**LOCK-IN AMPLIFIER MODULE**

# LI5501 / LI5502

# INSTRUCTION MANUAL

**NF Corporation**

DA00098273-002

**LOCK-IN AMPLIFIER MODULE**

# LI5501 / LI5502

INSTRUCTION MANUAL

# —— Preface ——

Thank you for purchasing the **"LI5501 / LI5502 LOCK-IN AMPLIFIER MODULE"**.
For safe and correct use of this instrument, please read the **"Safety Precautions"**
section that follows before attempting to use the instrument.

● **Marks and Symbols**

For safe operation by the user and to prevent damage to the instrument, please
give attention to the following marks and symbols that are used in this manual.

⚠ **WARNING**

This mark indicates information for preventing the possibility of death or serious
personal injury from electrical shock or other hazards in the use or handling of
this instrument.

⚠ **CAUTION**

This mark indicates information for preventing the possibility of injury to the user
or damage to the instrument in the use or handling of this instrument.

● **The chapters of this manual are described below.**

If you are using this instrument for the first time, begin reading from Chapter 1.

**1. Introduction**

This chapter describes a general description of the instrument, including its features, applications, functions, and basic operating principles.

**2. Preparation before use**

This chapter describes important preparation that must be done before operating the instrument.

**3. Names of each part**

This chapter describes names and functions of each part.

**4. Basic settings**

This chapter describes basic settings of the **"LI5501 / LI5502"**.

**5. Remote control**

This chapter describes remote control commands of the **"LI5501 / LI5502"**.

**6. Advanced settings**

This chapter describes advanced settings of the **"LI5501 / LI5502"**.

**7. Troubleshooting**

This chapter describes how to deal with error messages and cases in which you think the instrument is malfunctioning.

**8. Maintenance**

This chapter describes storage, repacking, transportation, and performance testing methods.

**9. Specifications**

This chapter describes the instruments specifications (functions and performance).

# —— Safety Precautions ——

For safe use of this product, give full attention to the following warnings and cautions.
The NF Corporation shall not be held liable for damages that arise from failure to observe these warnings and cautions.

● **Be sure to observe the contents of instruction manual.**

This instruction manual contains information for the safe operation and use of this instrument.
Be sure to read this instruction before using this instrument.
All of the warning items contained in this instruction are intended to avoid risks that may lead to serious accidents. Follow the warnings and instructions carefully.

● **Check the power supply voltage.**

This instrument operates on the power source voltage described in **"2.3 Grounding and power connections"**.
Before supplying power to this instrument, confirm that the supply voltage conforms to the rated power supply of this instrument.

● **If you think something is wrong, …**

If smoke or an unusual odor or sound comes from this instrument, immediately remove the power cord of the power supply from the outlet and cease use of this instrument.
If any such abnormality occurs, take measures to prevent the use of this instrument until repairs have been completed and promptly contact the NF Corporation or its authorized agent.

● **Do not use this instrument in explosive atmosphere.**

An explosion or other hazards may occur.

● **Do not open the instrument cover.**

Because there are precision electronic components inside this instrument, never remove the instrument cover.
Only technicians certified by the NF Corporation are authorized to inspect and touch anything inside the instrument cover.

● **Do not modify this instrument.**

Never modify this instrument in any way. Modification might create new risks. The NF Corporation may refuse to service an instrument that has an unauthorized modification.

● **Do not expose this product to water.**

Use of this instrument when it is wet may result in malfunction. If this instrument becomes wet, immediately unplug the power cord of the power supply and contact the NF Corporation or its authorized agent.

● **If lightning occurs nearby, unplug the power cord.**

A lightning strike may cause electrical shock, fire, or malfunction.
Immediately turn off the power supply and unplug the power cord of it.

● **Safety-related symbols**

The marks and symbols defined below are used in this manual or on the instrument itself to indicate safety information or instructions.

⚠

**Instruction Manual Reference Symbol**

This symbol notifies the user of a potential hazard and indicates that the user must refer to the instruction manual.

⚠ **WARNING**

**Warning Symbol**

This mark indicates information for preventing the possibility of death or serious personal injury from electrical shock or other hazards in the use or handling of this instrument.

⚠ **CAUTION**

**Caution Symbol**

This mark indicates information for preventing the possibility of injury to the user or damage to the instrument in the use or handling of this instrument.

● **Other Symbols**

⏚

This symbol indicates that connected to the instrument case.

42Vpk

This symbol indicates that the outer conductor of the connector is isolated from the instrument enclosure.
However, safe operation of the instrument requires that the potential difference from the grounding potential is restricted to 42 Vpk or less.
This instrument must be grounded when in use, so the power supply must be grounded.

● **Electromagnetic compatibility**

    Applied EMC standard: EN 61326-1, EN 61326-2-1

    Intended electromagnetic environment: Industrial

Emissions, which exceed the levels required by that standard, can occur when this product is connected to a test object.

This product is a CISPR 11 Group 1 Class A equipment.

This product may cause interference if used in residential areas. Such use must be avoided unless the user takes special measures to reduce electromagnetic emissions to prevent interference to the reception of radio broadcasts.

⚠ **CAUTION**

    This product is not intended for use in residential environments and may not provide adequate protection to radio reception in such environments.

● **Disposal of this instrument**

To protect the environment, follow the guidelines described below for the disposal of this instrument.

a) This instrument does not use batteries.

b) Use the services of an industrial waste disposal contractor for disposal of this instrument.

# Table of contents

# Figures and Tables

(Blank)

# 1. Introduction

## 1.1 Features

The **"LI5501 / LI5502 LOCK-IN AMPLIFIER MODULE"** is a dual-phase lock-in amplifier module with a frequency range of 10 mHz to 1 MHz.

They can be widely used to measure amplitude and a phase of small AC signal buried in noise taking advantage of the following features. The **LI5502** can measure amplitude ratio and phase difference between two channels.

- **Wideband**

  A signal from 10 mHz to 1 MHz can be measured.

- **Dual-phase lock-in amplifier**

  Because phase detection and subsequent processing are performed digitally, an output zero drift and orthogonal error are much smaller than an analog method.

  By mounting two of these phase detectors, amplitude ($R = \sqrt{(X^2+Y^2)}$) and a phase ($\theta = \tan^{-1}(Y / X)$) of a signal can be measured.

  The two-channel model **LI5502** is equipped with the two dual-phase detectors (same reference frequency), so amplitude ratio and phase difference between two channels can be measured.

- **Fractional harmonic measurement**

  In addition to harmonic measurement, a frequency of submultiple of fundamental wave (x 1 / 1 to 63 / 64) can be used as reference frequency.

- **Variety of filters**

  This instrument is equipped with the time constant filter and moving average filter.

  a) Time constant filter

    The attenuation slope of the filter can be set to 6, 12, 18, or 24 dB/oct.

    The minimum time constant of 1 μs enables fast response.

  b) Moving average filter

    This instrument is equipped with the moving average filter after the time constant filter. This filter can be set the averaging time from 1 μs to 100 s.

    Fast response can be obtained in low frequency measurement when this filter is combined with the time constant filter in appropriate setting.

- **Smooth output response**

  The maximum update rate is approximately 300 k Samples/s, and the amplitude resolution is 16 bits.

- **External synchronization**

  This instrument can be synchronized with reference frequency of another instrument by using the 10 MHz IN terminal.

- **Remote control**

  Setting changes and measurement data reception are performed via USB or LAN communication. The maximum transfer rate of measurement value is 300k words/s.

- **Small size**

  200 mm (W)×25 mm (H)×150 mm (D), approximately A5 size

  It is easy to mount the instrument on equipment by using the attached metal fittings.

## 1.2 Applications

The **LI5501 / LI5502** can be used in the following fields, taking advantage of its features.

- Signal detection in scanning probe microscope
- Thermal diffusivity measurement of thin film materials
- Spectroscopic analysis

  (material science using Auger electron spectroscopy and Raman spectroscopy)
- Analyses of mechanical vibration
- Noise measurement of electronic components

■ **Application example using the LI5502**

The following measurement can be performed using functions of the **LI5502**.

● **Low-impedance measurement**

In impedance measurement of samples whose characteristics change or that are damaged by several mA current, a method of increasing an applied voltage cannot be used because the current value increases with the voltage.

Alternatively, a small current is applied to the sample, and the voltage and current applied to the sample are amplified by a low-noise voltage amplifier and current amplifier, respectively.

The impedance equivalent value can be obtained by measuring the respective output voltages of the amplifiers and calculating with the **LI5502**.
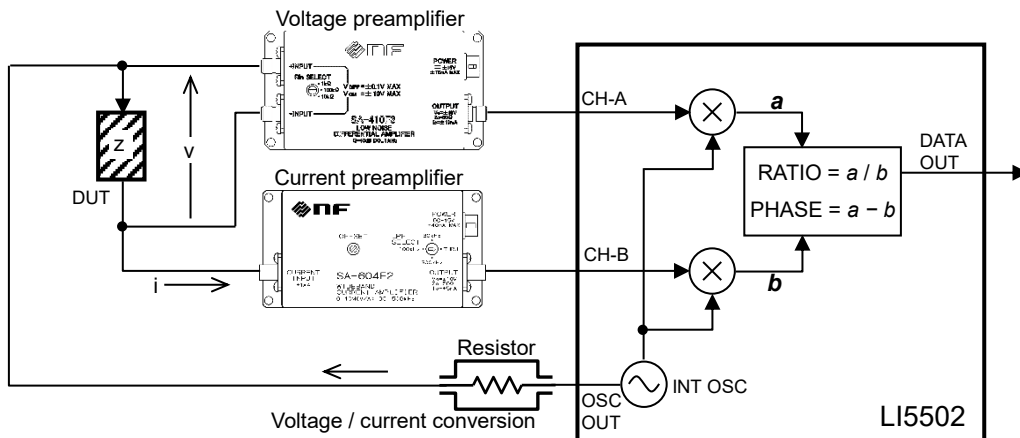
## 1.3 Operating principle

### 1.3.1 Basic principle of Lock-in Amplifier

A lock-in amplifier is a device that uses difference of frequencies to separate an signal and noise and amplify the signal. It works equivalently as a tuned amplifier or narrow band pass filter where the center frequency follows the signal.
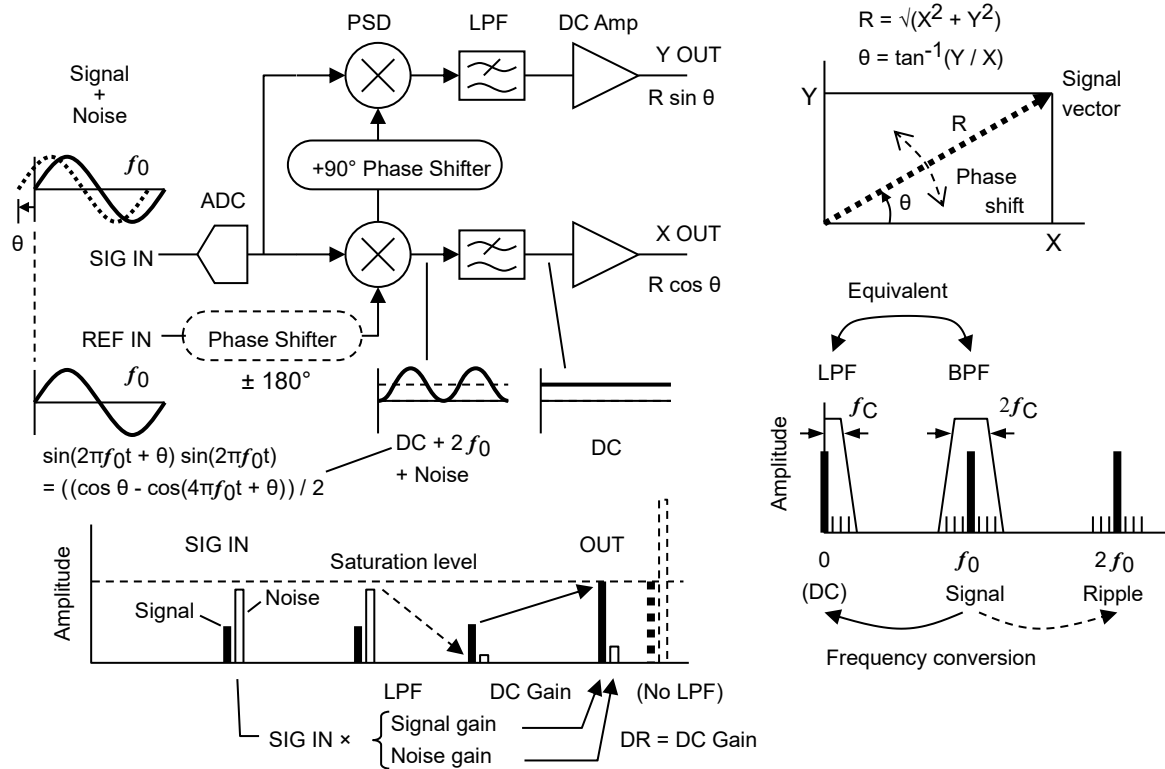
**Figure 1-1  Basic principle of Lock-in Amplifier**

