version No.	Unlit	E5

3.2.2 Initial setting

The following are initially set statuses summarized in Table 3-2 "List of Initial Values":

- Settings on factory shipment
- Settings on automatic resetting immediately after power turning on
- Settings after initialization by SHIFT + INITALIZE keys

The following information is also shown:

- Settings after automatic setting by AUTO SET key
- Provision for data storage and retrieval to/from the setting memory (No. 1 to 9)

a) Settings immediately after power on

When the unit is powered on, the system retrieves the settings when power was turned off last except for the case in which stored data has been destroyed for any reason.

b) Operation to return to known settings

- Resetting to factory default settings
  While holding down the AUTO SET key, turn on the power. Keep depressing the AUTO SET key until a measurement appears.

- Resetting only measurement-related settings to factory default settings
  Press the SHIFT + INITIALIZE key.
  For settings that relate to measured signals and reference signal selection, make setting separately by manual.

- Resetting to pre-stored settings
  Store settings in the setting memory in advance, and call the data by specifying the number.
  To call the data, press the SHIFT + RECALL keys, then select the number in the setting memory No. 1 to 9 using the MODIFY dial, and again press the SHIFT + RECALL keys.
  To store data, use STORE instead of RECALL.

- Resetting to the settings of the last power off
  After changing the settings, to reset to the settings when power was turned off last (on this power turning on), specify No. 0 and call the setting memory.

Table 3-2 List of Initial Values

Items		Range of value	Factory default	INITIALIZE	AUTO SET	Setting memory	Automatic resetting
SIGNAL INPUT	SIGNAL	I(10^6), I(10^8), A, A-B	A	no change	no change	○	○
	COUPLING	AC, DC	AC	no change	AUTO	○	○
	GROUND	GROUND, FLOAT	GROUND	no change	no change	○	○
FILTER	LINE	OFF, ON	OFF	OFF	no change	○	○
	LINE x2	OFF, ON	OFF	OFF	no change	○	○
	LINE FREQ	50Hz, 60Hz	50Hz	no change	no change	—	◇
	LPF THRU	OFF, ON(THRU)	OFF	OFF	OFF	○	○
DYN RESERVE	DR	HIGH, MEDIUM,LOW	LOW	LOW	AUTO	○	○
SENSITIVITY	V	2nV to 1V (1-2-5)	1V	1V	AUTO	○	○
	I	5fA to 1μA (1-2-5)	1μA	1μA	AUTO	○	○
TIME CONSTANT	TIME CONSTANT	10μs to 30ks (1-3)	100ms	100ms	AUTO	○	○
	SYNC	OFF, ON	OFF	OFF	AUTO	○	○
	SLOPE	6,12,18,24dB/oct	24dB/oct	24dB/oct	24dB/oct	○	○
RATIO	RATIO ON/OFF	OFF, ON	OFF	OFF	OFF	○	○
	K FACTOR	0.1000 to 9.999	1.0000	1.0000	1.0000	○	○
DATA1	DISPLAY	R, X, NOISE, AUX IN1	R	R	R	○	○
	NORMALIZE PARAM.	OFF, dB, %	OFF	OFF	OFF	○	○
	NORMALIZE STD V	1.0000nV to 1.0000V	1V	1V	no change	○	○
	NORMALIZE STD I	1.0000fA to 1.0000μA	1μA	1μA	no change	○	○
	X OFFSET ON/OFF	OFF, ON	OFF	OFF	OFF	○	○
	X OFFSET VALUE	0.00 to±100.00%	0%	0%	0%	○	○
	EXPAND	1(OFF), 10, 100	1	1	1	○	○
DATA2	DISPLAY	θ ,Y,AUX IN1,AUX IN2	θ	θ	θ	○	○
	Y OFFSET ON/OFF	OFF, ON	OFF	OFF	OFF	○	○
	Y OFFSET VALUE	0.00 to±100.00%	0%	0%	0%	○	○
	EXPAND	1(OFF), 10, 100	1	1	1	○	○
REFERENCE *1	DISPLAY	PHASE, FREQ, AMPTD, nF etc.	FREQ	FREQ	FREQ	○	○
	PHASE	-180.00 to +179.99°	0°	0°	0°	○	○
	FREQ (INT OSC)	0.0005 to 10500kHz	1kHz	no change	no change	○	○
	AMPTD	0.0mV to 5.00V (3 RANGE)	0.00V	no change	no change	○	○
	nF	1 to 19999	1	1	1	○	○
	SOURCE	REF IN, INT OSC, SIGNAL	REF IN	no change	no change	○	○
	EDGE	SINE POS, TTL POS, TTL NEG	SINE POS	no change	no change	○	○
KEY LOCK	KEY LOCK	FREE, LOCK	FREE	no change	no change	—	FREE
LAMP		ON, OFF	ON	no change	no change	—	ON
FAN		ON, OFF	ON	no change	no change	—	◇
AUX OUT	OUT1	±10.000V	0V	no change	no change	○	○
	OUT2	±10.000V	0V	no change	no change	○	○
GPIB	ADDRESS	0 to 30	2	no change	no change	—	◇
	TERMINATOR (TX)	CR, LF, CR+LF	LF	no change	no change	—	◇
RS-232	BAUD RATE	1200 to 19200	1200	no change	no change	—	◇
	PARITY	NO, ODD, EVEN	NO	no change	no change	—	◇
	CHAR LENGTH	7, 8	7	no change	no change	—	◇
SPECIAL	INTERFACE	GPIB/RS-232	GPIB	no change	no change	—	◇
	NOISE SMOOTHING	1,4,16,64	1	1	no change	○	○
	OPTION CONTROL	0 to 3 or 0 to 1	0	0	no change	○	○

Complement to Table 3-2 "List of Initial Values"

◇: These parameters return to the original setting when the power is turned on. However, they are stored separately from setting memory 0. Once these parameters are altered, the original setting cannot be retrieved even if the No. 0 setting memory is called by using the SHIFT + RECALL key operation.

*1: If the user turns off the power then turns on the power when any parameter other than PHASE, FREQ, AMPTD and nF appears on the REFERENCE digital display, the system will return to the previous state that was either of PHASE, FREQ, AMPTD and nF.

☞ For external control (GPIB or RS-232) proper initial values ➡ Refer to Section 5 "GPIB Interface".

3.2.3 Setting of power supply frequency

Be sure to make setting or confirmation of power supply frequency on any of the following conditions:

- Immediately after instrument purchasing
- If the unit is moved to a location in where power supply frequency is different
- If the system is reset to the factory default settings

Set the power supply frequency in the following procedure:

- Press the SHIFT + LINE keys to display the set value of power supply frequency.
- Turn the MODIFY dial to select 50 (Hz) or 60 (Hz).
- Press the SHIFT + EXIT keys to complete the setting of power supply frequency.

The above operation is essential to eliminate the noise of power supply frequency and its double frequency mixed in measured signals.

3.2.4 Warm-up

After power turning on, it requires approximately the following time period until the internal temperature stabilizes:

About 30 minutes if cooling fan is in operation

About 45 minutes if cooling fan is not in operation

Before perform precise measurement, wait for twice as long as the above period to ensure sufficiently stabilized temperature.

3.3 Input and output terminals

a) Measured signal input and ±24V power outputs ⚠

These input and power supply have a common ground. This signal ground is insulated from the chassis by ±1V or less. The signal ground is connected to the chassis via an about 10kΩ resistor if FLOAT is selected, and via an about 10Ω resistor if GROUND is selected. If a voltage exceeding ±1V is applied, this insulation cannot be maintained.

⚠CAUTION

If a voltage exceeding ±1V is applied between this signal or power supply ground and the chassis, a great current is allowed to flow, damaging the internal circuit.

☞ For the method of connecting measured signal ➡ Refer to Section 3.4.5 "Connection of measured signal and related setting" or Section 4.2 "Operation of measured signal system".

1) Voltage signal input (A and B) ⚠

Input impedance	: 10MΩ ±1.5%; about 50pF in parallel
Maximum allowable input voltage	:±7V (DC coupling) 5Vrms (AC coupling, sine wave)
Maximum nondestructive input voltage	: 10Vrms AC and ±50V DC for AC coupling ±14V for DC coupling

Application of a voltage exceeding the maximum allowable input voltage will saturate the amplifier, causing distortion. The actual maximum allowable input voltage is the sensitivity plus the value of the dynamic reserve. This value is smaller than the above value.

⚠CAUTION

In the case of AC coupling, application of sine wave greater than 10Vrms or DC voltage greater than ±50V will break the internal circuit. In the case of DC coupling, DC voltage greater than ±14V will do the same.

2) Current signal input (1) ⚠

Input impedance	: <1kΩ (for 500Hz, conversion gain of 10^6V/A) <20kΩ (for 500Hz, conversion gain of 10^8V/A)
Maximum nondestructive input current	: 10mA

⚠CAUTION

Application of ±10mA or greater current will break the internal circuit. Do not connect the voltage source. When it is not used, attach the supplied protection cap.

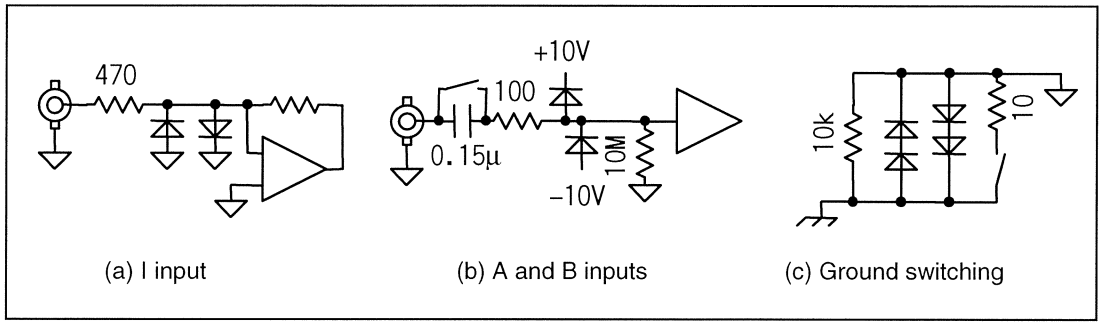


Fig. 3-2 SIGNAL INPUT (I, A and B) Input Circuit and Ground

3) ±24V power supply output (±24V OUT) ⚠

Current capacity : 50mA

±24V power output (±24V OUT on rear panel) is provided for the purpose of supplying power to an external preamplifier. Do not use this for other purposes, which may affect the measurement.

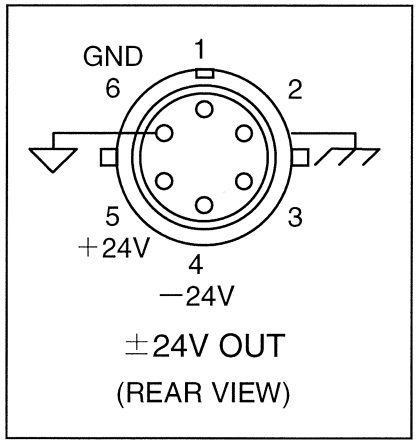


Fig. 3-3 ±24 V Power Supply Output

b) Auxiliary input (AUX IN1 and AUX IN2 on rear panel)

Maximum allowable input voltage : ±12V
Maximum nondestructive input voltage : ±40V
Input impedance : approx. 1MΩ,100pF or less in parallel

The ground for auxiliary input is isolated from the ground of the chassis and measured signal input (I, A and B). Connection may be made at the potential different from the ground of the chassis and measured signal input and within the range of maximum allowable input voltage. However, keep the voltage within ±1V because high potential difference increases measurement error of auxiliary input.

Supply of signals with frequency of 1kHz or greater and high amplitude or signals that suddenly change sharply may affect measurement of I, A or B input

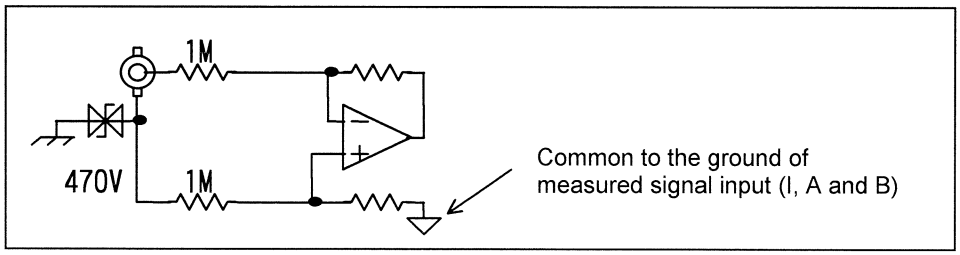


Fig. 3-4 AUX IN1/AUX IN2 Input Circuit

c) Reference signal input (REF IN) ⚠

Input impedance : approx. 1MΩ (1kHz), 100pF or less in parallel
Range of input voltage : 0.3 to 30Vp-p (SINE POS, sine wave)
0 to 5V (TTL POS/TTL NEG)
Maximum nondestructive input voltage : ±40V

The ground of REF IN is connected to the chassis.

If the user takes the point at which the reference signal wave crosses their average value as the phase reference point, set the EDGE to SINE POS. If it contains a DC component, keep the peak value from exceeding ±40V.

The range of input voltage for the case in which a square wave that has a remarkably different proportion between the high-level period and the low-level period is used will be 15Vp-p.

If a TTL-level logic signal is used, set to TTL POS or TTL NEG. The threshold voltage is about 1.5V.

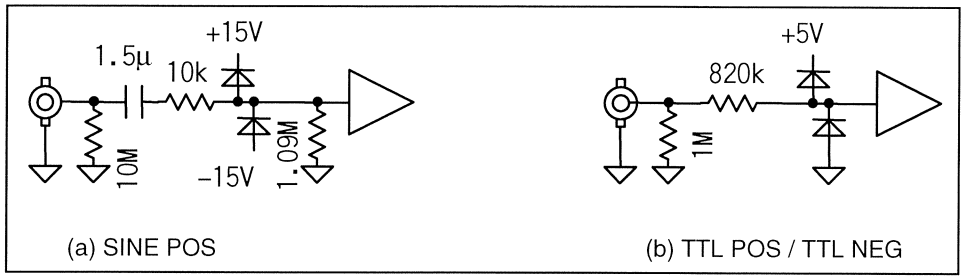


Fig. 3-5 REF IN Input Circuit

d) Reference signal output (internal oscillator) ⚠

The unit provides the output of the internal oscillator, or a signal that is synchronous with the external signal at the OSC OUT connector or at the rear panel REF OUT connector. At OSC OUT, available is a sine wave whose amplitude cab set in the range of 0 to 5Vrms and at REF OUT available is a TTL-level square wave. The signal ground is connected to the chassis.

OSC OUT output voltage : 0.0000 to 5.00Vrms (when no-load)

OSC OUT maximum output current : ±10mA

OSC OUT output impedance : 50Ω ±3 % (1kHz)

⚠CAUTION

Do not apply external voltage to the output connectors, which breaks the internal circuit.

OSC OUT has a limit for output current. 50Ω load cannot be connected.

Keep the load to the REF OUT ground or to +5V to 500Ω or higher.

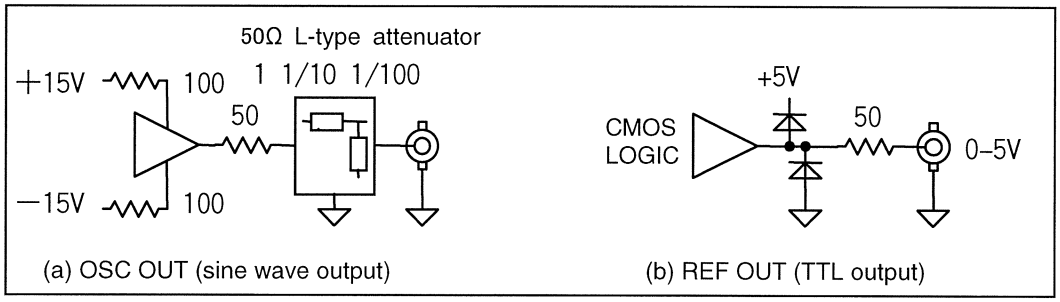


Fig. 3-6 Reference Signal Output Circuit (internal oscillator)

e) Output of measurement result, auxiliary output and monitor output

The following shows about connectors of DATA1 OUT, DATA2 OUT and rear panel X OUT, Y OUT, AUX OUT1, AUX OUT2 and MONITOR OUT.

Maximum output voltage : ±12V

Maximum output current : ±6mA

Output impedance : approx.1kΩ (DC)

The grounds of the above outputs are connected to the chassis.

Since the output impedance is approximately 1kΩ, connection of a low input impedance device will increase the error. For load, connect device with high input impedance such as recorder, multi-meter and oscillator.

⚠CAUTION

Do not apply external voltage to the output connectors, which breaks the internal circuit.

The connectors have a limit for output current. Keep the load impedance to 1kΩ or higher.

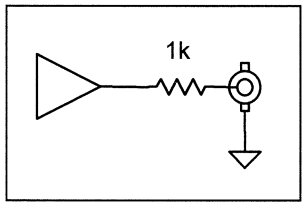


Fig. 3-7 Data1/2 OUT, X/Y OUT, AUX OUT1/2, and MONITOR OUT Output Circuits

f) Trigger input

Signal level	: TTL level (falling edge)
Input impedance	: approx. 10kΩ (pull up to +3.3V)
Maximum nondestructive input voltage	: ±40V

The ground of TRIG IN is connected to the chassis.

With a voltage exceeding approximately +4V, the input impedance will be decreased to about half level.

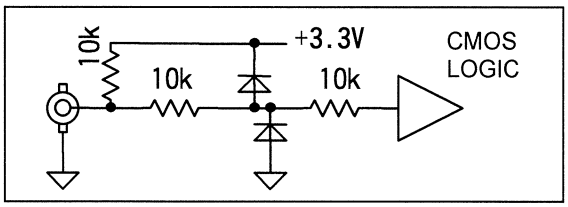


Fig. 3-8 TRIG IN Input Circuit

g) Others

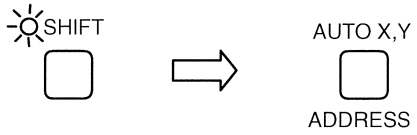
☞ For allotment of RS-232 connector signal ➡ Refer to Section 6.1.4 "Connection of RS-232 cables".

3.4 Basic operation

3.4.1 Shift and Modify operations

[Shift operation]

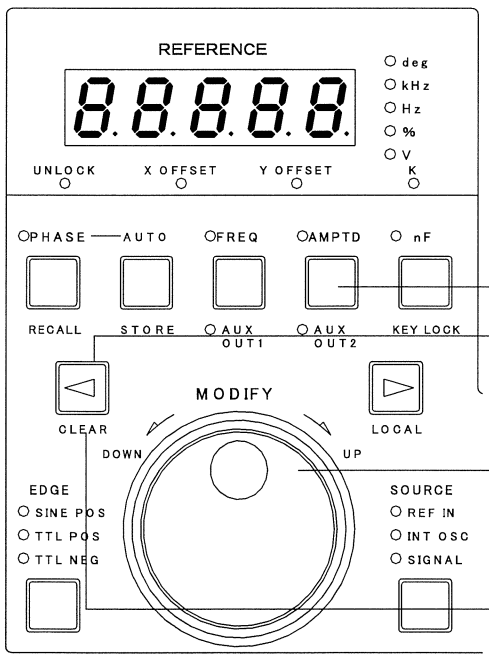
In the following sections, expression such as [SHIFT + ADDRESS] means: press the SHIFT key to turn on the SHIFT lamp, then press the key that has ADDRESS indicated in blue characters at the bottom.



[Modify (setting and selection of value)]

Press the key that correspond the parameter that the user wants to modify, and the value of that parameter will appear on the REFERENCE digital display. As you turn the MODIFY dial, the number in the blinking digit and upper changes. The blinking digit can be selected with the "Move modify digit" keys ◀ and ▶. For FREQ and AMPTD, move the blinking digit to the unit lamp, then you can change the number by ten times units (or change the range).

The value of some types of parameter is shown on the DATA1 or DATA2 displays and some other parameters should be selected by using the MODIFY dial.



Example: Changing the amplitude of internal oscillator

1) Display the amplitude.

2) Select the digit for change (the blinking digit).
To change the value by 10 times units
(change the range), make the unit lamp blink.

3) Alter the value or the range

4) If the user wants to zero the number in the blinking digit and lower, press: SHIFT + CLEAR

3.4.2 Operation when using the unit for the first time

Before using the instrument, read Section 2. "Preparation before Use".
If the settings on the previous occasion are unknown, it may be easy to turn the system to the initial state.

☞ For details ➡ Refer to Section 3.2.2 "Initial setting"

- Press the SHIFT + INITIALIZE keys. → Returns the measurement conditions to a specific setting.
- While holding down the AUTO SET key, turn on the power. → Returns to the factory default setting.

Operation should follow the procedure below:

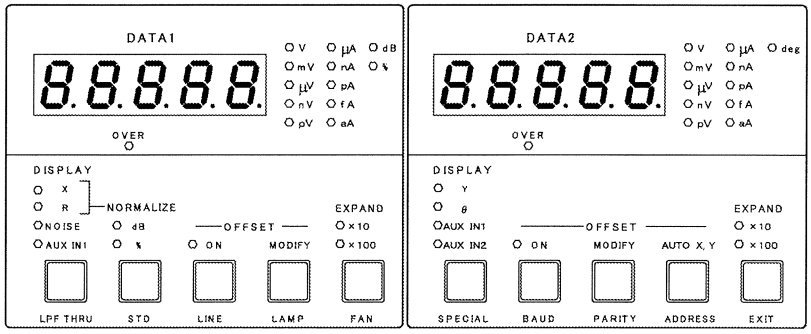
1. Select the parameter for measurement.
   Select the desired parameter for display such as X, Y, R and θ .

2. Connect the reference signal.
   Supply the reference signal from outside in order to give the frequency and the reference phase of the signal for measurement.
   It is also possible to generate reference signal using the internal oscillator.
   Automatic setting is not available for switching the reference signal.

3. Connect the measured signal.
   Connect the desired signal for measurement to the signal input connector of voltage or current.
   Automatic setting is not available for switching signal input.
   Also make setting for processing of ground according to measurement environment.

4. Set the measurement conditions.
   Select the sensitivity (or the meter full scale) to meet the magnitude of the signal to be measured.
   Select the dynamic reserve, time constant etc. to meet the intensity of the noise.
   The above can be automatically set using the AUTO SET key etc.
   Make automatic setting once, and then make fine adjustment so that a proper condition will be achieved.

3.4.3 Selection of measurement parameter



LI5640 can display two measurement parameters at the same time.

For selection, use the DISPLAY keys of DATA1 and DATA2.

- DATA1

X : The signal component of the same phase as that of the reference signal (phase of 0°)

R : The magnitude of signal ($=\sqrt{X^2+Y^2}$)

NOISE : The noise density (DATA2 indicates AUX IN1 regardless of setting.)

AUX IN1 : The DC voltage of AUX IN1 on the rear panel (up to ±12V)

- DATA2

Y : The signal component orthogonal to the reference signal (phase of 90°)

θ : The phase of the signal in relation to the reference signal

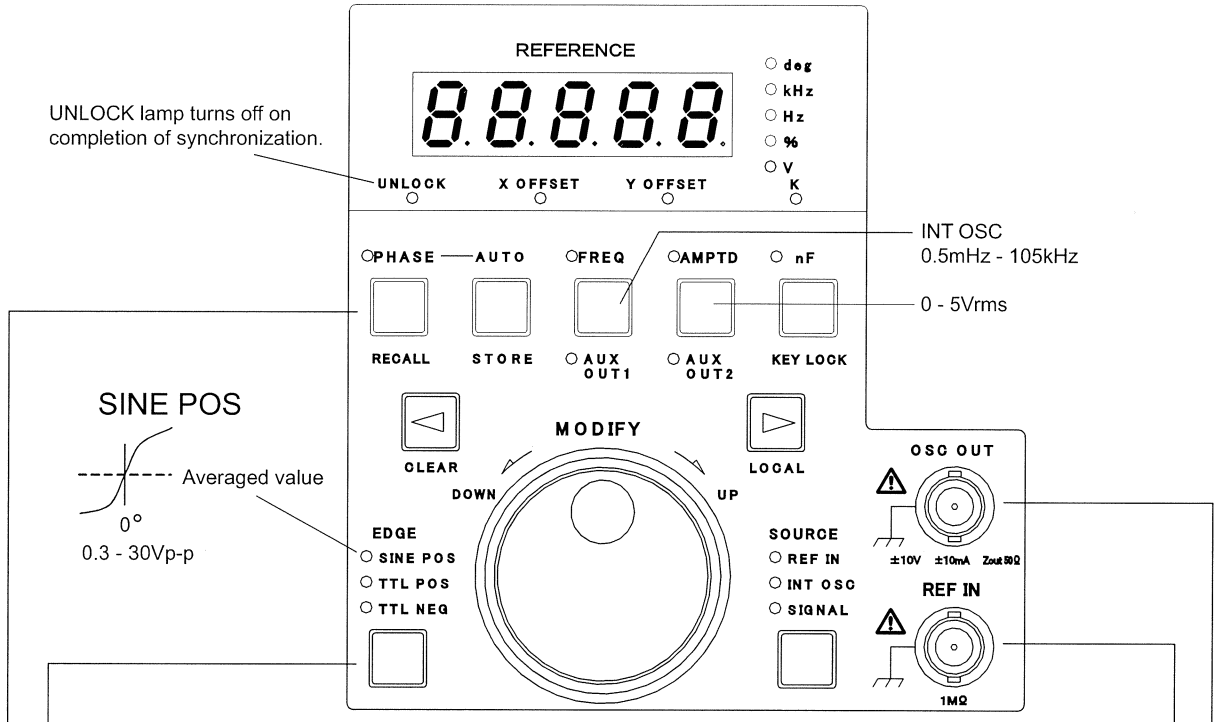
AUX IN1 : The DC voltage of AUX IN1 on the rear panel (up to ±12V)

AUX IN2 : The DC voltage of AUX IN2 on the rear panel (up to ±12V)

Two measurements can be obtained in the following three forms:

- Digital expression
- Analog meter indication
- Analog voltage (DATA1 OUT, DATA2 OUT; 16 bits, maximum 256k samples/s)

3.4.4 Connection and setting of reference signal



Connect to the REF IN connector an external reference signal having the same frequency as the measured signal in order to give the frequency and the reference phase of the signal for measurement. Select REF IN with the SOURCE button.

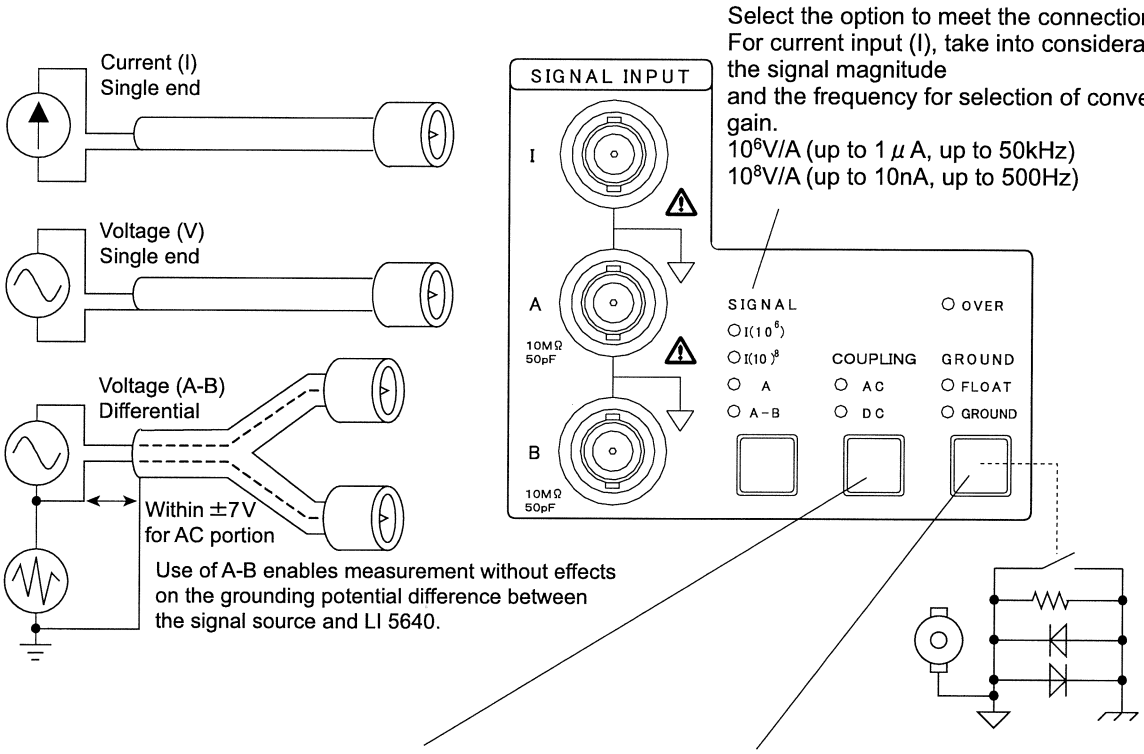
This button specifies the phase reference point to meet the external reference signal. If the user takes the point at which a sine wave or square wave crosses the mean average level upward from below as the reference point for the phase, select SINE POS with the EDGE button. When using a TTL-level square wave, the user can select either point of the rising edge (TTL POS) or the falling edge (TTL NEG).

The user may generate a sine wave reference signal of an arbitrary frequency (0.5 mHz to 105 kHz) and amplitude (0 to 5 Vrms) by means of the internal oscillator (INT OSC). To use the internal oscillator, select INT OSC with the SOURCE button. A TTL-level square wave is also obtained from REF OUT on the rear panel.
Set the frequency and amplitude of sine wave output after pressing the FREQ button or AMPTD button, respectively.

The user may shift the reference phase (position of 0 degree) from the reference signal.
To read the signal magnitude from the X measurement, first press the PHASE button, and then adjust the phase offset so that the Y measurement will be zero. The user can also use the AUTO button for automatic setting.

3.4.5 Connection of measured signal and related setting

Connect the signal for measurement to I, A and B connector of SIGNAL INPUT.
Also specify the conversion gain because the current will be converted into voltage for reference.



Select AC (AC coupling) for approximately 1Hz or higher frequencies and select DC (DC coupling) for frequencies lower than 1Hz. AUTO SET enables automatic selection.
Selection of AC will eliminate DC current, so you can measure signals that contain high DC current. However, measurement error is conspicuous for frequencies of 1Hz and lower.
If AC is selected with current input (I), DC current will be eliminated after conversion into voltage. Use this function in the following range of the peak value containing DC current.
±7 μA for 10^6 V/A
±70 nA for 10^8 V/A

Select FLOAT if the signal source is grounded, and select GROUND if it is not.
Grounding both the signal source and the LI5640 input may create a ground loop, admitting noise current in the system, which in turn affects measurement.
If the signal source is not grounded, select GROUND and connect the input signal ground to the enclosurechassis in order to stabilize the potential.

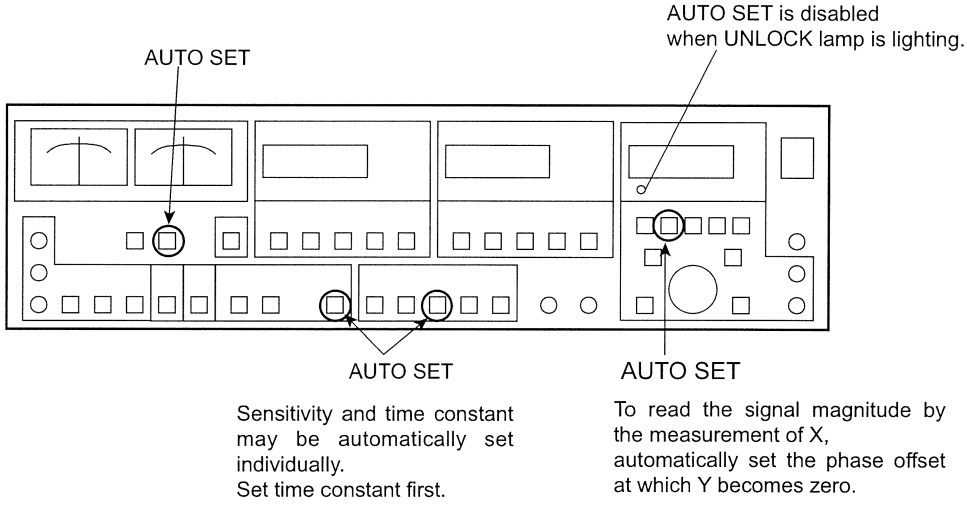
⚠CAUTION

If a voltage exceeding ±1V is applied between the I, A and B input sign ground (outer conductor of the connector) and the LI5640 chassis, a high current flows in the internal circuit and breaks it.

3.4.6 Setting measurement conditions (for makeshift measurement)

If the user is not yet familiar with the setting procedure, follow the procedure below:

- Connect the signal for measurement, set the ground and connect and set the reference signal.
  Selection of the measured signal and selection of reference signal should be set manually.
- Press the AUTO SET key.
  This step will set the sensitivity and time constants automatically, and the signal magnitude R and the phase θ will appear.



If AUTO SET could not measure satisfactorily, then modify only necessary settings to continue measurement.

For 1 Hz or lower, manual setting is preferable because automatic setting takes time.

AUTO SET displays the measurement in R and θ. To view X and Y, change the indication using the DISPLAY key of DATA1 and DATA2.

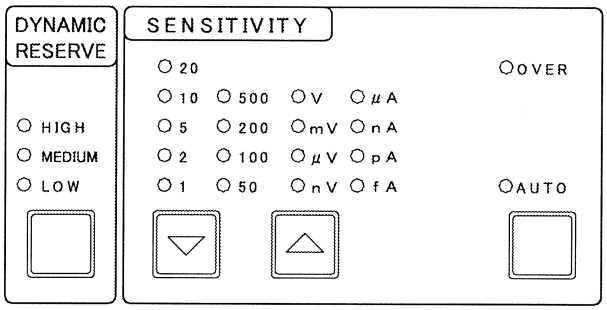
Instead of using the AUTO SET function, measure values broadly following the procedure below to figure out the situation:

- Set the attenuation slope (SLOPE) to 24dB/oct.
- If the frequency is several 10Hz or lower, press the SYNC key to light up the lamp.
- Set the time constant (TIME CONSTANT) to about three times the signal period. However, it must be 30 ms or higher. For frequencies of several 10Hz or lower, select a lower value to expedite response.
- Select HIGH for dynamic reserve.
- Adjust the sensitivity (SENSITIVITY) so that the OVER lamp will not light up and the measurement will come to near full-scale value. However include a margin in the value.
- Reduce the dynamic reserve insofar as the OVER lamp does not turn on.
- If the measurements have a large dispersion, increase the time constant.
- If the dispersion is small, shorten the time constant to have quicker response.
- Fine adjusts the sensitivity, dynamic reserve and time constant.

3.4.7 Optimizing the sensitivity

a) Indication value is too small, or too large causing OVER

If the measurements of X, Y and R are too small in relation to the meter full scale to read easily, or if they exceed the display range, causing the DATA1 and DATA2 OVER lamps to light up, adjust the sensitivity setting using the ▽ key and the △ key of SENSITIVITY.



b) OVER lamp of SIGNAL INPUT turns on

This is because the input circuit is set to an over-level value. Operate as follows:

- Increase the dynamic reserve (LOW → MEDUM → HIGH).
- Increase the sensitivity setting with the SENSITIVITY △ key.

If the OVER lamp tends to light up even with the dynamic reserve set to HIGH, it is because the input is exceeding the maximum LI5640 level. Input signal must be reduced. If the input signal contains a large number of DC components, select AC coupling (AC).

c) OVER lamp of SENSITIVITY turns on when the indication does not reach the full scale

This is because an over-level condition has occurred due to noise during signal processing.

If the OVER lamp of SENSITIVITY tends to turn on even when X, Y or R measurement does not reach the sensitivity full scale, try the following steps:

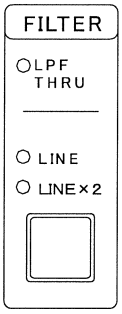
- Increase the time constant (TIME CONSTANT) and the attenuation slope (SLOPE).
- Increase the dynamic reserve (LOW → MEDUM → HIGH).
- Increase the sensitivity setting with the SENSITIVITY △ key.

(When the measurement lowers to 1/10 or less of the sensitivity full scale, you may still use the EXPAND key for enlarging.)

3.4.8 Narrowing the dispersion, or quicken the response

a) To narrow the dispersion

If X, Y, R or θ measurement is not readable because of dispersion due to noise, make adjustment shown below.



- If noise of power supply frequency (hum) interferes:

Press the LINE/LINEx2 key of FILTER to turn on the LINE or LINEx2 lamp in order to attenuate the power supply frequency components and their two-time frequency components.

☞ For setting of power supply frequency ➡ Refer to Section 3.2.3 "Setting of power supply frequency".

However, if the desired signal for measurement is close to these frequencies, the very signal will be attenuated, and also the phase will be changed.

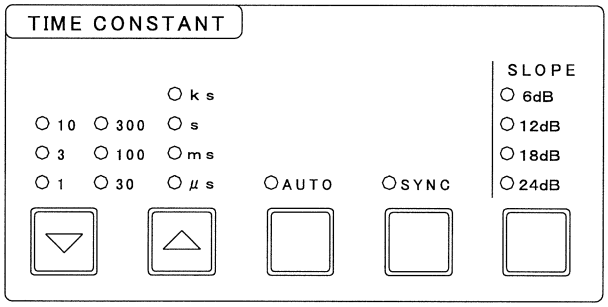
- If high noise comes from other than power supply frequency:

Increase the time constant (TIME CONSTANT) and the attenuation slope (SLOPE), and decrease the equivalent noise bandwidth.

If the SLOPE is low, use the SLOPE key for increasing.

If it is already 24 dB/oct, use the TIME CONSTANT △ key to increase the time constant.

The above measures can narrow the dispersion although the response is slowed.



In addition, if the reference signal is unstable, measurement dispersion becomes greater. Use stable and noise-free reference signal.

b) Quicken response

If noise is low, the user can quicken X, Y, R and θ response.

Decrease the time constant with the TIME CONSTANT ▽ key.

The above measure can quicken the response although the dispersion becomes greater.

In addition, a steeper attenuation slope and a shorter time constant will quicken the response if comparison is made on the same noise elimination performance (equivalent noise bandwidth).

c) Reduce ripples

Even if the noise is low, too much shortening of time constant (with low SLOPE, in particular) will leave ripples of the measured signal frequency and its two-time frequency in the

measurements. In such cases, press the SYNC key to light the lamp in order to control the ripples. However, effects will be low if the frequency is high.

3.4.9 Monitoring minor changes (magnitude of signals)

To monitor small changes in X, Y and R, or to remove signal leak-in, the user may subtract a certain amount from the X and Y measurements to display the values. Further, for X, Y and R, the user may magnify the result of subtraction to improve the apparent sensitivity and resolution.

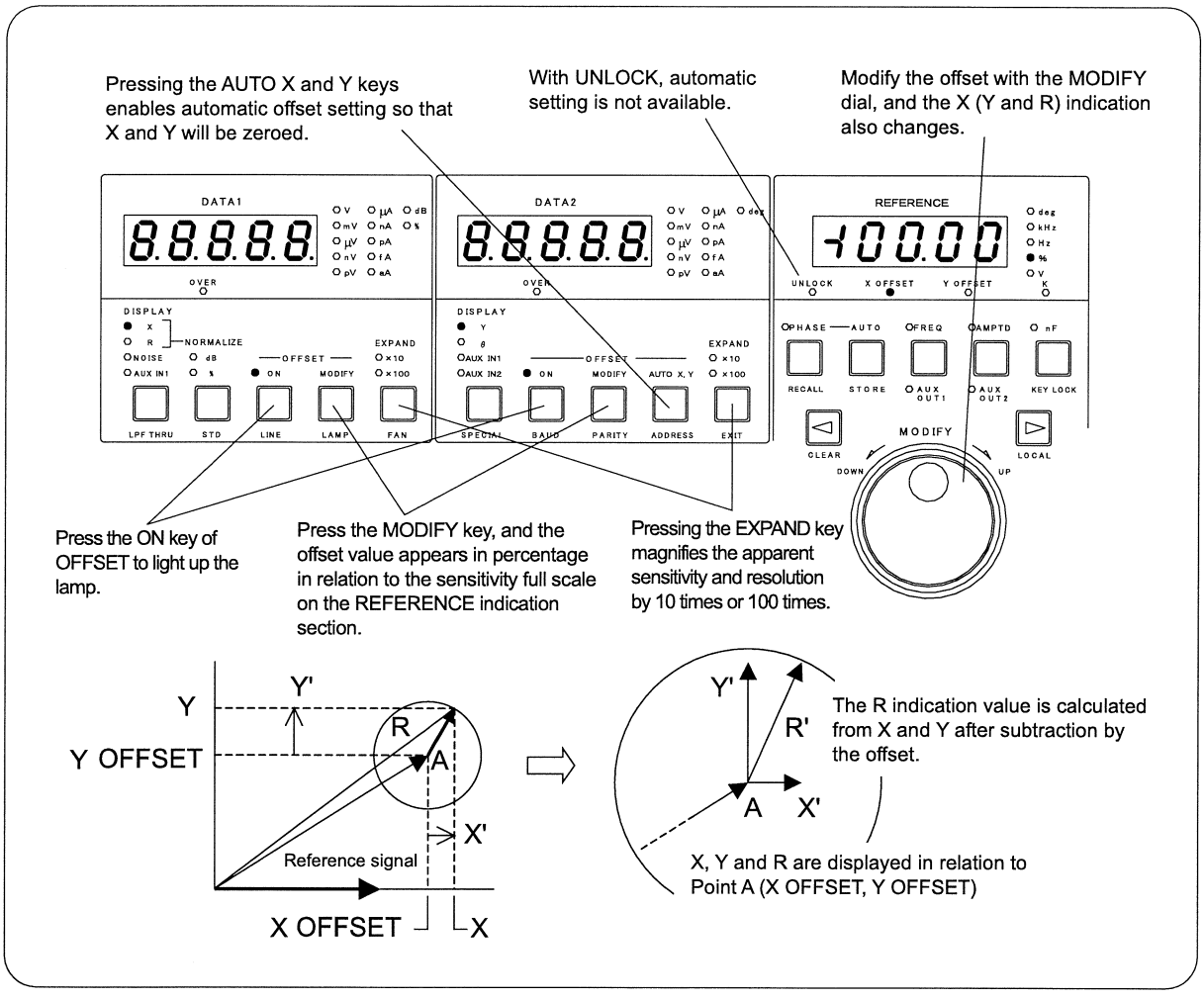


Fig. 3-9 Offset and Enlarging (EXPAND)

3.4.10 Monitoring minor changes (phase)

To monitor small change in phase, give the phase offset in relation to the reference signal.
The display resolution of phase is 0.01° . If further precise resolution is required, give a phase offset so that Y will be almost zero, and then view the Y value by magnifying it with the EXPAND key.
The measurement of the phase viewed from the new reference phase (0°)can be determined from the signal magnitude R and Y by means of the function $\sin^{-1}$ (Y/R).