Firstly, a signal including noise is converted to a DC voltage using a Phase Sensitive Detector (PSD). At this point, noise in the vicinity of the signal frequency is also converted to the vicinity of DC. Then, the noise and ripples caused by the detection are removed using a low pass filter (LPF) to obtain the DC component. When this is returned to the original frequency, the equivalent bandwidth is equal to the band pass filter that is double the cutoff frequency of the LPF. Increasing the time constant (response time) and attenuation slope of the LPF decreases the cutoff frequency, so more noise can be removed. After the noise is removed using the LPF, the DC signal can be amplified without being saturated by the noise. In short, the original signal can be measured even though the noise is greater than the signal. DC gain after the PSD are determined by the sensitivity (full-scale of signal voltage) and dynamic reserve (DR) setting.
(DR value = Allowable maximum noise level / Voltage sensitivity)

A lock-in amplifier needs a reference signal as reference of frequency and phase. The PSD is a multiplier of a measured signal and reference signal (both are sine waves and the same frequency). The PSD output is dependent on the amplitude of the measured value (R) and the phase ($\theta$) difference from the reference signal. The amplitude of the reference signal applied to the PSD is constant, and the phase of it can be shifted.

A dual-phase lock-in amplifier is equipped with the two PSDs, and works as a vector voltmeter that can obtain two orthogonal components X and Y (in other words, R and $\theta$) simultaneously.

The **LI5502** is equipped with two dual-phase PSDs, so two signals can be measured simultaneously using a single reference signal.

The internal oscillator is usually synchronized with an external reference signal by PLL and supplies a reference signal to the PSD. Its frequency can be set numerically and it can supply its harmonic to the PSD as a reference signal.

## 1.3.2  Block diagram

The block diagram of the **LI5501 / LI5502** is presented and its main functions are explained.
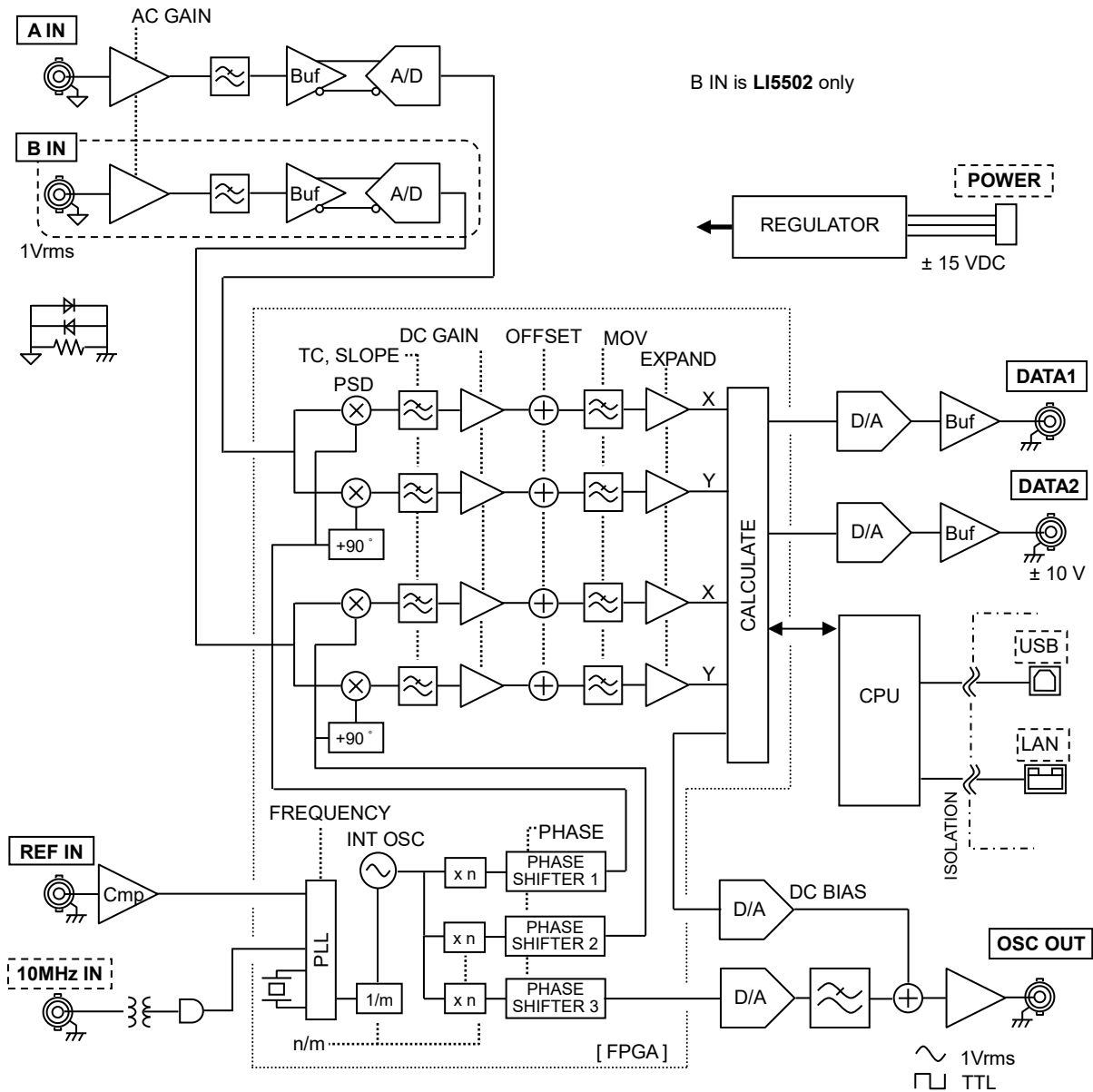


**Figure 1-2  Block diagram of the LI5501 / LI5502**

### a) Signal input section

#### Input connector selection (A IN, B IN*)

Two input signal channels are provided*. Two input signals can be detected to same reference signal.

*LI5502 only

#### Signal amplification (AC GAIN)

A signal with noise is amplified in the frequency band. The dynamic reserve affects AC GAIN and DC GAIN.

This instrument can be used in combination with our low-noise amplifiers, etc.

#### Sampling (A/D)

An input signal is converted to a 16-bit digital signal at a sampling rate of 2.5 M Samples/s.

### b) Detector (DETECTOR CKT)

#### Phase sensitive detection (PSD)

A frequency of signal is converted to a DC voltage using a Phase Sensitive Detector (PSD).

The amplitude and phase of a signal can be obtained by detecting it using two orthogonal phases. Phase sensitive detection is accomplished by multiplexing an input signal and internal reference signal. Since a reference signal applied to the PSD is a sine wave, there is no influence of harmonics of input signal, which becomes a problem when a simple square wave is used as reference signal. A ripple doubling a signal frequency occurs in the product of a measured signal and reference signal, and another ripple that equals to signal frequency occurs in the product of an input DC offset and reference signal, but they are removed by the time constant filter in the next stage. A lock-in amplifier only measures AC signals so it has the advantage that it is not affected by the thermal electromotive force that is a DC signal.

#### Time constant filter (TC, SLOPE)

A time constant filter removes noise and ripples caused by the detection. Normally, the time constant filter consists of a 1st order low pass filter (LPF) and 1 to 4 of it are cascade-connected (equivalent to 6 / 12 / 18 / 24 dB/oct attenuation slope). Increasing the time constant (TC) and attenuation slope (SLOPE) narrows the bandwidth and removes more noise, but slows an output response.

### Amplification (DC GAIN)

It is equivalent to sensitivity of this instrument.

After noise is removed by the time constant filter, a signal can be amplified without being saturated by noise. The phase sensitive detector, time constant filter, and DC signal amplification are performed in digital operations, so there is no limit to dynamic reserve caused by DC drift, which becomes a problem in analog method.

### Moving average filter (MOV)

This filter removes noise by moving average of averaging time. It can be used as a synchronous filter by setting an averaging time to a reference signal period. A ripple of detection output can be significantly reduced, so it is easy to obtain a fast response by setting a small time constant.

### Amplification (EXPAND)

The EXPAND function can amplify an output signal of the moving average filter. This function is equivalent to **EXPAND** function of our conventional lock-in amplifiers.


### c)Calculate section (CALCULATE)

Measured values X and Y of a lock-in amplifier are an RMS value of orthogonal phase components.

By operating X and Y, an RMS value and phase of signal can be obtained.

Amplitude ratio and phase difference between two channels can also be obtained*.

**\*LI5502** only

### d)Reference signal system (REFERENCE CKT)

An internal reference signal that is a sine wave and constant amplitude used by the PSD is supplied by the internal oscillator.

**External reference signal**

In principle, a lock-in amplifier performs measurement using an external reference signal as the reference of the frequency and phase. If the reference signal source is external reference, the internal oscillator generates the sine wave synchronized with the external reference signal using a Phase Locked Loop (PLL).

**Internal oscillator**

If the reference signal source is internal reference, the internal oscillator oscillates a signal at a designated frequency. The internal oscillator uses a direct digital synthesis method so the frequency is stabilized immediately. A signal of the internal oscillator is output as a sine wave or TTL-level square wave.

Also, a signal synchronized with external reference signal can be output.

If the amplitude of the internal oscillator is set to zero, interference from reference signal to measured signal can be reduced, which is often a problem in especially at high frequencies.

The internal oscillator has a function to generate a harmonic (harmonic, subharmonic, and fractional harmonic) signal. For example, this function can generate reference signals of two different frequencies, which enables measurement of a fundamental and a harmonic wave.

**External 10 MHz synchronization**

If a reference frequency for frequency synthesis is applied to the 10MHz IN terminal from an external source, the internal oscillator generates the reference signal synchronized with that external 10 MHz frequency. Therefore, measurement can be performed without applying an external reference signal. Not only the reference signal frequency but also the signal sampling rate, output update rate, and rate for recording to the data memory by the internal timer are also synchronized with the external 10MHz frequency.

(Blank)

# 2. Preparation before use

## 2.1　Inspection

■ **Safety check**

Before using the **LI5501 / LI5502**, read the **"Safety Precautions"** section at the beginning of this manual and perform the safety checks described there.

Before connecting the instrument to a power supply, read **"2.3 Grounding and power connections"** and perform all safety checks fully.

■ **Unpacking**

Firstly, check for any damage that may have occurred during transportation.

After unpacking, make sure that the contents listed in "**Table 2-1 Packing list"** are supplied.

**Table 2-1  Packing list**

> Main unit (including the metal fittings) ⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯⋯ 1

⚠ **WARNING**

Precision electronic components are mounted in this instrument. Do not remove the cover.

The interior of this instrument should not be inspected by anyone other than service technicians who are trained to avoid hazards.

■ **Related documents**

The following documents are available on our web site (http://www.nfcorp.co.jp/index.html).

● **LI5501 / LI5502 Instruction manual**

This instruction manual

● **Sample programs**

Programs written in LabVIEW that can control the **LI5501 / LI5502**

## 2.2 Installation

### 2.2.1 General cautions

⚠ **CAUTION**

Attention should be given to the following item to reduce the possibility of damage to the **LI5501 / LI5502**.

- Because the instrument is small and lightweight, if it is moved while connected to other devices by cables, it may fall.
  It must be placed on a flat and wide table or the like, being careful of the connections.

### 2.2.2 Installation environment

- Place the instrument in a location that satisfies the following conditions.

  Operation:          0 to +50 °C, 5 to 85 %RH

                          (absolute humidity is 1 to 25g/m³, non-condensing)

                          Altitude of 2000 m or less

  Storage:            −10 to +60 °C, 5 to 95 %RH

                          (absolute humidity is 1 to 29g/m³, non-condensing)

                          Altitude of 2000 m or less

- Avoid using the instrument in environments where there is strong radio-frequency electromagnetic radiation. Using the instrument in such environments may result in temporary fluctuations in measured values.

⚠ **CAUTION**

Avoid installation in the following locations.

- Where there is flammable gases
  There is a risk of explosioin. Never install or use it in such a location.
- Outdoors, where exposed to direct sunlight, or near fire or a heat source
  The performance may not be satisfied, or a failure may occur.
- Where there are corrosive gases and vapor, a lot of dust and particles, salty air and oily smoke, and metal powder, etc.
  Corrosion, a malfunction or failure may occur.
- Where there is a lot of vibration
  A malfunction or failiure may occur.
- Near an electromagnetic field source, high-voltage equipment, power line, or pulse noise source
  A malfunction may occur.

Signal cables should be placed away from power cords of this instrument or other equipment that may produce inductive noise. Failure to do so may result in instrument malfunction or a measurement error.

Warm up the instrument for at least 20 minutes before use for accurate measurement.

## 2.2.3　Mounting

Removable metal fittings are provided for this instrument.

When the fittings are removed, rubber feet on the bottom are available.

When installing this instrument in your equipment, it is recommended to screw the fittings to it.

For instrument dimensions → Refer to **"9.7 External dimensions"**



---
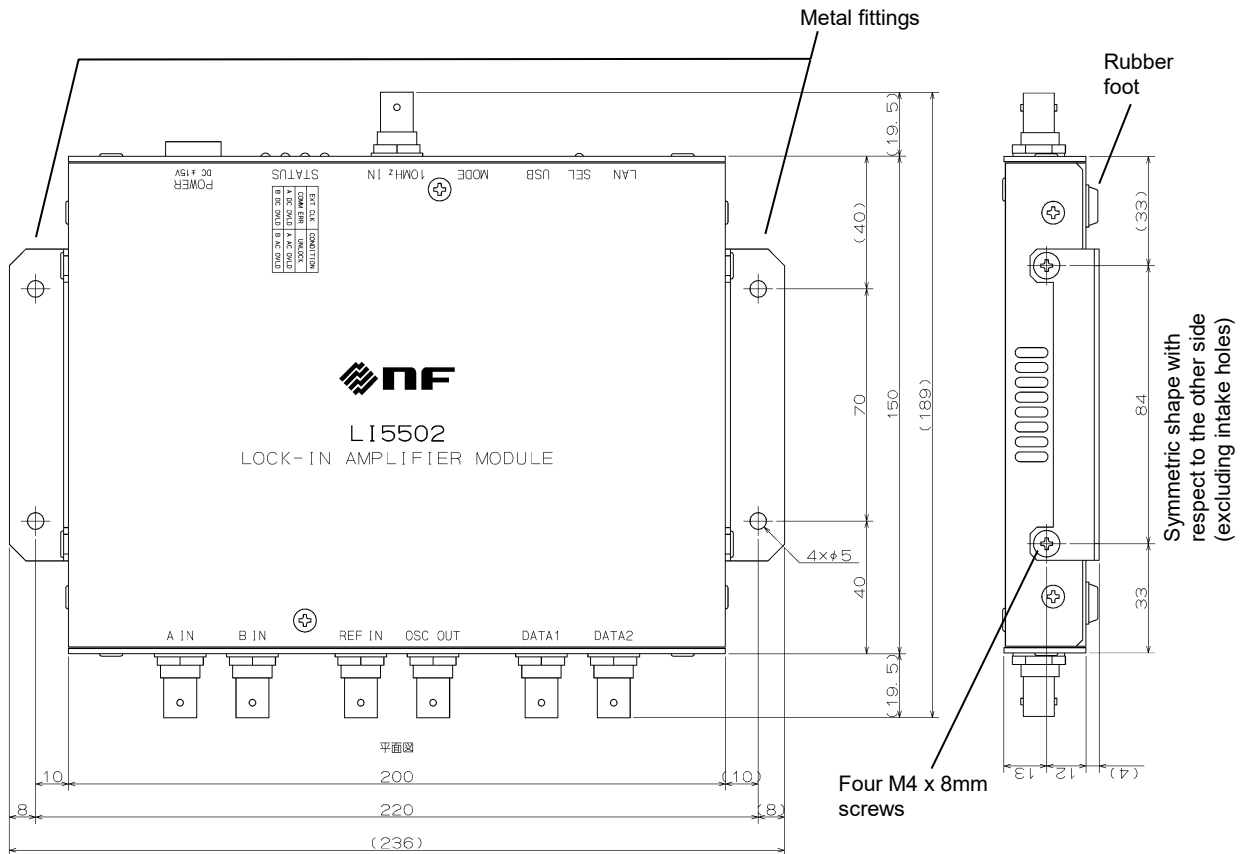
## ⚠ CAUTION

- Use 8 mm long screws to attach the metal fittings to the instrument.
  The internal structure may be damaged if screws longer than 8 mm are used.
- The equipment to be installed in this instrument should have sufficient ventilation holes or be air-cooled with cooling fans.
  If the ambient temperature exceeds the specification or the intake and exhaust holes are blocked when the equipped FAN is used, the performance of the instrument may decrease or it may be damaged.

## 2.3 Grounding and power connections

### ■ Grounding

**⚠ WARNING**

The USB and LAN connector shells are connected to the instrument enclosure. Applying a voltage of 42 Vpk (DC + ACpeak) or more to the terminals may damage the instrument.

When using the instrument, ground a power supply and take your own precautions against electric shock.

### ■ Power supply specifications

Power supply voltage range: ± 14 to 16 VDC

Current consumption: +400 mA / −110 mA (**LI5501**)

+480 mA / −120 mA (**LI5502**)

initial settings, no input siganls, and no loads

It is recommended to use a power supply with about twice the current capacity considering at power-on and overload conditions.

Power connector: Equivalent to DELC-J9PAF-20L9 (JAE)

Pin assignment: See below.
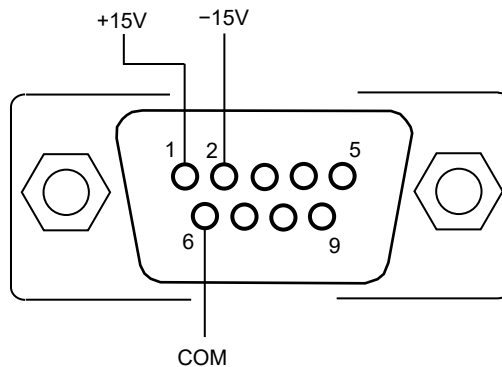


**⚠ CAUTION**

- Connect to a power supply paying attention to the voltage range and polarity of it.
- The positive and negative power supplies must start up at approximately the same time. It is recommended to use a dual tracking power supply.
- The instrument does not work with a single power supply (+30 V / GND). Be sure to use a dual power supply (+15 V / GND / −15 V).
- Do not supply power to any pins other than the power supply pins.

■ **Recommended power supply**

Fluctuations in power supply voltage may affect measured values.

For accurate measurement of minute signals, use a DC power supply with excellent stability and noise performance.

The recommended DC power supplies are shown below.

・NND30-1515 (TDK Lambda)

・TC-15 (Japan Stabilizer Industry)

## 2.4　Firmware update

How to check the firmware version → Refer to **"8.4 Checking the version number"**.

For the latest firmware version and firmware update procedure, please contact the NF Corporation or its authorized agent or visit our web site (http://www.nfcorp.co.jp/index.html).

Please check the contents of the update and if necessary, update the firmware version.

## 2.5　Calibration

This instrument is designed to be installed in equipment. It is recmmended to calibrate the instrument while it is installed in the equipment.

However, perform the unit test described in "**8.6 Calibration**" at least once a year although the appropriate calibration interval depends on how often the instrument is used and the conditions under which it is used.

Also, when the instrument is used for important measurement or tests, it is recommended that the same performance test be performed immediately before the measurement or tests.

If the instrument fails to satisfy the specifications in the performance test, the NF Corporation will make adjustments or calibrate the instrument to restore performance.

If an adjustment or calibration is required, please contact the NF Corporation or its authorized agent. This adjustment and calibration is available for a fee.

(Blank)

# 3. Names of each part

# 3.1 Names and functions of each part

This section describes the names and functions of each part of the **LI5502**.

## 3.1.1 Top side

**10MHz Input Connector**
To synchronize the frequency of the internal oscillator with other instruments, give them the same 10 MHz reference signal.

**USB Connector**
For remote control

**LAN Connector**
For remote control

**Power supply connector**
Connector for power supply
± 15 VDC

**Signal Input Connectors**
A IN and B IN
(B IN is only **LI5502.**)
DC to 1.05 MHz
Zin: 1 MΩ

**Reference signal system**
REF IN      External reference signal input connector
 DC (9.5 mHz) to 1.05 MHz
 Sine wave 0.4 to 6 Vp-p or TTL
OSC OUT   Internal oscillator output connector
 9.5 mHz to 1.05 MHz
 Sine wave 0 to 1 Vrms or TTL

**Data output connectors**
DATA1 and DATA2
 Voltage output corresponding to the measured value

**Figure 3-1  Top side**

## 3.1.2  Rear side



**SEL Switch**
Select USB or LAN interface for remote control.

**MODE Switch**
Settings can be saved.

**STATUS**
LEDs indicate status of the instrument

UNLOCK ———— A AC OVLD
CONDITION ———— B AC OVLD

EXT CLK ———— B DC OVLD
COMM ERR ———— A DC OVLD
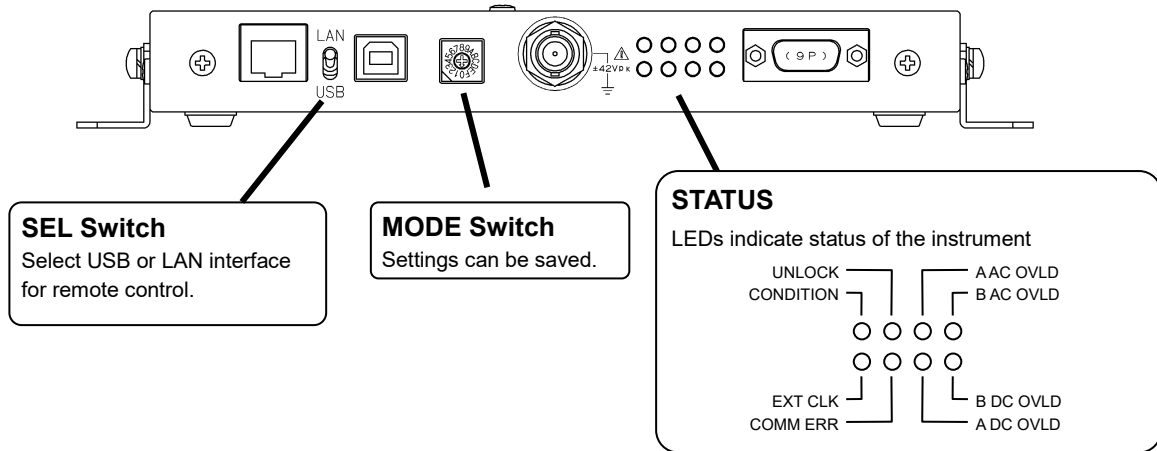
**Figure 3-2  Rear side**

■ **Status indication**

The table below describes the contents of the status LEDs.

| Status LED | Color | Description |
|---|---|---|
| CONDITION | Green | Lights up when normal operation<br>Blinks when the calibration information is lost and the specifications cannot be maintained due to some trouble<br>When it blinks, please contact the NF Corporation or its authorized agent as it is malfunction. |
| EXT-CLK | Green | The followings applies only when the external 10 MHz synchronization is enabled.<br>Lights up when synchronized with an external reference signal<br>Blinks when not synchronized with an external reference signal |
| UNLOCK | Orange | Out of synchronization<br>There are possibilities that a reference signal is not input, the reference signal settings are not appropriate, the signal level is low, or the frequency of it is out of range. |
| COMM ERR | Orange | A communication error<br>Overflowed the FIFO buffer when transmitting data |
| A AC OVLD | Orange | Saturates a signal on A IN side before the PSD<br>Confirm the input signal amplitude. |
| A DC OVLD | Orange | Saturates a signal on A IN side after the PSD<br>Adjusts the time constant filter settings and voltage sensitivity. |
| B AC OVLD (only **LI5502**) | Orange | Saturates a signal on B IN side before the PSD<br>Confirms the input signal amplitude. |
| B DC OVLD (only **LI5502**) | Orange | Saturates a signal on B IN side after the PSD<br>Adjusts the time constant filter settings and voltage sensitivity. |

## 3.2   I/O connectors

⚠ **WARNING**

> To avoid an electric shock, ensure that a voltage exceeding 42 Vpk (DC + AC peak) must not be applied between the outer or inner conductor of the BNC connectors and the enclosure.
> Similarly, a voltage exceeding 42 Vpk (DC + AC peak) must not be applied between the 10 MHz input connector and other BNC connectors.
> If doing so, the internal voltage limiters will become active and try to limit that voltage. However, if that voltage is too large, there is a risk of electrical shock.