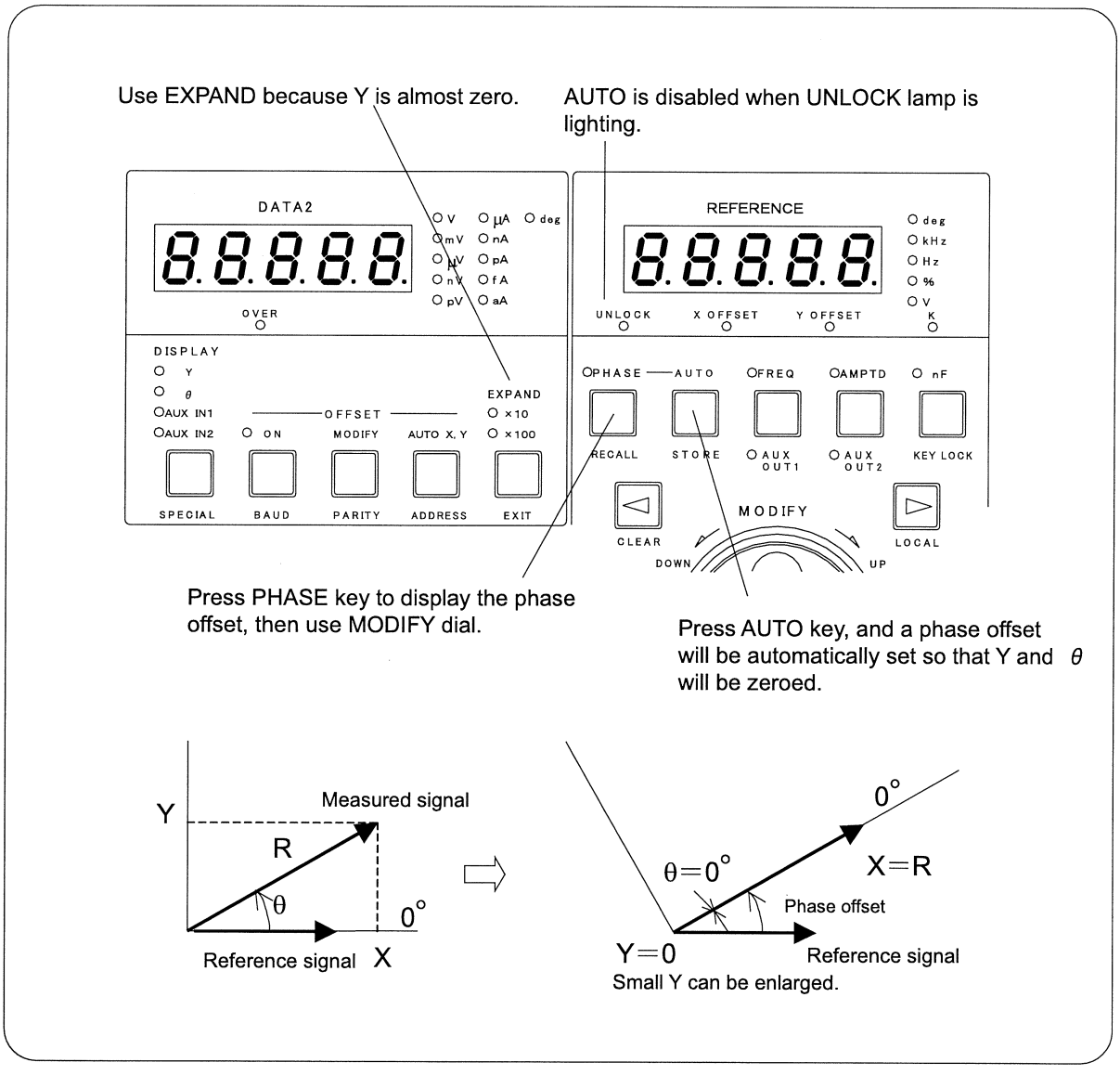


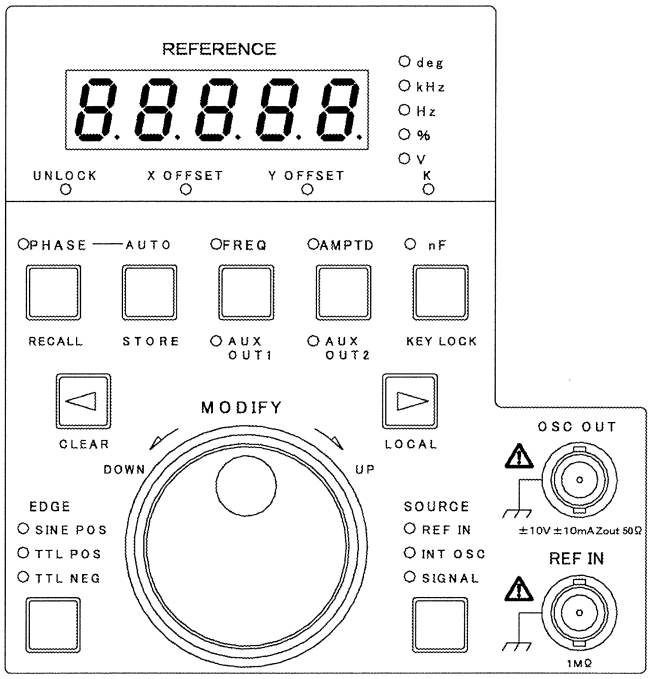
Fig. 3-10 Phase Offset and Phase Resolution Improvement

4. Detailed Description and Applied Operation

4.1 Operation of reference signal system

LI5640 requires a reference signal as the datum for frequency and phase.

4.1.1 Setting a reference signal (overview)



PHASE (- AUTO)

This key displays the phase offset. Shift the reference signal phase so that Y will be zeroed, and the user can read the magnitude of signal at X. It is also possible to do this automatically with the AUTO key.

FREQ

This displays the frequency. Select the internal oscillator INT OSC, and the user can set the frequency in the range from 0.5mHz to 105kHz.

AMPTD

This shows the amplitude of OSC OUT. The amplitude can be set in the range from 0 to 5Vrms.

nF

This shows the order of the harmonics. The order can be set in the range from 1 (fundamental wave) to 19999. However, harmonics must be up to 105kHz.

OSC OUT

This function provides a sine wave from the internal oscillator. Set SOURCE to INT OSC. REF OUT on the rear panel provides a TTL-level square wave.

REF IN

Supply here the external reference signal. Set SOURCE to REF IN. 0.3 to 30Vp-p sine waves (or square waves) and TTL-level square waves are acceptable here.

SOURCE

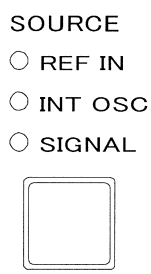
To use external reference signal, select REF IN. To use internal oscillator, select INT OSC. To achieve synchronization with SIGNAL INPUT without supplying a reference signal, select SIGNAL.

EDGE

Use this function to use REF IN. Select SINE POS when to use a sine wave or a square wave in which the phase reference is the point at which the wave crosses the average value. To use a TTL-level square wave, select TTL POS (rising edge) or TTL NEG (falling edge).

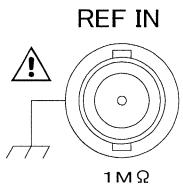
4.1.2 Selection of reference signal source (SOURCE)

LI5640 allows the user to use three types of reference signal. Select with the SOURCE key.



- External reference signal (REF IN)
  Supply reference signal from outside.
  ☞ Refer to Section 4.1.3 "External reference signal (REF IN)".
- Internal oscillator (INT OSC)
  LI5640 generates a reference signal having the specified frequency and amplitude.
- Measured signal (SIGNAL)
  A reference signal synchronous with the measured signal is created internally.

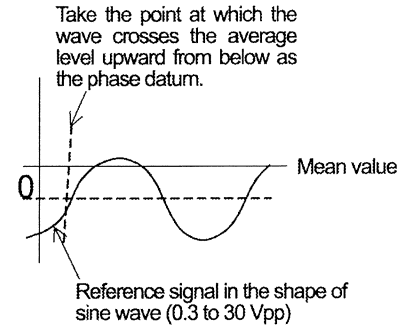
4.1.3 External reference signal (REF IN)



Supply a reference signal to the REF IN connector from a separately prepared signal generator.

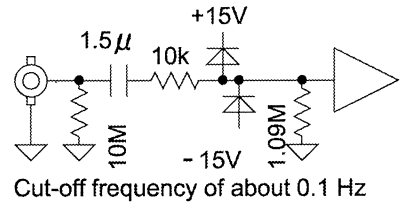
Input impedance	:approx. 1MΩ
Maximum nondestructive input voltage	:±40V
Signal ground	:connected to the chassis

When to use an external reference signal, specify the waveform and phase reference point using the EDGE key.
When the internal oscillator or measured signal is used as the reference signal, the REF IN and EDGE keys are not effective for selection.
In addition, if the reference signal contains noise or time fluctuation, phase noise will increase.

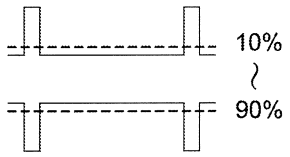


- SINE POS

Use SINE POS for reference signals in which the wave crosses the mean value two times in one period such as sine and square waves.
Input voltage range : 0.3 to 30Vp-p
(Mean value is ±15V for general waveforms)
If this range is exceeded, the protection circuit is activated to lower the input impedance.
If the noise is high, the wave crosses the mean value more than two times, which may hamper proper synchronization.



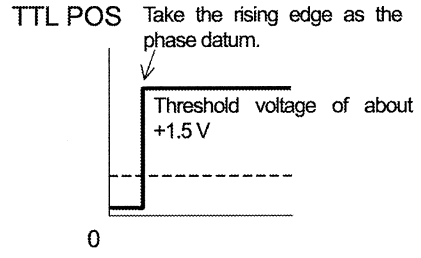
With SINE POS, the system operates regardless of DC components owing to the AC coupling circuit. However, signal attenuation and phase error becomes conspicuous if the frequency is approximately 1Hz or lower. Therefore, SINE POS should be used for 1Hz or higher frequencies. For lower frequencies, square waves with high amplitude are preferable rather than sine waves.

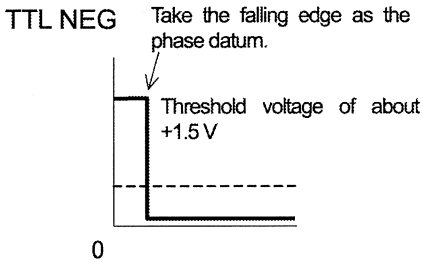


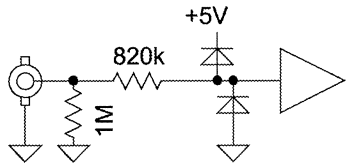
When using a square wave, keep the duty factor (the proportion of high level in one period) within the range of 10 to 90%. If the amplitude is small or frequency is low, keep the duty factor at approx. 50% to avoid malfunction.

- TTL POS/TTL NEG

Use this function when a TTL-level square wave is used for the reference signal.
For reference signal with the frequency of 0.1Hz or lower, a TTL-level square wave is recommended.
Signal level : 0 to 5V
Pulse width : 20ns or longer
(for both high and low levels)
Keep the transition time between the high and low levels to 1 μs or lower in order to avoid malfunction by noise. However, in the case of a square wave that transits very quickly, the waveform may be disturbed, causing malfunction. In such cases, add a resistor with 50Ω or so in series to the reference signal source.







If the range of 0 to 5V is exceeded, the protection circuit is activated to slightly lower the input impedance.

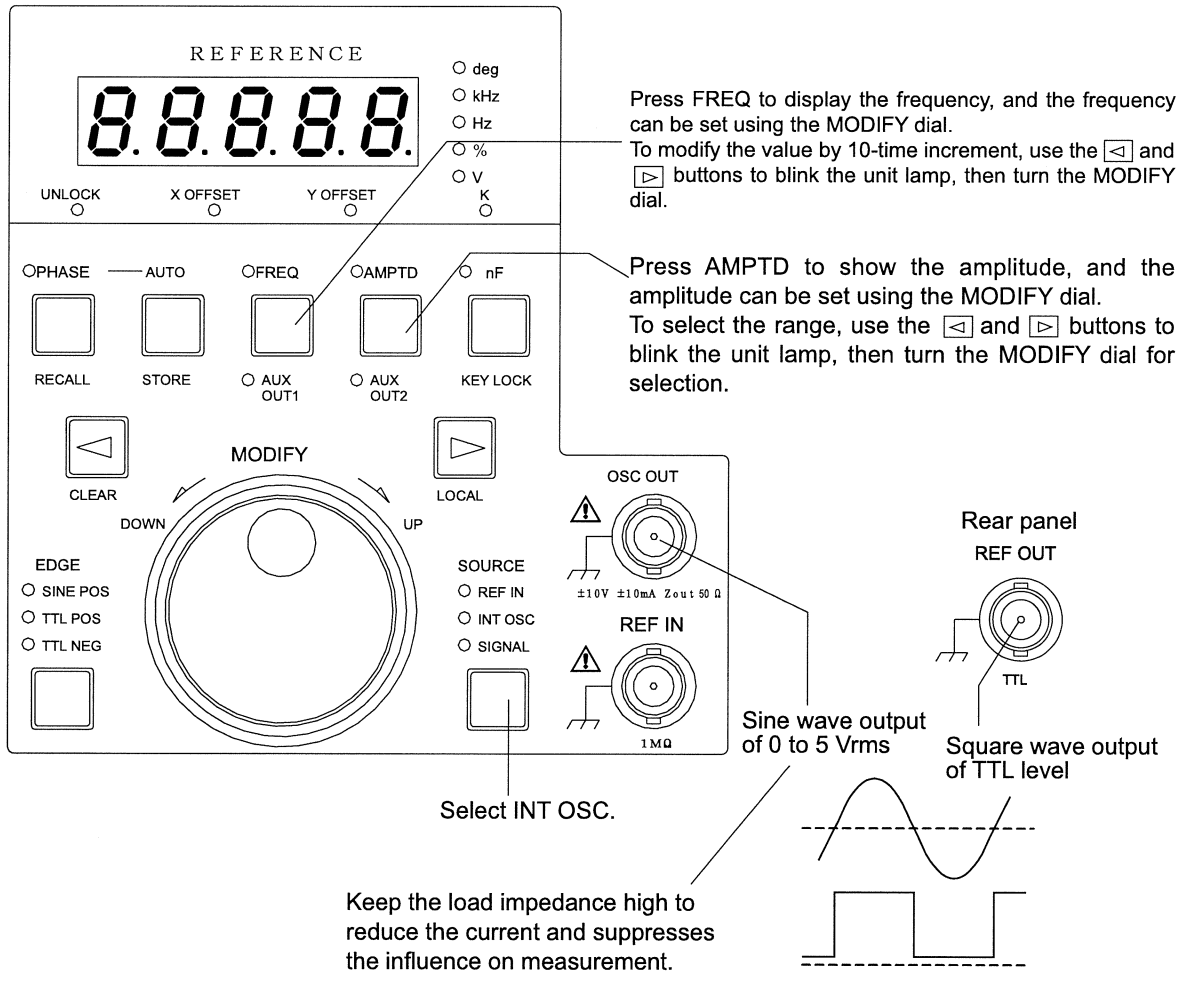
When an external reference signal is used, a synchronous sine wave (i.e., having the same frequency as the reference signal) is available at the OSC OUT connector. The amplitude can be set similarly to the case in which the internal oscillator is used. Also a TTL-level square wave is available at the REFOUT connector on the rear panel.

4.1.4 Internal oscillator (INT OSC)

LI5640 can generate a reference signal (sine wave and TTL-level square wave)

[Major specifications]

Oscillated frequency:	0.0005Hz to 105.00kHz (max. 19999)
Output voltage:	Three ranges of 0.0500, 0.500, and 5.00Vrms (max. 500)
	Amplitude diminishes drastically when approximately
	102kHz is exceeded.
Maximum output current:	±10mA
Output impedance:	50Ω ±3 %



⚠CAUTION

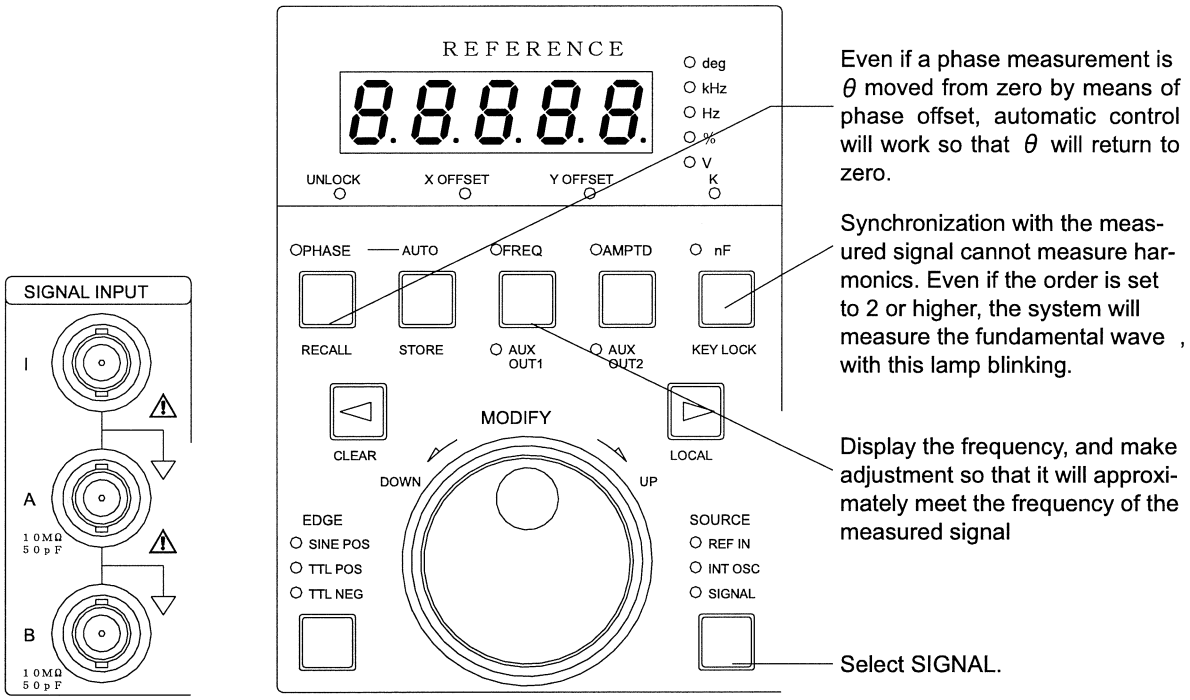
Do not apply external voltage to the output connectors. Doing this will break the internal circuit.

Maximum output current of OSC OUT is ±10mA. 50Ω load cannot be connected.

Keep the load from REF OUT to the ground or to +5 V to a 500Ω or higher value.

4.1.5 Synchronization with measured signal (SIGNAL)

LI5640 assures measurement in synchronization with the measured signal itself, which is supplied to the I, A or B connector of SIGNAL INPUT, even when no independent reference signal is supplied. However, the user has to have a broad knowledge of the signal frequency and magnitude and the degree of noise. To keep synchronization with the measured signal, LI5640 controls the internal oscillator so that measurements of phase (θ) will be zeroed. Therefore, the user should make such a system setting beforehand that the unit can start measurement once an independent reference signal is given.



a) Operation procedure

1) Set the time constant based on the signal frequency and noise level.
   If they are not clear, specify a value broadly three to ten times the signal period. (For quicker solution, first select a smaller value to look for a synchronization point, and when the synchronization point is detected, increase the value.)
   Do not use the synchronous filter (SYNC).
2) Set the dynamic reserve and sensitivity taking into consideration the magnitude of the signal and noise.
   If they are not clear, setting should be as follows:
   Sensitivity : The sensitivity that allows the user to measure the expected maximum signal.
   Dynamic reserve: MEDIUM; if the OVER lamp tends to light, then select HIGH.

3) Adjust the frequency so that it will be almost equal to the measured signal.
As the frequency approaches the measured signal, the frequency is automatically drawn in, and the phase θ continues to near zero until synchronization is attained.

b) Setting the time constant

To ensure stable system operation, the time constant must meet the following conditions:
Time constant $\geqq 1/(c \times \text{frequency})$ where c is 1, 2, 3 and 4 for SLOPE of 6, 12, 18 and 24 (dB/oct), respectively.
Time constant $\geqq 100\,\mu s$
If the noise is high, or if the signal is low, then select a time constant that allows sufficient elimination of noise and residual ripples.
Do not use the synchronous filter (SYNC).

c) Range of drawing

When the frequency of the subject signal comes in the following range in relation to the present frequency (FREQ), the frequency will be drawn. Keep manual adjustment to this range.

Table 4-1 Range of Drawing for Measured Signal

FREQ < 16kHz	FREQ/2
16kHz ≦ FREQ < 32kHz	FREQ/4
32kHz ≦ FREQ < 64kHz	FREQ/8
64kHz ≦ FREQ	FREQ/16

d) Restrictions on frequency change rate

Tracking becomes impossible if the frequency of measured signal fluctuates, exceeding the following broad change rate.
$1 / \{1280 \times (c \times \text{time constant})^2\}$ Hz/s
where c is 1, 2, 3 and 4 for SLOPE of 6, 12, 18 and 24 (dB/oct), respectively.
If the time constant is extremely high, the system cannot neglect even the temperature drift of crystal oscillator's frequency.

e) Relationship between the time constant and the time for synchronization

If the noise is low, the following expression may be used to determine a broad guideline for the settling time, which is taken from the point of approximate frequency coincidence, then through phase agreement to the time when the signal magnitude R reaches 99% of final value.
5cT; where T is the time constant and c is 1, 2, 3 and 4 for SLOPE of 6, 12, 18 and 24 (dB/oct), respectively.

f) Operation when control is drawn by other frequency than the intended one

It may happen that the system is drawn by other signal and adjustment of frequency is impossible if both of the following conditions are met:

- Time constant is short.
- Another signal(s) is present that has a frequency with which synchronization is possible.

In such cases, try the following steps:

- Move the blinking digit of frequency indication to upper one and swiftly adjust the frequency.
- Increase the time constant.
- First set SOURCE to INT OSC, and adjust the frequency to the intended signal as much as possible, and then switch SOURCE to SIGNAL.

4.1.6 Measurement of harmonics (nF)

With LI5640, the user can measure harmonics, or frequency components that are integral multiples of the reference signal frequency. The multiple is called the "Order" of the harmonic.

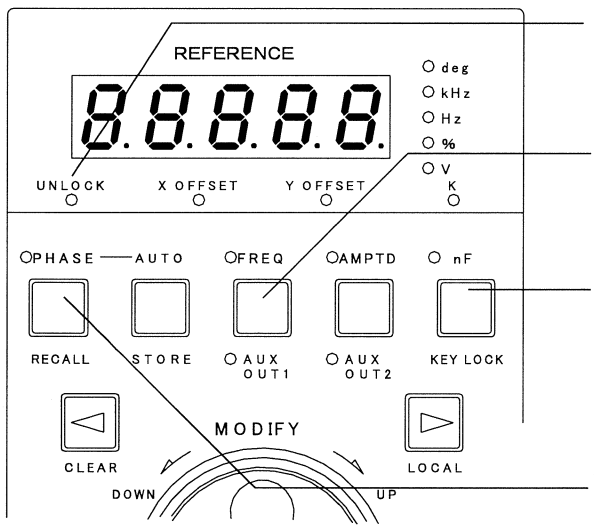
The range of order available: 1 to 19999. However, frequency of harmonics must be≦105kHz.

(Order = 1 means the fundamental wave instead of harmonics.)

Harmonic distortion of A and B inputs: -80dB or lower (10Hz to 5kHz), -70dB or lower (5kHz to 10 kHz)

For dynamic reserve of LOW, sensitivity of 1V and 1Vrms input

If dynamic reserve is high or signal is low, deterioration occurs.

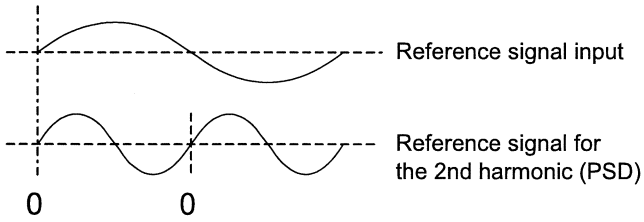


When harmonics exceed 105 kHz, the UNLOCK lamp lights up.

Frequency is always indicated in the fundamental wave instead of harmonics.

Press the nF button to display the order of harmonics, and use the MODIFY dial to set the order.
This lamp blinks if a parameter other than the order is displayed with the order ≧ 2, or if SIGNAL is selected for

This button can display the phase offset of harmonics for setting.



The datum (0°) for the phase of harmonics is the same as that for the fundamental wave. However, phase error becomes high if the order is high or the frequency is high.

[Instructions for harmonics measurement]

When SIGNAL is selected for SOURCE trying to achieve synchronization with the measured signal, harmonics cannot be measured. Even n≧2 is specified, the measured wave is the fundamental one.

The fluctuation of reference signal phase appears in by-the-order-multiplied values against harmonics. For high-order harmonics, measurement is impossible unless the reference signal and the measured signal are sufficiently stabilized.

In many cases, the signal level of harmonics is lower than that of the fundamental wave. Also, one-order different harmonics may be present on either side. The time constant must be set to a value high enough to attenuate them.

4.1.7 Phase offset (PHASE)

Although lock-in amplifiers take the reference signal as the datum for the phase, LI5640 can give an offset to this standard.

Range of phase adjustment: -180.00° to + 179.99° with resolution of 0.01°

Phase offset has major objectives as follows:

- To adjust the reference phase to an arbitrary point for the convenience of the measurement system.
- To measure the signal magnitude by means of X while adjusting so that θ will be 0 (Y = 0). Compared with the method of R measurement, this method can reduce the measurement dispersion due to noise to $1/\sqrt{2}$
- To monitor fine changes in the phase by means of Y while adjusting so that θ will be 0 (Y = 0). Use the EXPAND key to magnify Y by 10 times or 100 times. Phase can be calculated by the expression: $\sin^{-1}(Y / R)$

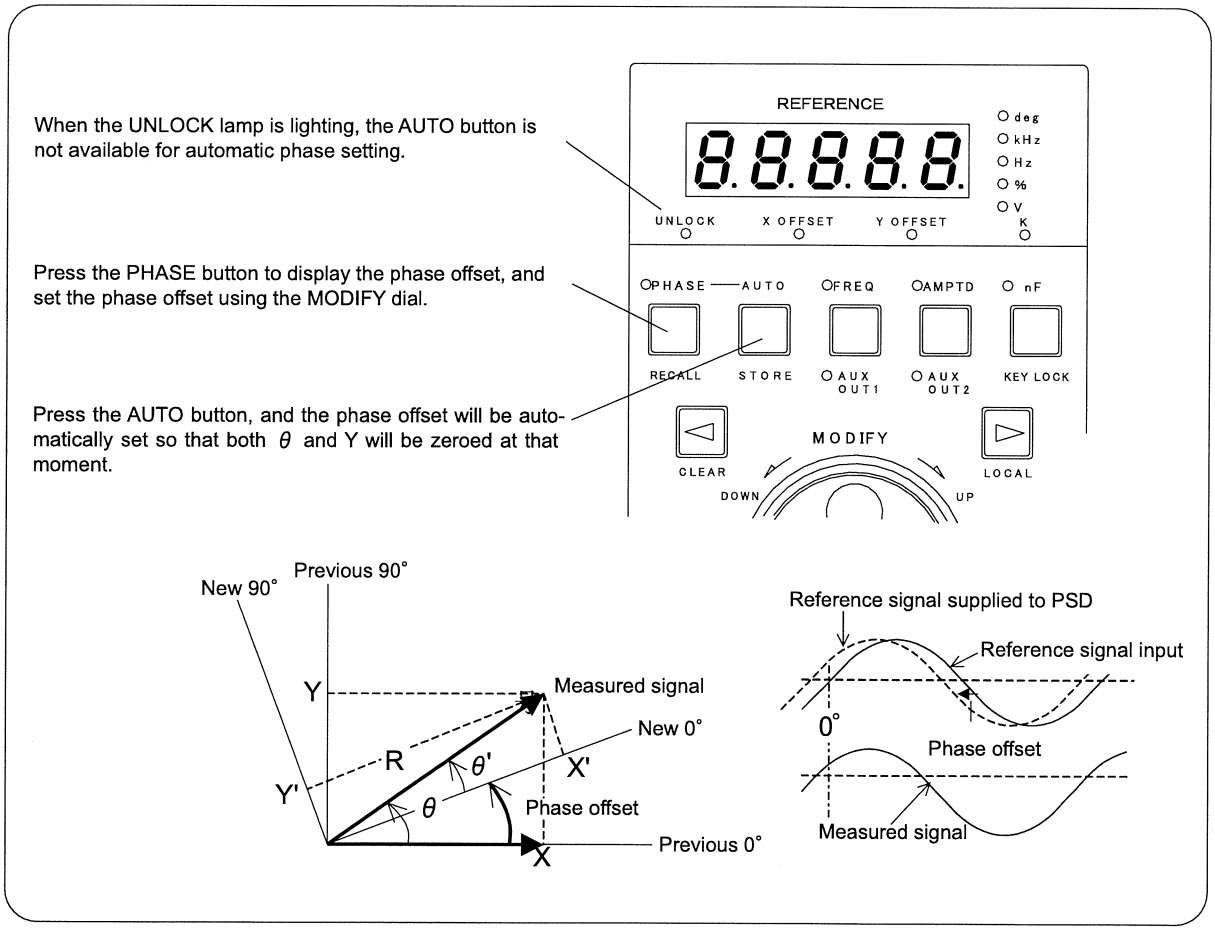
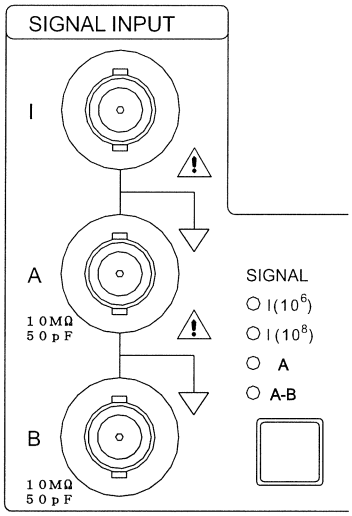


Fig. 4-1 Phase Offset

4.2 Operation of measured signal system

4.2.1 Connection and setting of measured signal



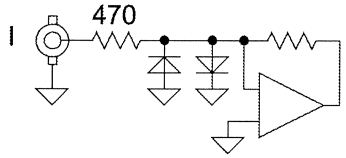
Connect the signal for measurement to the I, A and B connectors of SIGNAL INPUT.
With the SIGNAL keys, select one out of I (10^6), I (10^8), A and A-B according to the connection.

- Current
  Connect to the connector I.
  Select I (10^6) or I (10^8).
- Voltage
  Connect to the connector A.
  Select A.
- Voltage (differential)
  Connect to the connector A and B.
  Select A-B.

⚠CAUTION

Application of a voltage exceeding ±1V between the grounds of I, A and B input signals and the LI5640 chassis will admit high current to flow and break the internal circuit.

4.2.2 Current input



Current is measured after conversion to voltage.
When to use current input, specify the current/voltage conversion gain taking into consideration the signal magnitude and the frequency.

- I (10^6): 10^6 V/A (50fA to 1μA, up to 50kHz)
- I (10^8): 10^8 V/A (5fA to 10nA, up to 500Hz)

If AC is selected for COUPLING with current input, DC will be eliminated after voltage conversion. Use a peak value containing DC in the following range:

- $\pm$7μA for 10^6 V/A
- $\pm$70nA for 10^8 V/A

⚠CAUTION

Application of $\pm$10mA or greater current will break the internal circuit. Do not connect a signal source that has a great current supply capacity. When current input is not used, attach the supplied protection cap to the connector I.

The value of input impedance is as follows (both at 500Hz):

<1kΩ (at 10^6 V/A)

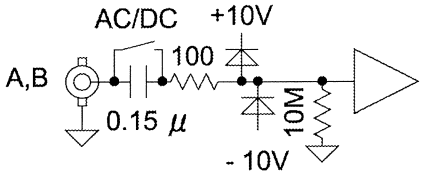
<20kΩ (at 10^8 V/A)

In the region of frequency higher than several 100s of Hz, the input impedance increases approximately in proportion to the frequency.

With current input, take into consideration the following points:

- Provide sufficient shield.
  If the electrostatic shield is incomplete, noise current will flow in from the part at which the potential fluctuates.
- For connection, use a low-noise cable, which is unlikely to admit occurrence of noise charge.
  Noise will arise in the cable or inside LI5640 if vibration occurs.
- Keep the connector cable as short as practicable.
  If a long cable is used, frequency characteristics may deteriorate, or operation may become unstable due to the cable's electrostatic capacity.
- If the system is prone to effects of noise, provide a separate current input amplifier (NF's LI-76, for example) in the vicinity of the signal source.

4.2.3 Voltage input



Voltage sensitivity

2nV to 1V

(effective value or root-mean-square value (rms) of the signal)

Input impedance

10MΩ ±1.5%, approx. 50pF in parallel

Maximum allowable input voltage (malfunction occurs if this range is exceeded)

For DC coupling :±7V

For AC coupling : 5Vrms (in sine wave) (mean value of ±7V for general waveforms)

The above values are available in the best condition; becomes smaller depending on the setting.

☞ For details ➡ Refer to Table 4-2 "Practical Values of Dynamic Reserve".

⚠CAUTION

For AC coupling, application of a voltage exceeding 10Vrms by sine wave, or DC voltage of ±50V will break the internal circuit. For DC coupling, a voltage exceeding ±14V will break.

4.2.4 Differential input

If differential connection (A-B) is used in a voltage input configuration, unaffected measurement is available regardless of the difference between the grounding potential of the signal source and that of LI5640. In this A-B mode, A is measured in relation to B.

The performance of eliminating noise components applicable commonly to both inputs is as follows:

Common mode reduction ratio (CMRR): 120dB (typical for 1kHz), 100dB (min. for 50Hz to 1kHz)

These values are for the cases of AC coupling, dynamic reserve of LOW, sensitivity setting of 20mV or lower, or dynamic reserve of MEDIUM and sensitivity setting of 2mV or lower. The CMRR varies with the frequency, sensitivity (SENS), dynamic reserve (DR) and input coupling (AC/DC) as broadly shown in Fig. 4-2 "Differential Connection and CMRR".

The potential between the signal ground and A, and between the signal ground and B, is allowed up to ±7V (for DC coupling) or the mean value of ±7V (for AC coupling) regardless of the sensitivity and the dynamic reserve.

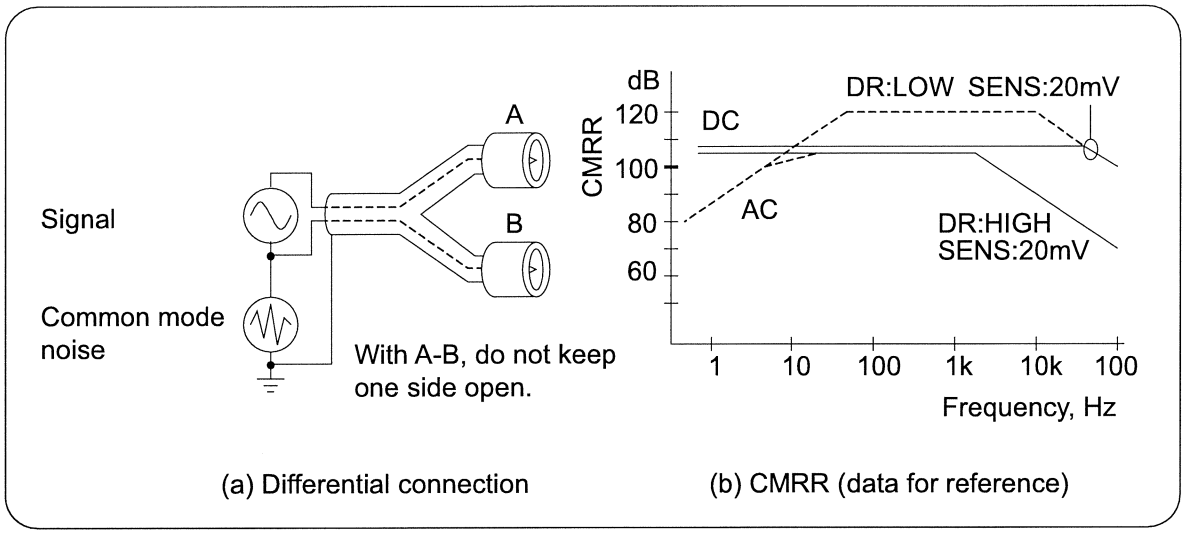
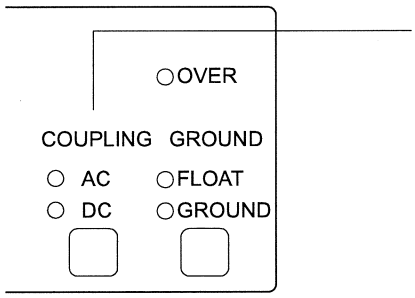


Fig. 4-2 Differential Connection and CMRR

4.2.5 Selection of input coupling



Select input coupling by taking into consideration the frequency and the DC components contained in the input.
Normally, use AC (AC coupling) for frequencies equal to or higher than approximately 1 Hz and use DC (DC coupling) for frequencies lower then 1 Hz. Input coupling may be left to automatic selection by AUTO SET.

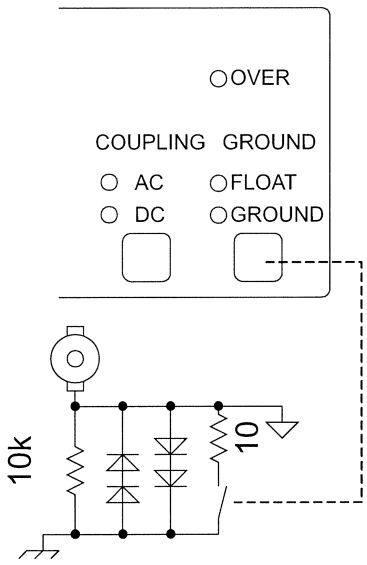
The cutoff frequency of AC (AC coupling) is approx. 0.1Hz, and DC up to ±50V can be eliminated. Although frequency characteristics by AC coupling are compensated up to approx. 0.1Hz, error will become greater with lower frequencies. With 0.1Hz or lower frequencies, error increases sharply.
If input contains high DC components, it may be advantageous to use AC even with low frequency. To use AC with 1Hz or lower frequencies, confirm the measurement accuracy beforehand.

	Merits	Demerits
AC	High accuracy is assured because the user can amplify the measured signal greatly even if the input contains high DC components.	If frequency lowers: • Measurement error increases. • CMRR decreases. • Takes time until value settles.
DC	Measurement error of amplitude and phase is small even if the frequency is low. Response is quick because transition response due to AC coupling does not exist when the signal changes.	If input contains high DC components: • Measurement error increases because it cannot be amplified. • Signal frequency ripples are likely to remain in output (low by synchronizing filter)

If AC is selected with current input, DC will be eliminated after voltage conversion. Use a peak value containing DC in the following range:

- ±7μA for 10^6 V/A
- ±70nA for 10^8 V/A

4.2.6 Selection of ground



Normally, select FLOAT if the signal source is grounded and select GROUND if it is not.

Grounding both the signal source and the LI5640 input may create a ground loop, admitting noise current in the system, which in turn affects measurement. If a noise current flows in the ground line, a noise voltage is generated in the ground line.

If the signal source is not grounded, select GROUND and connect the input signal ground to the chassis of LI5640 in order to stabilize the potential. If the both are set to floating, earth impedance will become higher. Therefore, the earth (against the chassis) potential of the signal ground fluctuates because of the electrostatic coupling with noise source in vicinity and for other reasons.

The fluctuation of ground potential affects signal measurement by means of the isolation mode reduction ratio that has similar characteristics to those of the common mode reduction ratio.