⚠ **CAUTION**

> Do not apply a voltage exceeding the maximum input range to the input connectors. Doing so may damage the instrument.

⚠ **CAUTION**

> Do not apply a voltage to the output connectors. Doing so may damage the instrument.

### 3.2.1 Signal input connectors

#### 1) Signal input (A IN and B IN*)

The signal input connectors **A IN** and **B IN*** are described below.

**\*LI5502** only

- Input impedance                1 MΩ (nominal value)

                                        20 pF in parallel (supplementary value)
- Maximum input voltage (linear operating range)

                                        ± 5 V
- Non-destructive maximum input voltage

                                        ± 10 V
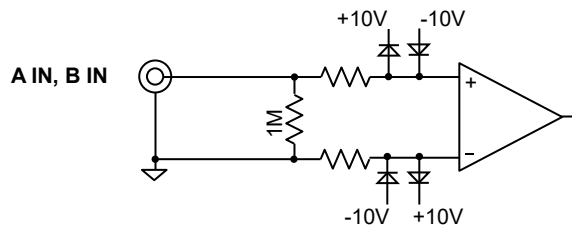


#### 2) Signal ground

The resistor is inserted between the signal ground and the internal ground (reference signal input ground, etc.).

The voltage between them is limited to ±1 V.

- Floating voltage (allowable voltage to enclosure)

                        ± 1 Vpk (DC＋AC)
- Impedance between signal ground and enclosure

                        22 Ω (nominal value)



---
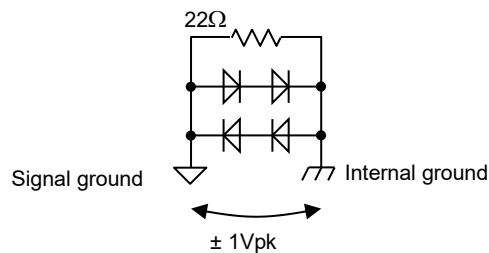
⚠ **CAUTION**

---

If a voltage exceeding 1.0 V is applied between the signal ground and the internal ground, a large current will flow and damage an internal circuit.

---

### 3.2.2 Reference signal I/O connectors

#### 1) Reference signal input (REF IN)

The reference signal input connectors **REF IN** are described below.

- Input impedance      1 MΩ (nominal value)

  20 pF in parallel (supplementary value)
- Input voltage range      SINE    0.4 V to 6 Vp-p

  TTL      0 to 5 V (low level 0.8 V or less,

  high level 2.6 V or more)
- Non-destructive maximum input voltage

  ± 10 V
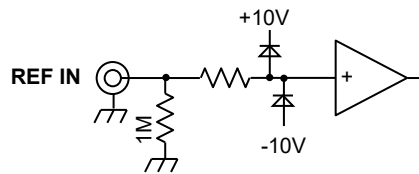


#### 2) Oscillator output (OSC OUT)

A sine wave or a TTL-level square wave synchronized with the internal oscillator is output from the **OSC OUT** connector.

When the reference signal source is external, the output signal is synchronized with the external reference signal.

- Output voltage range      SINE    1 Vrms ± 5 VDC

  TTL      0 to 3 V (nominal value)
- Maximum output current

  ± 15 mA
- Output impedance      53 Ω (nominal value)



---
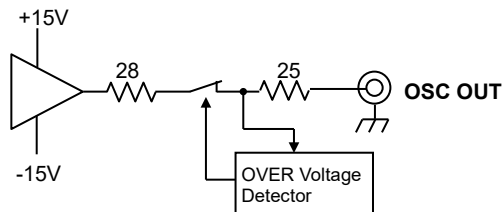
### ⚠ CAUTION

Do not apply a voltage exceeding the maximum input voltage range to REF IN.

There is a limit of output current at the OSC OUT terminal.

If an exceeding voltage is applied to the OSC OUT terminal, an overvoltage will be detected and an internal circuit will be disconnected.

After the overvoltage is removed, the disconnection will be restored automatically.

The non-destructive maximum input voltage of the OSC OUT terminal is ± 15 V (noiminal value).

---

### 3.2.3  Analog data output connectors

#### 1)Measured value output (DATA1 and DATA2)

The voltage proportional to the measured value such as R, X, and Y is output.

- Output voltage range　　± 12 V (no load)
- Maximum output current

    ± 10 mA
- Output impedance　　　440 Ω (nominal value)
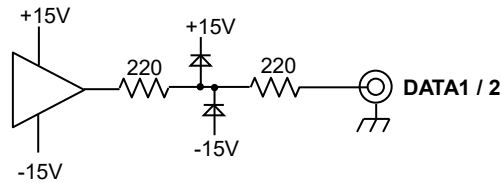


### 3.2.4  The other input connector

#### 1)External 10MHz synchronization (10MHz IN)

- Input impedance　　　Approximately 500 Ω, AC-coupling
- Signal level　　　　　0.5 to 5 Vp-p
- Non-destructive maximum input voltage

    10 Vp-p
- Withstand voltage (allowable voltage to enclosure)

    ± 42 Vpk (DC + ACpeak)
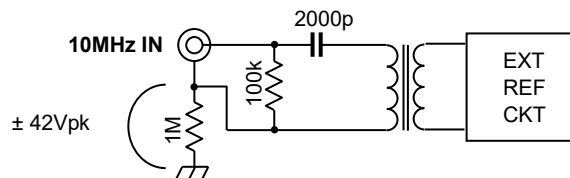
### 3.2.5  Power supply connector

#### 1) Power supply input (POWER)

The power supply connector is equivalent to DELC-J9PAF-20L9 (JAE).

It is recommended to use a power supply with about twice the current capacity considering at power-on and overload conditions.

- Voltage range        ± 14 to 16 VDC
- Current consumption   Approximately +400 mA / −110 mA (**LI5501**)

   Approximately +480 mA / −120 mA (**LI5502**)

   initial settings, no input signals, and no loads
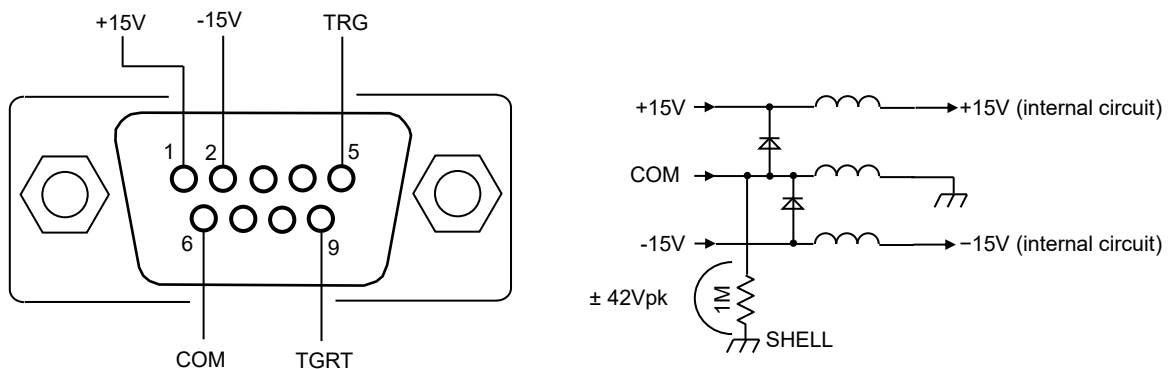


#### 2) External trigger input

This input is to start recording measurement data to the internal data buffer.

- Input impedance        10 kΩ (nominal value)
- Signal level           TTL (low level 0.8 V or less, high level 2.6 V or more)
- Non-destructive maximum input voltage

   ± 15 V



---
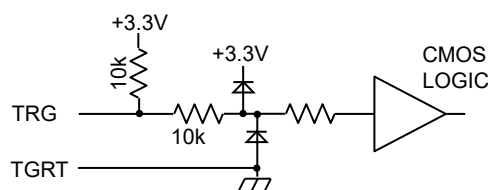
⚠ **CAUTION**

---

Applying a voltage exceeding the specified voltage range, incorrect polarity of the power supply, or wrong connection to terminals may result in failure.

---

## 3.3 Power-on

### 3.3.1 Confirmation before power-on

Check the power supply voltage and the pin assignments of the power connector before power-on.

Refer to **"2.3 Grounding and power connections"**.

### 3.3.2 Power-on

The **LI5501 / LI5502** have no power switch.

Supply power to the instrument from an external power supply.

A typical connection diagram is shown below.

When the power is turned on, the settings of the configuration memory number corresponding to the MODE switch number are recalled.

**For details → Refer to "6.2 Configuration memory".**
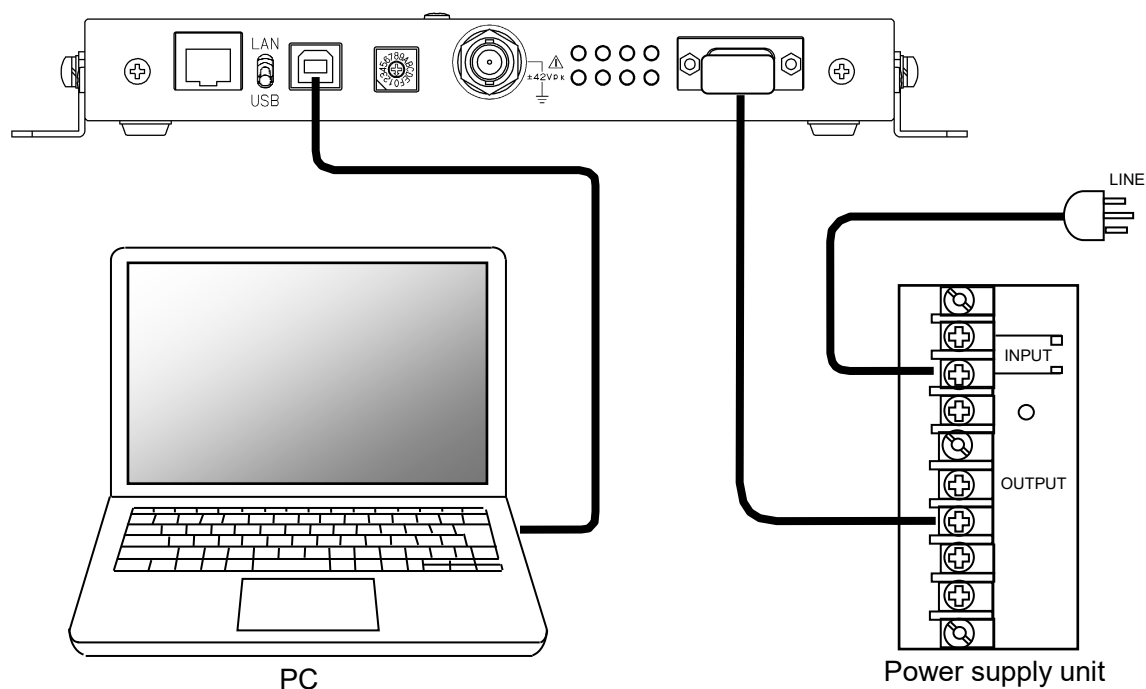


**Typical connection diagram**

(Blank)

# 4. Basic settings

# 4.1 Setting items

This section describes setting items of the **LI5501 / LI5502**.

## 4.1.1 Reference signal settings

A reference signal serves as frequency and phase reference.

This section describes how to select reference signal settings.

### 1) Reference signal source

Select a reference signal source from below to synchronize with the instrument.

- ● Reference signal source: RINP (External reference signal)

  Input a reference signal to the REF IN terminal.

  IOSC (Internal oscillator)

  The internal oscillator generates a designated frequency.

### 2) Waveform of external reference signal

When using an external reference signal, select a edge from below according to the input waveform.

- ● Edge: SIN (sine wave, 0.4 to 6 Vp-p,

  point where signal crosses 0 V from below to above)

  TPOS (square wave, rising edge of TTL-level)

  TNEG (square wave, falling edge of TTL-level)

REF IN waveform        SINE            TTL POS          TTL NEG

0V          0°          Vth / 0 V          Vth / 0 V          High level: 2.6V or more
                        0°                 0°                 Low level: 0.8V or less
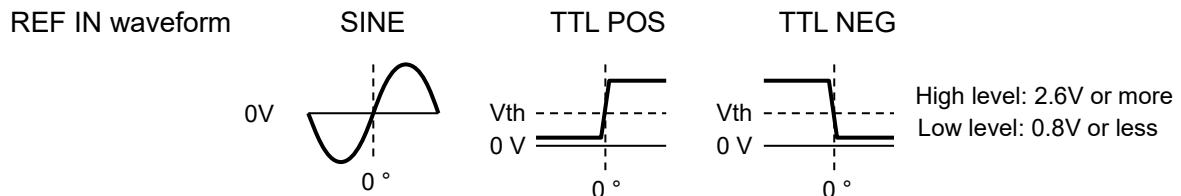
### ■ UNLOCK state

When the reference signal source is set for the external reference signal (RINP) and the reference signal is not synchronized with the instrument, the LED on the rear panel will light up and a flag is set in the status register.

In the UNLOCK state, a measured frequency and values do not correspond to those of the actual signal and fluctuate.

When the instrument cannot synchronize with a reference signal, the frequency, amplitude, or waveform of the signal may be different from the reference signal settings. Also, if a reference signal contains a lot of noise or frequency/amplitude variations, the instrument may be the UNLOCK state.

### 3) Internal oscillator

The internal oscillator frequency can be set.

This is available when the reference signal source is IOSC (internal oscillator).

- Frequency: 9.5 mHz to 1.05 MHz, 0.1 mHz resolution

### 4) 10MHz IN

The frequency reference source of the instrument can be synchronized with other instruments (such as function generators) that operate with a 10 MHz frequency reference source.

However, since the phase do not match, the phase adjustment is required every time the internal oscillator frequency is changed. Generally, once a signal (oscillation) stops, the phase is shifted, so the phase adjustment is required again.
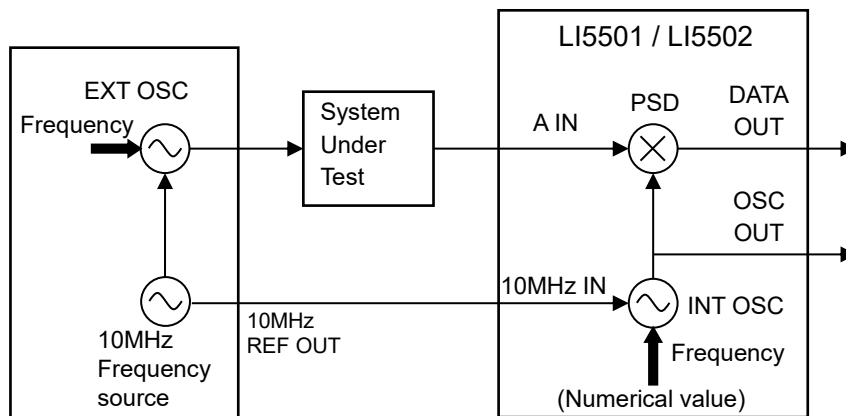


As a result, by matching the frequency setting of other devices with the internal oscillator frequency of the instrument, it can be synchronized with other devices even without inputting a reference signal to the REF IN terminal.

- 10MHz IN: ON (enabled), OFF (disabled)

### ■ EXT CLK LED

The table below shows the status of the LED corresponding to the 10 MHz IN setting and a signal to 10 MHz IN terminal.

| 10MHz IN setting | Signal to 10MHz IN terminal | LED (EXT CLK) |
|---|---|---|
| ON | 10MHz signal | ON |
| ON | Signal other than 10MHz or no signal | Blinking |
| OFF | —— | OFF |

■ **φSYNC function**

When the instrument is connected to the 10 MHz REF OUT terminal of our function generators (**WF1973 / 74, WF1947 / 48, WF1967 / 68**), the reference phase of the internal oscillator can be initialized by the φSYNC function of the function generators. For detials, refer to the instruction manual of the function generators.

## 4.1.2  Phase shift and harmonics measurement

The phase can be shifted with respect to the reference signal.
A fundamental wave (F), harmonic (n × F), subharmonic (F / m), and fractional harmonic (n × F / m) can be measured with a reference signal frequency "F" as the reference.

### 1) Phase shift

The phase shift amounts of A/B IN can be set with respect to the reference signal.
- Phase shift amount:     −180.000° to +179.999°, 1m° resolution

Basic usage of a lock-in amplifier is to adjust the phase of the reference signal to be applied to the PSD so that Y output is equal to zero ($\theta = 0$), and then measure the amplitude of the signal at the X output and the phase shift of the signal at the Y output.
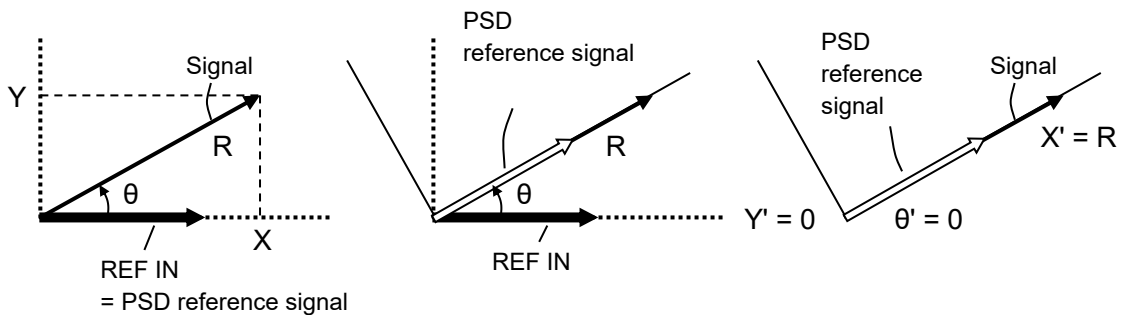


Phase shift amount = 0          ⟹          Phase shift amount = −θ
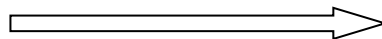
■ **Automatic phase shift adjustment**

By executing this adjustment, the reference signal phase shift amount is set so that the Y and θ outputs are equal to zero. However, it cannot be executed during the UNLOCK state.

## 2) Harmonic

The reference signal frequencies of A IN and B IN can be multiplied by "n".

● Harmonic:                1 to 63 or 0 (integer)

Set "n" to 1 when measuring a fundamental wave. When measuring a fractional harmonic, the "n" is the numerator.

When the "n" is set to zero, the input signal passes through the PSD.

## 3) Subharmonic

When the reference signal source is the external reference signal (RINP), the external reference signal can be divided by "m".

● Subharmonic:            1 to 64 (integer)

When measuring a fractional harmonic, the "m" is the denominator. This "m" is common to each PSD and the oscillator output.

The response to the frequency query command (:FREQ?) is the frequency input to the REF IN terminal diveded by the "m".

## 4) Multiplication and phase shift of oscillator output

The output frequency of the OSC OUT terminal can be multiplied by that of the reference signal source. The phase can also be shifted with respect to the reference signal source.

● Multiplication:          1 to 63 (integer)
● Phase:                    −180.000° to +179.999°, 1m° resolution

## ■ Note

The frequency range of harmonic, subharmonic, fractional harmonic, and multiplier oscillation output need to be within the synchronizable frequency range.

### 4.1.3  Oscillator output

The frequency synchronized with the reference signal can be output to the OSC OUT terminal.

**1) Oscillator output state**

When the oscillator output is turned on, the AC voltage is output from the OSC OUT terminal.

When the oscillator output is turned off, the D/A converter for the oscillator output is stopped and the output amplitude is set to zero.

However, DC offset is always output.

- Output state:                ON (enabled), OFF (disabled)

■ **Crosstalk reduction**

Crosstalk from the reference signal to the measured signal can be reduced by disabling the oscillator output.

**2) Output waveform selection**

The output waveform can be selected from a sine wave or TTL-level square wave.

- Output wave form:        SIN (sine wave), TTL

**3) Output amplitude and DC offset**

The output amplitude and DC offset can be set only when the output waveform is SIN (sine wave).

- Amplitude:                0 to 1 Vrms, 1 mVrms resolution
- DC offset:                0 to ± 5 V, 5 mV resolution
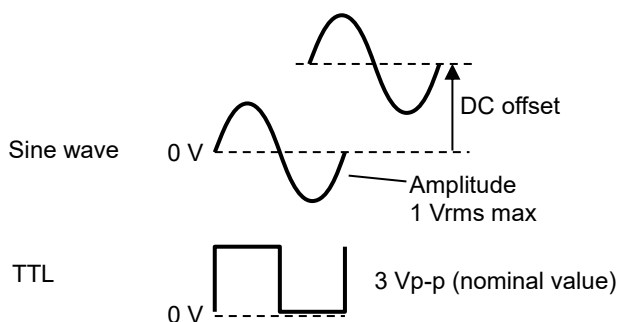
## 4.1.4  Analog data outputs

Parameters shown in the table below can be obtained.

| Parameter | Description |
|-----------|-------------|
| X | In-phase component (= R cos θ) |
| Y | Quadrature component (= R sin θ) |
| R | Signal amplitude (= $\sqrt{X^2 + Y^2}$ ) |
| θ | Signal phase (= $\tan^{-1} Y / X$ ) |
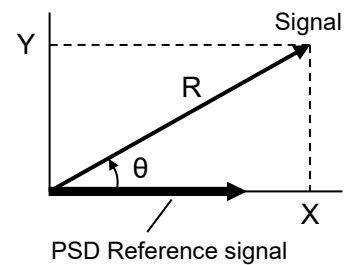
The voltage corresponding to the measured value of designated parameter can be output to the DATA1 or DATA2 terminal.

- DATA1:                      See the below table.
- DATA2:                      See the below table.

| Parameter | Description |
|-----------|-------------|
| $X_A$ | X value on A IN side (Rcosθ) |
| $Y_A$ | Y value on A IN side (Rsinθ) |
| $R_A$ | R value on A IN side (RMS amplitude) |
| $θ_A$ | θ value on A IN side (phase value) |
| $X_B$ | X value on B IN side (Rcosθ) |
| $Y_B$ | Y value on B IN side (Rsinθ) |
| $R_B$ | R value on B IN side (RMS amplitude) |
| $θ_B$ | θ value on B IN side (phase value) |
| RATIO | Amplitude ratio ($R_A / R_B$) |
| PHASE | Phase difference ($θ_A − θ_B$) |

Parameters related to B IN are available only for the **LI5502**.

### ■ Disabling analog data outputs

The DATA1 and DATA2 output terminals can be disabled. Doing so stops the clock signal to the D/A converter, which reduces noise and is resistant to interference when measuring minute signals.

### 4.1.5  Sensitivity and dynamic reserve

The dynamic reserve value depends on saturation signal level inside the instrument at a specific sensitivity (full scale of signal) and noise rejection characteristics of the time constant filter. In other words, it depends on frequency.
Set the value to the minimum. The higher the DR setting (lower AC GAIN) is set, the larger the input-referred noise and the drift of measured value will be.
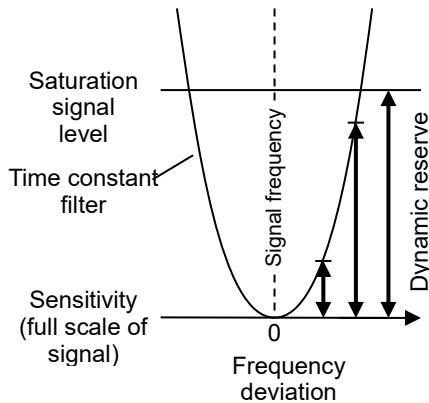
■ **Dynamic reserve for random noise**

Random noise (wideband noise) is acceptable until its peak value reaches the saturation signal level inside the instrument. Even if the RMS values of sine wave and random noise are equal, the peak value of noise is several times larger than that of sine wave. Set the dynamic reserve considering that peak value.