When the user is going to ground either the signal source or LI5640 input, fluctuation of potential difference between the both grounds affects the measurement of small signal to a certain degree. Take consideration to minimize the difference of ground potential as much as possible.

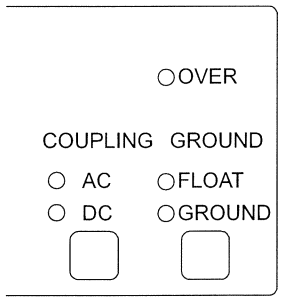
If environmental noise is high, also take the following measures:

- Use differential connection (A-B) for voltage signals.
- If the ground of the reference signal system is common to the ground of the measured signal source, provide an isolation transformer for signal in the reference signal input,

⚠CAUTION

Application of a voltage exceeding ±1V between the grounds of I, A and B input signals and the LI5640 chassis will admit high current to flow and break the internal circuit.

4.2.7 Measures for OVER lamp lighting



The OVER lamp of SIGNAL INPUT lights up when the first amplifier for voltage input or current/voltage converter for current input is saturated with excessive input.

If the OVER lamp is found lighting, take the following steps to turn off the OVER lamp:

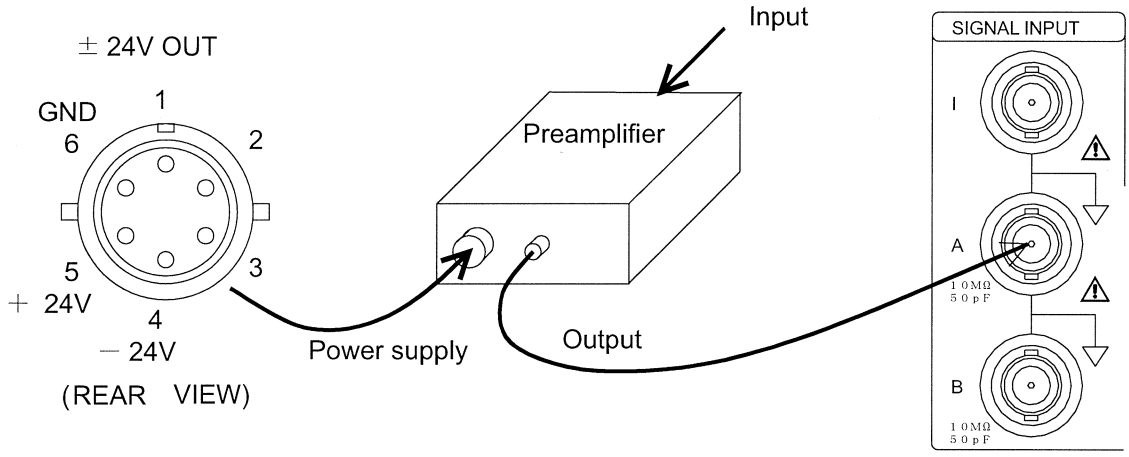
- Increase the dynamic reserve. (LOW → MEDIUM → HIGH)
  Decrease the gain of the first amplifier.
- Set the sensitivity to a higher value. (1mV → 2mV →)
  If the sensitivity has been set to 2mV or higher value, the user may increase the maximum allowable input voltage.
  If current input has been selected for measurement, decrease the current/voltage conversion gain (10^8 → 10^6) in addition to increasing the sensitivity setting.
  When the measurement lowers to 1/10 or less of the sensitivity full scale, the user may still use the EXPAND key for enlarging.
- Select AC coupling for signal input (DC → AC on COUPLING).
  This prevents DC components in the input from being amplified to an excessive level.
  Signal looks almost zero when full DC saturation occurs.

If the OVER lamp of SIGNAL INPUT lights up although both sensitivity and dynamic reserve are set to the maximum level (1V or 1μA and HIGH), it is because the input signal (or noise) is too high. LI5640 is not available for measurement in this situation; decrease the input signal.

4.2.8 Connection of preamplifier

When the noise from LI5640 itself is considered troublesome, use a preamplifier with less noise.
If the signal source is located at a distant position from LI5640, first amplify the signal near the signal source and then send the signal to LI5640 in order to reduce the surrounding noise influence.
NF Corporation provides a range of preamplifiers including Low-noise Preamplifier LI-75A and Current-Input Preamplifier LI-76. LI5640 can supply power to our product preamplifiers although special DC Power Supply PS-70A is available. Connection should be made with the cable supplied with the preamplifier.

Output voltage :±24V (DC)
Output current :±50mA (max)



⚠CAUTION

The ground of ±24 OUT power supply is connected to the grounds of I, A, and B input signals. Application of a voltage exceeding ±1V between these grounds and the LI5640 chassis will admit high current to flow and break the internal circuit.
Do not apply external voltage to the ±24V power supply terminals.

4.2.9 Use of input transformer

If noise is troublesome, also consider use of an input transformer.

An input transformer is effective in the following cases:

- To improve noise figure when signal source resistance is low.
- To isolate the ground of signal source from the signal grounds of the lock-in amplifier.

For the input transformer, NF Corporation recommends LI-771/772, which is specially designed for lock-in amplifiers.

If the signal source resistance is low, in general, noise figure becomes larger. In such cases, use an adequate input transformer to increase the voltage. This will increase the signal source resistance viewed from the lock-in amplifier and decrease the noise figure. In other words, this method can improve the signal to noise ratio (S/N).

[Noise figure]

Use of amplifiers or measuring instruments always deteriorates the S/N ratio because they generate noise internally. Noise figure (NF) indicates the degree of S/N deterioration. A small or almost zero NF value means excellent noise characteristics, and NF varies with the frequencies and signal source resistance. The noise figure of LI5640 is shown below.

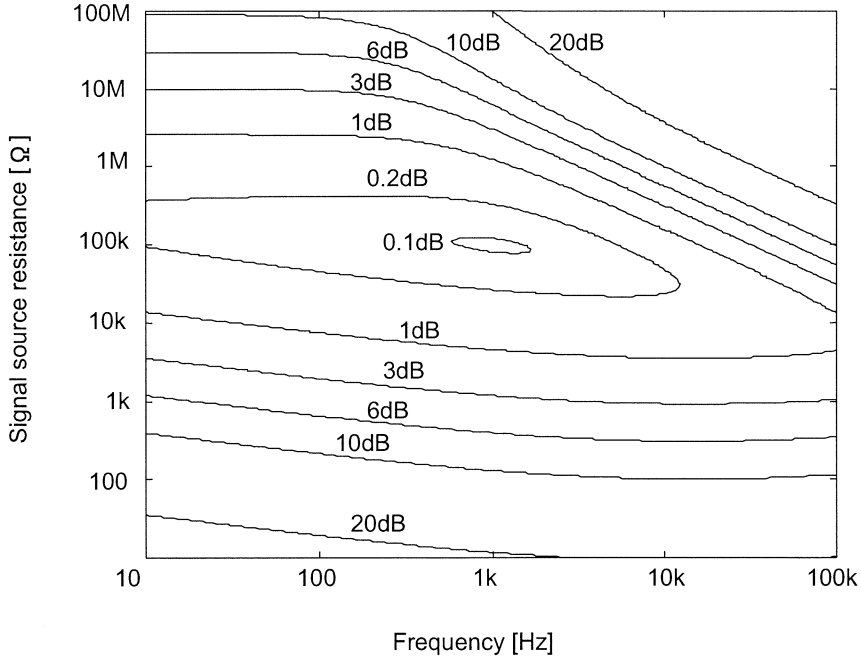
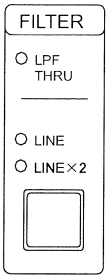


Fig. 4-3 Noise Figure (for reference)

4.3 Operation of power supply frequency noise reduction filter



When measurement is carried out in practice, it sometimes happens that signal contains interfering noise (or so-called hum) that has the frequency of commercial power supply or integral multiples of that frequency. The noise of which frequency is equal to that of or twice that of the power supply can be attenuated down to one tenth or lower level if the user adopts a power supply frequency noise reduction filter.

Press the FILTER key to light up the LINE or LINEx2 lamp. This will enable notch filters whose center frequency is the power supply frequency or twice that frequency respectively. It is also possible to use both LINE and LINEx2.

If the measured frequency is sufficiently far from the power supply frequency and integral multiples of that frequency, the band-limiting filter can eliminate the hum after phase sensitive detector. However, if noise other than hum is little, the dynamic reserve for that portion is required accordingly. If a power supply frequency noise reduction filter is used to attenuate hum, the user can select lower values for the time constant (TIME CONSTANT) of the band-limiting filter and attenuation slope (SLOPE), which can reduce the measurement time in turn. Also, sufficient amplification can be achieved, and the effects of input referred noise become small, assuring retained accuracy.

If the frequency of measured signal is too near to the center frequency of the notch filter, measurement error in amplitude and phase becomes greater on the contrary. In such cases, increase the time constant instead of using the power supply frequency noise reduction filter. The filter characteristics can be corrected to a certain degree in the region outside the center frequency ±10%, but further approach to the center frequency will suddenly increase the error.

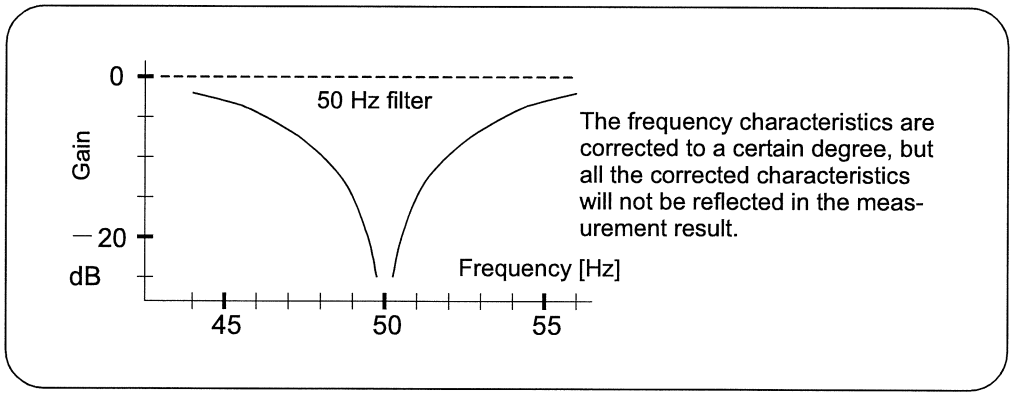
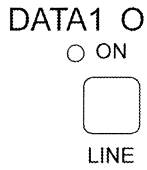


Fig. 4-4 Characteristics of Power Supply Frequency Noise Reduction Filter (for reference)

Although the product is applicable to either of 50 and 60Hz power supply frequency, the user has to specify the value. On the following occasions, be sure to specify the actual power supply frequency for setting:

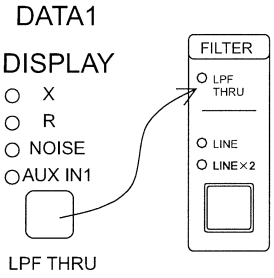
- Just after product delivery
- When the instrument is moved to a location of a different power supply frequency
- When the instrument is reset to the factory default setting



Press the SHIFT + LINE keys to display the power supply frequency, the user can select 50 (Hz) or 60 (Hz) using the MODIFY dial. Press the SHIFT + EXIT key to return to the previous indication.

DATA1	DATA2	REFERENCE
	Lin	50

4.4 Operation of anti-aliasing filter



LI5640 allows the user to disable the anti-aliasing filter provided before the A/D converter, and this measure exerts the following two effects:

- To facilitate capture of signal that quickly changes
- To halve the temperature drift of phase at high frequencies

Press the SHIFT + LPF THRU keys to light the LPF THROU lamp, and the anti-aliasing filter will be disabled.

LI5640 converts measured signals into digital data, when all frequency components that have 1/2 of sampling frequency and higher are folded back into the band. These folded components cannot be eliminated later. To avoid this problem, the anti-aliasing filter with steep cutoff characteristics is provided before the A/D converter. However, the delay time and settling time of this filter are long, and therefore it is difficult to capture quickly changing the signals.

If the noise is low enough, the user can observe up to 100μs response by specifying a shorter time constant. Then disabling the anti-aliasing filter will help somewhat quicken the response.

If the anti-aliasing filter is not used, however, noise becomes greater because those noises having high frequencies are folded back into the signal band. Measurement without using the anti-aliasing filter is effective only when noise is sufficiently low.

Be sure to turn off the LPF THRU lamp unless it is particularly needed.

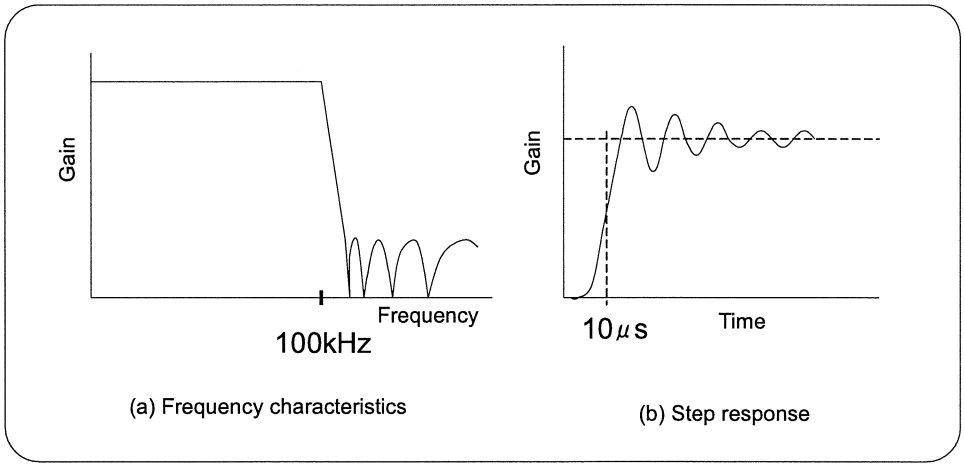
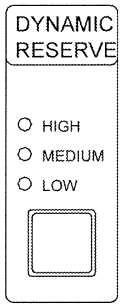


Fig. 4-5 Anti-aliasing Filter

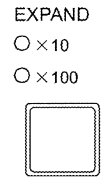
4.5 Operation of dynamic reserve

Dynamic reserve indicates the value of margin for noise. It means the upper limit of the noise level in relation to the sensitivity full scale in which noise saturation does not occur.

LI5640 provides 100dB or greater dynamic reserve. Since all processing after phase sensitive detector is executed via digital calculation, dynamic reserve is not restrained by the DC offset and its drift like in analog systems.



LI5640 allows the user to select dynamic reserve out of three levels of LOW, MEDIUM and HIGH. When the user has specified the sensitivity, select the minimum dynamic reserve so that the OVER lamp will not light up with that sensitivity. Selection of too high dynamic reserve would cause higher measurement error. Also, the AUTO key of SENSITIVITY may be used for automatic setting of dynamic reserve at the same time.



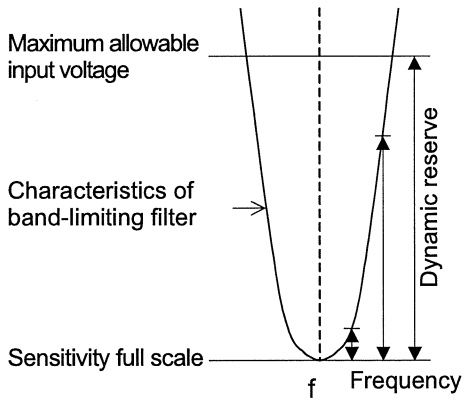
Use of the EXPAND key for magnified indication will produce the same result as increasing the dynamic reserve by enhancing the sensitivity. In effect, "×10" increases the apparent dynamic reserve by 20dB, and "×100" by 40dB.

If a sufficiently long time constant is selected, actually obtained dynamic reserve depends on the setting of DYNAMIC RESERVE and SENSITIVITY.

☞ Refer to Table 4-2 "Practical Values of Dynamic Reserve".

For specific noise, the value varies with the frequency distribution and the setting of time constant and attenuation slope. For further information, read the description below.

a) Dynamic reserve for noise having specific frequencies

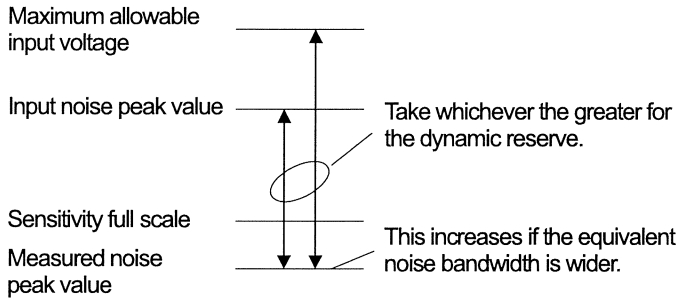


LI5640 equivalently works as a narrow band-pass filter. Therefore, the dynamic reserve that is actually secured depends on the frequency difference between the measured signal and noise.

For noise that has the same frequency as the signal, dynamic reserve becomes 0dB.

If the signal frequency and the noise frequency are sufficiently far away from each other in comparison with the bandwidth of the band-limiting filter, the dynamic reserve will be the ratio of the sensitivity against the maximum allowable input voltage (the effective value of sine wave). This value is shown in Table 4-2 "Practical Values of Dynamic Reserve".

b) Dynamic reserve for wide band noise



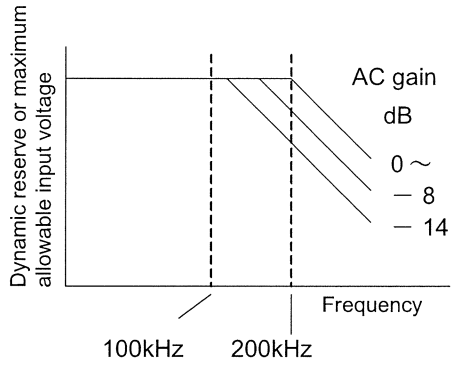
The effective value of noise contained in measurement is:

Noise density $\times\sqrt{\text{equivalent noise bandwidth}}$

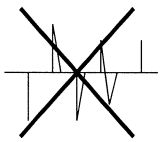
The peak value will be approx. several times to ten times the above value. The dynamic reserve is the ratio of peak value of input noise to the sensitivity when the peak value of noise contained in the measurement equals the sensitivity full scale. In general, frequency distribution of noise contained in input is various, and thus determination of dynamic reserve is not simple.

If the equivalent noise bandwidth can be sufficiently narrowed, dynamic reserve is the ratio of sensitivity to maximum allowable input voltage (peak value). If the equivalent noise bandwidth cannot be sufficiently narrowed, the dynamic reserve becomes smaller.

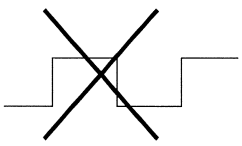
c) Dynamic reserve for noise having high frequencies



When the frequency goes beyond approximately 100kHz to 200kHz, the maximum allowable input voltage (RMS value of sine wave) lowers in inverse proportion to the frequency. In such a frequency area, dynamic reserve also decreases.



Pulsed noise contains a number of high frequency components. Therefore, the dynamic reserve for pulsed noise is low. Do not supply steep and high pulsed noise because this may cause distortion and measurement error.



Also a square wave signal contains high frequency components. If the edge change is steep, the signal must be passed an appropriate low-pass filter before connected to the measured signal input of LI5640.

Table 4-2 Practical Values of Dynamic Reserve (for reference)

DR stands for dynamic reserve

Dynamic reserve			LOW		MEDIUM		HIGH	
Sensitivity			AC gain	Actual DR	AC gain	Actual DR	AC gain	Actual DR
$I(10^{6})$	$I(10^{8})$	A,A-B	dB	dB	dB	dB	dB	dB
1μA	10nA	1V	0	0	−8	8	−14	14
500nA	5nA	500mV	6	0	−8	14	−8	14
200nA	2nA	200mV	12	2	0	14	0	14
100nA	1nA	100mV	18	2	6	14	0	20
50nA	500pA	50mV	24	2	6	20	0	26
20nA	200pA	20mV	30	4	12	22	0	34
10nA	100pA	10mV	36	4	12	28	0	40
5nA	50pA	5mV	42	4	18	28	0	46
2nA	20pA	2mV	48	6	22	32	0	54
1nA	10pA	1mV	48	12	22	38	0	60
500pA	5pA	500μV	48	18	22	44	0	66
200pA	2pA	200μV	48	26	22	52	0	74
100pA	1pA	100μV	48	32	22	58	0	80
50pA	500fA	50μV	48	38	22	64	0	86
20pA	200fA	20μV	48	46	22	72	0	94
10pA	100fA	10μV	48	52	22	78	0	100
5pA	50fA	5μV	48	58	22	84	0	106
2pA	20fA	2μV	48	66	22	92	0	114
1pA	10fA	1μV	48	72	22	98	0	120
500fA	5fA	500nV	48	78	22	104	0	126
200fA	—	200nV	48	86	22	112	0	134
100fA	—	100nV	48	92	22	118	0	140
50fA	—	50nV	48	98	22	124	0	146
—	—	20nV	48	106	22	132	0	154
—	—	10nV	48	112	22	138	0	160
—	—	5nV	48	118	22	144	0	166
—	—	2nV	48	126	22	152	0	174

AC gain : The gain before phase sensitive detector PSD.

Actual DR : The value of dynamic reserve. Equal to the DC gain after PSD.

Relation between dB and linear magnification:

0dB → 1 time, 6dB → 2 times, 10dB → 3 times, 12dB → 4 times, 14dB → 5 times, 18dB → 8 times, and 20dB → 10 times

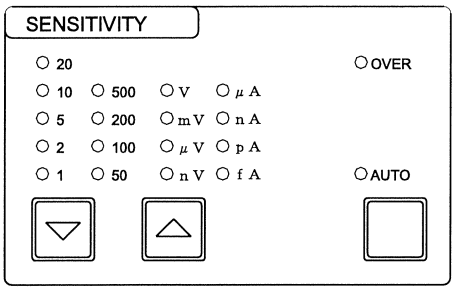
The values of dynamic reserve shown in this table are the ratio of the sensitivity and the maximum allowable input voltage (or current). In other words, they are the value obtainable under the best conditions.

The actual maximum allowable input voltage (or current) when a sine wave is assumed is the sensitivity full scale multiplied by the actual DR (= DC gain) shown in the above table.

If the user wants to perform measurement while securing 120dB or higher dynamic reserve, an extremely long time constant is required. Very high dynamic reserve cannot be secured if signal contains noise that has frequency components near to the frequency of measured signal.

4.6 Operation of sensitivity (SENSITIVITY)

a) Range of sensitivity



The magnitude of signals displayed on LI5640 is expressed in an RMS value (rms). The sensitivity of LI5640 can be set in the following range using the ▽ and △ keys.

Voltage sensitivity : 2nV to 1 V (e.g., 1mV, 2mV, 5mV, 10mV, ...)

Current sensitivity : 50fA to 1μA (at conversion gain of 10^6V/A)
5fA to 10nA (at conversion gain of 10^8V/A)

Voltage noise density sensitivity : 20nV/$\sqrt{\text{Hz}}$ to 1V/$\sqrt{\text{Hz}}$

Current noise density sensitivity : 1pA/$\sqrt{\text{Hz}}$ to 1μA/$\sqrt{\text{Hz}}$ (at conversion gain of 10^6 V/A)
100fA/$\sqrt{\text{Hz}}$ to 10nA/$\sqrt{\text{Hz}}$ (at conversion gain of 10^8 V/A)

When reading a noise density (NOISE), add /$\sqrt{\text{Hz}}$ to the unit shown on the panel.

b) Automatic setting of sensitivity by AUTO key

Press the AUTO key, and an optimal sensitivity will be automatically set according to the signal magnitude. This automatic setting is the same operation as the automatic sensitivity setting conducted when the AUTO SET key is pressed. The AUTO lamp keeps lighting during the automatic setting process. When a proper sensitivity has been identified, the automatic setting is complete.

Simultaneously, the dynamic reserve is adjusted to the optimal value (necessary lowest value). Only the sensitivity and dynamic reserve are modified.

In the following cases, adequate sensitivity may not be obtained because automatic setting is forced to end after sensitivity going up and down several times:

- Signal changes drastically.
- Noise is high.
- Signal is low.

If signal changes drastically, first broadly set the sensitivity via automatic sensitivity setting, and then fix it to a little larger range. If fluctuation by noise is high, increase the time constant and the attenuation slope in order to suppress the fluctuation due to noise, and then automatic setting will be available. When signal is low, manually set the sensitivity and the dynamic reserve.

[Abortion of automatic sensitivity setting operation]

Press the AUTO key, or any other key during automatic sensitivity setting, and the automatic setting will be aborted. If other key is used than AUTO of SENSITIVITY, the original function of that key is also effective.

c) OVER lamp

Lighting of the OVER lamp of SENSITIVITY indicates an over-level state of amplifiers except the first one, the phase sensitive detectors, the subsequent band-limiting filters due to signal or noise.

Use the following operation to turn off the OVER lamp:

- Increase the dynamic reserve. (LOW → MEDIUM → HIGH)
  Decrease the gain before the phase sensitive detector to prevent noise saturation.
- Set the sensitivity to a higher value. (1mV → 2mV →)
  If the sensitivity has been set to 2mV or higher value, the user may increase the maximum allowable input voltage.
  When the measurement lowers to 1/10 or less of the sensitivity full scale, the user may still use the EXPAND key for enlarging.
- Increase the time constant and the attenuation slope (10ms and 12dB/oct → 100ms and 24dB/oct)
  This attenuates the noise.
- Use the power supply frequency noise reduction filter (i.e., turn on the LINE and LINEx2 lamps).
  This attenuates the hum noise caused by power supply.
- Select AC coupling for signal input (DC → AC on COUPLING).
  This prevents DC components in the input from being amplified to an excessive level.
  Signal looks almost zero when full DC saturation occurs.

If it is suspected that noise is causing an over-level condition while signal magnitude R does not reach the sensitivity full scale, then preferably try the above items other than the sensitivity.

Once noise has been attenuated satisfactorily, the user can decrease the sensitivity setting, or lower the dynamic reserve as far as the OVER lamp will not light up.

Further, if the OVER lamp of SIGNAL INPUT lights up although both sensitivity and dynamic reserve are set to the maximum level, it is because the input signal (or noise) is too high. LI5640 is not available for the measurement in this situation.

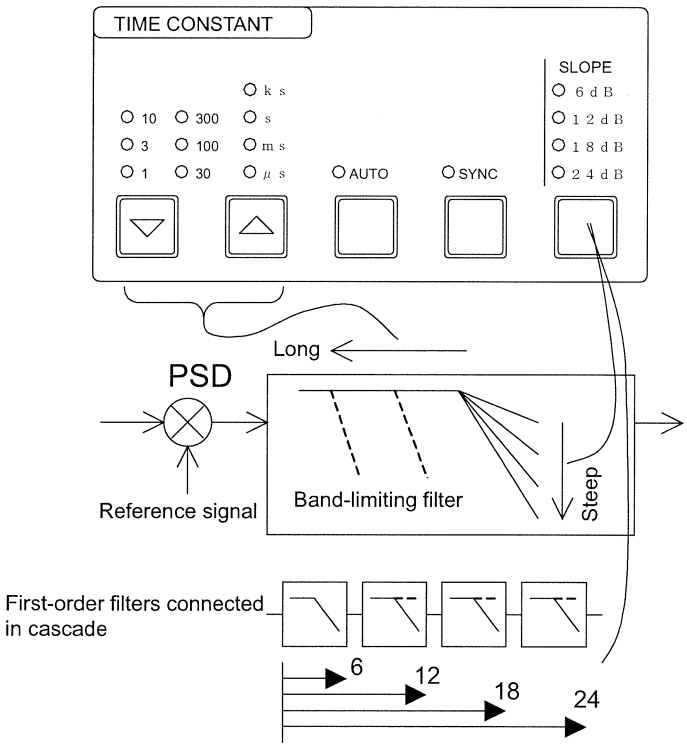
4.7 Operation of time constant and related matters (TIME CONSTANT)

4.7.1 Setting the time constant and the attenuation slope

The low-pass filter located downstream of the phase sensitive detector has the following functions:

- To remove noise (band-limiting filter).
- To remove ripples of two times the reference signal frequency, which are caused by phase sensitive detector of signals.
- To remove ripples of the reference signal frequency, which are caused by phase sensitive detector of DC offset.

The time constant of the filter can be set in the range from 10μs to 30ks using the ▽ and △ keys. The higher time constant can remove the more noise although response becomes the slower. Depending on the situation, select a value around three times the signal period but 30 ms or longer and monitor the situation for a while before taking further steps.



If a too short value is specified for the filter time constant, ripples will be conspicuous for the measurements. To measure a small signal or a signal of low frequency, select longer value to attenuate noise and ripples. If the signal is low or the dynamic reserve is high, ripples due to DC offset cannot be ignored. Therefore, a longer time constant is required.

To effectively reduce ripples that appear in the measurement, increase the attenuation slope, or use the synchronous filter.

☞ For synchronous filter ➡ Refer to Section 4.7.5 "Synchronous filter (SYNC)".

Attenuation slope can be selected with the SLOPE key out of 6, 12, 18 and 24 (dB/oct).
In the attenuation region, every time the frequency is doubled and the gain will be halved as 1/2, 1/4, 1/8 and 1/16.
Compared with the same equivalent noise bandwidth, it will take a shorter time until the final value is reached by selecting a bigger attenuation slope and a higher time constant. The value of 6dB/oct is prepared to prevent the system from getting unstable when LI5640 is put in a control loop. To read just values, 24dB/oct will be better to choose.

4.7.2 Automatic setting of time constant

Press the AUTO key, and the time constant and the attenuation slope will be automatically set from the frequency of the measured signal at the moment of key pressing. The steps of automatic time constant setting can be described broadly as follows:

- Set the SLOPE to 24dB/oct.
- Turn off SYNC if the frequency $\geqq$200Hz, and turn on if < 200Hz.
- Set the time constant to approx. three times the signal period (= 1 / frequency of measured signal). However, value will be limited within 30ms to 30s.

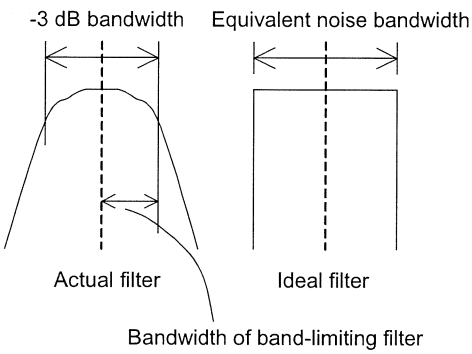
The above steps are the same as the operation associated to time constant in automatic setting by the AUTO SET key.

This automatic setting is disabled when the UNLOCK lamp is lighting.

In harmonics measurement (i.e., the nF key has been pressed to select 2 or higher), automatic setting will be made according to the frequency of harmonics.

In automatic setting, dispersion is conspicuous when noise is high or signal is low because the time constant is rather small. If noise is almost none, the user may select much smaller time constant to get quicker response. In such cases, manually adjust the time constant to an adequate value while monitoring the dispersion of measurements.

4.7.3 Equivalent noise bandwidth



The sensitivity to the broadband noise or, noise suppression performance in an opposite phrasing, is expressed by the equivalent noise bandwidth. The bandwidth of the ideal filter whose sensitivity to noise is equal to the actual filter is called the equivalent noise bandwidth of the filter.

Equivalent noise bandwidth B_N of LI5640 is twice the band-limiting filter (low-pass filter) defined by the time constant T and the attenuation slope and calculated by the following expressions:

$B_{N6}=\frac{1}{2T}$, $B_{N12}=\frac{1}{4T}$, $B_{N18}=\frac{3}{16T}$, $B_{N24}=\frac{5}{32T}$ (6, 12, 18 and 24dB/oct, respectively)

However, the above is the characteristics of an analog filter. Since a digital filter is used in LI5640, actual values slightly shift from the above expressions if the time constant is 1 ms or less.

The RMS value Vm of noise contained in the signal measurement is calculated from the input noise density Vn (assumed to be constant regardless of the frequency) and equivalent noise bandwidth B_N by the following expression:

$V_m=V_n \times \sqrt{B_N}$

To minify the noise contained in measurement by 1/10, the time constant must be magnified by 100.

Further, the -3dB bandwidth is determined by the following expression:

$B_{3dB}=\sqrt{m\sqrt{2}-1}/\pi T$

where T is the time constant and m = 1, 2, 3 and 4 (corresponding to attenuation slope of 6, 12, 18 and 24dB/oct).

4.7.4 Response time

The response when a step signal is supplied to the band-limiting filter downstream of phase sensitive detector is given by the following expression:

$$y(t)=1-\left\{\sum_{n=1}^{m}\frac{t^{n-1}}{T^{n-1}(n-1)!}\right\}e^{-\frac{t}{T}}$$

where T is the time constant and m = 1, 2, 3 and 4 (corresponding to attenuation slope of 6, 12, 18 and 24dB/oct).

However, the above is response of an analog filter. Since digital filter is used in LI5640, response varies a little if the time constant becomes smaller. In addition, this is joined by the fixed delay time of the power supply frequency noise reduction filter, anti-aliasing filter, data transfer and others on the input side. Therefore, use experimentation for confirmation if an exact response time is required.

Table 4-3 Step Response Time

(multiples of time constant T)

Response	SLOPE(dB/oct)			
	6	12	18	24
90%	2.3	3.9	5.3	6.7
99%	4.6	6.6	8.4	10.0
99.9%	6.9	9.2	11.2	13.1

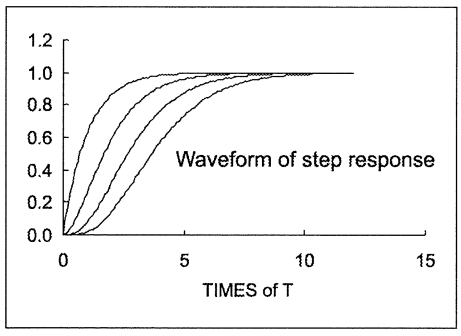
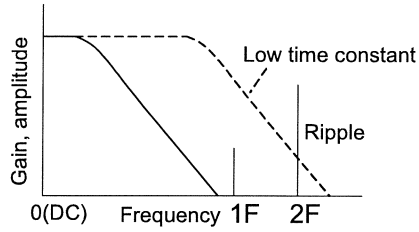


Fig. 4-6 Waveform of Step Response

4.7.5 Synchronous filter (SYNC)

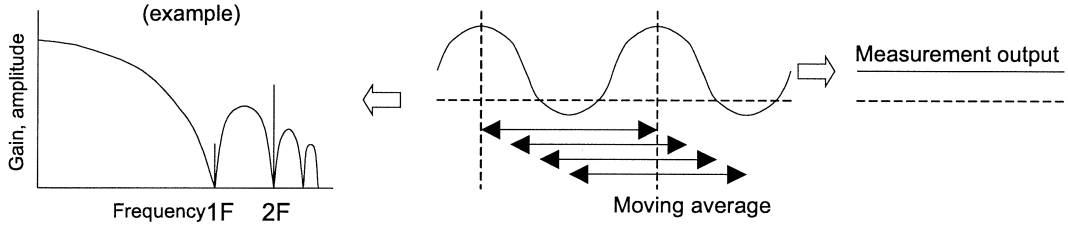
Frequency characteristics of normal filter

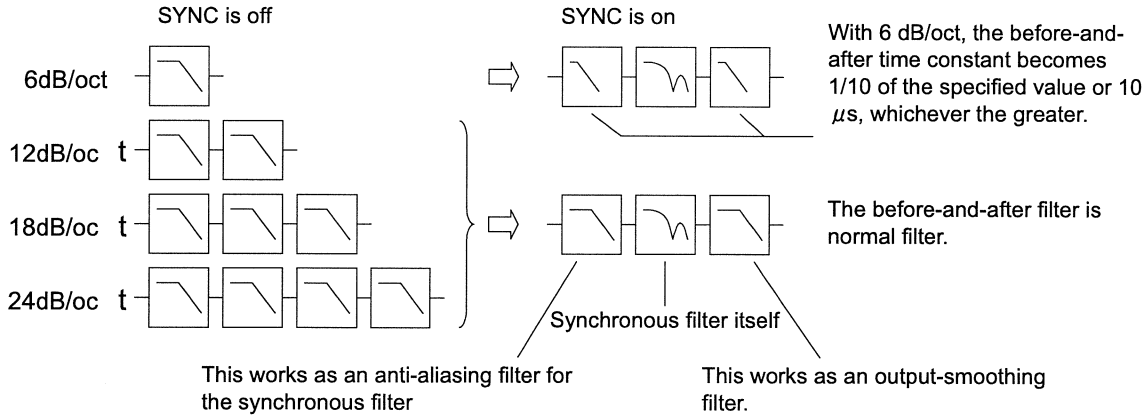


When noise is low, it is possible to suppress the noise to a sufficiently low level without increasing the time constant. However, the ripples generated in phase sensitive detector will appear in the measurement output if the time constant is kept low with a normal filter.

In such cases, use of a synchronous filter can keep ripples low. A synchronous filter is a moving-average filter of which the averaging section is equal to an integral multiple of signal period.

Frequency characteristics of synchronous filter (example)





○ SYNC To use the synchronous filter, press the SYNC key, turning on the lamp.

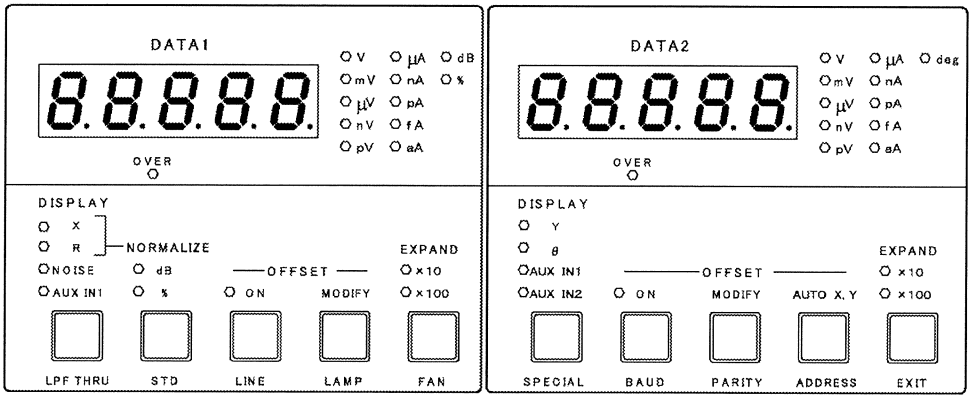
Although the synchronous filter operates independent of frequencies, ripple-removing performance drops as the frequency goes higher if the frequency is 200Hz or higher.

The band-limiting filer when SYNC is on is structured such that a normal primary filter is provided each before and after the synchronous filter.

If 6dB/oct is selected for SLOPE, the time constant of the before-and-after filters decreases. In this structure, output will be settled within approx. one period at shortest. This is useful when the frequency is low. However, the change looks stepwise because the average output is supplied at time intervals into which the averaging section is divided by approximately 100 to 200.

If synchronization is made with the external reference signal (REF IN), measurement may slightly vary due to frequency fluctuation.

4.8.1 Selection of measurement parameters (overview)



OVER (DATA1 and DATA2)

These lamps light up when the display range is exceeded or an over-level state is detected during data processing.

DATA1 DISPLAY

X

The signal component R cos θ with the same phase as the reference signal

R

The magnitude of R

NOISE

The noise density

AUX IN1

DC voltage at AUX IN1 (rear), ±12V

DATA2 DISPLAY

Y

The signal component R sin θ orthogonal to the reference signal

θ

The phase of signal in relation to the reference signal

AUX IN1

DC voltage at AUX IN1 (rear), ±12V

AUX IN2

DC voltage at AUX IN2 (rear), ±12V

NORMALIZE

The ratio of signal (X, R) to the standard value

dB

$20LOG_{10}|X \text{ or } R \text{ measurement} / \text{standard value}|$

%

(X or R measurement / standard value) × 100

DATA1 OFFSET

ON

Subtract the offset from X.

MODIFY

Set the X offset (% value of sensitivity full scale) using the MODIFY dial

DATA2 OFFSET

ON

Subtract the offset from Y.

MODIFY

Set the Y offset (% value of sensitivity full scale) using the MODIFY dial

AUTO X, Y

Turn on the offset to automatically set the offset so that both X and Y will be zero.

DATA1 EXPAND

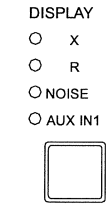
Expand the measurement of X.

DATA2 EXPAND

Expand the measurement of Y.

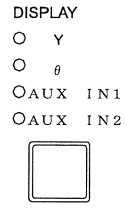
4.8.2 Selection of measurement parameters

LI5640 allows the user to view two measurement parameters at the same time.



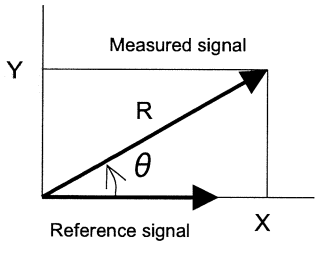
- DATA1

X	:The signal component of the same phase as the reference signal (R cos θ)
R	:The magnitude of signal ($=\sqrt{X^2+Y^2}$)
NOISE	:The noise density (this item is AUX IN1 for DATA2)
AUX IN1	:The DC voltage at rear panel AUX IN1 (up to±12V)



- DATA2

Y	: The signal component orthogonal to the reference signal (R sin θ)
θ	: The phase of signal in relation to the reference signal
AUX IN1	: The DC voltage at rear panel AUX IN1 (up to±12V)
AUX IN2	: The DC voltage at rear panel AUX IN2 (up to±12V)



When R is selected, the user can measure the magnitude of the signal regardless of the phase θ . If the phase is stable, however, adjust Y to zero and determine the signal magnitude by X, which can minimize the effect of noise.
The user can shift the phase (0°) of datum from the reference signal. Press the PHASE key of REFERENCE and set the phase offset. Press the AUTO key of PHASE, and Y and θ will be automatically set to zero.