#### 1) Dynamic reserve setting

The DR setting corresponds to the gain of the analog circuit before the PSD. This setting restricts the range of the voltage sensitivity.

●  DR setting:                LOW1, LOW2, MED, HIGH

#### 2) Voltage sensitivity

The voltage sensitivity is the DC gain after the time constant filter.

●  Voltage sensitivity:       See below (1-2-5 sequence).

| DR | AC GAIN | Range | |
|----|---------|-------|--|
| LOW1 | 100x | 10 nVrms  to | 10 mVrms |
| LOW2 | 10x | 100 nVrms  to | 100 mVrms |
| MED | 1x | 1 µVrms  to | 1 Vrms |
| HIGH | 0.2x | 5 µVrms  to | 1 Vrms |

■ **Note**

If the DR setting is changed and the voltage sensitivity is out of range, the sensitivity may be changed corresponding to the DR setting after the change.

■ **Dynamic reserve**

The actual dynamic reserve value depends on dynamic reserve setting, voltage
sensitivity, frequency difference between signal and noise, and settings of the time
constant filter.

The values in the table below are nominal values when noise is sufficiently removed by
the time constant filter.

Setting a dynamic reserve greater than 100 dB requires a large time constant setting
and may result in large error in measured value.

| DR setting | LOW1 | | LOW2 | | MED | | HIGH | |
|---|---|---|---|---|---|---|---|---|
| Voltage sensitivity (A/B IN) | AC gain dB | DR dB | AC gain dB | DR dB | AC gain dB | DR dB | AC gain dB | DR dB |
| 1 V | —— | —— | —— | —— | 0 | 6 | −14 | 20 |
| 500 mV | —— | —— | —— | —— | 0 | 12 | −14 | 26 |
| 200 mV | —— | —— | —— | —— | 0 | 20 | −14 | 32 |
| 100 mV | —— | —— | 20 | 6 | 0 | 26 | −14 | 40 |
| 50 mV | —— | —— | 20 | 12 | 0 | 32 | −14 | 46 |
| 20 mV | —— | —— | 20 | 20 | 0 | 40 | −14 | 52 |
| 10 mV | 40 | 6 | 20 | 26 | 0 | 46 | −14 | 60 |
| 5 mV | 40 | 12 | 20 | 32 | 0 | 52 | −14 | 66 |
| 2 mV | 40 | 20 | 20 | 40 | 0 | 60 | −14 | 72 |
| 1 mV | 40 | 26 | 20 | 46 | 0 | 66 | −14 | 80 |
| 500 μV | 40 | 32 | 20 | 52 | 0 | 72 | −14 | 86 |
| 200 μV | 40 | 40 | 20 | 60 | 0 | 80 | −14 | 92 |
| 100 μV | 40 | 46 | 20 | 66 | 0 | 86 | −14 | 100 |
| 50 μV | 40 | 52 | 20 | 72 | 0 | 92 | −14 | 106 |
| 20 μV | 40 | 60 | 20 | 80 | 0 | 100 | −14 | 112 |
| 10 μV | 40 | 66 | 20 | 86 | 0 | 106 | −14 | 120 |
| 5 μV | 40 | 72 | 20 | 92 | 0 | 112 | −14 | 126 |
| 2 μV | 40 | 80 | 20 | 100 | 0 | 120 | —— | —— |
| 1 μV | 40 | 86 | 20 | 106 | 0 | 126 | —— | —— |
| 500 nV | 40 | 92 | 20 | 112 | —— | —— | —— | —— |
| 200 nV | 40 | 100 | 20 | 120 | —— | —— | —— | —— |
| 100 nV | 40 | 106 | 20 | 126 | —— | —— | —— | —— |
| 50 nV | 40 | 112 | —— | —— | —— | —— | —— | —— |
| 20 nV | 40 | 120 | —— | —— | —— | —— | —— | —— |
| 10 nV | 40 | 126 | —— | —— | —— | —— | —— | —— |

## 4.1.6  Filters

This section describes the time constant filter, DC offset, moving average filter, and EXPAND function.

### 1) Time constant filter

The time constant of the time constant filter can be set.

- Time constant:　　　　　1 µs to 1 ks, 1-2-5 sequence

### 2) Attenuation slope

The attenuation slope of the time constant filter can be set.

- Attenuation slope:　　　6 / 12 / 18 / 24 dB/oct

### ■ Time constant filter

The characteristics of the time constant filter (TC) are those of cascade-connected first-order lowpass filter (cutoff frequency: fc). The attenuation slope per stage is 6 dB/oct (20 dB/dec). This means that in the transition band, doubling the frequency results in half attenuation (a ten-fold increase in frequency results in one-tenth attenuation).

By cascade-connecting 1 to 4 stages of this filter, the attenuation slope of 6 to 24 dB/oct (20 to 80 dB/dec) can be obtained.
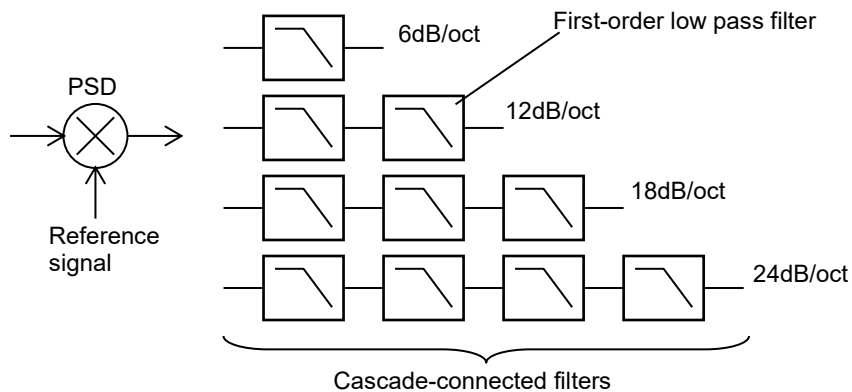
### a) Frequency response

Normalized frequency =

|Frequency difference from reference signal| / cutoff frequency (fc)

fc = 1 / (2πT)

Here, T indicates a time constant.



F: Signal frequency
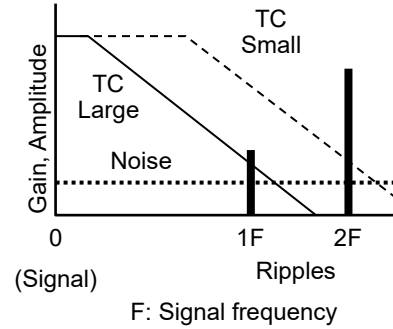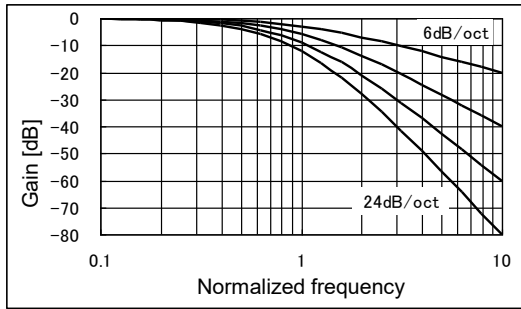
### b) Equivalent noise bandwidth $B_N$
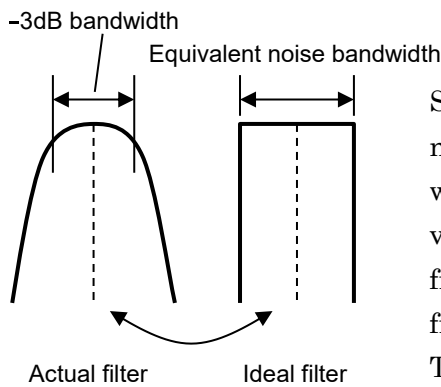


Sensitivity to white noise is represented by equivalent noise bandwidth. The bandwidth of an ideal filter where sensitivity to noise (in other words, an RMS value of output noise) is equal to that of an actual filter is called the equivalent noise bandwidth of that filter.

The equivalent noise bandwidth of this instrument $B_N$ is twice that of a low pass filter determined by the time constant T and attenuation slope. $B_N$ is represented by the following expression.

$$B_{N6} = \frac{1}{2T}, \quad B_{N12} = \frac{1}{4T}, \quad B_{N18} = \frac{3}{16T}, \quad B_{N24} = \frac{5}{32T}$$

corresponding to 6, 12, 18, and 24 dB/oct respectively

The RMS noise value Vm included in the output (measured value) can be obtained using the following expression.

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

Here, Vn indicates the noise density of the input and $B_N$ indicates the equivalent noise bandwidth.

### c) –3dB bandwidth $B_{3dB}$

$$B_{3dB} = \sqrt{\sqrt[m]{2} - 1} \Big/ (\pi T)$$

Here, T indicates the time constant, and m is equal to 1, 2, 3, or 4 (corresponding to 6, 12, 18, or 24 dB/oct respectively).

### d) Step response time

A response y(t) to applying a step signal to low pass filter after phase sensitive detection is represented by the following expression.

$$y(0) = 0, \;\; y(t) = 1 - \left\{ \sum_{n=1}^{m} \frac{t^{n-1}}{T^{n-1}(n-1)!} \right\} e^{-\frac{t}{T}} \quad \text{However, t is greater than 0.}$$

Here, T indicates the time constant, and m is equal to 1, 2, 3, or 4 (corresponding to 6, 12, 18, or 24 dB/oct respectively).

Step response time

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

Step response waveform
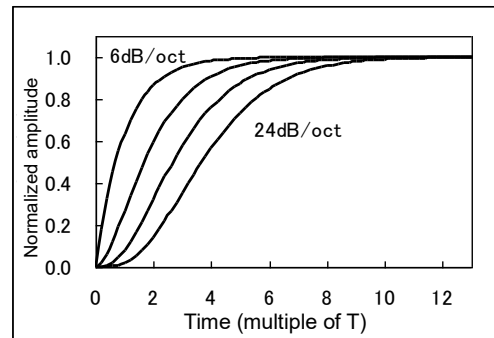


This is the case of analog filter. Since the instrument realizes this filter by digital processing, the filter characteristics when the time constant is small differ slightly from the above.

### 3) Offset function

An offset can be set in the X-axis and Y-axis for signal amplified by the voltage sensitivity (DC GAIN).

By moving a measured value near zero using the offset function, changes in the value can be magnified and small changes of it can be read.

- X-axis offset:         ± 120 % (relative to full scale)
- Y-axis offset:         ± 120 % (relative to full scale)
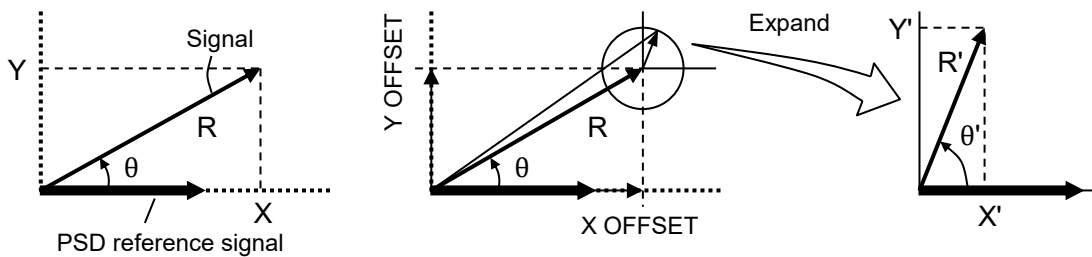
### 4) Moving average filter

The averaging time of the moving average filter can be set.

- Averaging time:        1 µs to 100 s, 1-2-5 sequence
  AUTO (Inverse of reference signal frequency is set.)
  OFF (Disabled)

When the time constant is reduced in the TC filter, integer multiple ripples of the reference signal frequency are difficult to attenuate. In this case, the output response will slow at low frequency because the time constant must be large even if noise is small. In such case, if the moving average filter is enabled, the ripple generated at integer multiples of the reference signal frequency can be attenuated.

The moving average filter is connected after the TC filter.

Frequency response of moving average filter
(Averaging interval equals to 1 cycle)
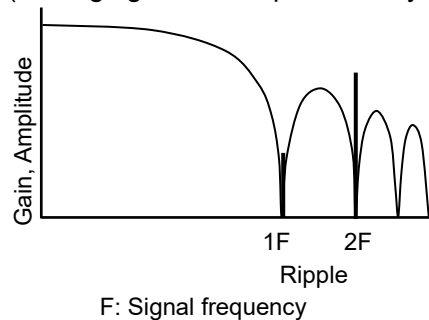
Diagram of filters
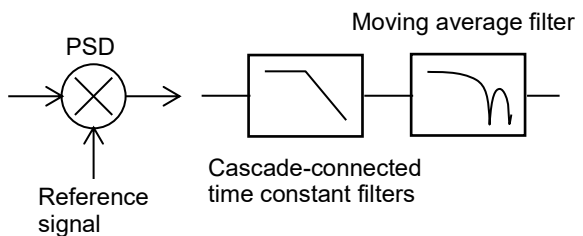
### 5) EXPAND function

The EXPAND value can be set to expand a signal after the MOV filter.

X, Y, and R values are commonly expanded. θ value is not affected.

- EXPAND:                    1 to 1000 [times], 1-2-5 sequence recommended

## 4.1.7  PSD input offset adjustment

The instrument has a function to cancel a DC offset of the PSD input.

If a DC component is included in the PSD input, a 1F ripple that is equal to the measurement frequency F occurs in the PSD output. A large time constant is required to remove the 1F ripple and an output response slows.

If a fast response is needed at high frequencies, it is recommended to perform the PSD input offset adjustment.

At low frequencies, it is effective to use the MOV filter simultaneously.
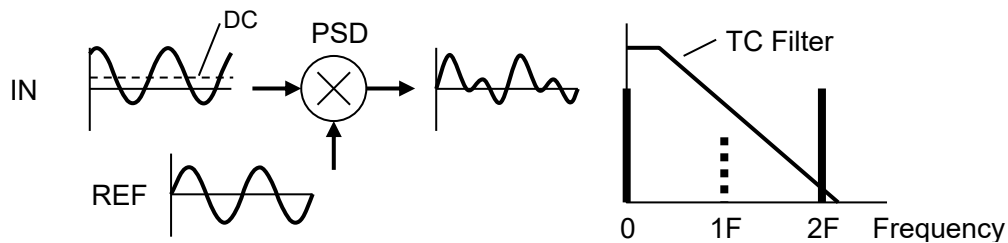


Before the adjustment, short-circuit input terminals (A/B IN).

Execute the PSD input offset adjustment command to start the adjustment.

The adjustment takes about 10 seconds. After adjustment, release short-circuit on the input terminals.

Executing the command to initialize the PSD input offset will return it to the factory default settings.

### ■ Preparation

The following preparation is needed to execute the PSD input offset adjustment.

- Set the actual operating conditions. When measurement parameters such as the dynamic reserve are changed after this adjustment, a re-adjustment is required.
- Set input signals to zero.
- Warm up the instrument sufficiently so that a temperature drift after the adjustment can be reduced.
- Keep the power supply voltage and ambient temperature as constant as possible.

## 4.2   Initial settings

The **LI5501 / LI5502** will be initialized at the following conditions below.

- When shipped from a factory and the MODE switch is set to "F"

  All of the settings are the factory default settings.

- When the system initialization is executed

  Settings other than the LAN interface are initialized.

  Use the ":SYSTem:RST" command.

- When the initialization is executed

  Contents of the resume memory are initialized.

  Use the "*RST" command.

- When there is an abnormality in the resume memory

  When the power is on, if there is an abnormality in the resume memory, abnormal parts will be initialized.

The details of the setting items and initial values are shown in **"Table 4-1 Setting items and initial values"**.

**Table 4-1  Setting items and initial values**

| Setting item | Parameter range | Initial value | :SYST:RST | *RST | Configuration memory | Resume |
|---|---|---|---|---|---|---|
| <Reference signal> | | | | | | |
| Reference signal source | REF IN, INT OSC | REF IN | ← | ← | Y | Y |
| Waveform (EDGE) | SIN+, TTL+, TTL- | SIN+ | ← | ← | Y | Y |
| <Internal oscillator> | | | | | | |
| Frequency | 9.5 mHz to 1.05000 MHz | 1.00000 kHz | ← | ← | Y | Y |
| 10MHz IN | OFF, ON | OFF | ← | ← | Y | Y |
| <Harmonics> | | | | | | |
| Common subharmonic | 1 to 64 | 1 | ← | ← | Y | Y |
| A IN harmonic | 1 to 63 | 1 | ← | ← | Y | Y |
| B IN harmonic | 1 to 63 | 1 | ← | ← | Y | Y |
| Oscillator multiplication | 1 to 63 | 1 | ← | ← | Y | Y |
| <Phase adjustment> | | | | | | |
| A IN phase shift | −180.000° to +179.999° | 0° | ← | ← | Y | Y |
| B IN phase shift | −180.000° to +179.999° | 0° | ← | ← | Y | Y |
| Oscillator phase shift | −180° to +179.999° | 0° | ← | ← | Y | Y |
| <Oscillator output> | | | | | | |
| Output state | OFF, ON | OFF | ← | ← | Y | Y |
| Waveform | SINE, TTL | SINE | ← | ← | Y | Y |
| Amplitude | 0.0 to 1.000 Vrms | 0.000 Vrms | ← | ← | Y | Y |
| DC offset | 0 to ± 5.000 V | 0 mV | ← | ← | Y | Y |

## Table 4-1  Setting items and initial values

| Setting item | Parameter range | Initial value | :SYST:RST | *RST | Configuration memory | Resume |
|---|---|---|:---:|:---:|:---:|:---:|
| **\<Analog data output\>** | | | | | | |
| DATA1 | $X_A$, $Y_A$, $R_A$, $\theta_A$, $X_B$, $Y_B$, $R_B$, $\theta_B$, G, P | $R_A$ | ← | ← | Y | Y |
| DATA2 | $X_A$, $Y_A$, $R_A$, $\theta_A$, $X_B$, $Y_B$, $R_B$, $\theta_B$, G, P | $\theta_A$ | ← | ← | Y | Y |
| **\<Dynamic reserve\>** | | | | | | |
| A IN DR | LOW1 / LOW2 / MED / HIGH | MED | ← | ← | Y | Y |
| B IN DR | LOW1 / LOW2 / MED / HIGH | MED | ← | ← | Y | Y |
| **\<Voltage sensitivity\>** | | | | | | |
| A IN sensitivity | 10 nV to 1 V | 1 V | ← | ← | Y | Y |
| B IN sensitivity | 10 nV to 1 V | 1 V | ← | ← | Y | Y |
| **\<Time constant filter\>** | | | | | | |
| A IN time constant | 1 µs to 10 ks (1-2-5) | 100 ms | ← | ← | Y | Y |
| B IN time constant | 1 µs to 10 ks (1-2-5) | 100 ms | ← | ← | Y | Y |
| A IN attenuation slope | 6 / 12 / 18 / 24 dB/oct | 24 dB/oct | ← | ← | Y | Y |
| B IN attenuation slope | 6 / 12 / 18 / 24 dB/oct | 24 dB/oct | ← | ← | Y | Y |
| **\<DC offset\>** | | | | | | |
| A IN X offset range | ± 120.000 % | 0 % | ← | ← | Y | Y |
| A IN Y offset range | ± 120.000 % | 0 % | ← | ← | Y | Y |
| B IN X offset range | ± 120.000 % | 0 % | ← | ← | Y | Y |
| B IN Y offset range | ± 120.000 % | 0 % | ← | ← | Y | Y |
| **\<Moving average filter\>** | | | | | | |
| A IN averaging time | 1 µs to 100 s (1-2-5), AUTO, OFF | OFF | ← | ← | Y | Y |
| B IN averaging time | 1 µs to 100 s (1-2-5), AUTO, OFF | OFF | ← | ← | Y | Y |
| **\<EXPAND multiplier\>** | | | | | | |
| A IN EXPAND multiplier | 1 to 1000 | 1 | ← | ← | Y | Y |
| B IN EXPAND multiplier | 1 to 1000 | 1 | ← | ← | Y | Y |
| **\<PSD input offset \>** | | | | | | |
| Offset amount | Default, Automatic adjustment | Default | ← | ← | Y | Y |
| **\<Communication\>** | | | | | | |
| Measurement data parameters | STATUS, FREQ-H, FREQ-L, $X_A$, $Y_A$, $R_A$, $\theta_A$, $X_B$, $Y_B$, $R_B$, $\theta_B$, RATIO, PHASE up to 7 words from above | $R_A$, $\theta_A$ | ← | ← | Y | Y |

### Table 4-1  Setting items and initial values

| Setting item | Parameter range | Initial value | :SYST:RST | *RST | Configuration memory | Resume |
|---|---|---|---|---|---|---|
| **<Measurement data buffer>** | | | | | | |
| Sampling interval | 0.4 µs to 26.2 ms | 0.8 µs | ← | ← | Y | Y |
| Buffer size | 1 to 65536 | 65536 | ← | ← | Y | Y |
| Trigger source | BUS, EXT | BUS | ← | ← | Y | Y |
| Trigger delay time | 0 to 1.67 s | 104 ms | ← | ← | Y | Y |
| **<Interface>** | | | | | | |
| LAN IP address | 0.0.0.0 to 255.255.255.255 | 192.168.0.2 | N | N | Y | Y |
| LAN subnet mask | 0.0.0.0 to 255.255.255.255 | 255.255.255.0 | N | N | Y | Y |
| LAN default gateway | 0.0.0.0 to 255.255.255.255 | 0.0.0.0 | N | N | Y | Y |
| **<FAN control>** | | | | | | |
| FAN control | ON, OFF, AUTO | AUTO | ← | ← | Y | Y |
| **<Configuration memory>** | | | | | | |
| Contents | — | Initial values | ← | N | — | — |
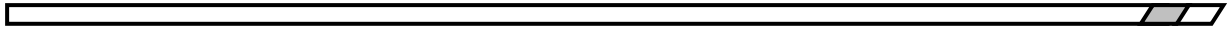
■ **Notes**

| | |
|---|---|
| Initial values | Factory default settings |
| :SYST:RST | When the :SYSTem:RST command is executed |
| *RST | When the *RST command is executed |
| ← | Same as left (initial value) |
| N | Has no function (not changed) |
| Y | Has a function (setting stored) |
| — | Not applicable |

The followings are not stored in the resume memory.
・Measurement data stored in the measurement data buffer
・Latest measurement data

The commands with respect to B IN and the measurement data parameters ($X_B$, $Y_B$, $R_B$, $\theta_B$, RATIO, and PHASE) are only applicable to the **LI5502**.

(Blank)

# 5. Remote control

# 5.1 Preparation before use

The **LI5501 / LI5502** can be controlled remotely via USB or LAN interface.
By sending messages from a controller (personal computer for control), it is possible to change settings, check current settings, and obtain measurement data.

## 5.1.1 Selection of the remote control interface

Select the USB or LAN interface by flipping the SEL switch on the rear panel.
The interface connectors are located on the rear panel of the **LI5501 / LI5502**.
It is not possible to use both of the two interfaces at the same time.

## 5.1.2 USB overview

### 5.1.2.1 Preparation of controller

To use the USB interface, prepare a controller equipped with a USB interface.
Install the USBCDC (Universal Serial Bus Communication Device Class) driver on the controller.

■ **USBCDC driver**

The USBCDC driver is required before Windows10.
It is available on our web site (http://www.nfcorp.co.jp).

### 5.1.2.2 Connections and cautions

The **LI5501 / LI5502** should be connected directly to the USB connector of the computer by a commercial USB cable. The instrument may not operate correctly if the connection is made via a USB hub.

### 5.1.2.3 Confirmation of connection

If the instrument-specific information can be obtained, the connection has been made correctly.
Vendor ID = 0D4A (hexadecimal notation): The number indicates the NF Corporation.
Product ID = 0078 (hexadecimal notation): The number indicates the product number for **LI5501**.
Product ID = 0079 (hexadecimal notation): The number indicates the product number for **LI5502**.
Serial Number = 1234567 (example): A 7-digit serial number is specific to the instrument.