DATA1 and DATA2 measurements are indicated or supplied in the following three expressions:

- Numerical indication
- Analog meter indication
- Analog voltage (DATA1 OUT and DATA2 out in 16 bits, at maximum 256k samples/s)

The measurement values that correspond to the meter full scale (analog output ±10V) are as follows:

X, Y and R	: The set sensitivity/EXPAND magnification
NOISE	: The set sensitivity
AUX IN1 and AUX IN2	:±10V
θ	:±180°
Ratio	:±2
% indication	:±200%
dB indication	:±100dB

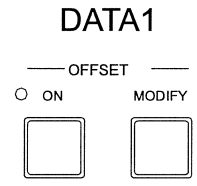
☞ For details of NOISE ➡ Refer to Section 4.10 "Measurement of noise density".

☞ For details of AUX IN1 and AUX IN2 ➡ Refer to Section 4.11 "Measurement of DC voltage (auxiliary input AUX IN1/AUX IN2)".

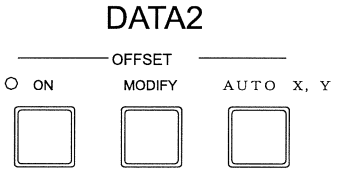
4.8.3 X and Y offset

The user can display the value of X and Y subtracted by the offset. This expression may be used for the following purposes:

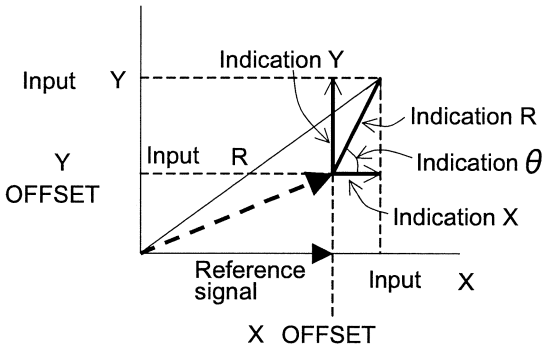
- To eliminate fixed noise.
- To monitor the change in relation to a certain value.



Press the OFFSET ON key of DATA1 to turn on the lamp, and the offset will be subtracted from X. Press the MODIFY key, and the REFERENCE digital display will show the offset of X. The offset is expressed in percentage to the sensitivity. If the user changes the offset using the MODIFY dial, the X indication value will be changed according to the offset.

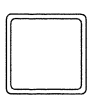


DATA2 allows the user to operate the Y offset in the same way as X.
To stop the offset indication of REFERENCE, press the SHIFT + EXIT keys, or otherwise specify other parameter with the FREQ or other keys.



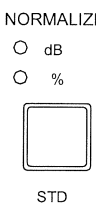
To monitor the change in relation to the current X and Y, press the AUTO X and Y keys. This will automatically set the X and Y offset values and turns on the offset so that X, Y and R indication will be zeroed.
When the UNLOCK lamp is lighting, automatic offset setting by the AUTO X and Y keys is not available because correct measurement cannot be obtained.
The value of R and θ can be determined from X and Y after offset subtraction. Direct R offset cannot be set. NOISE, AUX IN1 or AUX IN2 offset cannot be set either.

4.8.4 Expanding indications (EXPAND)



If X, Y or R indication is too small to ensure sufficient measurement resolution, the EXPAND key will magnify the substantial sensitivity (or resolution) by 10 or 100 times.
Press the EXPAND key of DATA1, and the apparent sensitivity of X or R will be magnified by 10 or 100 times.
Press the EXPAND key of DATA2, and the apparent sensitivity of Y will be magnified by 10 or 100 times. Turning on the ×10 or ×100 lamp of EXPAND cannot expand θ, AUX IN1 or AUX IN2.

4.8.5 Normalize (dB and %)



The user can view the ratio of X or R to a standard value expressed in dB or %.

Press the NORMALIZE key twice to turn on the dB or % lamp.

The indication value of dB = $20\ LOG_{10}\left|\frac{\text{X or R measurement}}{\text{Standard value}}\right|$; indication range: ±120.00dB

The indication value of % = $\left(\frac{\text{X or R measurement}}{\text{Standard value}}\right) \times 100$; indication range: ±199.99%

[Setting the standard value]

Press the SHIFT + STD keys, and the standard value will appear on DATA1. Set the value using the MODIFY dial. Use of the ◀ and ▶ keys to blink the unit lamp allows the user to change the value in ten-times decrement with the MODIFY dial.

DATA1	DATA2	REFERENCE
1.2345 μ	Std	

Selection of SIGNAL allows the user to set the standard value for voltage when voltage is measured, and the standard value for current when current is measured, independently. The range of standard value for setting is as follows:

- Voltage: 1.0000nV to 1.0000V
- Current: 1.0000fA to 1.0000 μA

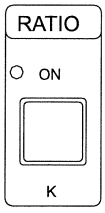
Press the Shift + EXIT keys and the original value will appear in the display.

[Restrictions]

- Specification of ×10 or ×100 of EXPAND cannot expand the value when the value is displayed in dB or %.
- Even if this dB or % lamp is turned on, indication in dB or % will not be available for NOISE or AUX IN1 or IN2.
- When ratio indication (RATIO) is specified, indication in dB or % will not be available, either.
- If X, Y or R exceeds the indication range to a certain degree using offset, the OVER lamp of DATA1 will light up.

4.9 Ratio indication

Ratio indication is used to counteract the sensor sensitivity fluctuation.
The sensitivity of sensor varies with temperature and other factors. If LI5640 measures the signal this sensor has captured, resulting measurement will not be correct. If any method can obtain a signal that compensates the fluctuation of sensitivity, ratio indication can correct the sensitivity.



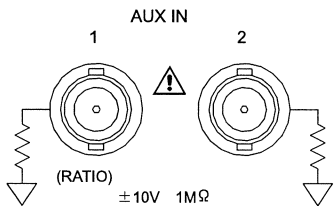
With ratio indication, the user can view the value of X, Y and R in the ratio to the absolute value of the voltage supplied to the AUX IN1 connector on the rear panel. To do this, press the RATIO key, tuning on the ON lamp.

$$\text{Ratio} = K \times \frac{\text{Percentage to the X, Y and R sensitivity}}{|\text{AUX IN1}|[\text{V}] \times 10}$$

Range of ratio indication: ±2.4 (0.0000 to ±1.9999, to ±2.400)

Analog output will be +10V when the ratio is 2.

K is an arbitrary constant ranging from 0.1000 to 1.9999 or from 2.000 to 9.999
Pressing the SHIFT + K keys will display the value of K constant on the REFERENCE digital display, and then use MODIFY dial for setting. Press the SHIFT + EXIT keys to return to the previous indication.
Example: If K = 1, AUX IN1 = 5V, sensitivity is 10mV and R is 3.5mV, then the value of ratio will be the following:
Ratio = 1 × {(3.5 / 10) × 100} / (5 × 10) = 0.7



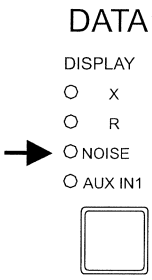
Supply the compensation-input signal to the AUX IN1 connector on the rear panel.
The maximum allowable input voltage is ±12V. Select a voltage of 1V or higher in order to minimize the error.
The auxiliary input AUX IN1 has a frequency bandwidth of approx. 130 Hz, and cannot respond to signals that change too quick. Do not supply sharp-changing signals to AUX IN1 or IN2 because this may affect measurement of I, A or B input.
To keep errors low, set the potential difference between the auxiliary input ground and the ground of measured signal input (I, A and B) within ±1V or so.

[Restrictions]

- With ratio indication, specifying ×10 or ×100 of EXPAND will not work enlargement.
- Specifying ratio indication will not enable ratio calculation for NOISE and AUX IN.
- With ratio indication, turning on the dB or % lamp of NORMALIZE will not enable dB or % indication.

4.10 Measurement of noise density (NOISE)

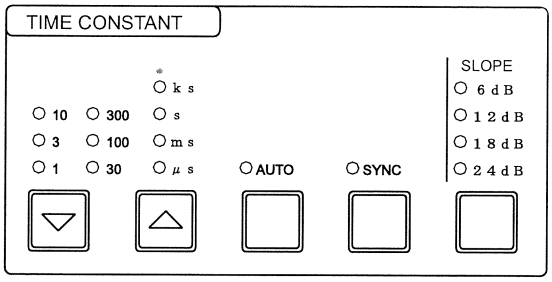
4.10.1 Operation of noise density measurement



a) Viewing noise density

Noise density is the magnitude of noise per unit frequency width. LI5640 works as a band-pass filter to measure the noise density in the reference signal frequency.

To measure noise density, select NOISE using the DISPLAY key of DATA1. DATA2 will show AUX IN1 regardless of DISPLAY selection. If Y or others have been specified, Y or other lamps will keep blinking during measurement of noise density.



b) Setting time constant and attenuation slope

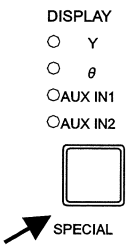
Set the attenuation slope (SLOPE) to 24dB/oct if the user have no inconvenience with it.

Set the time constant (TIME CONSTANT) to three or more times the signal period (= 1/frequency) and 300 μs or higher as a guideline. For frequency of several tens kHz, select a value of 1 ms or higher taking into consideration the swell of frequency characteristics.

If conditions allow, the user may shorten the time constant for the purpose of reducing the time for measurement.

When the time constant or the attenuation slope is too small, the measurements will involve signals and noise of distant frequency as well as ripples that arise in phase sensitive detector. As a result, the noise density may appear high. If noise density decreases with larger time constant or attenuation slope, this indicates that the time constant and the attenuation slope is too low. When automatic setting has been selected with the AUTO key, also check the values manually.

Even if the synchronous filter (SYNC) is specified, the filter remains the normal one, with the SYNC lamp blinking during measurement of noise density.



c) Specifying the response time constant for the noise-measurement smoothing filter

- Press the SHIFT + SPECIAL keys.
- Confirm that noiSE appears on DATA2.
- Using the ▶ key, move the blinking digit to value on the REFERENCE digital display.
- Select one out of 1, 4, 16 and 64 using the MODIFY dial.
- Press the SHIFT + EXIT keys to return to the previous indication.

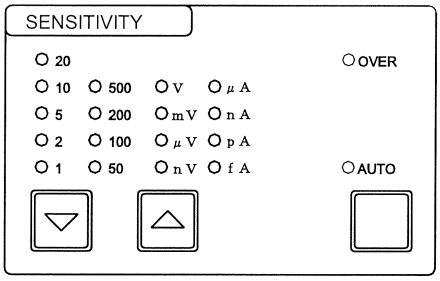
DATA1	DATA2	REFERENCE
	noiSE	4

Every selection of a four times the previous value will approximately halve the measurement dispersion. However, the response time will become longer in proportion to the specified value. Select 1 if the user wants to know a broad value quickly or if the user may read the central value after recording the value in the recorder. Select 4 or higher if direct reading of a stabilized value is desired.

When the attenuation slope is 24dB/oct, the time necessary for settling down to the final value is approximately the following:

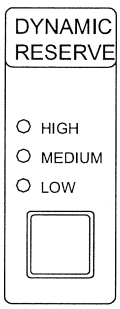
170 × The time constant × The smoothing filter setting (1 to 64)

d) Setting sensitivity



In measurement of noise density, set the sensitivity (SENSITIVITY) in the full scale of noise density.
Current I (10^6) : 1pA/$\sqrt{\text{Hz}}$ to 1 μA/r$\sqrt{\text{Hz}}$
Current I (10^8) : 100fA/$\sqrt{\text{Hz}}$ to 10nA/$\sqrt{\text{Hz}}$
Voltage A, A-B : 20nV/$\sqrt{\text{Hz}}$ to 1V/$\sqrt{\text{Hz}}$
Automatic setting with AUTO key is also available.
Sensitivity of an adequate RMS value will be set inside LI5640 from the sensitivity of noise density and the equivalent noise bandwidth. Noise density will be indicated in the converted value of the measured RMS value of noise with limited frequency band.

e) Setting dynamic reserve



Since noise is also a kind of measured signal, it involves a problem of dynamic reserve. It may occur that the user has to increase the dynamic reserve if the noise of frequencies that are different from the target frequency is strong.
If the OVER lamp would light up even when the measurement is far smaller than the full scale, then increase the dynamic reserve.
However, increased dynamic reserve will admit more LI5640 input referred noise. For white noise, it is hard to measure the noise smaller than the LI5640 noise because the following relationship holds:

$$\text{Measurement of noise density} = \sqrt{(\text{LI 5640 input-converted noise density})^2 + (\text{input signal noise density})^2}$$

The value of 6nV/$\sqrt{\text{Hz}}$ (1kHz at the maximum) as indicated in the specifications is a value for LOW dynamic reserve and low sensitivity setting. This phenomenon in current input is not so conspicuous as for voltage one because the noise by current/voltage conversion is dominant.
If the user wants to use the system in the best condition for input referred noise, then select LOW for dynamic reserve and decrease the input level. For voltage noise, set DISPLAY of DATA1 to R and select such an input level that the OVER lamp will not light up when measuring the input signal (noise) with the sensitivity of 2 mV.

[Complementary explanation]

The following describes some key points for measurement of noise density:

- Input referred noise varies with the sensitivity, dynamic reserve, time constant and attenuation slope.
- If time constant or attenuation slope is too low, unintended signal may be measured together.

Once sensitivity, time constant and other settings have been specified, check the input referred noise. For voltage, make a short circuit on the input, or for current, open the input, and measure the input referred noise. It would be acceptable to attach a shield cap because current input is likely to pick up surrounding noise. Do not make a short circuit on current input.
When measuring noise density in practice, try to increase the time constant to confirm that noise density changes little.

4.10.2 Principle of noise density measurement

Assuming the RMS value Vm of a certain noise is measured by passing through a filter with the equivalent noise bandwidth of B_N, the noise density Vn can be determined by the following expression:

$$Vn=\frac{Vm}{\sqrt{B_N}}$$

A lock-in amplifier works as a band-pass filter that has a center frequency at the frequency "fr" of reference signal. While normal measurement intends to measure only the center frequency, RMS values of all components are measured in noise measurement.

In practice, a high-pass filter is provided after the band-limiting filter to eliminate the reference signal frequency components (DC components after phase sensitive detection) in order to determine the RMS value. This device can suppress the effects of leak-in of reference signal and staggering of noise measurement.

The equivalent noise bandwidth Bbp when noise is measured is a little narrower than when signal magnitude is measured. Therefore, noise density is calculated by using the equivalent noise bandwidth for noise density.

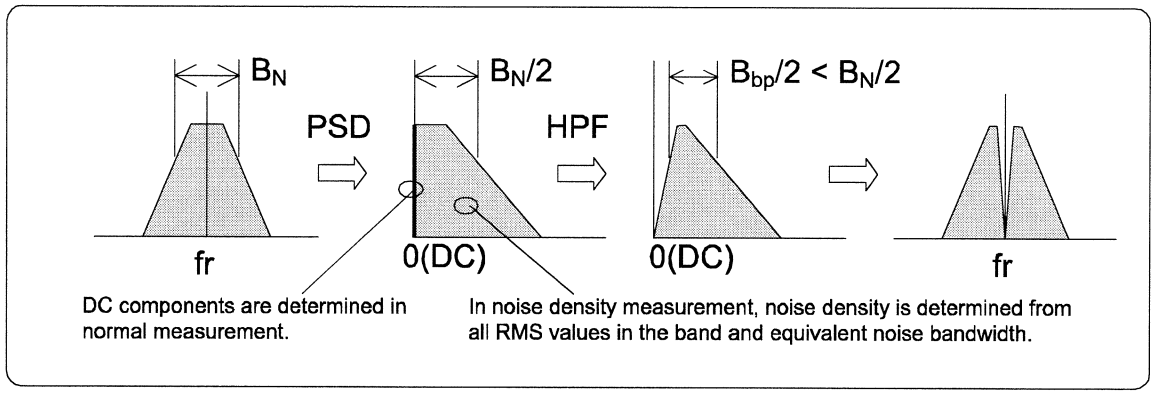
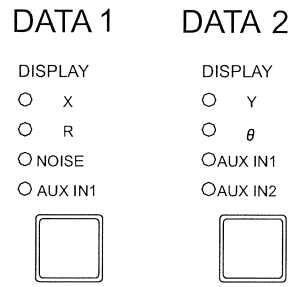


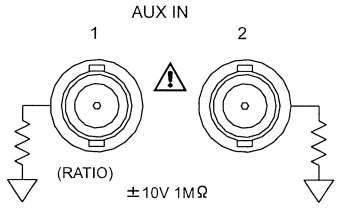
Fig. 4-7 Measurement of Noise and Bandwidth

Incidentally, LI5640 determines the RMS value based on the value from average detection. In random noise, the RMS value can be determined easily from the mean value because the noise density is constant within a narrow band.

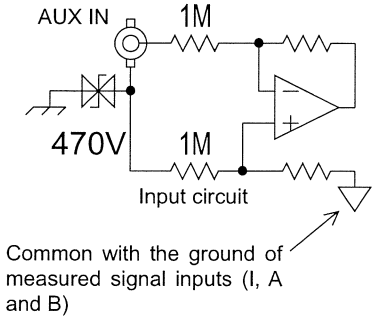
4.11 Measurement of DC voltage (auxiliary input AUX IN1/AUX IN2)



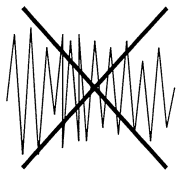
LI5640 can measure two DC voltages. To measure DC voltage, use the DISPLAY keys of DATA1 and DATA2 to select auxiliary input AUX IN1 or AUX IN2.
The range of measurement is within ±12V and the indication resolution is 0.001V.
Although the sampling rate is 16k samples/s, the frequency bandwidth is approx. 130Hz (-3dB).



Connect the DC voltage to AUX IN1 and AUX IN2 connectors on the rear panel.
Input impedance :approx. 1MΩ and 100pF or less in parallel
Maximum nondestructive input voltage : ±40V

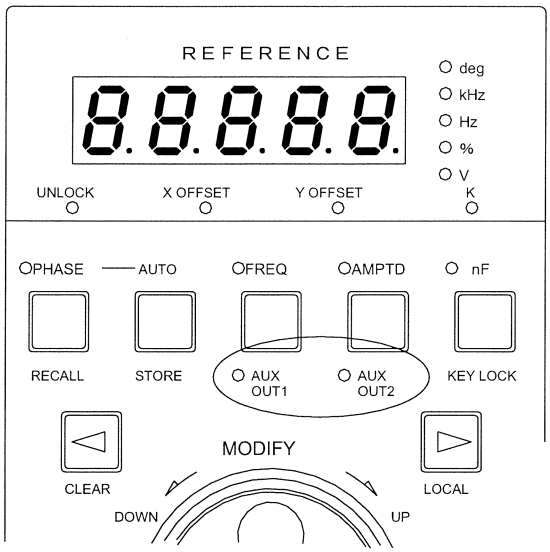


The signal ground of auxiliary input is isolated from the chassis and signal inputs (I, A and B connectors). However, measurement error of the auxiliary input becomes greater if the potential difference with the signal inputs (I, A and B) becomes higher. Keep the potential difference between the both grounds within 1V.



A steeply changing high-amplitude signal supplied to the auxiliary input may affect the measurement of signal input (I, A and B). If a 1kHz or higher signal, or a steeply changing signal such as a square wave is anticipated to enter the auxiliary input connector, be sure to confirm it will not affect the system badly before starting operation.

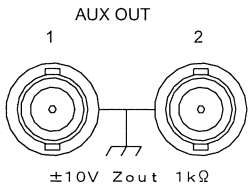
4.12 Output of DC voltage (auxiliary output AUX OUT1/AUX OUT2)



LI5640 provides two auxiliary outputs of DC voltage. The auxiliary outputs are available as a signal to control measurement conditions.

To set a DC voltage, press the SHIFT + AUX OUT1 or SHIFT + AUX OUT2 keys first to display a DC voltage on the REFERENCE digital display. Next, use the MODIFY dial for setting. Select the changing digit (or blinking digit) with the ◀ and ▶ keys.

The range of voltage setting is within ±10V and the resolution is 0.001V.



DC voltages will be supplied via the AUX OUT1 and AUX OUT2 connectors on the rear panel.

Output impedance: approx. 1kΩ

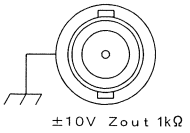
The signal ground of DC voltage output is connected to the chassis.

⚠CAUTION

Do not apply external voltage to the output connector. This will break the internal circuit.

Output current is limited. Keep the load impedance to 1kΩ or higher.

4.13 Monitor output



The user can check the input signal to the phase sensitive detector (PSD) at the MONITOR OUT connector. If the measurement does not run as the user expects, try to check the monitor output on an oscilloscope or other devices. This will help the user to figure out the situation of signal and noise.

If the monitor output is too small for observation, set the dynamic reserve to LOW, and decrease the sensitivity setting.

The output impedance is approx. 1kΩ, and the signal ground is connected to the chassis. It is isolated from the signal input section with a differential amplifier so that it will not affect the measurement.

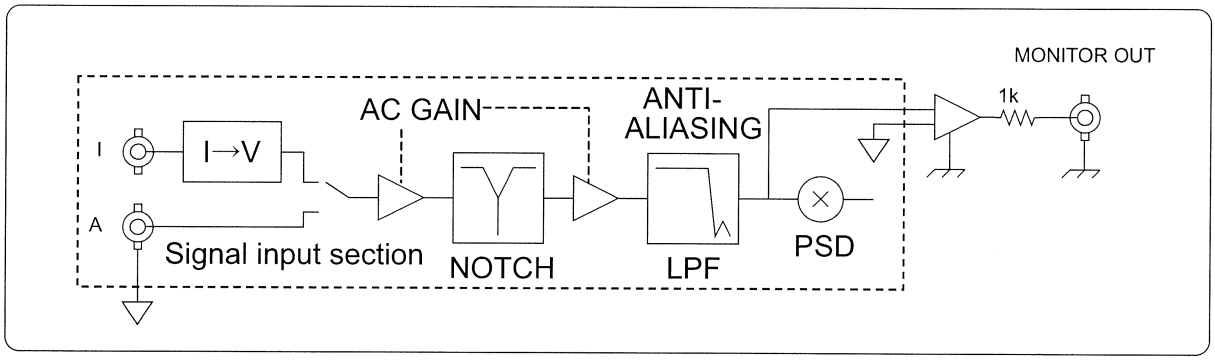


Fig. 4-8 Paths from Input to Monitor Output

⚠CAUTION

Do not apply external voltage to the output connector. This will break the internal circuit.

Output current is limited. Keep the load impedance to 1kΩ or higher.

[Gain of monitor output]

The gain from the signal inputs (I, A and B) to the monitor output is defined by the AC gain. When the AC gain is 0dB, the gain from the signal input (A) to the monitor output is about seven times (approx. 17dB). If the gain is not 0dB, the gain will be multiplied by value of the AC gain. The AC gain is determined by using Table 4-2 "Actual Value of Dynamic Reserve" based on the sensitivity and dynamic reserve.

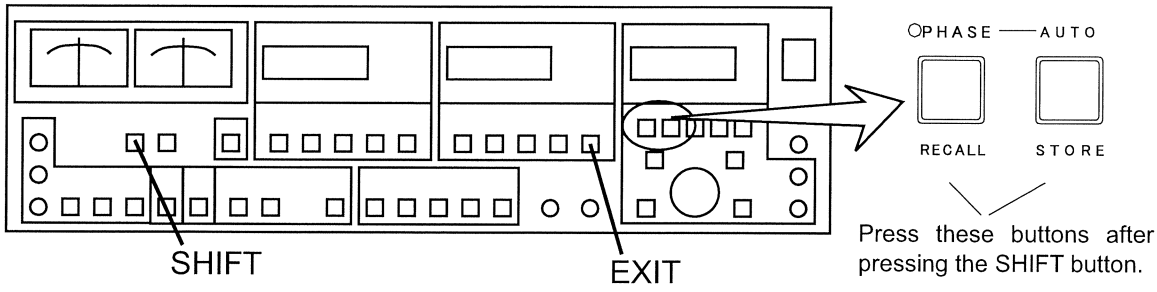
For current input, multiply by the value of the current/voltage conversion gain (10^6, 10^8V/A) according to the selection of SIGNAL in the signal input section.

Further, do not use the monitor output to confirm the phase because the phase is rotated drastically by the steep anti-aliasing filter.

[Phase inversion on current input]

In the current input connector (I) of LI5640, the direction of flowing-out current is called positive. If the current flowing into the I connector is considered as the positive direction, the phase of measurement value and monitor output is inversed.

4.14 Operation of setting memory (RECALL/STORE)



LI5640 can store nine sets of settings.

In addition to the above, LI5640 has another memory to store the settings on the last power off occasion.

☞ For details of settings that can be stored in the setting memory, and the settings that are automatically reset when power is turned on.

➡ Refer to Table 3-2 "List of Initial Values".

Measurement conditions are reset, but settings that relate to external interface are not changed.

a) Storing settings

To store the current settings into the setting memory, follow the steps below:

- Press the SHIFT + STORE keys. → Setting memory numbers appear.
- Select the desired setting memory number in the range from 1 to 9 using the MODIFY dial.
- Press the SHIFT + STORE keys again. → The set data is restored.

DATA1	DATA2	REFERENCE	
	Str	1	← Memory number

b) Recalling settings

To read stored settings from the setting memory, follow the steps below:

- Press the SHIFT + RECALL keys. → Setting memory numbers appear.
- Select the desired setting memory number in the range from 1 to 9 using the MODIFY dial.
- Press the SHIFT + RECALL keys again. → Set data is retrieved.

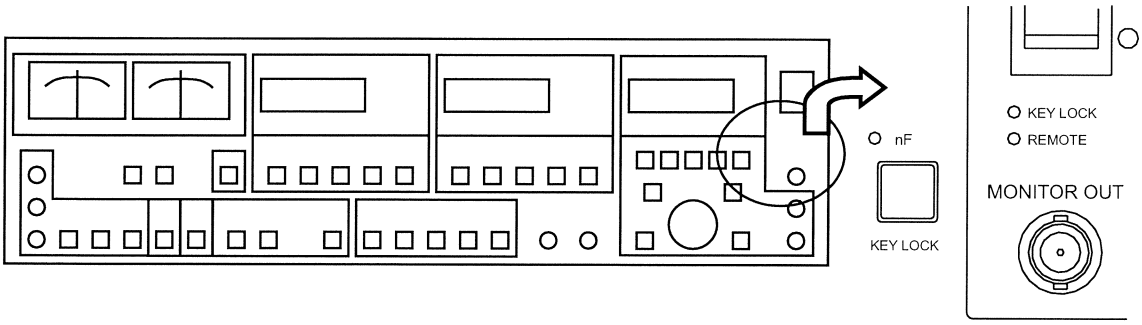
DATA1	DATA2	REFERENCE	
	rcL	1	← Memory number

If zero is specified for the setting memory number, the settings on the last power off can be retrieved. In other words, the user can recall the state of the system when the user turned on the power for the current operation.

c) Aborting storage and recall

If the user wants to abort the current storing/recalling data into/from the setting memory halfway, press the SHIFT + EXIT keys, or otherwise press the FREQ or any other key to display another parameter.

4.15 Disabling panel operation (KEY LOCK)



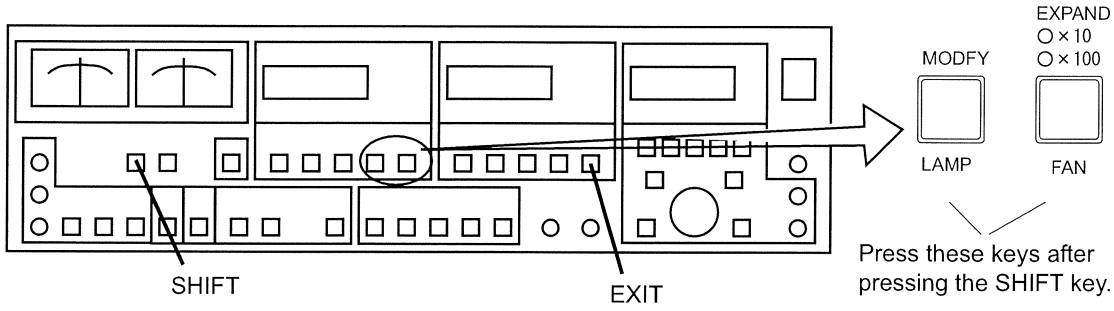
LI5640 allows the user to set panel keys inoperable. Disabling key operation can prevent settings from being changed accidentally during measurement.

Pressing the SHIFT + KEY LOCK keys toggles the KEY LOCK lamp between ON and OFF.
When the KEY LOCK lamp is lighting, panel operation is disabled except the operation of the SHIFT + KEY LOCK keys and SHIFT + LOCAL keys.
If the user wants to set all panel keys operable, press the SHIFT + KEY LOCK keys, turning off the KEY LOCK lamp.
Turning off the power releases panel keys from disabled state.

[Relation with external interface]

Control via external interface (GPIB or RS-232) is still effective even when the KEY LOCK lamp is lighting.
However, if the user selects remote state for GPIB control (the REMOTE lamp lights up) when the KEY LOCK lamp is lighting, KEY LOCK cannot be released from the panel. Also SHIFT + LOCAL keys are inoperable.

4.16 Turning ON/OFF lamps and cooling fan



4.16.1 Turning ON/OFF lamps

During optical measurement, the light emitted from LI5640 may affect the measuring system. In such cases, turn off LI5640 lamps. Buttons are operable even when the lamps are turned off.

Pressing the SHIFT + LAMP keys turns off all lamps and digital displays.
Press the SHIFT + LAMP keys when all lamps are off to return to the previous lighting condition.
When the unit is powered, lamps are always turned on.

4.16.2 Turning ON/OFF cooling fan

During acoustic measurement, the sound emitted from the LI5640 cooling fan may affect the measuring system. In such cases, turn off the LI5640 cooling fan.
If measurement is conducted in an environment of steeply changing ambient temperature, stop the fan in order to control temperature change inside LI5640 and to improve stable measurement.
To switch fan ON/OFF, operate as shown below:

- Press the SHIFT + FAN keys. → The current ON/OFF state is shown.
- Select on or oFF using the MODIFY dial.
- Press the SHIFT + EXIT keys to return to the previous indication.

DATA1	DATA2	REFERENCE
	FAn	oFF

Stopped fan will permit the internal temperature to rise, shortening the equipment life. Do not keep the fan turned off for an extended time if the ambient temperature is higher than 30℃.
Dissimilar to lamp ON/OFF setting, fan ON/OFF setting will be retained even when the power is turned off. Do not leave the equipment with the cooling fan turned off indiscriminately.

5. GPIB Interface

5.1 Preparation before use

5.1.1 GPIB overview

Most of the functions that are operated on the panel can be operated via GPIB with some exceptions. In addition, the user can transfer measurement data to other devices over GPIB. Once measurement data is stored in the data memory, it can be transferred to other devices.
The functions that can be operated via GPIB can also be operated via RS-232 with some exceptions.
Practical operation and programming depend on the programming languages and the GPIB driver on the controller side.
For details, refer to the manuals of the programming language being used and the GPIB driver.

a) Functions that cannot be operated via GPIB include:

- Turning the power supply ON/OFF
- Initializing to the factory default settings
- Switching between GPIB and RS-232
- GPIB address and message terminator for transmission
- RS-232 baud rate, parity and character length

b) Functions that can be operated via GPIB but cannot be operated on the panel include:

- Operation of data memory
- Functions that are specific to the GPIB (status byte, remote/local etc.)

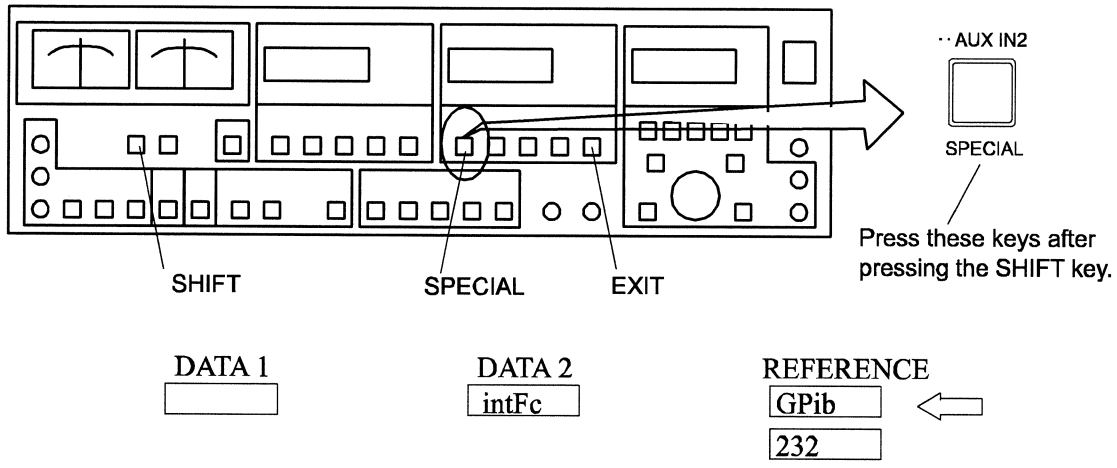
c) Applicable standards

- Conforming to IEEE std 488.1-1987, partially conforming to IEEE std 488.2-1992
- Interface functions

Table 5-1 Interface Functions

SH1	Completely capable of source handshake
AH1	Completely capable of acceptor handshake
T6	Capable of basic talker, serial poll and listener-defined untalk; not capable of talk only.
L4	Capable of basic listener and talker-defined unlisten; not capable of listen only.
SR1	Completely capable of service request
RL1	Completely capable of remote-local function
PP0	Not capable of parallel poll
DC1	Completely capable of device clear
DT1	Completely capable of device trigger
C0	No controller functions
E1	Open collector drive

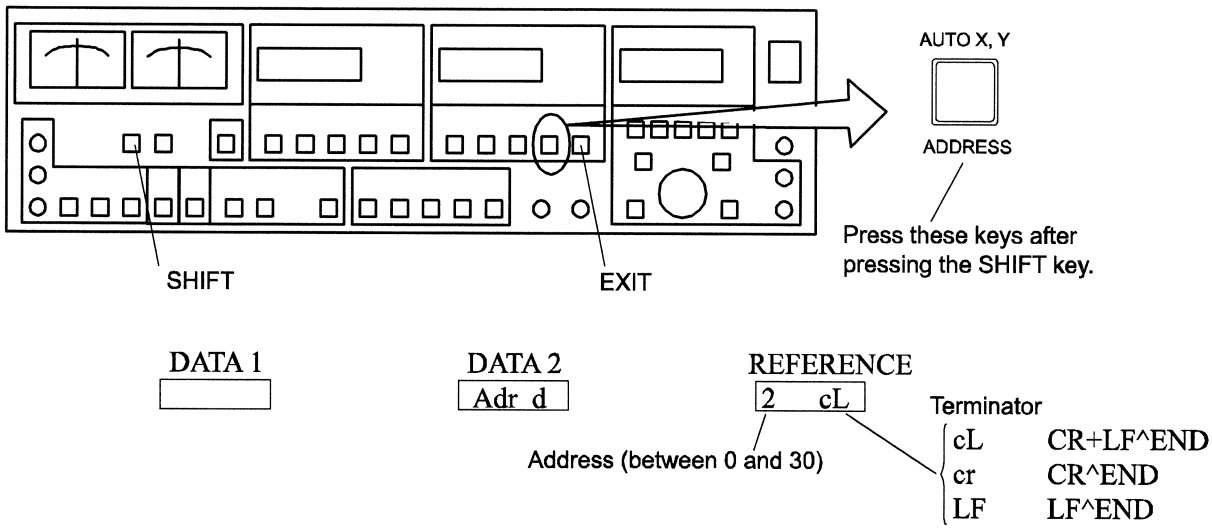
5.1.2 Switching to GPIB



Both GPIB and RS-232 cannot be used at the same time. When to use GPIB, follow the procedure below to switch the external interface to GPIB:

1) Press the SHIFT + SPECIAL keys.
2) Make sure intFc appears on the DATA2 display.
   (Other parameters may be selected using the MODIFY dial.)
3) Use the ▶ key to move the blinking digit to the REFERENCE indication section.
   (Or use the ◀ key to return to the DATA2 display.)
4) Use the MODIFY dial to select GPIB.
5) Press the SHIFT + EXIT keys to return to the previous indication.

5.1.3 Setting the address and message terminator



Before controlling devices via GPIB, each device must be assigned a unique primary address in order to identify them.

The message terminator that indicates the termination of a transmitted message or data may vary with the system. Therefore specify a message terminator according to the system.

Set the address of LI5640 and the message terminator to be used in transmission using the following procedure:

1) Press the SHIFT + ADDRESS keys.
2) Use the MODIFY dial to set the address.
   GPIB address can be set in the range between 0 and 30.
3) Use the ▶ key to move to selection of terminator.
   (Press the ◀ key to return to address setting.)
4) Use the MODIFY dial to select the transmission terminator for LI5640. Select one out of CR + LF^END, CR^END and LF^END. ^END specifies to output the END message together with the last code.
   Most systems accept CR + LF^END as the terminator.
5) Press the SHIFT + EXIT keys to return to the previous indication.

Further, any of the above terminator functions when LI5640 is receiving data (setting is made from the controller). In addition, an END message may be omitted.

CR : Carriage return

LF : Line feed (same as NL or New line)

5.1.4 Connecting GPIB cable

A connector for GPIB connection is located on the rear panel.

Connect LI5640 to the GPIB bus line with the GPIB cable as specified by the standard. Before bus connection, turn off the power to every connected device. Securely tighten the connector mounting screws for prevention of loosening.

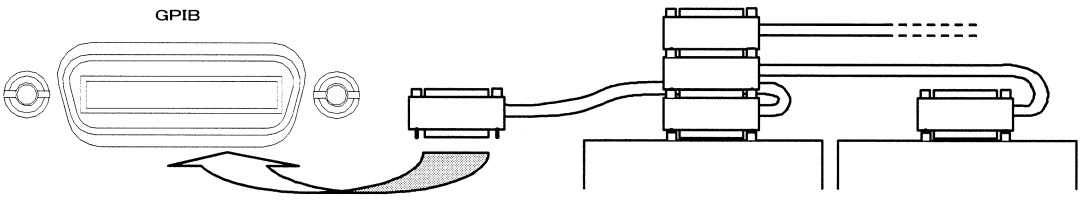
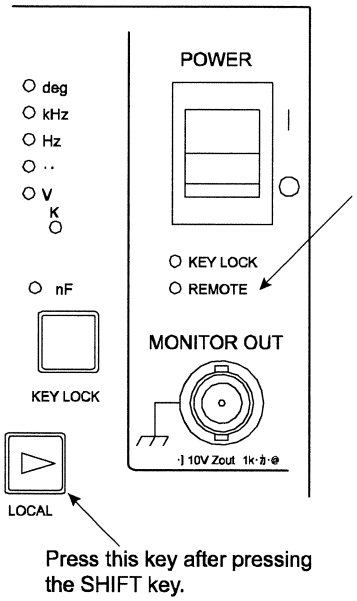


Fig. 5-1 Connection of GPIB Cables

5.1.5 Precautions on GPIB use

- Before connecting or disconnecting the GPIB connector, turn off the power to every device that is connected to the bus.
  Devices may be damaged if connected or disconnected while the power is supplied.
- When using GPIB, turn on the power to every device that is connected to the bus.
- Up to 15 devices can be connected to one bus, including the controller.
- The length of cabling is subject to the following limit:
  Cable length between devices must be no longer than 4m.
  Total length of all cabling must be within either 2m times the number of interconnected devices or 20m, whichever is shorter.
- Assign a unique address to each device connected to one bus. If different devices are assigned the same address, the devices may be damaged.
- Use a unified message terminator in the system.
  If the message terminator does not match between the talker and the listener, malfunction may occur.
- GPIB is an interface designed for use in relatively good working environment. Avoid use in the environment where the power supply fluctuates or noise is high.

5.2 Remote status and releasing remote control state



a) Switching to remote

Select 1 (True, line is at low level) on REN (Remote ENable) and send a program message to LI5640. This will enable remote control state, disabling the local operation on the panel. The REMOTE lamp keeps lighting when the system is in a remote control state.

The system usually stays in a remote control state even after setting completion, depending on the GPIB driver software on controller side.

b) Switching to local

Pressing the SHIFT + LOCAL keys of LI5640 allows the user to return from remote to local (except when local lockout is active).

The user on the controller side should use either of the following steps to return LI5640 to local:

- Specify the address and send a GTL (Go To Local) interface message.
- Select 0 (False, High level) on REN (Remote ENable line).

GTL brings the specified device into a local state.

Removing the cable from the GPIB connector of device also returns LI5640 to local. However connecting or disconnecting the cable during operation may damage the devices.

c) Activating local lockout

Once local lockout is activated from controller side, pressing the SHIFT + LOCAL keys cannot return LI5640 to local. This can avoid wrong operation during automatic measuring. To activate local lockout, use the following operation:

- Send an LLO (Local LockOut) interface message.

LLO activates local lockout on every device that is connected to the bus and has the local lockout function.

To deactivate local lockout, set REN to 0.

The method of programming depends on the GPIB driver software on controller side.

For details, refer to the instruction manual of the use's driver.

5.3 Service request and status structure

5.3.1 Outline of status report

GPIB has a function that advises device status to a controller.
For example, it is available for interrupting by transmitting a service request (SRQ) to the controller when automatic sensitive setting of LI5640 is completed. When reading out the related register of LI5640, it is possible to know the status on the time.

[Status Byte]

The device has some pairs of status data, and they are summarized in the status byte of the device.

[Sending of a service request]

If a bit of the service request enable register is set to 1, then the system will send a service request (SRQ) when each status bit of status byte becomes 1.

[Capture of an event]

Device condition is shown on the condition register, its change is recorded in the event register. If the corresponding bit of the event enable register is set to 1, each bit of the event register will be summarized in the specific one bit of the status byte.
LI5640 has total three event registers including the standard event status register. The event register and the condition register can be read.
When *PSC command is used, it can be select whether clearing of enable register or keeping of previous conditions at power on.

[Clasp of queue condition]

The device is waiting queue to retain the information of waiting output. The status byte has a status bit that indicates whether the queue has information or not.
LI5640 prepares MAV bit that indicates the queue condition of output of response message and EAV bit that indicates queue condition of error code (number and message).

[CAUTION: Performance is reduced in frequent read out status]

If a serial poll is performed frequently for checking the device condition without a service request, the resource of controller is consumed by performing of serial poll. If the status is quarried by a query message frequently, the controller performance (operation speed) is not only reduced but also receiving device of query. Perform a query appropriate period.

5.3.2. Status byte and sending a service request

A status byte register has summary of device conditions.

If a corresponding bit of a service request enable register is set to 1, then the system will send a service request (SRQ) when the status bit becomes 1.

The status byte can be read by following methods.

- Serial poll
- Query by *STB? of common command (the response message is decimal integer). When serial poll is performed, each bit is not cleared in reading status byte register without RQS bit is reset.

Serial poll is a GPIB function in which controller assigns an address to read the status byte of each GPIB device. The method of programming depends on the language of the controller and GPIB driver software.

Service request enable register can execute setting and query using following messages.

- Setting : *SRE of common command
- Query : *SRE? of common command

The data to be set and the response data are decimal integers in which the weight of the bit set to one in each register was added.

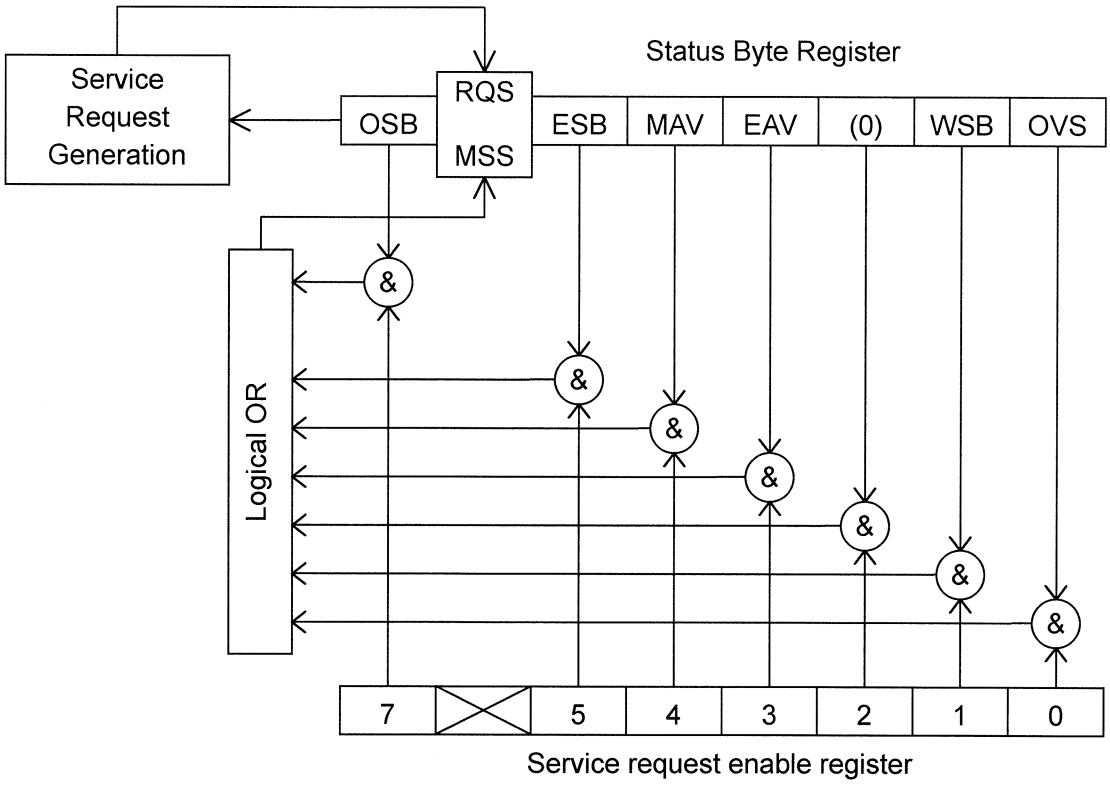


Fig5-2 Enabling SRQ transmission

Table5-2 Status Byte Register

Bit (weight)	Mnemonic	Description
7(128)	OSB	Summary of operation event register If any bit of operation event register becomes 1,this bit will be set to 1, and if all bits become 0, then this bit will be cleared to 0.
6(64)	RQS	Request service (at serial poll *Note1) If any of permitted bit of the status byte becomes 1 and service request occurs, RSQ is set to 1 and will be cleared to 0 by reading serial poll.
	MSS	Master summary status (at *STB? *Note1) If any of permitted bit of status byte becomes 1 and service request occurs , MSS is set to 1 and will be cleared to 0. MSS is not cleared with serial poll.
5(32)	ESB	Summary of standard event status register If any of permitted bit of standard event status register becomes 1, ESB is set to 1, and if all of permitted bit of standard event status become 0, ESB will be cleared to 0.
4(16)	MAV	Available for output of response message. If response message is written to output queue against query message and output valid, MAV is set to 1. If output queue will be empty by assigning the talker and reading the response message, MAV will be cleared to 0.
3(8)	EAV	Error occur (available for output error message) If error occurs and error number and error code are written to error queue and then it available for output, EAV will be set to 1. If an error number and a message are read by a query message "ERROR?" and then error code queue will be empty, EAV will be cleared to 0.
2(4)		Always 0. (Not used)
1(2)	WSB	Summary of warning event register If any of permitted bit of warning event register becomes 1, WSB is set to 1, and if all of permitted bit of warning event register become 0, ESB will be cleared to 0. (*Note 1)
0(1)	OVS	Summary of over level event register If any of permitted bit of over level event register becomes 1, OVS is set to 1, and if all of permitted bit of over level event register is set to 0, ESB will be cleared to 0. (*Note 2)

*Note 1: Bit 6 will be RQS if status byte is read by serial poll.

Bit 6 will be MSS in response message against query message "*STB?"

*Note 2: "permitted" means that "the bit against enable register is set to 1".

5.3.3 Detail structure of status data

a) Outline

The previous status prior to summarizing in a status byte register exists in several event registers.

In every event register, exists a corresponding enable register, and summary into status byte can be permitted or prohibited by bits.

Please note that the event register will not be cleared to 0 even if the status byte register is read by serial poll or query message.

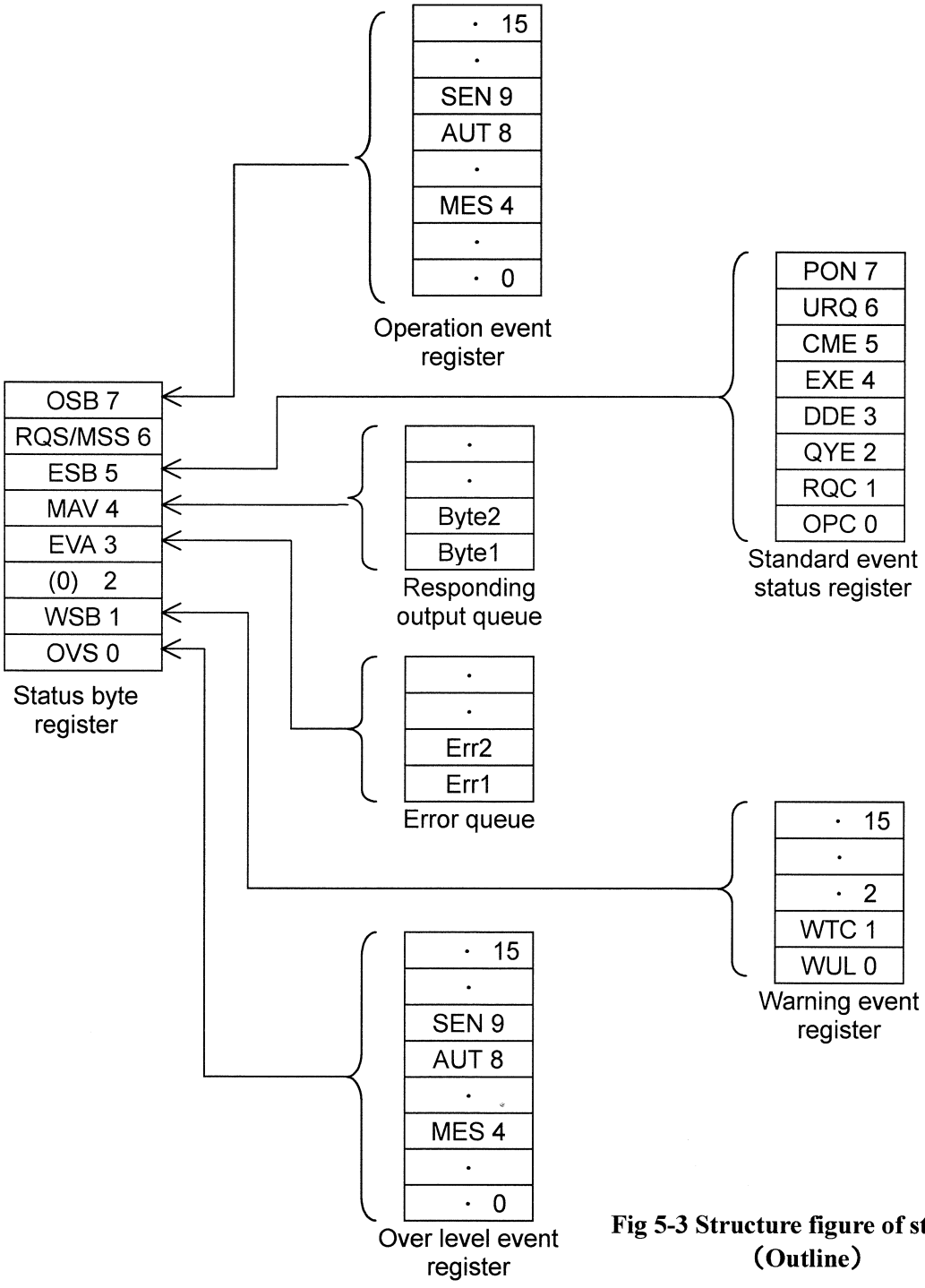


Fig 5-3 Structure figure of status (Outline)

b) Standard event status register and related registers

The standard event status register is a register that is commonly given to every GPIB device that conforms to IEEE-488.2 standards. This register express the condition of a device as shown in table5-3 "Assign of standard event register".

A standard event status register can be queried with the following query messages.

- *ESR? of common command (Response data will be in decimal integer)

Every bit of standard event status register is cleared in following conditions.

- Standard event status register is read.
- Common command *CLS (clear status) is sent.

Every bit of standard event status register can be summarized into an ESB bit of the status byte register by setting the corresponding bit of the standard event status enable register to 1,

A standard event status enable register can be set or queried using the following messages where the data is the total of the weight of each factor that are set to 1.

- Setting : *ESE of common command. (The setting data will be in decimal integer).
- Query : *ESE? of common command. (The responding data will be in decimal integer).

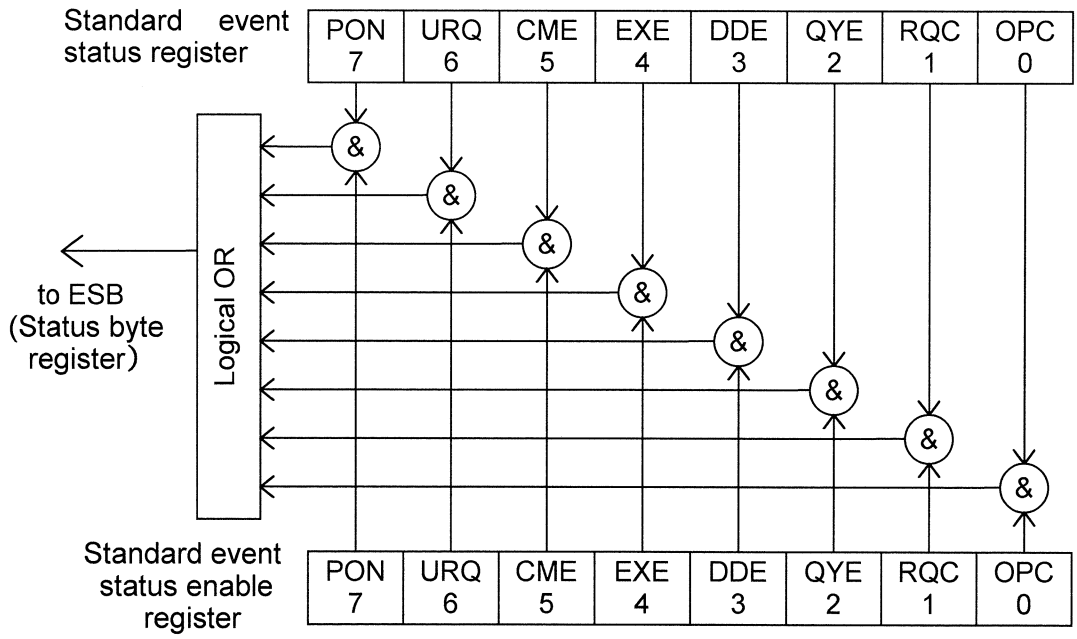


Fig 5-4 Standard event status register

Table 5-3 Bit assignment of standard event status registers

Bit (Weight)	Mnemonic	Description
7(128)	PON	**Power on** When power is on, PON is set to 1. When clearing to 0 by read out, it remains 0 until the power is changed again.
6(64)	URQ	**User request** Always 0 (not used)
5(32)	CME	**Command error** This will be set to 1 if any syntax error is detected in the program message.
4(16)	EXE	**Execution error** This will be set to 1 if the program data is out of setting possible range or specified setting is not possible due to the current condition.
3(8)	DDE	**Device defective error** This will be set to 1 if the inherent error occurs in the device. In this device, this will be set if error code queue is over flow
2 (4)	QYE	**Query error** This will be set to 1 if any of the following occurs. ● Reading is attempted when the queue contains no response message. (RS232C does not yield this error.) ● Query capacity limit(1024 characters) is exceeded. ● A next program message was received when sending of response message to a query has not been completed.
1 (2)	RQC	**Request for control authority** Always 0 (not used)
0(1)	OPC	**Operation completed** If common command *OPC is sent during following command is executed, when all of operation is completed, OPC will be set to 1. If recording to data memory, automatic setting (AUTOSET) and automatic sensitive setting are not executed, OPC setting is executed at once.

C) Operation event register and related register

LI5640 has operation condition register that always reflects vary of operation conditions of this device. This register can be queried by the following query message.

- OPCR? (the response data will be decimal integer)

Every bit of operation condition register changes from 1 to 0(completion of operation),Corresponding bit of operation event register will be set to 1.

Operation event register can be queried by the following query message.

- OPER? (the response data will be decimal integer)

Every bit of operation event register is cleared to 0 by the following conditions.

- Read operation event register.
- Common command *CLS(clear status) is sent.

Every bit of operation event register is summarized into the OSB bit of status byte register by setting corresponding bit of an operation event enable register to 1.

An operation event enable register can be set or queried using the following messages where the data is the total of the weight of each factor that is set to 1.

- Setting : OPEE (the setting data will be in a decimal integer)
- Query : OPEE? (the response data will be in decimal integer)

Table 5-4 Bit assignment of operation condition register

Bit(weight)	Mnemonic	Description
15		Always 0 (not used)
14		
13		
12		
11		
10		
9(512)	SEN	Under automatic sensitive setting (SENSITIVE AUTO)
8(256)	AUT	Under automatic setting(AUTO SET)
7		Always 0 (not used)
6		
5		
4(16)	MES	Under recording to data memory
3		Always 0 (not used)
2		
1		
0		

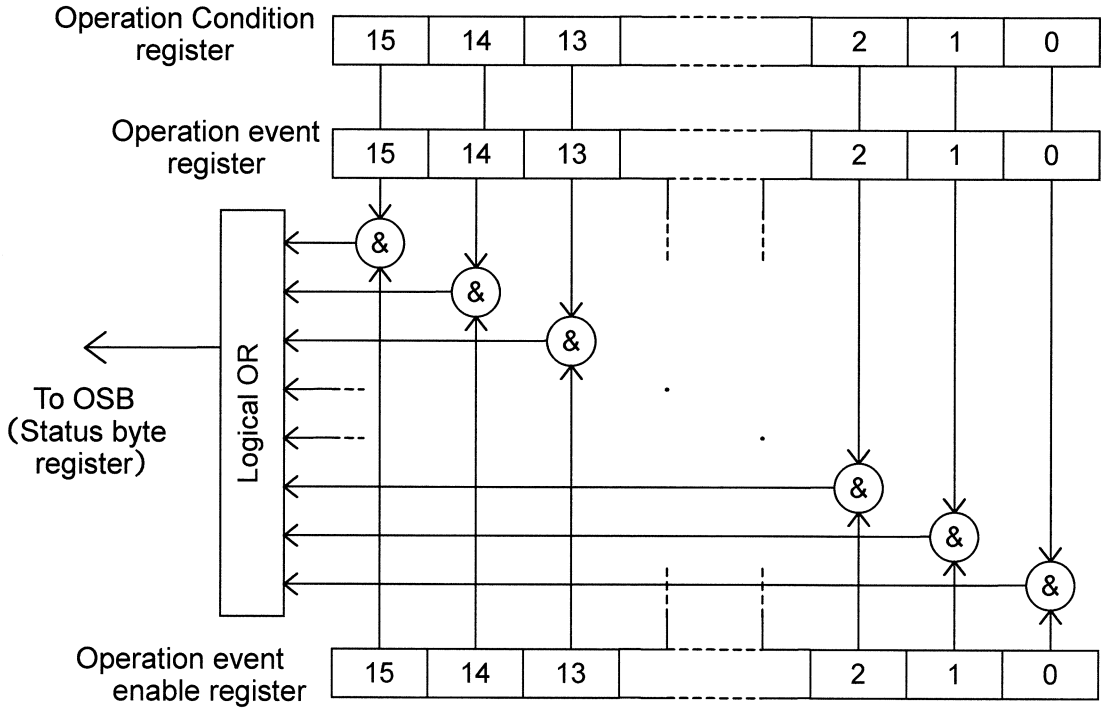


Fig 5-5 Operation Status

Even any system of operation, warning and over level, relation of three conditions register, event register and enable register are same.

Program message of direct setting or clear program are not exist.

d) Warning event register and related registers

LI5640 has a register that reflects varying of warning conditions.

This register can be queried by the following query message.

- WRCR? (the response data will be in a decimal integer)

Every bit of warning condition register changes from 0 to 1, corresponding bit of warning register will be set to 1.

Warning event register can be queried by the following query message.

- WRER? (Response data will be in a decimal integer)

Every bit of warning event register is cleared to 0 by the following occurs:

- When warning register is read.
- When common command *CLS (Clear status) is sent.

Every bit of warning register can be summarized into WSB bit of status byte register by setting the corresponding bit of warning event enable register to 1.

Warning event enable register can be queried and set by the following program messages where the data is the total of the weight of each factor that is set to 1.

- Setting : WREE (the setting data will be in a decimal integer)
- Query : WREE? (the response data will be in a decimal integer)

Table 5-5 Assignment of warning condition register

Bit(weight)	Mnemonic	Description
15		↑ Always 0 (not used) ↓
14		
...		
...		
2		
1(2)	WTC	It is impossible to lock as time constant is too small compare with frequency and roll off if reference signal source(SOURCE) is SIGANL.
0(1)	WUL	Not synchronized to reference signal.(lit on UNLOCK lamp)

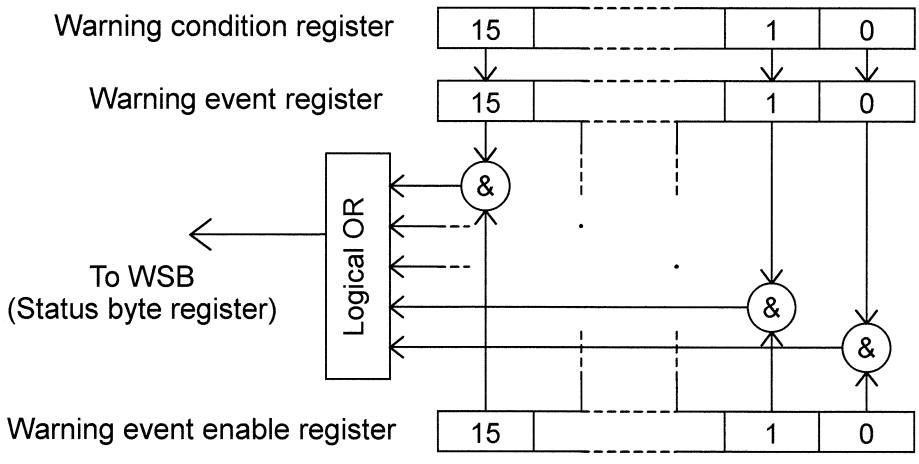


Fig 5-6 Warning status

e) Over level event register and related register

LI5640 has register that always reflects change of an over level condition of a signal system. This register can be queried by the following query messages.

- OVCR? (Response data will be into a decimal integer)

If every bit of over level condition register changes from 0 to 1, corresponding bit of over level event register will be set to 1.

Over level event register can be queried by the following query messages:

- OVER? (the response data will be in a decimal integer)

Every bit of over level event register is cleared to 0 by the following conditions.

- When over level event register is read.
- When common command *CLS(Clear status) is sent.

Every bit of over level event register can be summarized to the OVS bit of status byte register by setting the corresponding bit of over level event enable register to 1.

Over level event enable register can be set or queried by the following program message where the data is the total of weight of each factor that is set to 1.

- Setting: OVEE (the setting data will be in a decimal integer)
- Query: OVEE? (the response data will be in a decimal integer)

Table 5-6 Assignment of over level condition register

Bit(Weight)	Mnemonic	Description
15		Always 0 (not used)
...		
6		
5(32)	OR2	DATA 2 Ratio display, AUX IN1 is over level condition.
4(16)	OR1	DATA 1 Ratio display, AUX IN1 is over level condition.
3(8)	OD2	DATA2 is display over level condition.
2(4)	OD1	DATA1 is display over level condition.
1(2)	OSE	Over level condition in the middle stage.
0(1)	OIE	Over level condition in the input stage.

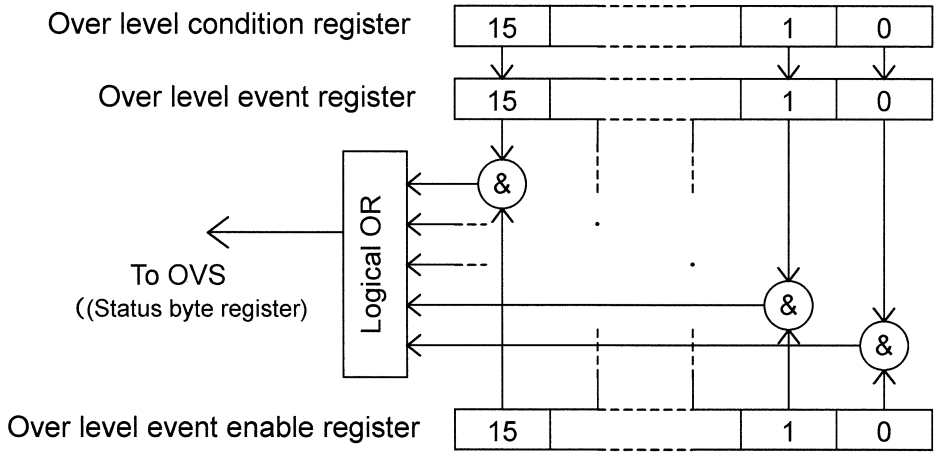


Fig5-7 Over level status

5.4 Outline of program message

The operation procedure is same as operation from the panel when LI5640 is controlled by external interface (GPIB or RS232C).
Refer to the description of the panel operation procedure in the external operation.

a) Syntax of program messages

A program message can be sent from a controller when LI5640 is controlled by a remote operation. The program message consists of a command message that instructs setting and a operation, and a query message that queries a setting or condition.

Program messages { Command message : Setting and an operation instruction
Query messages : Query a setting or conditions

The syntax of a program message is shown below.

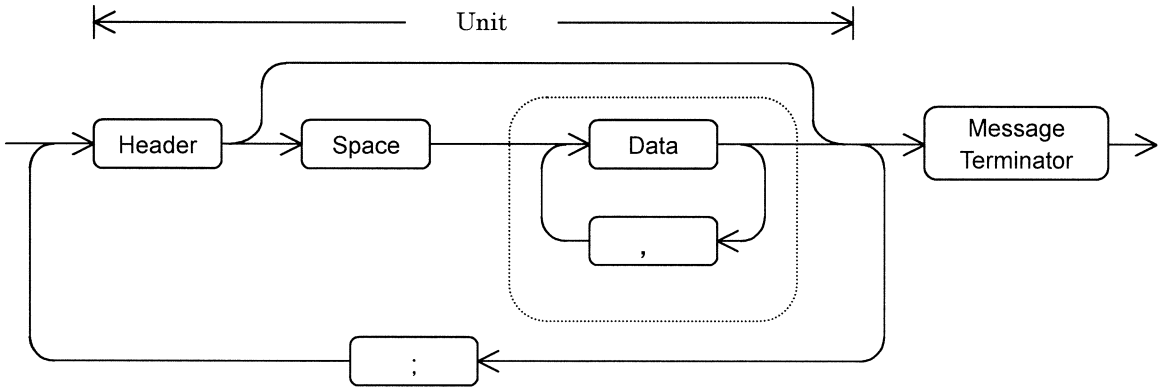


Fig5-8 Constructions of program messages (Outline)

Used character code is ASCII 7 bit code.
If this device is received a data, upper case letters and lower case letters are not classified. The parity bit is ignored.
Main constructed elements of program messages are the header, data and the terminator.

- Header(Command program header or query program header)
  Alphabet character strings that express a function. A query header is character strings that is appended "?" at the end of command header in a corresponding command
- Data (Program data)
  Instructs a detail of function.
  No header data is also existing. (In simple operation instruction)
  The data can be set into an integer, real or exponential form.
  Example : 3 +123 −5.6 .789E+3

- Message terminator

  Indicates the end of program message. This command is used for following commands.

  CR LF, CR, LF, CRLF^END, LF^END, ^END

  ^END means that END message (EOI line of bus is LOW) is sent with just before characters(byte).

- Space

  If the data is exit, it must be punctuated by one character or more of space character (ASCII code is 20H) between the header and the data.

- Comma

  If the data number is plural, every data must be punctuated by a comma (,). Available for putting space before and after a space.

- Semicolon

  When a plural program message is sent at one time, each unit must be punctuated by semicolon. The space can be put before and after semicolon.

b) Input buffer

A program message can be sent continuously within input buffer capacity (1024 words).

A program message is stored in an input buffer temporary, and when terminator is receive, an input is interpreted in order and executed. Null (00H) and CR, LF can not be not entered an input buffer.

When a program message is exceeded a capacity of an input buffer, a message within capacity of an input buffer is executed, however, a part exceeded an input buffer message is destructed.

When a program message is interpreted and irregular header or date is detected, error occurs. At this time, input buffer is cleared, and after cleared it, a program messages are not executed

After completed the interpretation and the execution, the input buffer is cleared and it will be made an accepted condition of next input.

c) Compatible messages

A compatible messages of NF conventional model(510A or 5600A) is prepared. It is easy to correct a program on a controller side by using a compatible message when replacing to LI5640 from the conventional models.

However, as there are different between both models about functions, a perfect compatibility is impossible. Please note that a compatible message is required semicolon (;) for difference between conventional models and this lock-in amplifier.

	Message of conventional models (5610A/5600A)	Compatible messages	LI5640 Original messages
When plural program messages are sent continuously, semicolon";" have to be put between each unit.	Possible to neglect	Necessary	Necessary
A space between a header and a data	Possible to neglect	Possible to neglect	Necessary
Position of "?" for a query header	Front of a command header Example: ?OFQ	Front of a command a header Example: ?OFQ	End of a command header Example: FREQ?
Addition for a response message	Possible	Possible	Impossible

5.5 Response against query messages

If a query messages is sent to LI5640, its response message is put to output queue of LI5640.
Its message is obtained if a data from LI5640 is received.
If plural messages are sent at one time, a response message against each query message is punctuated by a semicolon";" and put to the output queue. However, When the total of a response string exceeds 1024 characters, the error occurs. The terminator is impossible to use.

Example:
If | of "・・Resmmm,Re|snnn,・・" is limit, characters before Resmmm are put to the output queue and after Resnnn are disappeared.

An output queue is cleared when a controller sends next message by not receiving a response message that is put on the output queue. Send next message after receiving all response messages when a program message including a query message is sent

Query message		Response message
xxx?;yyy?;zzz? Terminator	→	Resxxx;Resyyy;Reszzz Terminator

Maximum 1024 characters

Approximate syntax of response message are shown the below.

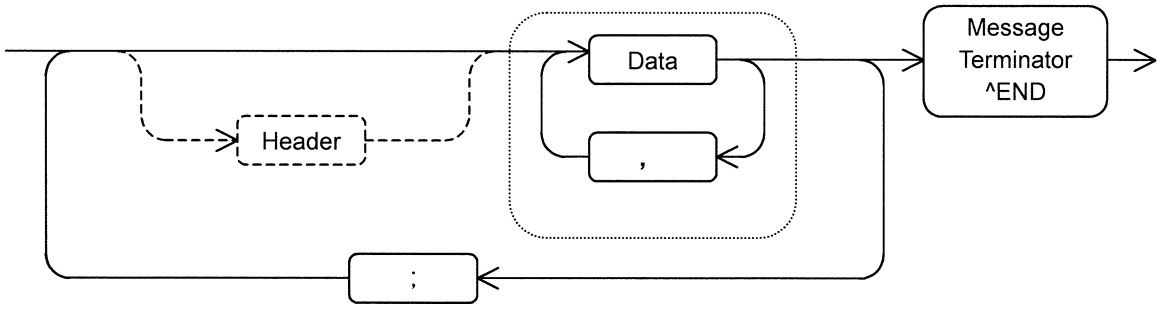


Fig5-9 Structures of response messages (Outline)

Message terminator is CFLF, CR or LF that is selected by the panel. END message is output with the last character (EOI line of bus will be LOW.)

[Response message against a compatible message]

When querying only by a compatible message of 5610B/5600A, it is available for output of a header. It is available for a prohibition of header output, and a header can not be set when power is on.

5.6 List of Program messages

5.6.1 List of Program messages

[Complement of the list]

Items	Header	Operation and range of data
Indicates an item name that conforms the indicating item name on the panel name	Indicates a command header if a command exists, or indicates a header of query if a query only exists.	**< Indicates a description of operation >** Command : Indicates an example of command message. Query : Indicates an example of a query message. Response : Indicate an example of response message. syntax : Indicates a data endian when a command or a query has plural data. Range : Indicates a data range in a command, a query and a response. INIT : Indicates a setting by INIT command.

- In case of a corresponding query message is existing, if putting "?" after a command message header, it will be query message header.
- A space is required between a header and a data followed a header.
- Plural data must be punctuated by comma ",".

[Initial value of GPIB at power on (parameters that can not be set from the panel)]

OTYP	A kinds of read out measurement data	1,2 (DATA1, DATA2)
OSMP	Output sampling period of continuous data output	1,0
OSTR	Start and stop of continuous data output	0 (stop)
DTYP	A kind of recording data	2 (DATA1, DATA2)
DSIZ	Record length	0 (2K data)
DNUM	Number of recording data memory number	0
DSMP	Recording sampling period	5(1ms)
TENB	Permission/prohibition of external trigger input TRIGER IN	0 (prohibition)
SPTS?	Number of recording sampling	0
*PSC	Power on status clear flag	No change

☞ **About parameters that can be set from the panel ➡ Refer to [Table 3-2 The list of initial values].**

An initial value of enable register depends on setting of power on status clear flag.

A setting of power on status clear at a delivery is zero(0).

a) REFERENCE system-related messages

Items	Header	Operation and Data Range
PHASE	PHAS	**<Setting and Query of Phase offset>** Command : PHAS 90.0 (+180.00 is changed to -180.00) Query : PHAS? Response : 90.00 Range : -180.00 to +179.99 [degrees] (and +180.00 degrees) At INIT : 0.00
PHASE-AUTO	APHS	**<Execution of automatic phase offset command>** Command : APHS Query : None
FREQ	FREQ	**<Setting and query of internal-oscillator frequency>** Command : FREQ 1.0 E3 Query : FREQ? Response : 1.0000E+03 Range : 0.0005 Hz to 105.00 kHz At INIT : Not changed **Note**: It is not the measured frequency. The reference signal frequency under measurement is read using Query which reads measured value, such as DOUT?.
AMPTD	AMPL	**<Setting and Query of amplitude(OSC OUT)>** Command : AMPL 0.1,1 Syntax : AMPL x, i Query : AMPL? Response : 0.100,1 Range : x = Amplitude [Vrms] 0.0 m to 50.0 m (Resolution 0.1m) 0 m to 500 m (Resolution 1m) 0.00 to 5.00 (Resolution 0.01) i = Amplitude range 0 50 mV 1 500 mV 2 5 V At INIT : Not changed
nF	HARM	**<Setting and Query of harmonic order>** Command : HARM 2 Query : HARM? Response : 2 Range : 1 to 19999 (integer) At INIT : 1

a) REFERENCE system-related messages 2/2

Items	Header	Operation and Data Range
SOURCE	RSRC	**<Setting and Query of refference signal>** Command : RSRC 0 Query : RSRC? Response : 0 Range : 0 REF IN 1 INT OSC 2 SIGNAL At INIT : Not changed
EDGE	REDG	**<Setting and query of reference signal synchronous edge>** Command : REDG 0 Query : REDG? Response : 0 Range : 0 SINE POS 1 TTL POS 2 TTL NEG At INIT : Not changed

b) Messages of SIGNAL INPUT system

Items	Header	Operation and setting range
SIGNAL	ISRC	**<Setting and query of measured signal input>** Command : ISRC 0 Query : ISRC? Response : 0 Range : 0 A 1 A - B 2 I (10^6) 3 I (10^8) At INIT : Not changed
COUPLING	ICPL	**<Setting and query of measured signal input coupling>** Command : ICPL 0 Query : ICPL? Response : 0 Range : 0 AC 1 DC At INIT : Not changed
GROUND	IGND	**<Setting and query of measured signal ground>** Command : IGND 0 Query : IGND? Response : 0 Range : 0 FLOAT 1 GROUND At INIT : Not changed

c) AUTO SET Command

Items	Header	Operation and setting range
AUTO SET	ASET	**<Excution of automatic setting>** Command : ASET(Ignored during execution) Query : None

d) FILTER-related messages

Items	Header	Operation and setting range
LINE LINE×2	ILIN	**<Setting and query of line frequency noise filter>** Command : ILIN 0 Query : ILIN? Response : 0 Range : 0 THRU (not used) 1 LINE 2 LINE x 2 3 LINE & LINE x 2 At INIT : THRU
LINE (SHIFT+)	IFRQ	**<Setting and query of line frequency>** Command : IFRQ 0 Query : IFRQ? Response : 0 Range : 0 50Hz 1 60Hz At INIT : No change
LPF THRU	ITHR	**<Setting and Query of low-pass filter on/off>** Command : ITHR 0 Query : ITHR? Response : 0 Range : 0 Used 1 through (not used)(Lit) At INIT : used (Unlit)

e) DYNAMIC RESERVE-related messages

Items	Header	Operation and setting range
DYNAMIC RESERVE	DRSV	**<Setting and query for dynamic reserve>** Command : DRSV 1 Query : DRSV? Response : 1 Range : 0 HIGH : 1 MEDIUM 2 LOW At INIT : LOW

f) SENSITIVITY-related messages

Items	Header	Operation and setting range
SENSITIVITY	VSEN	**<Setting and query of voltge sensitivity>** Command : VSEN 23 Query : VSEN? Response : 23 Range : 0 2nV, 1 5nV, 2 10nV, 3 20nV, 4 50nV, 5 100nV, 6 200nV, 7 500nV, 8 1μV, 9 2μV, 10 5μV, 11 10μV, 12 20μV, 13 50μV, 14 100μV, 15 200μV, 16 500μV, 17 1mV, 18 2mV, 19 5mV, 20 10mV, 21 20mV, 22 50mV, 23 100mV, 24 200mV, 25 500mV, 26 1V When having measured noise dennsity, setting ranges differ. At INIT : 1V
SENSITIVITY	ISEN	**<Setting and query of current sensitivity>** Command : ISEN 23 Query : ISEN? Response : 23 Range : 1 5 fA, 2 10 fA, 3 20 fA, 4 50 fA, 5 100 fA, 6 200 fA, 7 500 fA, 8 1 pA, 9 2 pA, 10 5 pA, 11 10 pA, 12 20 pA, 13 50 pA, 14 100 pA, 15 200 pA, 16 500 pA, 17 1 nA, 18 2 nA, 19 5 nA, 20 10 nA, 21 20 nA, 22 50 nA, 23 100 nA, 24 200 nA, 25 500 nA, 26 1 μA It will become an error if 0 is specified. A setting range differ. with current-voltage conversion gain. When having measured noise density, setting ranges differ. At INIT : 1 μA
AUTO (SENSITIVITY)	ASEN	**<Excecution of automatic sensitivity setting>** Command : ASEN(Nothing is done during execution.) Query : None

g) TIME CONSTANT-related messages

Items	Header	Operation and setting range
TIME CONSTANT	TCON	**<Setting and query of time constant>** Command : TCON 9 Query : TCON? Response : 9 Range : 0 10 µs 10 1 s 1 30 µs 11 3 s 2 100 µs 12 10 s 3 300 µs 13 30 s 4 1 ms 14 100 s 5 3 ms 15 300 s 6 10 ms 16 1 ks 7 30 ms 17 3 ks 8 100 ms 18 10 ks 9 300 ms 19 30 ks At INIT : 100ms
AUTO (TIME CONSTANT)	ATIM	**<Excecution of automatic time constant setup>** Command : ATIM Query : None
SYNC	SYNC	**<Setting and query of synchronous filter>** Command : SYNC 0 Query : SYNC? Response : 0 Range : 0 off (Conventional filter) 1 on (Synchronous filter) At INIT : off
SLOPE	SLOP	**<Setting and query attenuation slope>** Command : SLOP 1 Query : SLOP? Response : 1 Range : 0 6 dB/oct 1 12 dB/oct 2 18 dB/oct 3 24 dB/oct At INIT : 24 dB/oct

h) Measurement data display (DATA1,DATA2)-related messages 1/2

Items	Header	Operation and setting range
DATA1 DATA2	DDEF	**<Setting and query of display parameter>** Command : DDEF 1, 2 Syntax: DDEF i, j Query : DDEF? 1 Response : 2 Range : i = 1 DATA1 = 2 DATA2 i = 1 i = 2 j = 0 X Y 1 R θ 2 NOISE AUX IN1 3 AUX IN1 AUX IN2 At INIT : DATA1 R, DATA2 θ
NORMALIZE	NORM	**<Setting and query of normalized display>** Command : NORM 1 Query : NORM? Response : 1 Range : 0 off (Conventional display) 1 dB 2 % At INIT : off
STD	VSTD	**<Setting and query of voltage normalized-standard>** Command : VSTD 51.2E-6 Query : VSTD? Response : 51.20E-6 Range : 1.0000 nV to 1.0000 V At INIT : 1.0000 V
	ISTD	**<Setting and Query of current normalized-standard>** Command : ISTD 51.2E-12 Query : ISTD? Response : 51.20E-12 Range : 1.0000 fA to 1.0000 μA At INIT : 1.0000 μA
NOISE	NOIS	**<Setting and query of noise measurement smoothing coefficient>** Command : NOIS 1 Query : NOIS? Response : 1 Range : 0 ×1 1 ×4 2 ×16 3 ×32 4 ×64 At INIT : Not changed

h) Measurement data display(DATA1,DATA2)-related messages 2/2

Items	Header	Operation and setting range
X OFFSET ON Y OFFSET ON	OFSO	**<Setting and Query of offset on/off>** Command : OFSO 1, 1 Syntax : OFSO i, j Query : OFSO? 1 Syntax : OFSO? i Response : 1 Range : i = 1 X j = 0 off 2 Y 1 on At INIT : X, Y (both off)
X OFFSET Y OFFSET	OFFS	**<Setting and Query offset value>** Command : OFFS 1, 10.0 Syntax : OFFS i, u Query : OFFS? 1 Syntax : OFFS? i Response: 10.00 Range : i = 1 X 2 Y u = Offset value (-100.00 to +100.00 [%] of sensitivity) At INIT : X, Y (both zero)
AUTO X,Y (OFFSET)	AOFS	**<Excecution of automatic offset setting>** Command : AOFS Query : None
EXPAND	OEXP	**<Setting and Query of display magnification>** Command : OEXP 1, 0 Syntax: OEXP i, j Query : OEXP? 1 Syntax: OEXP? i Response : 0 Range : i = 1 DATA1 (X,R) j = 0 ×1 2 DATA2 (Y) 1 ×10 2 ×100 At INIT : X, Y (both ×1)

i) RATIO display-related messages

Items	Header	Operation and setting range
RATIO ON	RAT	**<Setting and Query of ratio display on/off>** Command : RAT 1 Query : RAT? Response : 1 Range : 0 off 1 on (ratio display) At INIT : off
RATIO K (SHIFT+)	KFAC	**<Setting and Query of K-constant>** Command : KFAC 0.25 Query : KFAC? Response : 0.25 Range : 0.1000 to 1.9999 and 2.000 to 9.999 At INIT : 1.0000

j) Messages of auxiliary output(AUX OUT1,AUX OUT2)

Items	Header	Operation and setting range
AUX OUT1 AUX OUT2	AUXV	**<Setting and Query of auxiliary output(DC voltage)>** Command : AUXV 1, 1.0 Syntax: AUXV i, x Query : AUXV? 1 Syntax: AUXV? i Response : 1.000 Range : i = 1 AUX OUT1 2 AUX OUT2 x = voltage -10.000 to +10.000 [V] At INIT : No change

k) Setting memory(STORE,RECALL)-related Messages

Items	Header	Operation and setting range
STORE	*SAV	**<Saving setup>** Command : *SAV 1 Query : None Range : 1 to 9 At INIT : The contents of a setting memory do not change.
RECALL	*RCL	**<Recall setup>** Command : *RCL 1 Query : None Range : 1 to 9 and 0 (0: setup of power on) At INIT : Not recall

I) Other panel operations-related command

Items	Header	Operation and setting range
INITIALIZE	INIT	**<Changes into an initial-setting state>** Command : INIT Query : None
LAMP	LAMP	**<Setting and Query of lamp>** Command : LAMP 0 Query : LAMP? Response : 0 Range : 0 off(all lights off) 1 on At INIT : Not changed
FAN	FAN	**<Setting and Query fan>** Command : FAN 0 Query : FAN? Response : 0 Range : 0 off(stopped fan) 1 on At INIT : Not changed
KEY LOCK	KLOC	**<Setting and Query of key-lock>** Command : KLOC 0 Query : KLOC? Response : 0 Range : 0 off 1 on (locked) At INIT : Not changed
CONTROL	CONT	**<Setting and Query of auxiliary control signal>** Command : CONT 0,1 Syntax: CONT i,j Query : CONT? 0 Syntax: CONT? i Response : 1 Range : i = Specification of a control port 0 to 13 j = control code 0 to 3 (i = 0 or 1) 0 to 1 (i ≧ 2) At INIT : Not changed

m) Ralated messages of measurement data read-out (Not operated from a panel)

Items	Header	Operation and setting range
OUTPUT TYPE	OTYP	**<Setting and Query of the kind of measurement data to read>** Command : OTYP 1,2,3 Syntax : OTYP i {,j,k,l,m,n} Query : OTYP? Response : 1,2,3 Range : i, j, k, l, m, n (respectively) 0 line number 1 DATA1 display value 2 DATA2 display value 3 FREQ (frequency of reference signal) 4 SENSITIVITY 5 OVERLEVEL The number of data is 1 to 6. It divides with a comma at the time of plurality. Two or more selections of the same parameter are possible. The oder of parameter is arbitrary. At INIT : Not changed
DATA OUTPUT	DOUT?	**<Query of the newest measurement data>** Command : None Query : DOUT? Response : 1.2345E-06, -0.7890E-06, 1.0000E+03 (It is outputted to the order chosen by OTYP.) Range : line number always 00000 DATA1 display data of DATA1 DATA2 display data of DATA2 FREQ frequency of reference signal [Hz] (fundamental frequency at harmonic measurement) SENSITIVITY Response data of VSEN? or ISEN? (Dependent on a setup of a measurement signal input) OVERLEVEL Response data of OVCR?
OUTPUT SAMPLING PERIOD	OSMP	**<Setting and Query of continuation data output sampling period>** Command : OSMP 1.0 Query : OSMP? Response : 1.0 Range : 0.1 to 10000.0 [s], Resolution 0.1 s At INIT : Not changed
OUTPUT START	OSTR	**<Directions of start and stop of a continuation data output, and inquiry of the state>** Command : OSTR 1 Query : OSTR? Response : 1 Range : 0 Stop (under stop) 1 Start (under output) After directing to start, if a trigger is performed, measurement data will be put on output cue with the set-up cycle. The value of the line number increases by one between 00000 to 99999. If maximum is exceeded, it will return to 00000. At INIT : Stop

n) Data memory-related messages (Cannot be operated from the panel) **1/3**

Items	Header	Operation and setting range
DATA MEMORY TYPE	DTYP	**<Setting and Query of the kind of data to record >** Command : DTYP 1 Query : DTYP? Response : 1 Range : 0 DATA1 1 DATA2 2 DATA1,DATA2 3 DATA2,AUX IN2 4 DATA1,DATA2,FREQ 5 DATA1,DATA2,AUX IN1,AUX IN2 (Recorded by FREQ is 32 bits and the other is 16 bits) At INIT : Not changed
DATA MEMORY SIZE	DSIZ	**<Setting and Query of record length>** Command : DSIZ 1 Query : DSIZ? Response : 1 Range : 0 2K Record length describes by 1 4K the number of data. 2 8K of data. 3 16K 16 bit / data converted 4 32K 1K is 1024 bits. 5 64K The total record length is divided into specified length. At INIT : Not changed
DATA MEMORY NUMBER	DNUM	**<Setting and Query of data memory number to record>** Command : DNUM 0 Query : DNUM? Response : 0 Range : 0 to 31 From 0 to (divided number - 1) can be used. At INIT : Not changed
DATA MEMORY SAMPLING PERIOD	DSMP	**<Setting and Query of record sampling period>** Command : DSMP 5 Query : DSMP? Response : 5 Range : 0 Trigger 10 50ms 1 0.0625ms 11 100ms 2 0.125ms 12 200ms 3 0.25ms 13 500ms 4 0.5ms 14 1s 5 1ms 15 2s 6 2ms 16 5s 7 5ms 17 10s 8 10ms 18 20s 9 20ms If a trigger is chosen, it is recorded for every trigger signal. When using TRIG of the rear panel, permission by the TENB command is required. At INIT : 1 ms

n) Data memory-related messages (Cannot be operated from the panel) **2/3**

Items	Header	Operation and setting range
TRIGGER ENABLE	TENB	**<Setting and Query of enable/disable of external trigger input TRIG IN >** Command : TENB 1 Query : TENB? Response : 1 Range : 0 Enable 1 Disable At INIT : Not changed
TRIGGER	*TRG	**<Excecution of trigger>** Command : *TRG Recording start, or record 1sample Query : None
STORE START	STRT	**<prepared recording start>** Command : STRT Query : None After this, recording start by a trigger signal This command is ignored at the time under record.
STORE STOP	STOP	**<Stop recording>** Command : STOP Query : None Not under recording, this command is ignored.

n) Data memory-related messages (Cannot be operated from the panel) **3/3**

Items	Header	Operation and setting range
STORED POINTS	SPTS?	**<Query of the recorded number of sampling times>** Command : None Query : SPTS? Response : 1024 Range : 0 to 65536 At INIT : 0
READ DATA MEMORY ASCII	DASC?	**<Query of the recorded data(ASCII)>** Command : None Query : DASC? 0, 256 Syntax: DASC? i, j Range : i = Read-out start position From 0 to (number of record sampling - 1) Record start position is 0. j = Number of samples to read From 1 to (Number of times of record sampling) Response : An integer of 16 bits or 32 bits(2's complement) is changed and outputted to decimal string. 12345, 678, 16777000 terminator 10813,-1000, 16776789 terminator ・ ・ ・ ・ In the order which recorded, it divides with the terminator every 1 sample. ・ When two or more data is in 1 sample, it divides with a comma. ・ Within 1 sample, it is the order in explanation of DTYP.
READ DATA MEMORY BINARY	DBIN?	**<Inquiry of the recorded data (binary)>** Command : None Query : DBIN? 0,256 Syntax: DBIN? i, j Range : i = Read-out start position j = The number of samples to read (Range: same as ASCII) Response : 16-bit data is 2 bytes, and 32-bit data is 4 bytes and is outputted with a binary. Neither a comma nor CR/LF is included. The order of an output is the same as ASCII. ・ Within one word, it outputs sequentially from the upper byte. ・ An END message is outputted with the last byte (EOI).

☞ About the operation of data memory ➡ Refer to "5.10 operation of data memory".

o) Messages of status system (Cannot be operated from the panel) 1/6

Items	Header	Operation and setting range
CLEAR STATUS	*CLS	**<Clear status>** Command : *CLS Query : None ・ The following registers are cleared. Standard event status register Operation event register Over level event register Warning event register. ・ Excecution of *OPC or *OPC? command is cancelled. ・ Cleared error code queue ・ Not cleared enable registers
POWER-ON STATUS CLEAR	*PSC	**<Setting and Query of power on status clear flag>** Command : *PSC 1 Query : *PSC? Response : 1 Range : At the setup -32767 to +32767 When it is not 0, the following registers are cleared at power on. In the case of 0, it does not clear. ・ Service request enable register ・ Standard event status enable register. ・ Operation event enable register ・ Over level event enable register ・ Warning event enable register. At Response : 0 or 1 0 will be returned if set as 0. 1 will be returned if set up except for 0. At INIT : Not changed

[The clearance of a status byte register]

*CLS command does not clear a status byte register directly. However, except for MAV bit and RQS bit, the bit of a status byte register is cleared indirectly.

The MAV bit of status byte register is indirectly clearable by clearing input buffer using device clear.

The RQS bit is clearable by serial-poll.

o) Messages of status system (Cannot be operated from the panel) **2/6**

Items	Header	Operation and setting range
OPERATION COMPLETE	*OPC	**<Reporting the end of operation>** Command : *OPC When all processings of the overlap command under execution are completed, the OPC bit of a standard event status register is set. Query : *OPC? Response : 1 "1" is returned when all processings of the overlap Command under execution are completed ("1" is put on output queue). Thereby, the MAV bit of a status byte register is set. If it is going to receive the response to this query, it will be kept waiting until processing of an overlap command is completed. When there is no overlap command under execution, an OPC bit is set or "1" is returned immediately. Supplement: SRQ can be sent in OPC or MAV bit. →Refer to "5.3 Service request and the status structure".
WAIT TO CONTINUE	*WAI	**<Until a command finishes performing, the succession command is made to stand by. >** Command : *WAI Query : None It is made to wait for execution of a succession command until all processings of the following command under execution are completed.

[Overlap Command]

There are two kinds of commands. One side executes the following command, after processing is completed. Another side can start execution of the following command, before processing of a command is completed.

The command to start the execution of the next command during the processing is called an overlap command.

There is the following overlap command in the LI5640.

- Record in a data memory
- Automatic setting (AUTO SET)
- Automatic sensitivity setting

By commands other than these, after the execution finishes, the following command is executed. Such a command is called sequential command.

After ending execution of an overlap command, *OPC, *OPC?, or *WAI Command is used to perform the following command or an query.

In order to make it operate correctly, please send *OPC, *OPC?, and *WAI command after the last of a program message.

Recommend : Overlap command1; Overlap command2; *OPC

Not recommend1 : Overlap command1; *OPC; Overlap command2 terminator

Not recommend2 : Overlap command terminator *OPC terminator

o) Messages of status system(Cannot be operated from the panel) **3/6**

Items	Header	Operation and setting range
STATUS BYTE	*STB?	**<Query of status-byte register>** Command : None Query : *STB? Response : 32 Range : The sum of weight about the set factor. (decimal) Weight Factor 1 Over level event 2 Warning event 8 Error occurring 16 Response : Message of output enable 32 Standard event status 64 Master summary status 128 Operation event At INIT : Not changed
SERVICE REQUEST ENABLE REGISTER	*SRE	**<Setting and Query of the service request enable register>** Command : *SRE 17 Query : *SRE? Response : 17 Range : The sum of weight about the factor to permit (decimal) Same as status byte register. At INIT : Not changed
STANDARD EVENT STATUS REGISTER	*ESR?	**<Query of standard event status register>** Command : None Query : *ESR? Response : 32 Range : The sum of weight of the set factor (decimal) Weight Factor 1 Completion of operation 4 Query error 8 Error peculiar to equipment 16 Execution error 32 Command error 128 Power supply on
STANDARD EVENT STATUS ENABLE REGISTER	*ESE	**<Setting and Query of standard event status register>** Command : *ESE 1 Query : *ESE? Response : 1 Range : The sum of weight about the set factor (decimal) The factor is the same as the standard event status byte register. At INIT : Not changed

o) Messages of status system (Cannot be operated from the panel) **4/6**

Items	Header	Operation and setting range
OPERATION CONDITION REGISTER	OPCR?	**<Query of operation condition register>** Command : None Query : OPCR? Response : 16 Range : The sum of the weight about the set factor (decimal) Weight Factor 16 Under the data memory record 256 Under the automatic setup 512 Umder the automatic sensitivity setup At INIT : Although it does not act directly, since operation used as a factor is forced to terminate, it is set to 0.
OPERATION EVENT REGISTER	OPER?	**<Query of operation event register>** Command : None Query : OPER? Response : 16 Range : The sum of the weight about the set factor (decimal) Weight Factor 16 Record in a data memory is ended. 256 Automatic setup is ended. 512 Automatic sensitivity setup is ended. At INIT : Not changed
OPERATION EVENT ENABLE REGISTER	OPEE	**<Setting and Query of operation event enable register>** Command : OPEE 16 Query : OPEE? Response : 16 Range : The sum of the weight about the factor to permit.(decimal) A factor is the same as the operation event register. At INIT : Not changed

o) Messages of status system (Cannot be operated from the panel) **5/6**

Items	Header	Operation and setting range
WARNING CONDITION REGISTER	WRCR?	**<Query of warning condition register>** Command : None Query : WRCR? Response : 1 Range : The sum total of the weight of the set factor(decimal) Weight Factor 1 Not synchronize with a reference signal (UNLOCK lamp lit) 2 SOURCE is set as SIGNAL, and compared with frequency and attenation slope(dB/oct.), since the time constant is too small, it cannot lock. At INIT : Although it does not act directly,condition may change with change of a setup.
WARNING EVENT REGISTER	WRER?	**<Query of warning event register>** Command : None Query : WRER? Response : 1 Range : The sum of the weight about the set factor (decimal) Weight Factor 1 Not synchronized with a reference signal 2 SOURCE is set as SIGNAL,and compared with frequency, since the time constant is too small, it cannot lock. At INIT : Not changed
WARNING EVENT ENABLE REGISTER	WREE	**<Setting and Query of warning event register>** Command : WREE 1 Query : WREE? Response : 1 Range : The sum of the weight about the factor to permit (decimal) A factor is the same as the warning event register. At INIT : Not changed

o) Messages of status system (Cannot be operated from the panel) 6/6

Items	Header	Operation and setting range
OVERLEVEL CONDITION REGISTER	OVCR?	**<Query of over-level condition register>** Command : None Query : OVCR? Response : 1 Range : The sum of the weight about the set factor (decimal) Weight Factor 1 Input over level 2 Middle stage over level 4 Over level of DATA1 display 8 Over level of DATA2 display 16 Over level of DATA1 ratio-display 32 Over level of DATA2 ratio-display At INIT : Although it does not act directly, condition may change with change of a setup.
OVERLEVEL EVENT REGISTER	OVER?	**<Query of over level event register>** Command : None Query : OVER? Response : 1 Range : The sum of the weight about the set factor (decimal) Weight Factor 1 Input over-level occurred. 2 Middle stage over-level occurred. 4 DATA1 display over-level occurred. 8 The over level for DATA2 display occurred. 16 The over level for DATA1 ratio-display occurred. 32 The over level for DATA2 ratio-display occurred. At INIT : Not changed
OVERLEVEL EVENT ENABLE REGISTER	OVEE	**<Setting and Query of over-level event enable register>** Command : None Query : OVEE? Response : 1 Range : The sum of the weight about the factor to permit (decimal) A factor is the same as the warning event register. At INIT : Not changed
ERROR	EROR?	**<Query of error code>** Command : None Query : EROR? Response : -113,"Undefined header" Error number and error message are returned. Refer to "5.8 Error message of an external interface."

p) Messages peculiar to other GPIB (Cannot be operated from the panel)

Items	Header	Operation and setting range
RESET	*RST	**<Excecution of reset>** Command : *RST Query : None ・ Each setup is set as the state at the time of INIT execution. ・ Execution of the received command *OPC and *OPC? is cancelled. ・ Record in a data memory is ended. ・ All data memories are cleared.
IDENTIFI-CATION	*IDN?	**<Query of the maker, the model name, etc>** Command : None Query : *IDN? Response: : The following strings are responded. "NF-ELECTRONIC-INSTRUMENTS,model name,serial number,version" After the model name changes with every device. ex.: "LI5640,1234567,1.00"
TEST	*TST?	**<Query of self-check result>** Command : None Query : *TST? Response : 0 (0 is always returned.) Range : 0 With no abnormalities 1 With abnormalities

5.6.2 Program Message List (Compatible Message)

The compatible message is prepared for LI5640 so that the program created for the conventional model (5610B,5600A) can be corrected easily. Since the almost same description as the conventional program code can be used, it ends with the minimum correction. However, there is a functionally different portion with the conventional model and LI5640. For this reason, there is no perfect compatibility. When you do change work, please check all these tables beforehand.

The compatible message is not based on IEEE-488.2.

[The supplement about a table]

Items	Header	Operation and Data Range
	The header of a command is shown when there is a command. The header of Query is shown when there is only Query.	<Show the contents of operation> Command : Show the example of command message Query : Show the example of query message Response : Show the example of response message Syntax : When it has two or more data by a setup or inquiry, how to locate data in a line is shown. Range : The range of data in a setup, an inquiry, or a response is shown. At INIT : The setup by the INIT is shown.
		A dotted line to the bottom is a new corresponding message. Only the outline is shown. ☞ For details ➡ Refer to "5.6.1 Program message list".

- When there is a corresponding query message, it becomes header of command message that "?" is attached in front of the command message.
- When using two or more data, it divides with a comma ",".

a) Compatible messages of reference system(REFERENCE) 1/2

Items	Header	Operation and Data Range
ADJUST PHASE	ADP	**<Setting and Query of phase offset>** Command : ADP 9000 (18000 is changed into -18000.) Query : ?ADP Response : 9000 Range : -18000 to +18000 (-180.00° to +180.00° equivalent) At INIT : 0
PHASE	PHAS	Command : PHAS 90.0 Query : PHAS? Response : 90.00 Range : -180.00 to +179.99 [°] (+180 is changed into -180)
AUTO FUNCTION PHASE SET	AUP	**<Excecution of automatic phase-offset setting>** Command : AUP Query : None
PHASE-AUTO	APHS	Command : APHS Query : None
INT OSC FREQ	OFQ	**<Setting and Query of frequency about internal oscilltor>** Command : OFQ 100,3 Syntax : OFQ i,j Query : ?OFQ Response : 100,3 Range : i = Oscillation frequency Range in the following ( ) j = Oscillation frequency range -2: 0.0005 to 0.1200Hz (5 to 1200) -1: .0010 to 1.2000Hz (1 to 1200) 0: .01 to 12.000Hz (1 to 1200) 1: .10 to 120.00Hz (1 to 1200) 2: .0010k to 1.2000kHz (1 to 1200) 3: .010k to 12.000kHz (1 to 1200) 4: .10k to 105.00kHz (1 to 1050) Since there is no range of oscillation frequency in the LI5640, therefore command and query are not necessarily the same. At INIT : Not changed
FREQ	FREQ	Command : FREQ 1E3 Query : FREQ? Response : 1.0000E+03 Range : 0.0005 Hz to 105.00 kHz It is used when having chosen INT OSC.
BASIC FUNCTION F RANGE	BFR	**<Setting and Query of analysis frequency range>** Command : BFR 1 (Since this function does not exist, only a range check performs it.) Command : ?BFR Response : 2 (2 is always returned.) Range : 0 0.5 to 12 Hz 1 10 to 120 Hz 2 100 to 1.2kHz 3 1k to 12kHz 4 10k to 200kHz
	None	

a) Compatible message of reference system(REFERENCE) 2/2

Items	Header	Operation and Data Range
INT OSC LEVEL	OLV	**<Setting and Query of amplitude>** Command : OLV 100,1 Syntax : OLV i,j Query : ?OLV Response : 100,1 Range : i = Oscillator output level 0 to 500 j = Oscillator output level range 0: 0.0 m to 50.0 mV 1: 0 m to 500 mV 2: 0.00 to 5.00 V At INIT : Not changed
AMPTD	AMPL	Command : AMPL 0.1,1 Syntax : AMPL x, i Query : AMPL? Response : 0.100,1 Range : x = Amplitude 0.0 m to 5.00 Vrms (within range) i = Amplitude range 0: 50mV, 1: 500 mV, 2: 5V
BASIC FUNCTION REF MODE	BRM	**<Setting of reference signal>** Command : BRM 2 Query : ?BRM Response : 2 Range : 0 : INT OSC F 4 : SIGNAL F (no previous model) 1 : INT OSC 2F 5 : SIGNAL 2F (no previous model) 2 : REF IN F 6 : INT OSC (order>2, only response) 3 : REF IN 2F 7 : REF IN (order>2, only response) 8 : SIGNAL (order>2, only Response) Operation by SIGNAL 2F is not guaranteed. In order to maintain compatibility in case of REF IN, it is set as SINE POS by the REDG command. At INIT : Not changed
SOURCE	RSRC	**<Setting and Query of reference signal source>** Command : RSRC 0 Query : RSRC? Response : 0 Range : 0 REF IN, 1 INT OSC, 2 SIGNAL
EDGE	REDG	**<Setting and Query of reference signal synchronous edge>** Command : REDG 0 Query : REDG? Response : 0 Range : 0 SINE POS, 1 TTL POS, 2 TTL NEG
nF	HARM	**<Setting and Query of harmonic order>** Command : HARM 2 Query: HARM? Response : 2 Range : 1 to 19999 (integer)

b) Compatible messages of measured signal system (SIGNAL INPUT)

Items	Header	Operation and setting range
	None	**<Setting and Query of measured signal input >** Set as A or A-B by the ISRC command.
SIGNAL	ISRC	Command : ISRC 0 Query : ISRC? Response : 0 Range : 0 A, 1 A-B, 2 I(10^6), 3 I(10^8)
	None	**<Setting and Query of input coupling>** Set as AC by the ICPL command.
COUPLING	ICPL	Command : ISRC 0 Query : ISRC? Response : 0 Range : 0 AC, 1 DC
	None	**<Setting and Query of measured sibnal ground>** Set as FLOAT by IGNDC ommand.
GROUND	IGND	Command : IGND 0 Query : IGND? Response : 0 Range : 0 FLOAT, 1 GROUND

In order to maintain compatibility, it is necessary to make it a setup shown in the table using the new command.

c) Compatible messages of automatic setup (AUTO SET)

Items	Header	Operation and Data Range
AUTO FUNCTION AUTO SET	AUS	**<Excecution of automatic setup>** Command : AUS 10 Query : None Range : Forced-termination time 0 to 9999 [s] (In the case of 0, it does not force to terminate.)
AUTO SET	ASET	Command : ASET Query : None When sensitivity is not decided, it ends automatically.

d) Filter(FILTER)-related compatible messages

Items	Header	Operation and Data Range
FILTER FREQ	FFQ	**<Command of cut-off frequency>** Command : FFQ 123, 2 Syntax : FFQ i, j (Since this function does not exist, it performs only the check of the range.) Since this function does not exist, in order to remove noise and to secure dynamic reserve, the attenation slope or the time-constant is enlarged. Query : ?FFQ Response : 400,2(400,2 are always returned.) Range : i = Cut-off frequency 100 to 1200 (5 to 1200 only at the time of i = 1) j = Cut-off frequency range 1 0.5 to 120.0Hz 3 1k to 12.00kHz 2 100 to 1200Hz 4 10k to 120.0kHz
	None	
FILTER MODE	FMO	**<Setting and Query of filter>** Command : FMO 33 (Since this function does not exist, only a Range check performs it.) Query : ?FMO Response : 0 (THRU is always returned.) Range : 0 THRU 1 HPF 2 LPF 30 Normal Q1 33 LPF Type Q1 36 HPF Type Q1 31 Normal Q5 34 LPF Type Q5 37 HPF Type Q5 32 Normal Q30 35 LPF Type Q30 38 HPF Type Q30
	None	
AUTO FUNCTION AUTO TUNE	AUT	**<Setting and Query of auto tune>** Command : AUT 0 (Since this function does not exist, only a range check performs it.) Query : ?AUT Response : 0 (zero is always returned.) Range : 0 AUTO TUNE OFF, 1 AUTO TUNE ON
	None	
	None	**<Setting and Query of line frequency noise reduction filter>** Since this function is not in the conventional models, ILIN 0 is set up (Not used). When measurement frequency is separated from power supply frequency and its twice enough, it may use this filter.
LINE LINE × 2	ILIN	Command : ILIN 0 Query: ILIN? Response : 0 Range : 0 Not used, 1 LINE, 2 LINE × 2、 3 LINE and LINE × 2
	None	**<Setting and Query of low-pass filter>** Since this function is not in the conventional models, ITHR 0 is set up (Used).
LPF THRU	ITHR	Command : ITHR 0 Query : ITHR? Response : 0 Range : 0 Used, 1 Not used (LHP THRU lamp lit)

e) Dynamic reserve(DYNAMIC RESERVE)-related compatible messages

Items	Header	Operation and Data Range
BASIC FUNCTION DYN RES	BDR	**<Setting and Query of dynamic reserve>** Command : BDR 1 Query : ?BDR Response : 1 Range : 0 HIGH 1 MEDIUM 2 LOW At INIT : LOW The value (dB) of actual dynamic reserve is different even if it is the same setup when LI5640 is compared with a conventional model. Moreover, it differs also with setup of a filter or time constant. →Refer to **"4.5 Operation of dynamic reserve."**
DYNAMIC RESERVE	DRSV	Command : DRSV 1 Query: DRSV? Response : 1 Range : 0 HIGH, 1 MEDIUM, 2 LOW

f) Sensitivity(SENSITIVITY)-related compatible messages

Items	Header	Operation and Data Range
BASIC FUNCTION SENSITIVITY	BSS	**<Setting and Query of Sensitivity>** Command : BSS 10 Query : ?BSS Response: 10 Range: -5 5n V/fA, -4 10 nV/fA, -3 50 nV/fA, -2 100 nV/fA, -1 500 nV/fA, 0 1 µV/pA, 1 5 µV/pA, 2 10 µV/pA, 3 50 µV/pA, 4 100 µV/pA, 5 500µV/pA, 6 1 mV/nA, 7 5 mV/nA, 8 10 mV/nA, 9 50 mV/nA, 10 100 mV/nA, 11 500 mV/nA, 12 1 V/uA, Only Response 13 2 nV/--, 14 20 nV/fA, 15 200 nV/fA, 16 2 µV/pA, 17 20 µV/pA, 18 200 µV/pA, 19 2 mV/nA, 20 20 mV/nA, 21 200 mV/nA The conventional model is 1-3 sequence. For example, 5 mV are used when it is conventional 3 mV. A unit is the order of voltage/current. When a signal input is A or A-B, it becomes an inquiry of voltage sensitivity. It becomes an inquiry to a setup of current sensitivity at the time of I(10^6) or I(10^8). The setting range changes with selections or noise measurement of a signal input. At INIT : 1 V/µA
SENSITIVITY	VSEN	**<Setting and Query of Voltage Sensitivity>** Command : VSEN 23 Query: VSEN? Response: 23 Range : 0 2 nV to 26 1V (1-2-5 Sequence)
	ISEN	**<Setting and Query of Current Sensitivity>** Command : ISEN 23 Query: ISEN? Response: 23 Range : 1 5 fA to 26 1 µA (1-2-5 Sequence) The setting range changes with differences in current to voltage conversion gain.
AUTO FUNCTION AUTO RANGE	AUR	**<Execution of Automatic Sensitivity Adjustment>** Command : AUR 1 (Nothing is carried out during execution.) Query : ?AUR Response: 0 (Zero is always returned.) Range: : 0 Off (No execution) 1 On (Execute automatic sensitivity adjustment) At INIT : Off
AUTO (SENSITIVITY)	ASEN	Command : ASEN Query : None
SPECIAL FUNCTION LIMIT	SLM	**<Setting and Query of the highest sensitivity restrictions at the auto-range-operation.>** Command : SLM 5 (Since this function does not exist, it performs only a range check.) Query : ?SLM Response: 0 (Zero is always returned.) Range : 0 1 µV/pA, 1 5 µV/pA, 2 10 µV/pA, 3 50 µV/pA, 4 100 µV/pA, 5 500 µV/pA, 6 1 mV/nA, 7 5 mV/nA, 8 10 mV/nA, 9 50 mV/nA, 10 100 mV/nA, 11 500 mV/nA, 12 1 V/µA, 13 OFF
	None	

g) Time Constant(TIME CONSTANT) and Averaging-related compatible messages

Items	Header	Operation and Data Range
BASIC FUNCTION T CONST	BTC	**<Setting and Query of Time Constant>** Command : BTC 5 Query : ?BTC Response: 5 Range : -4 10 µs 0 1 ms 10 100 s -3 30 µs 1 3 ms 11 300 s -2 100 µs 2 10 ms 12 1 ks -1 300 µs 3 30 ms 13 3 ks 4 100 ms 14 10 ks 5 300 ms 15 30 ks 6 1 s 7 3 s 8 10 s 9 30 s At INIT : 100 ms (1ms to 30 s for conventional model)
TIME CONSTANT	TCON	Command : TCON 9 Query: TCON? Response: 9 Range : 0 10 µs to 19 30 ks
BASIC FUNCTION dB/OCT	BDO	**<Setting and Query of Attenuation slope >** Command : BDO 1 Query : ?BDO Response: 1 Range : 0 6 dB/oct 1 12 dB/oct 2 18 dB/oct 3 24 dB/oct At INIT : 24 dB/oct (0 and 1 for conventional model)
SLOPE	SLOP	Command : SLOP 1 Query: SLOP? Response: 1 Range: 0 6 dB/oct, 1 12 dB/oct, 2 18 dB/oct, 3 24 dB/oct
	None	**<Setting and Query of synchronous filter on/off >** Since this function does not exist, it sets a SYNC 0.(Normal filter)
SYNC	SYNC	Command : SYNC 0 Query: SYNC? Response: 0 Range : 0 Off (Normal filter), 1 On (synchronous filter)
AVERAGE TIMES	AVT	**<Setting and Query of averaging times (n of the 2^n) >** Command : AVT 5 (Since this function does not exist, it performs only a range check.) Query : ?AVT Response: 6 (6 is always returned.) Range : 0 to 9
	None	
AVERAGE MODE	AVM	**<Setting and Query of averaging mode>** Command : AVM 1 (Since averaging function does not exist, it performs only a range check.) Query : ?AVM Response: 0 (Zero is always returned.) Range : 0 No averaging, 1 LIN, 2 EXP
	None	

h) Measurement data display(DATA1,DATA2)-related compatible messages 1/3

Items	Header	Operation and Data Range
DISPLAY DATA1,2,3	DDT	**<Setting and Query of display parameter>** Command : DDT 224 (3-digit) Query : ?DDT Response: 0224 (4-digit, Most significant digit is always zero.) Range : the third digit DATA1: 2 R(A), 3 No execution, 4 X, 5 NOISE, 6 AUX IN1; the second digit DATA2: 2 θ (φ), 3 Y, 4 AUX IN1, 5 AUX IN2; the first digit REFERENCE: 4 No execution, 5 No execution, 6 FREQ, 7 PHASE, 8 AMPTD, 9 nF If DATA1 is set to NOISE, AUX IN1 will be compulsorily displayed on DATA2. The NORM command is used in order to display % or dB. The RAT command is used in order to display RATIO. AUX IN1 or AUX IN2 are substituted for conventional EXT DC. At INIT : R, θ , FREQ
DATA1 DATA2	DDEF	Command : DDEF 1,2 Query : DDEF? 1 Response: 2 Range : DATA1 1,0 X; 1,1 R; 1,2 NOISE; 1,3 AUX IN1; DATA2 2,0 Y; 2,1 θ; 2,2 AUX IN1; 2,3 AUX IN2

h) Measurement data display(DATA1,DATA2)-related compatible messages 2/3

Items	Header	Operation and Data Range
NORMALIZE MODE	NMO	**<Setting and Query of normalizing measurement>** Command : NMO 1 Query : ?NMO Response: 1 Range : -1 Off (Normal display) 0 dB 1 % At INIT : Off
NORMALIZE	NORM	Command : NORM 1 Query: NORM? Response: 1 Range : 0 Off, 1 dB, 2 %
NORMALIZE VALUE	NVL	**<Setting and Query of normalizing standard>** Command : NVL 512, 4 Syntax: NVL i, j Query : ?NVL Response: 512,4 Range : i = Standard value, Range in the following parenthesis j = Range of standard value j Range Standard value -5 5 nV/fA 1.000 to 9.999 (1000 to 9999) -4 10 nV/fA 1.000 to 99.990 (100 to 9999) -3 50 nV/fA 1.00 to 99.99 (100 to 9999) -2 100 nV/fA 1.00 to 999.90 (10 to 9999) -1 500 nV/fA 1.0 to 999.9 (10 to 9999) 0 1 μV/pA 0.0010 to 9.9990 (1 to 9999) 1 5 μV/pA 0.001 to 9.999 (1 to 9999) 2 10 μV/pA 0.010 to 99.990 (1 to 9999) 3 50 μV/pA 0.01 to 99.99 (1 to 9999) 4 100 μV/pA 0.10 to 999.90 (1 to 9999) 5 500 μV/pA 0.1 to 999.9 (1 to 9999) 6 1 mV/nA 0.0010 to 9.9990 (1 to 9999) 7 5 mV/nA 0.001 to 9.999 (1 to 9999) 8 10 mV/nA 0.010 to 99.990 (1 to 9999) 9 50 mV/nA 0.01 to 99.99 (1 to 9999) 10 100 mV/nA 0.10 to 999.90 (1 to 9999) 11 500 mV/nA 0.1 to 999.9 (1 to 9999) 12 1 V/uA 0.0010 to 1.0000 (1 to 1000) At INIT : 1000, 1 V/μA
STD	VSTD (Voltage)	Command : VSTD 51.2E-6 Query: VSTD? Response: 51.20E-6 Range : 1.0000 nV to 1.0000 V (In measurement of noise density, it differs.)
	ISTD (Current)	Command : ISTD 51.2E-12 Query: ISTD? Response: 51.20E-12 Range : 1.0000 fA to 1.0000 μA (It varies in the gain of the current-voltage conversion and so on.)

h) Measurement data display(DATA1,DATA2)-related compatible messages 3/3

Items	Header	Operation and Data Range
ADJUST OFFSET	ADO	**<Setting and Query of X offset value>** Command : ADO -316 Query : ?ADO Response: -316 Range : -5000 to +5000 100% of a sensitivity full scale corresponds to 1000 at the time of 1×10^n And it corresponds to 2000 at the time of 2×10^n, and corresponds to 5000 at the time of 5×10^n. X offset is set as ON. It is not turned off even if it sets it as zero after this. The same setup can be performed by OFSO and OFFS commands. If Y offset is turned OFF, about X, it will be compatibility mostly with the conventional model. R independent offset cannot be set up. At INIT : 0
X OFFSET Y OFFSET	OFFS	**<Offset value>** Command : OFFS 1,10.0 Query: OFFS? 1 Response: 10.00 Range : The first number = 1 X, 2 Y The second value = Offset value -100.00 to +100.00 [%] The value of a sensitivity full scale is made into 100%.
X OFFSET ON Y OFFSET ON	OFSO	**<Offset ON/OFF>** Command : OFSO 1,1 Query: OFSO? 1 Response: 1 Range : The first number 1 X, 2 Y The second number 0 Off, 1 On
	None	**<Execution of automatic offset setting>**
AUTO X,Y (OFFSET)	AOFS	Command : AOFS Query: None Offset is set up so that the value of X and Y may become zero.
METER MAG X	MMX	**<Setting and Query of X meter sensitivity(X and R of DATA1)>** Command : MMX 1 Query : ?MMX Response: 1 Range : 0 ×1, 1 ×10, 2 ×100 At INIT : ×1
METER MAG Y	MMY	**<Setting and Query of Y meter sensitivity(Y of DATA2)>** Command : MMY 1 Query : ?MMY Response: 1 Range : 0 ×1, 1 ×10, 2 ×100 At INIT : ×1
EXPAND	OEXP	**<Expansion of the display>** Command : OEXP 1,0 Query:OEXP? 1 Response: 0 Range : The first number 1 DATA1(X,R), 2 DATA2(Y) The second number 0 ×1, 1 ×10, 2 ×100

i) Ratio display(RATIO)-related compatible messages

Items	Header	Operation and Data Range
	None	**<Setting and Query of ratio display ON/OFF>**
RATIO ON	RAT	Command : RAT 1 Query: RAT? Response: 1 Range : 0 Off, 1 On (Ratio display)
RATIO K	RAK	**<Setting and Query of K-constant>** Command : RAK 0.25 Query : ?RAK Response: 0.25 Range : 0.1000 to 1.9999 (Resolution 0.0001) 2.000 to 9.999 (Resolution 0.001) At INIT : 1.0000
RATIO K (SHIFT+)	KFAC	Command : KFAC 0.25 Query: KFAC? Response: 0.25 Range : 0.1000 to 1.9999 and 2.000 to 9.999

j) Compatible messages of auxiliary output(AUX OUT1, AUX OUT2)

Items	Header	Operation and Data Range
	None	**<Setting and Query of auxiliary output(DC voltage) >**
AUX OUT1 AUX OUT2	AUXV	Command : AUXV 1,1.0 Syntax: AUXV i,x Query : AUXV? 1 Syntax: AUXV? i Response: 1.000 Range : i=1 AUX OUT1, 2 AUX OUT2 x = Voltage - 0.000 to +10.000 [V]

k) Setting memory(STORE,RECALL)-related compatible messages

Items	Header	Operation and Data Range
	None	**<Storing settings>**
STORE	*SAV	Command : *SAV 1 Query: None Range : 1 to 9
	None	**<Recalling settings>**
RECALL	*RCL	Command : *RCL 1 Query: None Range : 1 to 9 and 0 (When power is turned on, the value is 0.)

l) Other pannel operation-related compatible messages 1/2

Items	Header	Operation and Data Range
SPECIAL FUNCTION INITIALIZE	SIN	**<Change into initially set statuses>** Command : SIN Query : None
INITIALIZE	INIT	Command : INIT Query: None
SPECIAL FUNCTION LAMP	SLP	**<Setting and Query of lamp>** Command : SLP 0 Query : ?SLP Response: 0 Range : 0 Off (all unlit), 1 On At INIT : No change
LAMP	LAMP	Command : LAMP 0 Query: LAMP? Response: 0 Range : 0 Off (all unlit), 1 On

I) Other pannel operation-related compatible messages 2/2

Items	Header	Operation and Data Range
KEY LOCK	KLK	**<Setting and Query of key lock>** Command : KLK 0 Query : ?KLK Response: 0 Range : 0 Off 1 On (Lock) At INIT : No change
KEY LOCK	KLOC	Command : KLOC 0 Query: KLOC? Response: 0 Range : 0 Off, 1 On (Lock)
SPECIAL FUNCTION BEEP	SBP	**<Setting and Query of beep function>** Command : SBP 1 (Since this function does not exist, it performs only a range check.) Query : ?SBP Response: 0 (Zero is always returned.) Range : 0 OFF 1 ON
	None	
SPECIAL FUNCTION CAL	SCA	**<Execution of PSD gain calibration>** Command : SCA (Since this function does not exist, it performs nothing.) Query : None
	None	
SPECIAL FUNCTION PSD ZERO	SPZ	**<Execution of PSD zero drift compensation>** Command : SPZ (Since this function does not exist, it performs nothing.) Query : None
	None	
SPECIAL FUNCTION DAC	SDA	**<Setting and Query about the analog output data of D/A converter>** Command : SDA 22 (Since this function does not exist, it performs only a range check.) Query : ?SDA Response: 0022 (The value twenty two is always returned.) Range : the second digit DATA1: 2 A (R); 3 A dB/A%; 4 X (A COSΦ); 5 X dB/X%; 6 Y (A SINΦ); 7 Y dB/Y% the first digit DATA2: 2 Φ(θ); 3 Y (A SINΦ); 4 EXT DC; 5 RATIO; 6 REF FREQ
	None	

m) Measurment data reading-related compatible messages (Can't be operated from a panel.) 1/2

Items	Header	Operation and Data Range
OUTPUT DATA SEL	ODS	**<Setting and Query of external output digital data>** Command : ODS 12, 245 Syntax : ODS i, j Query : ?ODS Response : 12,245 Range : i = 0 No data j = 0 No data 1 Line number 1 No data 2 DATA1 2 No data 3 DATA2 3 No data 4 No data 4 No data 5 No data 5 No data 6 No data 6 FREQ 7 No data 7 SENSITIVITY 8 No data 8 OVERLEVEL 9 No data 9 No data Both i and j can be specified to four maximums. (including the case "No data"). Both i and j can be specified to six in total when it removes "No data". When more than one data are chosen, for example DATA1,DATA2,FREQ,SENSITIVITY is made ODS 23,67. At INIT : No change
OUTPUT TYPE	OTYP	Command : OTYP 1,2,3 Syntax: OTYP i { ,j,k,l,m,n} 1 to 6 Query : OTYP? Response: 1,2,3 Range : Each data 0 Line number 3 FREQ 1 DATA1 4 SENSITIVITY 2 DATA2 5 OVERLEVEL
OUTPUT DATA	?ODT	**<Query of measurment data>** Command : None Query : ?ODT Response : 1.2345E-06, -0.7890E-06, 1.0000E+03, Range : Line number Always 00000 DATA1 Display data of DATA1 DATA2 Disply data of DATA2 FREQ Frequency of reference signal [Hz] (By harmonics measurement, it is the frequency of a fundamental.) SENSITIVITY Response data of VSEN? or ISEN? (Depend on the setting of measurement signal input.) It is not response data of ?BSS. OVERLEVEL It is response data of OVCR?
DATA OUTPUT	DOUT?	Command : None Query : DOUT? Response : 1.2345E-06, -0.7890E-06, 1.0000E+03 Range : Same as ?ODT

m) Measurment data reading-related compatible messages (Can't be operated from a panel.) 2/2

Items	Header	Operation and Data Range
SPECIAL FUNCTION SAMPLING	SSA	**<Setting and Queryof of the data transfer interval and the measurement processing interval>** Command : SSA 4, 1 Syntax:SSA i, j Query : ?SSA Response: 4,1 Range : i = Data transfer interval(n of the 2^n) 0 to 16 j = Measurement processing interval 0 Stop 3 1s 1 100ms 4 3s 2 300ms 5 10s It is output in the time interval by 2^i of the measurement processing interval. At INIT : No change
OUTPUT SAMPLING PERIOD	OSMP	**<Setting and Query of continuous data output sampling period >** Command : OSMP 1.0 Query: OSMP? Response: 1.0 Range : 0.1 to 10000.0[s], Resolution 0.1 s
OUTPUT START/STOP	OSS	**<Setting and Query about start/stop of measurement data output >** Command : OSS 1 Query : ?OSS Response: 1 Range : 0 Stop 1 Start (On output) When a trigger is carried out after the start, measurement data are put in the interval set up with a SSA command in the output queue. The line number increases every 1 from 00000. A line number is returned to 00000 when it exceeds 99999. Even if it turns ON the header of output data (HDR1), the header is not attached to this output. At INIT : Stop
OUTPUT START	OSTR	**<Directions for the start, stop of the continuous data output >** Command : OSTR 1 Query: OSTR? Response: 1 Range : 0 Stop (On stop), 1 Start (On output) When a trigger is executed after the start, measurement data are put in the output queue in the period set up with an OSMP command.

n) The data memory-related compatible message (it cannot be operated from panel)

Since there is no data memory in conventional model, there is no compatible message. Please use "5.6.1 Program message list n data memory-related message." The following is an extract.

Items	Header	Operation and setting range
DATA MEMORY TYPE	DTYP	**<Setting and Query of the kind of recording data.>** Command : DTYP 1 Query: DTYP? Response : 1 Range : 0 DATA1, 1 DATA 2, 2 DATA1, DATA2 3 DATA2, AUX IN 2, 4 DATA1, DATA2, FREQ, 5 DATA1, DATA2, AUX IN1, AUX IN2 FREQ is recorded by32 bits and others are recorded by 16 bits
DATA MEMORY SIZE	DSIZ	**<Setting and Query of the record length.>** Command : DSIZ 1 Query: DSIZ? Response : 1 Range : 0 to 5 (corresponding with 2K to 64K data. 16bits/ data conversion)
DATA MEMORY NUMBER	DNUM	**<Setting and Query of the number of recording data memory>** Command : DNUM 0 Query: DNUM? Response : 0 Range : 0 to 31. Can be used from 0 (division number – 1).
DATA MEMORY SAMPLING PERIOD	DSMP	**<Setting and Query of a record sampling cycle>** Command : DSMP 5 Query: DSMP? Response : 5 Range : 0 to 18 (Corresponding with a trigger 0.0625ms to 20s)
TRIGGER ENABLE	TENB	**<Setting and Query for permission/prohibition of the external trigger input TRIG IN.>** Command : TENB 1 Query: TENB? Response : 1 Range : 0 Prohibition, 1 Permission
TRIGGER	*TRG	**<Execution of a trigger (start of record, or 1 sample record) >** Command : *TRG Query: None
STORE START	STRT	**<A record start is prepared.>** Command : STRT Query: None A trigger is performed in order to actually start record.
STORE STOP	STOP	**<Record is stopped.>** Command : STOP Query: None
STORED POINTS	SPTS?	**<Query for times of a sampling >** Command : None Query: SPTS? Response : 1024 Range : 0～65536
READ DATA MEMORY ASCII	DASC?	**<Query of the recorded data (ASCII) >** Command : None Query: DASC? 0, 256 Syntax : DASC? i, j Range : i＝Read-out start position 0 to (The number of times of a record sampling－1) j＝The number of samples to read, The number of times of record sampling (from 0). Response : Output data (16 bits and 32 bits) by Decimal character.
READ DATA MEMORY BINARY	DBIN?	**<Query of the recorded data (binary) >** Command : None Query: DBIN? 0, 256 Syntax : DBIN? i, j Range : Same as ASCII Response : Output data (16 bits and 32 bits) by the binary. Within 1 word, it outputs sequentially from a high-order byte

o) The compatible message of a status system (it cannot be operated from a panel) 1/4

Items	Header	Operation and Data Range
	None	**<Status is cleared.>** In order to maintain compatibility, it clears by the beginning of a program.
CLEAR STATUS	*CLS	Command : *CLS Query: None ● Clear the following registers. Standard event status register Operation event register Over level event register Warning event register ● Cancellation of *OPC or *OPC? command. ● Clearing for error code queue
	None	**<Setting and Query of a power on status clear flag.>** *PSC 1 is set up in order to maintain compatibility.
POWER-ON STATUS CLEAR	*PSC	Command : *PSC 1 Query: *PSC? Response : 1 Range : −32767 to +32767 When it is not 0, the following registers are cleared at the time of a power supply on. ● Service request enable register ● Standard event status enable register ● Operation event enable register ● Over level event enable register ● Warning event enable register
	None	**<An end of operation is made to report.>**
OPERATION COMPLETE	*OPC	Command : *OPC Query: *OPC? Response : 1 When the next operation is completed, the OPC bit of a standard event status register is set, or 1 is returned. ● Record in a data memory ● Automatic setting (AUTO SET) ● Automatic sensitivity setting
	None	**<It is made to wait for a succession command until a command finishes performing.>**
WAIT TO CONTINUE	*WAI	Command : *WAI Query: None It is made to wait for execution of a succession command until the following operation is completed. ● Record in a data memory ● Automatic setting (AUTO SET) ● Automatic sensitivity setting

o) Compatible message of a status system (it cannot be operated from a panel) **2/4**

Items	Header	Operation and Data Range
STATUS	?STS	**<Query of status byte register>** Command : None Query : ?STS Response: 17 Range : The sum of the weight of the set factor.(decimal) Weight Factor 1 Over level event 2 Warning event 8 Error generating 16 A response message output is possible. 32 Standard event status 64 Master status summary 128 Operation event At INIT : Not changed
STATUS BYTE	*STB?	Command : None Query: *STB? Response : 17
SRQ MASK	SRQ	**<Setting and Query of service request enable register>** Command : SRQ 17 Query : ?SRQ Response : 17 Range : The sum of the weight of the factor to permit.(decimal) Factor is the same as a status byte register. At INIT : Not changed
SERVICE REQUEST ENABLE REGISTER	*SRE	Command : *SRE 17 Query: *SRE? Response : 17
	None	**<Query of a standard event status register>**
STANDARD EVENT STATUS REGISTER	*ESR?	Command : None Query: *ESR? Response : 32 Range : The sum of the weight of the set factor.(decimal) Weight Factor Weight Factor 1 Completion of operation 16 Execution error 4 Query error 32 Command error 8 Inherent error of the equipment 128 Power on
	None	**<Setting and Query of a standard event status enable register.>**
STANDARD EVENT STATUS ENABLE REGISTER	*ESE	Command : *ESE 1 Query: *ESE? Response : 1 Range : The sum of the weight of the factor to permit.(decimal) Factor is the same as a standard event status register.

o) Compatible message of a status system (it cannot be operated from a panel) 3/4

Items	Header	Operation and Data Range
	None	**<Query of an operation condition register>**
OPERATION CONDITION REGISTER	OPCR?	Command : None Query: OPCR? Response : 16 Range : The sum of the weight of the set factor. (decimal) Weight Factor 16 Under data memory record 256 During automatic setting 512 During automatic sensitivity setting at INIT : Although it does not act directly, since operation used as a factor is forced to terminate, it is set to 0.
	None	**<Query of an operation event register>**
OPERATION EVENT REGISTER	OPER?	Command : None Query: OPER? Response : 16 Range : The sum of the weight of the set factor. (decimal) When the bit of a condition register is reset, the bit to which an event register corresponds is set.
	None	**<Setting and Query of an operation event enable register >**
OPERATION EVENT ENABLE REGISTER	OPEE	Command : OPEE 16 Query: OPEE? Response : 16 Range : The sum of the weight of the factor to permit. (decimal) A factor is the same as an operation event register.
	None	**<Query of a warning condition register>**
WARNING CONDITION REGISTER	WRCR?	Command :None Query: WRCR? Response : 1 Range : The sum of the weight of the set factor. (decimal) Weight Factor 1 It does not synchronize with a reference signal. 2 As SOURCE is set to SIGNAL, it is impossible to lock for which the time constant is too small under comparing with frequency and roll-off. At INIT : Although it does not act directly, condition may change with change of setting.
	None	**<Query of a warning event register>**
WARNING EVENT REGISTER	WRER?	Command : None Query: WRER? Response : 1 Range : The sum of the weight of the set factor. (decimal) When the bit of a condition register is set, the bit to which an event register corresponds is set.
	None	**<Setting and Query of a warning event enable register>**
WARNING EVENT ENABLE REGISTER	WREE	Command : WREE 1 Query: WREE? Response : 1 Range : The sum of the weight of the factor to permit.(decimal) A factor is the same as a warning event register.

o) Compatible message of a status system (it cannot be operated from a panel) 4/4

Items	Header	Operation and Data Range
OVER LEVEL	OVR	**<Query of an over level condition register>** Command : None Query : ?OVR Response: 1 Range : The sum of the weight of the set factor. (decimal) Weight Factor 1 Input over level 2 Middle stage over level 4 DATA1 display over level 8 DATA2 display over level 16 DATA1 ratio display over level 32 DATA2 ratio display over level The contents differ from the conventional model. At INIT : Although it does not act directly, condition may change with change of setting.
OVERLEVEL CONDITION REGISTER	OVCR?	Command : None Query: OVCR? Response : 1
	None	**<Query of over level event register>**
OVERLEVEL EVENT REGISTER	OVER?	Command : None Query: OVER? Response : 1 Range : The sum of weight of set factor. (decimal) When the bit of a condition register is set, the corresponding bit of the event register is set. .
	None	**<Setting and Query of over level event register>**
OVERLEVEL EVENT ENABLE REGISTER	OVEE	Command : None Query: OVEE? Response : 1 Range : The sum of weight of factor to permit. (decimal) Factor is the same as over level event register.
ERROR	?ERR	**<Query of error code>** Command : None Query : ?ERR Response : -113 (An error number is returned.) ☞ Refer to **"5.8 Error message of an external interface."** At INIT : No change.
ERROR	EROR?	Command : None Query: EROR? Response : Error number. and error message

p) Other compatible message of inherent GPIB (it cannot be operated from a panel)

Items	Header	Operation and Data Range
	None	**<Execution of reset>**
RESET	*RST	Command : *RST Query: None ● Each setting is set in the state at the time of INIT command execution. ● Execution of which received *OPC or a *OPC? command is canceled. ● End record in a data memory. ● All data memories are cleared.。
Model name	?IDX	**<Query of model name>** Command : None Query : ?IDX Response : LI5640
IDENTIFI-CATION	*IDN?	**<Query of maker name, model name and etc.>** Command : None Query: *IDN? Response : as follows "NF-ELECTRONIC-INSTRUMENTS, a model name, a serial number, a version"
ADR	HDR	**<Setting and Query of header existence of output data>** Command : HDR 1 Query : ?HDR Response : 1 Range : 0 None 1 Existence (It is restricted when there is an inquiry by the compatible message.) At INIT : None
	None	Header is not outputted when it asks by the new query message.
Beginning of Sample	BOS	**<Setting of the measurement start after controlling by RS-232 >** Command : BOS (Since this function does not exist, nothing is performed.) Query : None
	None	

5.7 Standard execution time

Here, time to start processing of a program message is shown. Time to start transmission of a program message is included in this time.

Since time to actually start changes with the computer to be used, a GPIB interface board, a programming language, and driver software, the value shown here is a reference value.

a) Use devices

Computer	: PC 386 SR / Seiko Epson
Language	: N88BASIC / NEC
Interface board	: PC-9801-29N / NEC

b) Specific command and query

INIT(SIN)	: approx. 90 ms	The inside of ( ) is a compatible message.
*RST	: approx. 90 ms	
*RCL	: approx. 90 ms	
ASET (AUS)	: approx. 200 ms	The inside of ( ) is a compatible message.
DBIN?	: approx. 15 ms	

c) Other commands and queries (except the above)

Command	: approx. 60 ms
Query	: approx. 30 ms

Although it changes with the contents of response, or states of apparatus of operation, if time for listeners to receive a response message is included in the case of a query, it will become long for about 10 ms.

d) Data read-out from a data memory

The data transmission time when querying and reading the data recorded on the data memory becomes the following value.

Approx. 30 s / 2Kdata (ASCII)

Approx. 0.5 s / 2Kdata (Binary)

However, the program and apparatus that were used are as follows.

Program	: Example of the following in "5.13 GPIB sample program"
	" d) Recording and reading to data memory (ASCII)"
	" f) Recording and reading to data memory (binary)"
Computer	: Venturis fx2(Pentium II 200 MHz) (DEC)
OS	: Windows 95 (Microsoft)
Language	: Visual Basic 5 (Microsoft)
Interface board	: PCI-488(PCI) (National Instruments)

Compared with ASCII, a binary is very high-speed. For this reason, it is convenient when handling a lot of data.

5.8 Error message of external interface

If an error occurs while carrying out external control by GPIB or RS-232, an error number will be displayed on a REFERENCE number display for several seconds.

Example : E − 1 0 3

If query message EROR? is used, this error number and a more detailed error message can be checked. The format of a response message is as follows.

Error No., error message Example : -103, "Invalid separator"

Table 5-7 Error message list of external interfaces (part 1)

Error No.	Error message	Description
0	No error	There is no error.
-101	Invalid character	There is an invalid character in the receiving character sequence. Example : #
-103	Invalid separator	There is an invalid separator in the receiving character sequence. Example : AMPL 1.0 2 (The punctuation mark which must be a comma is a space)
-108	Parameter not allowed	There is too many data after header.
-109	Missing parameter	The number of the data after header is insufficient.
-112	Program mnemonic too long	There is a header that exceeds twelve characters in the receiving character sequence.
-113	Undefined header	There is an invalid header in the receiving character sequence.
-120	Numeric data error	Numeric data error. Example: 1.0E-555 (an index part is too large)
-121	Invalid character in number	There is an invalid character to the indication of the numerical value data.
-211	Trigger ignored	Since it was not ready for starting a continuation data output, the trigger was ignored. After a start is prepared, send the command of a trigger.
-221	Settings conflict	The specified setting couldn't be carried out because of the setting and conditions at that time.
	Settings conflict; auto time constant has not been accepted	An automatic time constant setting can't do because UNLOCK, or frequency is out of range, or reference signal is SIGNAL, or DATA1 display is NOISE.
	Settings conflict; auto set has not been accepted	An automatic setting can't do because UNLOCK, or frequency is out of range, or reference signal is SIGNAL.
	Settings conflict; auto phase has not been accepted	An automatic phase setting wasn't made because UNLOCK or a phase couldn't be measured.
	Settings conflict; offset auto X,Y has not been accepted	An automatic offset setting couldn't be done because UNLOCK or X or Y couldn't be measured.

Table 5-7 Error message list of external interfaces (part2)

Error No.	Error message	Description
-222	Data out of range	Command data following header are outside possible range with setting.
	Data out of range; memory	Command data related to the setting memory are outside possible range with setting.
	Data out of range; aux output	The command data of the auxiliary output are outside possible range with setting.
	Data out of range; auto set	Command data related to automatic setting are outside possible Range with setting.
	Data out of range; ratio	Command data related to RATIO are outside possible range with setting.
	Data out of range; data1	Command data related to DATA1 are outside possible range with setting.
	Data out of range; data2	Command data related to DATA2 are outside possible range with setting.
	Data out of range; reference	Command data related to the reference are outside possible Range with Setting.
	Data out of range; signal input	Command data related to the signal input are outside possible range with setting.
	Data out of range; filter	Command data related to the filter are outside possible range with setting.
	Data out of range; dynamic reserve	Command data related to the dynamic reserve are outside possible range with setting.
	Data out of range; sensitivity	Command data related to the sensitivity are outside possible range with setting.
	Data out of range; time constant	Command data related to the time constant are outside possible range with setting.
	Data out of range; data memory	Command data related to the data memory are outside possible range with setting.
	Data out of range; data output	Command data related to the data output are outside possible range with setting.
	Data out of range; others	Command data except for the above are outside possible range with setting.
-350	Queue overflow	Previous error code was destroyed not to finish going into the error code queue though an error occurred. (maximum 20 error code) Begin to read it, or clear it with a *CLS command before being full.
-410	Query INTERRUPTED	An output queue was cleared because the next program code was received before finishing the output of the response message for query message. Send the next program message after you receive response when you query.
-420	Query UNTERMINATED	There is no response message to output though it was specified a talker. Specify it in talker after you query.
-430	Query DEADLOCKED	Since response to query message exceeded 1024 characters, Response after it was destroyed.
-440	Query UNTERMINATED after indefinite response	"*IDN?", "DASC? " or "DBIN?" should be the last query in the program message. Other query can't be sent until that is stopped after continuous data output is actually started with a *TRG command.

Table 5-7 Error message list of external interfaces (part3)

Error No.	Error message	Description
511	RS-232 framing error	Framing error occurred. Confirm that setting of baud rate, the data bit length and the parity are right.
512	RS-232 overrun error	Over run error occurred. A part of the data was lost for some reasons because new data were received before processing previous data. And, this error doesn't usually happen.
513	RS-232 parity error	A parity error occurred. Confirm that Setting of baud rate, the data bit length and the parity are right.
521	Input buffer overflow	A program message exceeded input buffer capacity (1024 characters). Because of this reason, the part which exceeded it was lost.
522	Output buffer overflow	Since one set of response messages exceeded output buffer capacity (1024 characters), the response message was destroyed. Divide a query and receive response for every query.

[Relations with the standard event status]

Relations between the four-error bit in the standard event status register and the error number are as follows:

CME (Command error) : -100 to -199
EXE (Execution error) : -200 to -299
DDE (Device inherent error) : -300 to -399 and 500 to 599
QYE (query error) : -400 to -499

5.9 Reading out measured data

There are three methods of reading measured data.

- Reading latest measured data
- Sending measured data in a certain interval
- Reading measured data after memory

Data memory is not mentioned here.

☞ Refer to " 5.10 Operation of data memory ".

a) Operation of reading out latest measured data

The operation is executed in following procedures.

- Setting kinds of measured data to be output (OTYP primary data, secondary Data, ···)

  It can be chosen from (Line number,) DATA1, DATA2, FREQ, SENSITIVITY, OVERLEVEL.

  And also can be selected in operator's disposal.

  It is possible to specify the same data plurally, up to 6 kinds.
- Query measured data (DOUT?)
- Receive response message

  Line number always stays at zero.

b) Operation of transmission at constant interval

To be operated as following procedure.

- Set kinds of output measurement data (OTYP first data , second data ···)
- Set sampling interval for output (OSMP sampling interval 0.1s to 10000.0s)
- Prepare for output of measurement data (DSTR 1)
- Execute trigger (transmit *TRG or GET), TRIG IN at rear panel is not available.
- Receive response message

  Line number starts from zero, and increases at every sample.
- Stop the output of measurement data. (DSTR 0)

c) Syntax of response message

Measured data are produced in separation by comma in the order to be specified when setting the kinds of output measured data.

DATA1, DATA2 and FREQ are output in the form of accordance with panel display.

For example, 0.0001E-0.3, -1.2345E-03 and 10.000E+03 are output to OTYP 1, 2 and 3.

Corresponding to the selection of the voltage and current at that time, the response to SENSITIVITY becomes the same integer of 0 to 26 as the response to VSEN? or ISEN? which is an inquiry of sensitivity.

The response to OVERLEVEL is the same integer as the response to over level condition register query OVCR?.

5.10 Operation of data memory

5.10.1 Outline of data memory

In case of LI5640, GPIB data transmitting speed is not always enough compared with minimum time constant. Also the lowest data transmitting speed is not guaranteed, and it is difficult to keep constant transmitting speed too.

Therefore in order to measure quick change signals, the function of transmitting to outside after registering measured data in memory is available.

Recording speed to data memory is max.16k sample/s

No back-up data memory. All data memory is cleared after cutting power off.

In case of measuring slow change speed signals, it is not necessary to use data memory. It is more convenient to read out measured data from LI5640 and input them to computer directly every constant time or at only required cases.

In case of setting items related to only data memory, all are to be operated through external interface (GPIB or RS-232)

The operation from panel is not available. And recorded data can't be confirmed on panel.

Recorded data is utilized by transmitting to computer through external interface.

Followings as main program message headers related to the data memory operation.

DTYP	Setting kind of data which are recorded in data memory
DSIZ	Setting recording length of data memory (setting of the dividing number)
DNUM	Specifying number of recording data memory
DSMP	Setting sampling frequency to be recorded in data memory
TENB	Admit / prohibit of rear panel external trigger input
*TRG	Generate trigger signal
STRT	Start ready for recording into data memory
STOP	Stop of recording into data memory (stop)
SPTS?	Query of recorded sampling frequency in data memory
DASC?	Query of data memory contents (read out in ASCII string)
DBIN?	Query of data memory contents (read out in binary)

5.10.2 Preparation of recording to data memory

It is necessary to specify following parameters when recording measured data in data memory.

a) Kinds of data to be recorded in data memory DTYP 0 to 5

Either of following 6 kinds is designated.

- DATA1 (1 data / sample)
- DATA2 (1 data / sample)
- DATA1, DATA2 (2 data / sample)
- DATA2, AUX IN2 (2 data / sample)
- DATA1, DATA2, FREQ (4 data / sample, FREQ is reference signal frequency)
- DATA1, DATA2, AUX IN1 and AUX IN2 (4 data / sample)

Only reference signal frequency is recorded in resolution of 32 bits, and others in 16 bits.

Frequency corresponds to two data because 16 bits in equivalent express one data.

b) Record length of data memory DSIZ 0 to 5

Data memory can be used as one block, or plural blocks which are divided equally.

When specifying record length (block length), data memory is equally divided according to record length. Recording to data memory terminates after only specified block length's data is recorded.

Total capacity : 64K data (16 bits/data , 1K: 1024)

Record length : 2K data (32 blocks), 4K data (16 blocks), 8K data (8 blocks),

16K data (4 blocks), 32K data (2 blocks), 64K data (1 block)

For example, when DATA1 and DATA2 are recorded by record length 2K data, 1K data is recorded (1024 sampling points).

c) Data memory number DNUM 0 to 31

Specify block to be used. The number of data memory starts from zero. When record length is 2k data, the range of number is 0 to 31. In case of no division, specify zero.

d) Sampling period of data memory DSMP 0 to 18

Sampling data can be selected in the range of 62.5 μs (= 1/16ms) to 20s.

It is also possible to record one sample at every trigger which is given from the outside(DSMP 0).

However there is a certainty of about 62.5 μs between external trigger and real sampling point. Any of followings are available for trigger (Start of record, or record of one sample.).

- Fall edge of TTL level square waveform which input to TRIG IN connector at rear pane.
  It is necessary to admit rear panel external trigger input
- *TRG command message
- GET (Group Execute Trigger) interface message

5.10.3 Start of recording into data and termination of detection

In case of starting record into data memory, command of trigger (*TRG or GET) is transmitted after START command is transmitted. GET is not program message.

☞ About GET ➡ refer to "5.11. Response to interface message".

If an external trigger input is permitted (TENB), record can be started by applying a trigger signal into the TRIG IN connector of the rear panel, or sending the command (* TRG or GET) of a trigger by the external interface.

If an external trigger signal is forbidden (TENB0), the trigger command (* TRG or GET) of an external interface will start record.

Only record length which is set is recorded and then terminates the record.

When operators want to stop recording on the way, stop command (STOP) should be transmitted.

It is possible to query the number of samples by SPTS? Query, which are actually recorded in the blocks with specified memory numbers.

Record start command under recording into data memory is ignored. When there is possibility of under recording, stop recording forcedly by stop command (STOP), or transmit STRT command after confirming of not under recording by MES bit of operation condition resister.

In case of commanding to record 1 sample at every trigger(DSMP 0), trigger signal is input to TRIG IN connector at the rear panel after staring to record by STRT command, or transmit the command of trigger (TRG or GET) by external interface.

It is simple to use *WAI command for reading out the contents of data memory at the end of record. The execution after query until the end of record will be waited when command or query is transmitted in following order.

- Prepare for starting record by STRT
- Start to record actually by *TRG command (or GET)
- Command to make the execution of next query delay until ending the record by *WAI command.
- Query data by DASC? or DBIN? (query of data memory's contents)

☞ For details, ➡ please refer to "5.13 GPIB sample program"

For recognizing the end of record into data memory, or waiting until the end of record, there are following methods including *WAI command.

- Make the execution of next command wait by *WAI command.
- Make response message 1 return at ending record by *OPC ? query.
  When specified in talker, output 1 is provided after ending record.
- As MAV bit of status bite resister is set by *OPC? query, MAV bit is polled by serial poll. (read out orderly)
- While setting MAV bit, transmit service request (SRQ) at the end of record with setting responding bit of service request enable to 1.
- Specify to set OPC bit of standard event status resister to 1 at ending record by *OPC command and poll OPC bit by serial poll.
- While setting OPC bit, transmit service request (SRQ) at the end of record with setting ESB bit of service request enable resister to 1.
- Poll MES bit of operation condition resister (under record into data memory) by OPCR? query.
- Poll MES bit of operation event resister (ending record into data memory) by OPER? query.
- Through setting MES bit of operation enable resister and OSB bit of service request enable resister to 1, transmit service request at the end of record.

☞ About resister related to various status and service request
➡ Refer to "5.3 service request and status structure".

In addition: Recording into data memory will be stopped in case of following operations.

- Setting displayed parameters, kinds of data to be recorded, record length, or data memory numbers.
- Start of continuous data output
- Query of latest measurement data.

Data memory will be cleared in case of following operations

- Setting kinds of data to be recorded or record length
- *RST command

5.10.4 Reading out data memory

Operate by following procedure for reading out data memory.

- Specify the number of reading out data memory (from 0)
  (DNUM number of data memory)
- Query the number of recorded samples actually when making stop on the way.
  (SPTS? → 1024 (an example))
- Query contents of data memory after specifying samples to be read out.
  (DASC? Sample position for starting to read out (from 0), numbers of read out samples)
- Receive response message.

It is possible to read out partially data which is already recorded even if blocks under recorded.
DASC? query is used in case of reading out in ASCII letter row.
When read out in binary, DBIN? is used instead of DASC?

Format of response message is as below

- Response to DASC? (ASCII)
  According to data's kinds to be recorded in data memory, integers which show each measured value (punctuated by comma if plural) are put into output in described order on the table.
  First data, second data, ··· terminator (←first sample)
  First data, second data, ··· terminator (←second sample)
  ··· Only specified samples are put into output ···
  Each data shows integer equivalent to 16 bit (approx. $\pm 2^{15}$) or 32 bit (approx. $\pm 2^{31}$) is converted into ASCII letter row (figure).

- Response to DBIN? (Binary)
  The order for output is the same as ASCII letter row output, but output is provided in binary of 16 bits or 32 bits (2's complement). The output of comma, or terminator is not available.
  The output starts from upper bytes in order out of one data.
  End message is output with final data (byte).

Relation between each data and parameters are shown as below.

- X, Y, R, NOISE, AUX IN1, AUX IN2

  Data is output as 16 bits integer (2's complement)

  Actual value is calculated in following formula.

  Parameter value = output data $\times 2^{-15} \times 1.2 \times$ meter full scale

  Meter full scale is as below

X, Y, R	: sensitivity X EXPAND multiply
RATIO	: 2
dB	: 100 dB
%	: 200 %
AUX IN1	: 10 V
AUX IN2	: 10 V

  For example, if output data is 12345 in case of measuring R by sensitivity 10mV, actual value is as follows.

  $12345 \times 2^{-15} \times 1.2 \times 10\text{mV} = +4.521\ \text{mV}$

- Phase(θ)

  Data is output as 16 bit integer (2's complement).

  Actual value is calculated in following formula.

  Phase = output data $\times 2^{-16} \times 360^{\circ}$

- Reference signal frequency (FREQ)

  Data is output as 32 bit integer (2's complement)

  Actual value is calculated in following formula.

  Frequency = output data $\times 2^{-32} \times 256$ kHz.

5.11 Response to interface message

LI5640 response to interface message is shown on following table.

Table 5-8 Response to interface message

IFC	<Interface Clear> Initializes GPIB interface. Releases specified listener and talker.
DCL SDC	<Device Clear > <Selected Device Clear> Clears input buffer, and aborts interpretation and execution of command. Clears output queue, and clear bit 4 (MAV) of status byte register. Releases hold off of over-wrap command by WAI, *OPC command.
LL0	<Local Lockout> Disables operation of front panel SHIFT + LOCAL key.
GTL	<Go to Local> Puts the system in a local status.
GET	<Group Execute Trigger> Execute trigger. It works in the same way as TRG command message.

The use of interface message varies with the GPIB driver on the controller side.

For details, refer to the manual for the GPIB driver.

5.12 Initialization of GPIB

Generally, in external control, the state of the equipment when performing a program is unknown. For this reason, initial setting is required before sending the command and query from an actual operates equipment. A following interface message and a following command are mainly used for initial setting.

- Interface clear (IFC)
- device clear (DCL, SDC)
- reset (*RST)
- clear status (*CLS)

a) Interface clear (IFC)

This interface message initializes fundamental interface functions of a bus, such as canceling listener and talker.

In some GPIB driver of a controllers, when declaration of using GPIB, the interface massage IFC is sent automatically. Otherwise, it is necessary to send IFC clearly using the command which sends IFC of a GPIB driver.

b) Device clear (DCL, SDC)

This interface message clears the input buffer and output cue in which the contents may remain by error etc. Moreover, hold-off of overlap command is canceled. And LI5640 is enabled to execute the following command.

Although there are some equipment which changes with device clear to a specific setup, the setup does not change in LI5640.

☞ IFC, DCL, and SDC → Refer to "5.11 Response to an interface message"

c) Reset (*RST)

Equipment is returned to the state where the INIT command was executed, and a data memory is cleared. Moreover, execution of *OPC command and *OPC? query is canceled, and it is made not to perform the set of OPC bit, and the return of "1" at the end of a command.

d) Clear status (*CLS)

Program message *CLS clears the event register and error code cue of a status system. Moreover, execution of *OPC command and *OPC? query is canceled, and it is made not to perform the set of OPC bit, and the return of "1" at the end of a command.

The *CLS command does not clear an enable register. It is more safe to use *CLS command after carrying out the zero clear of all the bits of enable register, and to use *CLS command, in order to suppress generating of a new event. Then, enable register is set up if needed.

The *CLS command clears a status byte indirectly except for a MAV bit and a RQS bit. MAV bit is clearable by device clear. RQS bit is clearable by performing one time of a serial pole.

It is forgotten to clear the RQS bit in many cases. For this reason, when a service request (SRQ) occurs, it is problem to check generating of a factor only in a RQS bit. After checking generating of the event used as the factor, it recommends performing corresponding processing.

5.13 Sample GPIB program

5.13.1 Outline of sample program

The following section introduces samples of remote control that uses GPIB interface.
Here, the following case is shown:

- Case where Microsoft's Visual Basic and National Instruments' GPIB interface board are Used.

The description here will focus on the following six types of remote control.

a) Setup and Query

This is the simplest type of remote control. After initialization, the amplitude of the oscillator is set, and then it is confirmed by running a query.

b) Query of measurement data

After simple setting, conduct query of measurement data repeatedly.

c) Auto setting (AUTO SET)

Start auto setting ,and then measure after the end of it.

d) Record in data memory and read out (ASCII)

Start to record in data memory, and read out data after confirming the end of record.
ASCII format is used for reading out from data memory.

e) Use of SRQ

The over level is detected by using SRQ.

f) Record in data memory and read out (BINARY)

Measurement data in data memory is recorded and read out in the same as "d) Record in data memory and read out (ASCII)". Binary format is used for reading out.

In any cases, error check and etc. are abbreviated.
Please take care for error processing and initialization procedure when preparing a practical program.

5.13.1 Case where Visual Basic and National Instruments' GPIB Interface board are used.

When using National Instruments' GPIB interface board and driver software, it is necessary to add characters expressly because EOS characters are not added automatically in sending characters string.

When receiving a response message(ibrd), the number of received characters are limited to the receiving buffer length. Sample program in this case uses fixed length character string. In case of using variable length character string, it is necessary to secure receiving buffer length by space ( ), etc. in front of ibrd.
The number of reception characters is obtained by global variable ibcnt.

a) Setting and query

If the button is pressed, voltage sensitivity is set and result of query is displayed.

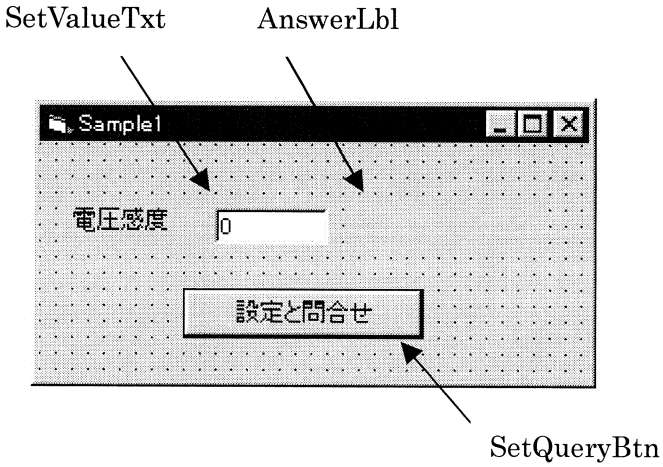
Necessary initialization is executed by load of form.

Here, the device descriptor (Dev) is opened with the timeout of 300 ms, GPIB address 2, EOI valid and terminator LF.

In SetQueryBtn, the command of setting voltage sensitivity is transmitted to the device in parameters that are converted from input character string to SetValueTxt.

Terminator at transmission is required to be added by program code.

In form unload, the device should be returned in local condition.

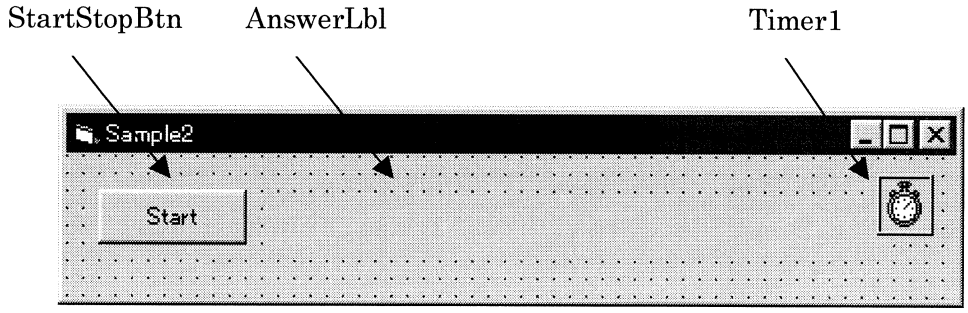



```
Const Adr As Integer = 2                                    ' GPIB adress
Const EOSCHAR As Integer = &HA                              ' specify LF at terminator
Const EOS As Integer = XEOS + REOS + EOSCHAR
Dim Dev As Integer

Private Sub Form_Load()
    ibdev 0, Adr, 0, T300ms, 1, EOS, Dev                    ' device open
    ibclr Dev                                               ' device clear
End Sub

Private Sub Form_Unload(Cancel As Integer)
    ibloc Dev                                               'Go to Local
    ibonl Dev, 0                                            'Device off line set
End Sub

Private Sub SetQueryBtn_Click()
    Dim rdbuf As String * 256
    ibwrt Dev, "VSEN " & SetValueTxt & Chr(EOSCHAR)         ' set voltage sensitivity
    ibwrt Dev, "VSEN?" & Chr(EOSCHAR)                       ' query voltage sensitivity
    ibrd Dev, rdbuf                                         ' receive response message
    AnswerLbl = Left(rdbuf, ibcnt)
End Sub
```

b) Query of measurement data

When pressing the button, measurement data is repeatedly displayed.

In this case, terminator is not specified, only EOI is available.
When pressing StartStopBtn after specifying measurement data at setting initialization, measurement data is displayed with querying every 500 ms by Timer 1



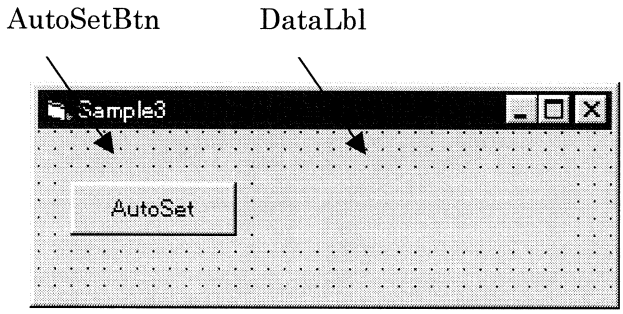

```
Const Adr As Integer = 2
Dim Dev As Integer

Private Sub Form_Load()
    ibdev 0, Adr, 0, T300ms, 1, 0, Dev          'Device open
    ibclr Dev                                   'Device clear
    ibwrt Dev, "OTYP 1,3,5"                     'Specify measurement data
    Timer1.Enabled = False
    Timer1.Interval = 500
End Sub

Private Sub Form_Unload(Cancel As Integer)
    ibloc Dev                                   'Go to Local
    ibonl Dev, 0                                ' setting device offline

End Sub

Private Sub StartStopBtn_Click()
    If StartStopBtn.Caption = "Start" Then
        Timer1.Enabled = True                   ' start repeat
        StartStopBtn.Caption = "Stop"
    Else
        Timer1.Enabled = False                  ' stop repeat
        StartStopBtn.Caption = "Start"
    End If
End Sub

Private Sub Timer1_Timer()
    Dim buf As String * 256
    ibwrt Dev, "DOUT?"                          ' Query of measurement data

    ibrd Dev, buf                               ' Receive response message

    AnswerLbl = Left(buf, ibcnt)
End Sub
```

c) Auto setting

When pressing the button, Auto setting(AUTO SET) is executed, and measurement data is displayed.

When transmitting *WAI command, any command is not executed until terminating all executions of over wrap command before then.
In this case, query of measurement data (DUT?) is not executed until the end of auto setting.
This is specified by initialization for avoiding time out before the termination of auto setting(TONE).
While waiting for the end of execution by *WAI, software can't be performed.
Using polling or SRQ, other processing is performed during end is waited.

☞ Example of polling ➡ Refer to " d) Record to data memory and read out (ASCII)".
☞ Example of SRQ ➡ Refer to " e) Use of SRQ".



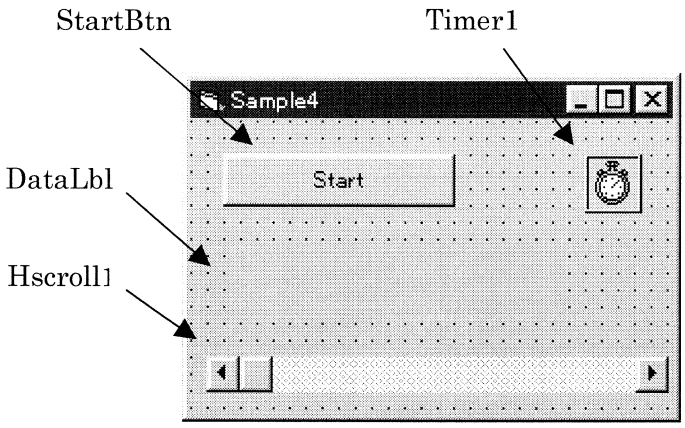

```
Private Sub Form_Load()
    ibdev 0, Adr, 0, TNONE, 1, 0, Dev          ' Device open
    ibclr Dev                                  ' Device clear
End Sub

Private Sub AutoSetBtn_Click()
    Dim rdbuf As String * 256
    AutoSetBtn.Enabled = False
    DataLbl = "Start Auto Set"
    DataLbl.Refresh
    ibwrt Dev, "ASET; *WAI"                    ' Start Auto setting
    ibwrt Dev, "DOUT?"                         ' Query of measurement

    ibrd Dev, rdbuf
    DataLbl = Left(rdbuf, ibcnt)
    AutoSetBtn.Enabled = True
End Sub
```

d) Record and read-out to the data memory (ASCII)

The pressing on the button executes the start of recording to data memory and reading out after the end of record. Read out data can be displayed by operating scroll bar.

For examining the end of record to data memory, query repeatedly contents of operation event register by the timer.
The press on StartBtn executes the start of record by various settings. The end of record should be clear before starting because it is examined by operation event register.
After starting to record, the contents of operation event register are examined (Polling) every 500 ms by the timer, and the end is waited. During this time, software is available for other processing. Here, for performance confirmation of the timer, "*" and "+" are displayed alternatively on DataLbl.
After confirming the end of record, data memory is read out in ASCII format by BlockRead routine. Read out data is stored in DataValue ( ).

It is also possible to use SRQ for recognizing the end of record.
☞ Example of using SRQ ➡ Refer to " e) Use of SRQ".



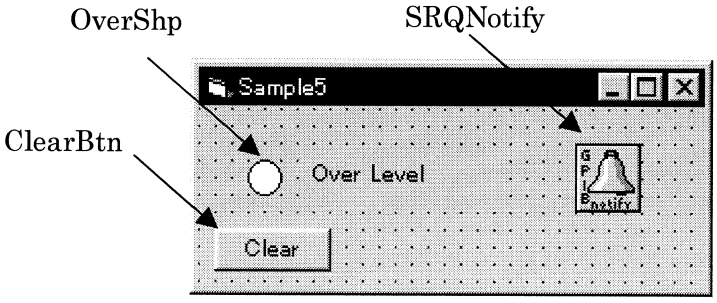

```
Dim Dev As Integer
Const Adr As Integer = 2                    ' GPIB address

Dim DataCount As Long
Dim DataValue(2048) As Integer

Private Sub Form_Load()
    ibdev 0, Adr, 0, T300ms, 1, 0, Dev      'Device open
    ibclr Dev                               ' Device clear
End Sub

Private Sub Form_Unload(Cancel As Integer)
    ibloc Dev                               'Go to Local
    ibonl Dev, 0                            ' Setting device off line
End Sub
```

```
Private Sub StartBtn_Click()
    StartBtn.Enabled = False
    HScroll1.Enabled = False
    DataLbl = "Start Measure"
    DataCount = 0
    ibwrt Dev, "*CLS"                          ' Event register clear
    ibwrt Dev, "DSIZ 0; DNUM 0; DTYP 0;"       ' Specify record length, memory number, data
    ibwrt Dev, "DSMP 6; STRT; *TRG"            ' Specify frequency and measurement start
    Timer1.Interval = 500
    Timer1.Enabled = True
End Sub


Private Sub Timer1_Timer()
    Dim rdbuf As String * 256
    ibwrt Dev, "OPER?"                         ' Query of operation event register
    ibrd Dev, rdbuf
    rdbuf = Left(rdbuf, ibcnt)
    If Left(DataLbl, 1) = "*" Then DataLbl = "+ " & rdbuf Else DataLbl = "* " & rdbuf
    If CInt(rdbuf) And 16 Then
        Timer1.Enabled = False
        BlockRead
        HScroll1.Max = DataCount - 1
        HScroll1.Enabled = True
        HScroll1 = 1: HScroll1 = 0
        StartBtn.Enabled = True
    End If
End Sub

Private Sub BlockRead()
    Dim i As Integer
    Dim rdbuf As String * 256
    ibwrt Dev, "SPTS?"                         ' Query of recorded sampling frequency
    ibrd Dev, rdbuf
    DataCount = Val(Left(rdbuf, ibcnt))
    ibwrt Dev, "DASC? 0," & CStr(DataCount)    ' Read out data memory (ASCII)
    For i = 0 To DataCount – 1
        ibrd Dev, rdbuf
        DataValue(i) = CInt(Left(rdbuf, ibcnt))
        DataLbl = CStr(i + 1) & "/" & CStr(DataCount)
        DataLbl.Refresh
    Next
End Sub

Private Sub HScroll1_Change()
    DataLbl = CStr(HScroll1) & ": " & DataValue(HScroll1)
End Sub
```

e) Use of SRQ

This case shows Over level is detected by using SRQ.
When over level occurs, OverShp (round shaped control) turns on red light. In case of resetting, ClearBtn should be pressed.

GPIBNotify control is used for observing SRQ and causing event.
GPIBNotify control can be used if selecting gpibNotify [OLE Module] out of components of Project menu in Visual Basic.
In event procedure(SRQNotify-Notify)that starts by SRQ, over level is detected by Querying serial poll and over level event register.




```
Const Adr As Integer = 2
Dim Dev As Integer

Private Sub Form_Load()
    Dim stat As Integer
    ibdev 0, Adr, 0, T300ms, 1, 0, Dev          'Device open
    ibclr Dev                                   'Device clear
    ibwrt Dev, "*SRE 1; OVEE 1"                 'Setting enable register for SRQ

    stat = SRQNotify.SetupNotify(Dev, RQS)      'Setting observation of SRQ

End Sub

Private Sub SRQNotify_Notify(ByVal LocalUd As Long, ByVal LocalIbsta As Long, ByVal
LocalIberr As Long, ByVal LocalIbcntl As Long, RearmMask As Long)
    Dim stb As Integer
    Dim rdbuf As String * 256
    If (LocalIbsta And RQS) Then                'confirmation of RQS event
        ibrsp Dev, stb                          'Serial poll
        If (stb And 1) Then                     'Checking the cause of RQS event
            ibwrt Dev, "OVER?"                  'Query of over level event register
            ibrd Dev, rdbuf
            If (CInt(Left(rdbuf, ibcnt)) And 1) Then
                OverShp.FillColor = &HFF&       ' Detection of over level
            End If
        End If
        RearmMask = RQS                         ' resetting SRQ observation
    End If
End Sub

Private Sub ClearBtn_Click()
    OverShp.FillColor = &HFFFFFF
End Sub
```

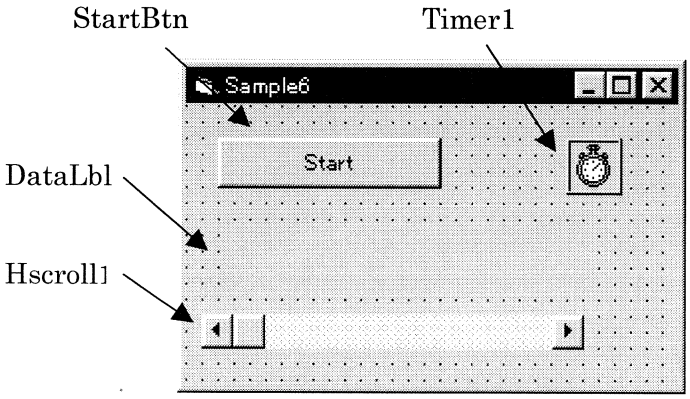
f) Record and read-out to the data memory (Binary)

As the same as "d) Record and read-out to the data memory (ASCII)", measurement data is recorded into the data memory, or is read from the data memory. However, binary form is available for reading out.

It is the same as "d) Record and read-out to the data memory" except BlockReadBin and ByteSwap.

In BlockReadBin, data memory is directly read into integer array DataValue( ). In transmitting binary, byte's order is reversely stored in integer array because of transmitting in order from upper byte to lower byte. Correct data is derived through swapping upper and lower of each data by ByteSwap.

ByteSwap is more speedy in arithmetic way, but here 16 character string operation is introduced for easier understanding.




```
Dim Dev As Integer
Const Adr As Integer = 2                        'GPIB address
Dim DataCount As Long
Dim DataValue(2048) As Integer

Private Sub Form_Load()
    ibdev 0, Adr, 0, 0, 1, 0, Dev               ' Device open
    ibclr Dev                                   ' Device clear
End Sub

Private Sub Form_Unload(Cancel As Integer)
    ibloc Dev                                   'Go to Local
    ibonl Dev, 0                                ' setting device off line
End Sub


Private Sub StartBtn_Click()
    StartBtn.Enabled = False
    HScroll1.Enabled = False
    DataLbl = "Start Measure"
    DataCount = 0
    ibwrt Dev, "*CLS"                           ' event register clear
    ibwrt Dev, "DSIZ 0; DNUM 0; DTYP 0;"        ' Specify record length, memory No. data
    ibwrt Dev, "DSMP 6; STRT; *TRG"             ' Specify frequency and measurement start
    Timer1.Interval = 500
    Timer1.Enabled = True
End Sub
```

```
Private Sub Timer1_Timer()
    Dim rdbuf As String * 256
    ibwrt Dev, "OPER?"                          ' Query of operation event register
    ibrd Dev, rdbuf
    rdbuf = Left(rdbuf, ibcnt)
    If Left(DataLbl, 1) = "*" Then DataLbl = "+ " & rdbuf Else DataLbl = "* " & rdbuf
    If CInt(rdbuf) And 16 Then
        Timer1.Enabled = False
        BlockReadBin
        HScroll1.Max = DataCount - 1
        HScroll1.Enabled = True
        HScroll1 = 1: HScroll1 = 0
        StartBtn.Enabled = True
    End If
End Sub

Private Sub BlockReadBin()
    Dim rdbuf As String * 256
    ibwrt Dev, "SPTS?"                          ' Query of recorded number of sampes
    ibrd Dev, rdbuf
    DataCount = Val(Left(rdbuf, ibcnt))
    ibwrt Dev, "DBIN? 0," & CStr(DataCount)     ' Read out data memory (Binary )
    ibrdi Dev, DataValue(), DataCount * 2
    ByteSwap DataValue(), DataCount
End Sub

Private Sub ByteSwap(dt() As Integer, n As Long)
    Dim t As String
    Dim i As Long
    For i = 0 To n - 1
        t = Right("000" & Hex(dt(i)), 4)
        dt(i) = CInt("&h" & Right(t, 2) & Left(t, 2))
    Next
End Sub


Private Sub HScroll1_Change()
    DataLbl = CStr(HScroll1) & ": " & DataValue(HScroll1))
End Sub
```

Information Multi-line Interface Messages

*2 b7 b6 b5					0 0 0	*1 MSG	0 0 1	MSG	0 1 0	MSG	0 1 1	MSG	1 0 0	MSG	1 0 1	MSG	1 1 0	MSG	1 1 1	MSG
b4	b3	b2	b1	Column / ROW	0		1		2		3		4		5		6		7	
0	0	0	0	0	NUL		DLE		SP	↑	0	↑	@	↑	P	↑	`	↑	p	↑
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	*3 PPC	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		*4		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	↓

Listener address to be allocated to the equipment

Listener address to be allocated to the equipment

Talker address to be allocated to the equipment

Listener address to be allocated to the equipment

The meaning is defined by the primary command

The meaning is defined by the primary command

Address Command Group (ACG)

Universal Command Group (UCG)

Listener Address Group (LAG)

Talker Address Group (TAG)

Primary Command Group (PCG)

Secondary Command Group (SCG)

Note: *1 MSG is an interface message

*2 b1=DIO1 ・・・ b7=DIO7. DIO8 is not used.

*3 Involves a secondary command

*4 "＼" in IEC standard; "¥" in JIS

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

6. RS-232 Interface

6.1 Preparation before use

6.1.1 RS-232 overview

Similarly to GPIB, the RS-232 interface allows the user to perform external control except GPIB specific functions. Setting and queries are available by using the same program messages as those for GPIB. Response messages to queries are also in the same format as for GPIB.
Parts of the descriptions that are the same as in the above GPIB sections are omitted here because of large overlapping. Before performing external control via RS-232, read the sections describing GPIB operations.

a) Functions that are available in GPIB but not available in RS-232 (GPIB specific functions)

- Switching between remote and local.
  The user can disable panel operation using a program message KLOC, which is equivalent to KEY LOCK.

- Interrupt to the controller and serial poll by service request
  The user can read status using a query message STB? etc.

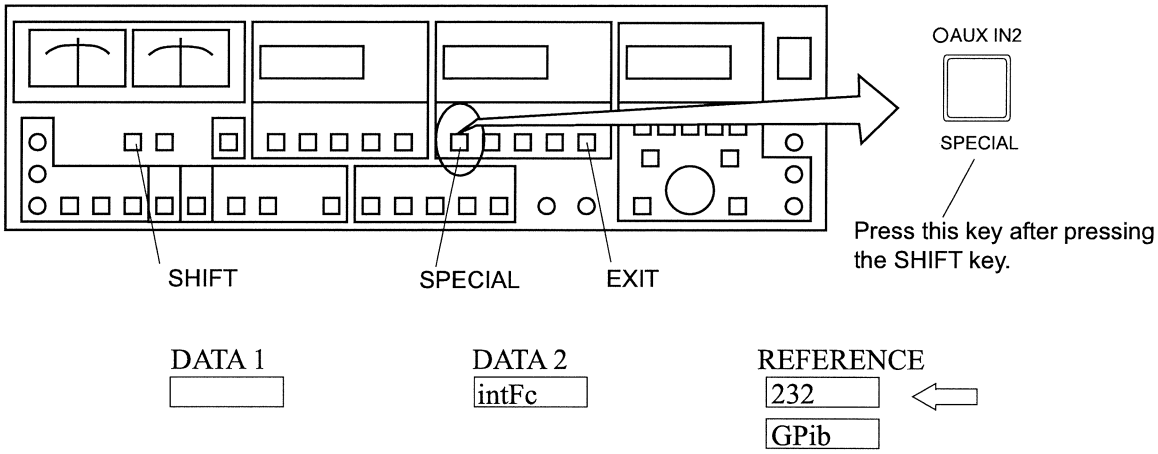
- GPIB specific commands such as Device Clear, GET etc.
  The user can use a program message *TRG in place of the trigger.

- Connection of two or more devices
  RS-232 can connect only one device to another.

b) Specifications

- Baud rate: 1200, 2400, 4800, 9600 and 19200
- Data bit length: 7 or 8 bits
- Stop bit length: fixed to 1 for reception and 2 for transmission
- Parity: Even, Odd, or None

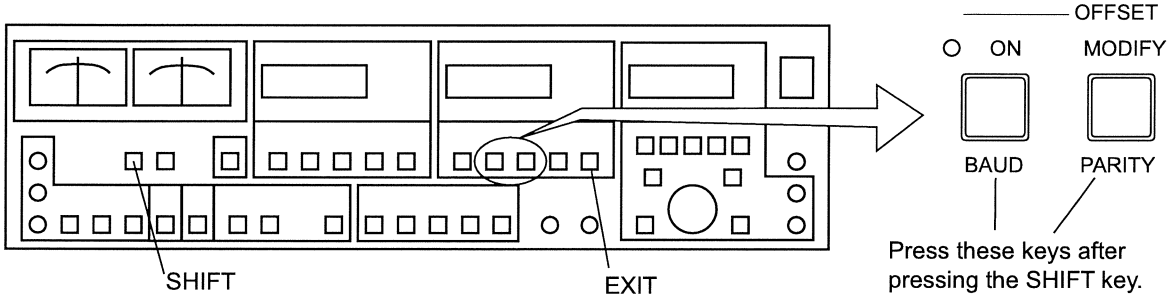
6.1.2 Switching to RS-232



Both RS-232 and GPIB cannot be used at the same time. When to use RS-232, follow the procedure below to switch the external control to RS-232:

1) Press the SHIFT + SPECIAL keys.
2) Make sure intFc appears on the DATA2 display.
   Other parameters may be selected using the MODIFY dial.
3) Use the ▶ key to move the blinking digit to the REFERENCE indication section.
   Or use the ◀ key to return to the DATA2 display.
4) Use the MODIFY dial to select 232.
5) Press the SHIFT + EXIT keys to return to the previous indication.

6.1.3 Setting the baud rate, data bit length and parity



a) Setting the baud rate

When performing serial communication via RS-232, the transmission speed (baud rate) must match at the transmitting and receiving ends. Follow the procedure below for setting on LI5640 side:

1) Press the SHIFT + BAUD keys.
   The current baud rate setting appears on the REFERENCE digital display.
2) Use the MODIFY dial to select the baud rate.
   Select from 1200, 2400, 4800, 9600 and 19200.
3) Press the SHIFT + EXIT keys to return to the previous indication.

DATA1	DATA2	REFERENCE
	bAud	9600

b) Setting the parity and character length

When performing serial communication via RS-232, parity bit and character length must match at the transmitting and receiving ends. Follow the procedure below for setting on LI5640 side.

1) Press the SHIFT + PARITY keys.
2) Use the MODIFY dial to select parity bit.
   Select the parity bit from even, odd or none.
3) Use the ▶ key to move to selection of character length.
   The blinking digit moves to the right. (Press the ◀ key to return to parity bit selection.)
4) Use the MODIFY dial to select the character length.
   Select either 7 bits or 8 bits.
5) Press the SHIFT + EXIT keys to return to the previous indication.

DATA1	DATA2	REFERENCE
	Prt c	no 7

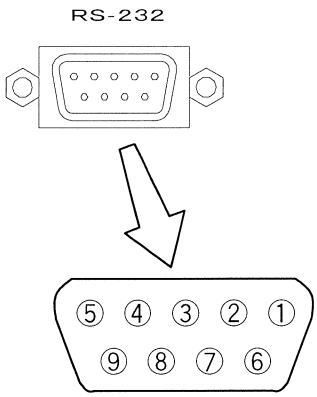
Parity: no None; odd Odd number; even Even number

Character Length

c) Stop bit

Stop bit length is fixed to 2 bits for transmission and 1 bit for reception. Therefore, any of 1, 1.5 and 2 is available for both transmission and reception as the stop bit length on the control side.

6.1.4 Connecting RS-232 cable



To use RS-232, connect it to the RS-232 connector on the rear panel. Specifications of this connector are D-sub, 9 pins, female, and inch screw. For connection to a PC-AT compatible device, marketed RS-232 (serial) cables with both end 9 pins, male-female and straight connection (e.g., "RS-232c extension cable") can be used. However they must have the same specifications for screws and handshake.

In order to avoid unnecessary electromagnetic field radiation, the connecting cable should be a double-shielded cable of which shield is connected to the metal shell of connector. Use of an inferior cable may interfere with the environment.

Fig. 6-1 Pin Configuration of RS-232 Connector

Table 6-1 Signal Assignment of RS-232 Connector

LI5640				PC-AT compatible device	
Pin No.	Signal name			Pin No.	Signal name
1	N.C. No Connection	→		1	CD : Carrier Detect
2	TD Transmission Data	→		2	RD : Received Data
3	RD Reception Data	←		3	TD : Transmitted Data
4	DSR Indicates that the other end is operable. If this is not active, transmission from LI5640 will be delayed.	←		4	DTR : Data Terminal Ready
5	SG Signal Ground	—		5	SG : Signal Ground
6	DTR Indicates that LI5640 is operable.	→		6	DSR : Data Set Ready
7	CTS Indicates that the other end is ready for receiving. If this is not active, transmission from LI5640 will be delayed.	←		7	RTS : Request To Send
8	RTS Indicates that LI5640 is ready for receiving.	→		8	CTS : Clear To Send
9	N.C. No Connection	→		9	RI : Ring Indicator

Signal ground of RS-232 is connected to the enclosure of LI5640.

If hardware handshake is not used, directly connect the pins of LI5640 as follows:

6 (DTR) to 4 (DSR) and 7 (CTS) to 8 (RTS)

Signal names vary depending on the standards etc. The above signal names are in accordance with PC-AT compatibles.

6.2 Handshake

GPIB uses three-line handshake to ensure always-proper communication through adjustment to the slowest device, while RS-232 does not specify only one method for handshake. For this reason, the same method must have been set for handshake at the transmitting and receiving ends; otherwise the transmitted data will not be received properly at the receiving end.

The following handshakes are available in LI5640.

- Software handshake (X-ON, X-OFF)
- Hardware handshake (DTR-DSR and CTS-RTS)

If a hardware handshake signal is not available or is not in use on the controller side, the corresponding signal lines of LI5640 must be directly connected; otherwise communication may fail. The controller is required to support either one of the above.

In respect of handshake, LI5640 performs as follows:

a) From controller to LI5640

- When the input buffer (1024 characters) is filled by approximately 2/3 or more, LI5640 executes the following steps:
  Outputs X-OFF code (11_{16}).
  Disables RTS.
  Disables DTR.
- When the input buffer is emptied by approximately 2/3 or more, LI5640 executes the following steps:
  Outputs X-ON code (13_{16}).
  Enables RTS.
  Enables DTR.

b) From LI5640 to controller

- LI5640 suspends transmission when any of the following is experienced:
  X-OFF code (11_{16}) is received.
  CTS is inactive.
  DSR is inactive.
- LI5640 resumes transmission when the following conditions are met:
  When X-OFF is in use: CTS and DSR are active and X-ON code (13_{16}) is received.
  When X-OFF is not in use: CTS and DSR are active.

6.3 Error messages of RS-232

This section describes errors that are specific to RS-232.

When an error occurs, the error number appears on the REFERENCE digital display for a few seconds.

Example : E513

The user may use a query message EROR? to see a more detailed message for this error number. However query does not work properly in the environment that produced these errors.

Table 6-2 Error Messages of RS-232

Error No.	Error Message	Descriptions
511	RS-232 framing error	A framing error is detected. Check if the settings of baud rate, data bit length and parity are correct.
512	RS-232 overrun error	An overrun error is detected. Part of data has been lost because new data was received before the previous data has been processed for some reason. Usually this error does not occur.
513	RS-232 parity error	A parity error is detected. Check if the settings of baud rate, data bit length and parity are correct.

Framing error and parity error occur when the settings of baud rate, data bit length and parity are incorrect. Or otherwise, they occur when malfunction due to noise or contact failure is detected.

7. Specifications

7.1 Measured signal system

a) Voltage input

Input connector	Two BNC receptacles (for A and B)
Input format	A (single end) and A-B (differential)
Voltage sensitivity	2nV to 1V full scale (1-2-5 sequence)
Voltage accuracy	±0.5% (1kHz, signal level of 1mV or greater, 23±5℃) ±2% (1kHz, signal level of 1μV or greater) (Dynamic reserve LOW, 30% or higher of full scale) ±0.5% (for DC coupling, 20kHz or less) ±1% (for DC coupling, 50kHz or less) ±2.5% (for DC coupling, 100kHz or less) (Dynamic reserve at LOW, sensitivity 1V, signal level 1V)
Gain drift	±100ppm/℃ (typically 1kHz) High dynamic reserve may deteriorate the gain drift.
Input impedance	10MΩ±1.5%, about 50pF in parallel
Input referred noise	6nV/$\sqrt{\text{Hz}}$ (max), 4.5nV/$\sqrt{\text{Hz}}$ (typically) for dynamic reserve at LOW, sensitivity set to 2mV or less, frequency at 1kHz and input short-circuited.
Maximum allowable input voltage	±7V (DC coupling) 5Vrms (AC coupling, sine wave); as allowable noise level for sensitivity at 1V and dynamic reserve at HIGH
Maximum nondestructive input voltage	For AC coupling: Sine wave 10Vrms, DC ±50V For DC coupling: ±14V
Frequency range	1mHz to 100kHz (DC coupling), 0.5Hz to 100kHz (AC coupling)
Common-mode rejection ratio	120dB (typically 1kHz), 100dB (min. 50Hz to 1kHz) for AC coupling, dynamic reserve at LOW, sensitivity set to 20mV or less, at MEDIUM and 2mV or less
Harmonic distortion	-90dBtyp (1kHz), -80dB or less (10Hz to 5kHz), -70dB or less (5 to 10 kHz) all for dynamic reserve at LOW, sensitivity at 1V, signal level at 1V

b) Current input

Input connector	BNC receptacle (I)
Input type	Single-ended
Current sensitivity	50fA to 1μA 1-2-5 sequence (for conversion gain 10^6V/A)
	5fA to 10nA 1-2-5 sequence (for conversion gain 10^8V/A)
Current accuracy	±1% (1kHz and magnitude of signal 1nA to 1μA for conversion gain 10^6V/A; 10Hz and magnitude of signal 10pA to 10nA for conversion gain 10^8V/A both for dynamic reserve at LOW and magnitude of signal at 30% or greater of sensitivity full scale and 23±5℃)
Gain drift	±150ppm/℃ typically (at 1kHz for 10^6V/A and 10Hz for 10^8V/A)
	High dynamic reserve may deteriorate the gain drift.
Input referred noise	130fA/$\sqrt{\text{Hz}}$ typically (1kHz for conversion gain 10^6V/A)
	13fA/$\sqrt{\text{Hz}}$ (125Hz for conversion gain 10^6V/A)
Input impedance	<1kΩ (500Hz for conversion gain 10^6V/A)
	<20kΩ (50kHz for conversion gain 10^6V/A, for reference)
	<20kΩ (500Hz for conversion gain 10^8V/A)
Maximum allowable input current	
	±7μA; as allowable noise level for conversion gain of 10^6V/A, sensitivity at 1μA and dynamic reserve at HIGH
Maximum nondestructive input current	
	10mA
Frequency range	1mHz to 50kHz (DC coupling, for conversion gain 10^6V/A)
	1mHz to 500Hz (DC coupling, for conversion gain 10^8V/A)
	0.5Hz or greater for both of the above in AC coupling

c) Specifications common to voltage and current

Input coupling	AC/DC (AC coupling after conversion to voltage for current input)
Input ground	Float/chassis ground
	Voltage between chassis and signal ground is ±1V max when floating
	Ground impedance is about 10kΩ (DC) when floating
	Ground impedance is about 10Ω (DC) when chassis is grounded
Line filter	Power supply frequency (50 or 60Hz) and its doubled value
	Attenuation in center frequency 20dB or greater
Anti-aliasing filter	ON/OFF
	(OFF; response speed and phase drift to be improved when not in use)

7.2 Phase sensitive detector section

Dynamic reserve	100dB or greater; the ratio of sensitivity full scale (rms) to maximum allowable noise level (rms)
Time constant	10μs to 30ks (1-3 sequence)
Attenuation slope	6, 12, 18 and 24dB/oct
Synchronous filter	ON/OFF; when filter is ON, output ripples can be reduced by moving average of integral cycle. However, ripples may not be attenuated sufficiently if 200Hz is exceeded.
Phase noise	0.001° rms typically (1kHz) Sine wave reference signal, time constant 100ms, attenuation slope 18 dB/oct 0.003° rms typically (100kHz) Sine wave reference signal, time constant 100ms, attenuation slope 12 dB/oct This specification may not be applicable if noise or jitter in reference signal is large, or amplitude is less than 1Vrms.
Phase drift	Within ±0.01°/℃ (≧100Hz, ≦10kHz) Within ±0.1°/℃ (>10kHz, ≦60kHz) Within ±0.2°/℃ (>60kHz) This specification may not be applicable if an external sine wave signal of less than 1Vrms is used as the reference signal.

7.3 Reference signal system

Reference mode	REF IN (external), INT OSC (internal oscillator), SIGNAL (measured signal)
Frequency range	0.5mHz to 102kHz for TTL input or INT OSC
	0.5Hz to 102kHz for SINE input or SIGNAL
Harmonics measurement	1 to 19999 times of the reference signal
	(frequencies of harmonics must be within the above frequency range)
Input type	Single-ended
Input impedance	Approx. 1MΩ (1kHz), 100pF or less in parallel
Input voltage range	0.3 to 30Vp-p (SINE input, sine wave)
	0 to 5V (TTL input, threshold voltage of approx. 1.5V)
Maximum nondestructive input voltage	
	±40V
External reference signal waveform	
	SINE/TTL POS/TTL NEG
SINE :	A regular waveform that crosses the mean value only twice in a cycle Duty factor is 10 to 90% for a square wave The point at which the wave crosses the mean value upward from below is defined as 0 degree.
TTL POS:	A waveform with stable cycle that crosses the threshold voltage only twice in a cycle. The point at which low level changes to high level is defined as 0 degree.
TTL NEG:	A waveform with stable cycle that crosses the threshold voltage only twice in a cycle. The point at which high level changes to low level is defined as 0 degree.
External reference signal synchronization time	
	2 cycles + 50ms typically (Synchronization time is zero when internal oscillator is used)
Phase adjustment range	-180.00° to +179.99° , resolution 0.01°
Orthogonality	Within ±0.001°
Phase accuracy	±1° (DC coupling, ≦10kHz, sensitivity 1V, signal level 1V)
	±5° (DC coupling, ≦100kHz, sensitivity 1V, signal level 1V)
Frequency display resolution	
	4 1/2 digits (maximum 19999) or 0.1mHz, whichever is greater
Frequency measurement accuracy	
	±30ppm
UNLOCK indication	Indicates that the system is not synchronized to external reference signal.
Reference signal output	Connector BNC receptacle (rear panel)
	Signal level TTL (0 to 5V)

7.4 Internal oscillator

Oscillation frequency	Range	0.5mHz to 105kHz
	Resolution	4 1/2 digits (maximum 19999) or 0.1mHz, whichever is greater
	Accuracy	±30ppm
Output voltage Range	Full scale	0.0500Vrms, 0.500Vrms, 5.00Vrms (no loaded) 3-range manual switching
	Resolution	0.1mV, 1mV, 10mV (for each range)
	Accuracy	2% of set value + 0.5% of full scale (frequency ≦1kHz) 5% of set value + 0.5% of full scale (frequency ≦10kHz) 20% of set value + 0.5% of full scale (frequency ≦100kHz) When approx. 102kHz is exceeded, the amplitude suddenly drops.
	Stability	±50ppm/℃ typically (for 1kHz, 1rms)
Maximum output current		±10mA (when 5Vrms, load impedance ≧660Ω)
Output impedance		50Ω ±3% (1kHz)
Harmonic distortion		-80dB or less (for 20Hz to 5kHz, maximum amplitude selected) -70dB or less (for frequencies ≦100kHz, maximum amplitude selected)

7.5 Measurement output section

a) Digital display

DATA1 parameter	X (= R cos θ), R, NOISE, AUX IN 1
DATA2 parameter	Y (= R sin θ), θ , AUX IN 1, AUX IN 2
X, Y and R	Indication range 0 to 120% of sensitivity setting, resolution 4 1/2 digits (maximum 19999)
	θ Indication range -180.00 to +179.99° , resolution 0.01°
NOISE	Indication range 0 to 120% of the following noise density sensitivity
	Voltage : 20nV/$\sqrt{\text{Hz}}$ to 1V/$\sqrt{\text{Hz}}$
	Current (10^6V/A) : 1pA/$\sqrt{\text{Hz}}$ to 1μA/$\sqrt{\text{Hz}}$
	Current (10^8V/A) :100fA/$\sqrt{\text{Hz}}$ to 10nA/$\sqrt{\text{Hz}}$
	(1-2-5 sequence in any case)
	Resolution 4 1/2 digits (maximum 19999)
AUX IN1 and IN2	Indication range ±12.000V, resolution 0.001V
Ratio indication	Displays the value of the ratio of X, Y and R to AUX IN1 multiplied by arbitrary coefficient K.

$$\text{Ratio} = K \times \frac{\text{Percentage to the X, Y and R sensitivity}}{|\text{AUX IN1}|[\text{V}] \times 10}$$

Indication range: ±1.9999, resolution 0.0001

K constant range: 0.1000 to 1.9999, and 2.000 to 9.999

Normalize — Displays the ratio of the X and R to the standard value in dB or %.

$$\text{dB value} = 20\ \text{LOG}_{10} \left| \frac{\text{X or R measurement}}{\text{Standard value}} \right|$$

$$\%\text{value} = \left(\frac{\text{X or R measurement}}{\text{Standard value}} \right) \times 100$$

Indication range: ±120.00dB, resolution 0.01dB

±199.99%, resolution 0.01%

Standard value range:

Voltage 1.0000nV to 1.0000V

(4 1/2 digits, maximum 19999)

Current 1.0000fA to 1.0000 μA

(4 1/2 digits, maximum 19999)

Offset	±100.00% of sensitivity to X and Y. Resolution 0.01%.
Expand (EXPAND)	Magnifies X, Y and R by 1, 10 or 100 times

b) Analog output

Front panel output

DATA1 OUT	Same as DATA1 display parameter
DATA2 OUT	Same as DATA2 display parameter

Update rate for the above data

X, Y, R and θ : 256k samples/s

Others : 16k samples/s

The rate may be slower depending on the measurement conditions.

Rear panel output

X OUT	Same as X of DATA1 display parameter
Y OUT	Same as Y of DATA2 display parameter

Update rate for the above data

16k samples/s. The rate may be slower depending on the measurement.

Common specifications

Connector	BNC receptacle
Maximum output voltage	±12V (θ , % is ±10V)
Maximum output current	±6mA
Output impedance	Approx. 1kΩ (DC)
Output voltage accuracy	±(Analog output voltage equivalent to 0.35% of displayed value +15mV); (in DC)

Measurement values corresponding to meter full scale (analog output ±10V)

X, Y and R	Sensitivity set value/EXPAND magnification
NOISE	Sensitivity setting
AUX IN1 and AUX IN2	±10V
θ	±180°
Ratio	±2
% indication	±200%
dB indication	±100dB

c) Analog meter

DATA1	Indicates the same parameter as DATA1 display parameter
DATA2	Indicates the same parameter as DATA2 display parameter.

7.6 Monitor output (input signal to phase sensitive detector)

Connector	BNC receptacle
Maximum output voltage	±12V
Maximum output current	±6mA
Output impedance	Approx. 1kΩ (1kHz)

7.7 Auxiliary input (DC voltage measurement)

Number of channels	2
Connectors	Two BNC receptacles (AUX IN1 and AUX IN2 on rear panel)
Maximum allowable input voltage	±12V
Maximum nondestructive input voltage	±40V
Input impedance	Approx. 1MΩ, 100pF or less in parallel
Accuracy	± (0.35% of reading value + 15mV)
Frequency band	DC up to approx. 130Hz (-3dB)
Sampling rate	16k samples/s

7.8 Auxiliary output (DC voltage output)

Number of channels	2
Connectors	Two BNC receptacle (AUX OUT1 and AUX OUT2 on rear panel)
Setting voltage range	±10.000V (resolution 0.001V)
Maximum output current	±5mA
Output impedance	Approx. 1kΩ
Output voltage accuracy	± (0.35% of setting + 15mV)

7.9 Data memory

Type of data	Select from the following: DATA1, DATA2, DATA1/DATA2, DATA2/AUX IN2, DATA1/DATA2 /reference signal frequency, DATA1/DATA2/AUX IN1 /AUX IN2
Data resolution	16 bits (reference signal frequency is 32 bits)
Recording capacity	64K data (total of all parameters to be recorded; assuming 16 bits per data)
Number of memory divisions	1, 2, 4, 8, 16 and 32
Sampling interval	1/16ms, 1/8ms, 1/4ms, 1/2ms, 1ms, 2ms, 5ms, 10ms, 20ms, 50ms, 100ms, 200ms, 500ms, 1s, 2s, 5s, 10s, 20s; or by trigger signal

Trigger signal	TRIG IN on rear panel or via external interface		
TRIG IN	Connector	BNC receptacle	
	Signal level	TTL level (falling edge)	
	Input impedance	Approx. 10kΩ	
	Maximum nondestructive input voltage		±40V
	Minimum trigger interval		1/16ms
Operation	Via external interface		

7.10 Automatic setting function

AUTO SET	Sets optimum sensitivity, dynamic reserve, time constant, phase etc. according to the input signal.
Sensitivity	Adjusts sensitivity of voltage or current, and dynamic reserve according to the input signal.
Time constant	Adjusts time constant corresponding to the frequency of reference signal.
Phase	Sets the phase of reference signal so that the measurement θ of phase will be zero.
Offset	Sets all offsets so that output of X and Y will be zero.

7.11 External interface (GPIB and RS-232)

Either of GPIB and RS-232 is capable of setting and reading parameters, reading statuses and reading measurement data.
In addition, various commands are provided most of which are compatible with NF's 5610B/5600A as much as practicable to ensure previous programs are available with minimal modification.

a) GPIB

Standard	Conforming to IEEE std 488.1-1987 and IEEE std 488.2-1992
Interface functions	SH1, AH1, T6, L4, SR1, RL1, PPO, DC1, DT1, CO and E1

b) RS-232

Baud rate	1200, 2400, 4800, 9600 and 19200
Data bit length	7 or 8 bits
Stop bit length	Fixed to 1 for reception and 2 for transmission
Parity	Even, Odd, or None

Please note that RS-232 does not provide the function that corresponds to service request of GPIB.

7.12 General specifications

Power output to preamplifier	±24V, ±50mA
Setting memories	9
Initializing function	Returns to specified initial setting
Key lock	ON/OFF
Lamp control	ON/OFF
Fan control	ON/OFF
Power supply voltage range	100/120/230V±10%
Power supply frequency range	50/60Hz±2Hz
Power consumption	50VA maximum
Temperature/humidity range for performance guarantee	0 to +40℃, 10 to 95%RH (no dew condensation) Some of specifications limit the temperature range.
Storage temperature/humidity range	-10 to +50℃, 10 to 85%RH (no dew condensation)
Outer dimensions	434 (W) x 132.5 (H) x 450 (D) mm (excluding protruding portions)
Mass	Approx. 10kg

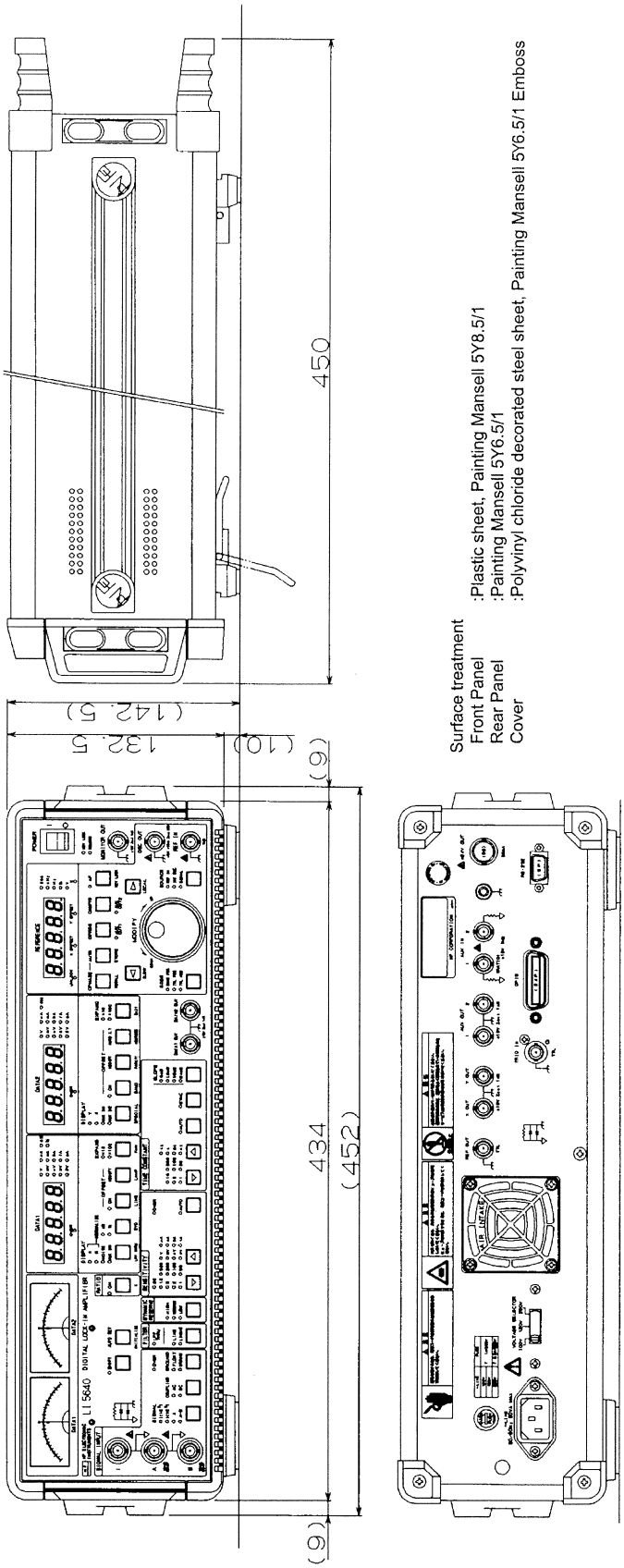


Figure 7-1 External Dimensions

WARRANTY

NF CORPORATION certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from our factory.

All **NF** products are warranted against defects in materials and workmanship for a period of one year from the date of shipment. During the warranty period of, **NF** will, at its option, either will repair the defective product without any charge for the parts and labor, or either repair or replace products which prove to be defective. For repair service under warranty, the product must be returned to a service center designated by **NF**. Purchaser shall prepay all shipping cost, duties, and taxes for the product to **NF** from another country, and *NF* shall pay shipping charge to return the product to purchaser.

This warranty shall not apply to any defect, failure or damage caused by improper use, improper or inadequate maintenance and care or modified by purchaser or personnel other than **NF** representatives.

NF CORPORATION

WABUN (D:508525-2)

If there are any misplaced or missing pages, we will replace the manual. Contact the sales representative.

NOTES:

- Reproduction of the contents of this manual is forbidden by applicable laws.
- The contents of this manual may be revised without notice.
- Information provided in this manual is intended to be accurate and reliable. However, we assume no responsibility for any damage regarding the contents of this manual.
- We assume no responsibility for influences resulting from the operations in this manual.

LI5640 Multi-function Digital Lock-in Amplifier Instruction Manual

NF CORPORATION
3-20 Tsunashima Higashi 6-chome, Kohoku-ku. Yokohama-shi
223-8508, JAPAN
Phone: 81-45-545-8128 Fax: 81-45-545-8187

http://www.nfcorp.co.jp/

NF Corporation

6-3-20, Tsunashima-higashi, Kohoku-ku,Yokohama 223-8508 JAPAN