■ **Message terminator**

A set of commands and responses must end with a terminator that indicates the end of the message.

The response message terminator sent by the **LI5501 / LI5502** is always LF.

The program message terminator received by the **LI5501 / LI5502** is always LF.

### 5.1.3 LAN overview

### 5.1.3.1 Preparation of controller

To use the LAN interface, prepare a controller equipped with a LAN interface (a personal computer for control). The **LI5501 / LI5502** can communicate by using the TCP/IP protocol.

### 5.1.3.2 Connections

The **LI5501 / LI5502** can distinguish a straight and a crossover cable, so either type of cable can be used.

### 5.1.3.3 Settings of the LI5501 / LI5502

Configure the following settings when the instrument is connected via the USB interface.

■ **IP address**

In the IP (Internet Protocol), an address that identifies an instrument is set (logical address). The range of addresses from 192.168.0.0 to 192.168.255.255 is for private IP addresses that can be used freely within a small-scale local network (class C).

■ **Subnet mask**

A subnet mask is set to separate the IP addresses of a higher-level network and those of lower-level network.

■ **Default gateway**

When an instrument accesses an external network, the IP address of the gateway (repeater) to be used will be set implicitly.

■ **Port number**

The specific port number is used when the **LI5501 / LI5502** communicates using the TCP protocol.

The number is 5025 (decimal notation) and cannot be changed.

■ **MAC address**

This indicates an instrument-specific address (physical address). It cannot be changed.

For example, when a serial number is 1234567, the MAC address is "00:14:CE:12:D6:87".

"00:14:CE" is fixed.

1234567 (decimal notation) → 12D687 (hexadecimal notation)

■ **Message terminator**

A set of commands and responses must end with a terminator that indicates the end of the message.

The response message terminator sent by the **LI5501 / LI5502** is always LF.

The program message terminator received by the **LI5501 / LI5502** is always LF.

## 5.1.4 Precautions of communication

■ **Input buffer**

- Commands that have been sent are temporarily stored in the input buffer and then they are interpreted and executed in sequence. The input buffer capacity is 1024 bytes. Even if program messages exceed that size, these messages will be interpreted and executed in sequence.

- If an invalid command is encountered during interpretation and execution, an error will occur and none of the subsequent commands up to the program message terminator will be executed.

■ **Output buffer**

- The output buffer capacity is 1024 bytes.

- If the maximum capacity is exceeded, the output buffer will be cleared and the query error bit of the standard event status register is set to "1". Subsequently, command interpretation and execution proceeds in the normal manner, but all generated response messages are discarded up to the program message terminator.

■ **Error queue**

- The queue can hold up to 16 error messages.

- If there are more than 17 error messages, the 16th message will return "Queue overflow" and subsequent error messages will be discarded. The error messages up to the 15th message will be retained.

■ **Program message terminator**

- When commands are sent from the controller, be sure to append the program message terminator, which is either LF (Line Feed, 0x0A hex) or CRLF (Carriage Return, 0x0D hex + Line Feed, 0x0A hex) to the end of the message.

## 5.2 List of commands and command tree

### 5.2.1 List of commands

The remote control commands and subsystem commands for the **LI5501 / LI5502** are listed in the **"Table 5-1 Common commands"** and **"Table 5-2 Subsystem commands"**.

The descriptions here are in short-form format, which omits all optional keywords. For the long-form format and the parameter format of the commands, refer to pages listed in the column of "Details".

Supplement: Commands that perform a query end with a question mark (?). In these tables, the queries are omitted for commands that can both set and query a parameter.

The rows of "R/W" in the tables indicate whether there are functions for querying (R) and setting (W). The rows of "*RST" indicate whether the function can be initialized by the "*RST" command.

**Table 5-1  Common commands**

| Command | Function | R/W | *RST | Details |
|---------|----------|-----|------|---------|
| *CLS | Clears status register and error queue | W | — | P5-21 |
| *ESE | Standard event status enable register | R/W | — | P5-21 |
| *ESR? | Queries standard event status register | R | — | P5-21 |
| *IDN? | Queries instrument-specific information | R | — | P5-21 |
| *OPC | Notification that all previous commands have ended | R/W | — | P5-21 |
| *RCL | Reads from the configuration memory | W | — | P5-22 |
| *RST | Initializes configuration | W | — | P5-22 |
| *SAV | Saves to the configuration memory | W | — | P5-22 |
| *SRE | Service request enable register | R/W | — | P5-22 |
| *STB? | Queries status byte register | R | — | P5-22 |
| *TST? | Queries results of the self-diagnostic test | R | — | P5-22 |
| *WAI | Waits for execution of commands and queries | W | — | P5-22 |

**Table 5-2  Subsystem commands**

| Command | Function | R/W | *RST | Details |
|---------|----------|-----|------|---------|
| **ABORt subsystem** | | | | |
| :ABORt | Aborts recording of measurement data | W | — | P5-23 |
| **CALCulate subsystem** | | | | |
| :CALC:FORM | Sets DATA1 output parameter | R/W | ✓ | P5-23 |
| :CALC:MULT | Sets A IN EXPAND multiplier | R/W | ✓ | P5-23 |
| :CALC:OFFS | Sets A IN offset value for X output | R/W | ✓ | P5-23 |
| **CALCulate2 subsystem** | | | | |
| :CALC2:FORM | Sets DATA2 output parameter | R/W | ✓ | P5-24 |
| :CALC2:OFFS | Sets A IN offset value for Y output | R/W | ✓ | P5-24 |
| **CALCulate3 subsystem** | | | | |
| :CALC3:MULT | Sets B IN EXPAND multiplier | R/W | ✓ | P5-24 |
| :CALC3:OFFS | Sets B IN offset value for X output | R/W | ✓ | P5-24 |
| **CALCulate4 subsystem** | | | | |
| :CALC4:OFFS | Sets B IN offset value for Y output | R/W | ✓ | P5-25 |

| Command | Function | R/W | *RST | Details |
|---|---|---|---|---|
| **DATA subsystem** | | | | |
| :DATA:COUN? | Queries the number of data sampling points | R | ✓ | P5-25 |
| :DATA:DATA? | Queries measurement values | R | ✓ | P5-25 |
| :DATA:DEL | Clears measurement data buffer | W | ✓ | P5-25 |
| :DATA:FEED | Sets data parameters to record | R/W | ✓ | P5-26 |
| :DATA:FEED:CONT | Whether to record measurement data | R/W | ✓ | P5-26 |
| :DATA:POIN | Sets measurement data buffer size | R/W | ✓ | P5-26 |
| :DATA:PER | Sets recording interval | R/W | ✓ | P5-27 |
| **FETCh subsystem** | | | | |
| :FETC? | Queries latest measurement data | R | ✓ | P5-27 |
| **INITiate subsystem** | | | | |
| :INIT | Starts triggering system | W | ✓ | P5-27 |
| **INPut1 subsystem** | | | | |
| :INP:OFFS:AUTO:ONCE | Executes PSD input offset adjustment (A IN) | W | ✓ | P5-27 |
| :INP:OFFS:RST | Disables PSD input offset adjustment (A IN) | W | ✓ | P5-27 |
| **INPut2 subsystem** | | | | |
| :INP2:OFFS:AUTO:ONCE | Executes PSD input offset adjustment (B IN) | W | ✓ | P5-27 |
| :INP2:OFFS:RST | Disables PSD input offset adjustment (B IN) | W | ✓ | P5-27 |
| **INPut3 subsystem** | | | | |
| :INP3:TYPE | Selects reference signal waveform | R/W | ✓ | P5-28 |
| **MEMory subsystem** | | | | |
| :MEM:STAT:DEL | Clears contents of designated memory | W | — | P5-28 |
| **OUTPut subsystem** | | | | |
| :OUTP | Sets output state of DATA1 terminal | R/W | ✓ | P5-28 |
| **OUTPut2 subsystem** | | | | |
| :OUTP2 | Sets output state of DATA2 terminal | R/W | ✓ | P5-28 |
| **ROUTe subsystem** | | | | |
| :ROUT | Selects reference signal source | R/W | ✓ | P5-28 |
| **SENSe subsystem** | | | | |
| :DRES | Sets A IN dynamic reserve | R/W | ✓ | P5-29 |
| :DRES2 | Sets B IN dynamic reserve | R/W | ✓ | P5-29 |
| :FREQ? | Queries frequency | R | — | P5-30 |
| :FREQ:MULT | Sets harmonic order "n" (A IN) | R/W | ✓ | P5-31 |
| :FREQ:SMUL | Sets subharmonic order "m" (A/B IN) | R/W | ✓ | P5-31 |
| :FREQ2:MULT | Sets harmonic order "n" (B IN) | R/W | ✓ | P5-31 |
| :FILT:SLOP | Sets attenuation slope of TC filter (A IN) | R/W | ✓ | P5-29 |
| :FILT:TCON | Sets time constant of TC filter (A IN) | R/W | ✓ | P5-30 |
| :FILT:MOV | Sets averaging time of MOV filter (A IN) | R/W | ✓ | P5-29 |
| :FILT2:SLOP | Sets attenuation slope of TC filter (B IN) | R/W | ✓ | P5-30 |
| :FILT2:TCON | Sets time constant of TC filter (B IN) | R/W | ✓ | P5-30 |
| :FILT2:MOV | Sets averaging time of MOV filter (B IN) | R/W | ✓ | P5-30 |
| :PHAS | Sets phase shift amount (A IN) | R/W | ✓ | P5-31 |
| :PHAS:AUTO:ONCE | Automatic phase adjustment (A IN) | W | ✓ | P5-31 |
| :PHAS2 | Sets phase shift amount (B IN) | R/W | ✓ | P5-32 |
| :PHAS2:AUTO:ONCE | Automatic phase adjustment (B IN) | W | ✓ | P5-32 |
| :ROSC:SOUR | Selects reference frequency source | R/W | ✓ | P5-32 |
| :VOLT:AC:RANG | Sets voltage sensitivity (A IN) | R/W | ✓ | P5-32 |
| :VOLT2:AC:RANG | Sets voltage sensitivity (B IN) | R/W | ✓ | P5-33 |

| Command | Function | R/W | *RST | Details |
|---|---|---|---|---|
| **SOURce subsystem** | | | | |
| :SOUR:FREQ | Sets internal oscillator frequency | R/W | ✓ | P5-33 |
| :SOUR:FREQ:MULT | Sets harmonic order "n" of oscillator output | R/W | ✓ | P5-33 |
| :SOUR:VOLT | Sets amplitude of internal oscillator | R/W | ✓ | P5-34 |
| :SOUR:VOLT:OFFS | Sets DC offset of internal oscillator | R/W | ✓ | P5-34 |
| :SOUR:OUTP | Sets output state of internal oscillator | R/W | ✓ | P5-33 |
| :SOUR:PHAS: | Sets phase shift amount of internal oscillator | R/W | ✓ | P5-34 |
| :SOUR:PHAS:INIT | Initializes phase reference of internal oscillator | W | — | P5-34 |
| :SOUR:TYPE | Selects internal oscillator waveform | R/W | ✓ | P5-34 |
| **STATus subsystem** | | | | |
| :STAT:OPER? | Queries operation status event register | R | — | P5-35 |
| :STAT:OPER:COND? | Queries operation status condition register | R | — | P5-35 |
| :STAT:OPER:ENAB | Operation status event enable register | R/W | — | P5-35 |
| :STAT:OPER:NTR | Negative operation status transition filter | R/W | — | P5-35 |
| :STAT:OPER:PTR | Positive operation status transition filter | R/W | — | P5-35 |
| :STAT:QUES? | Queries questionable event register | R | — | P5-36 |
| :STAT:QUES:COND? | Queries questionable condition register | R | — | P5-36 |
| :STAT:QUES:ENAB | Questionable event enable register | R/W | — | P5-36 |
| :STAT:QUES:NTR | Questionable status negative transition filter | R/W | — | P5-36 |
| :STAT:QUES:PTR | Questionable status positive transition filter | R/W | — | P5-36 |
| **SYSTem subsystem** | | | | |
| :SYST:ERR? | Queries error messages | R | — | P5-37 |
| :SYST:FAN:CONT | FAN control | R/W | — | P5-37 |
| :SYST:REM:LAN:IPAD | Sets IP address | R/W | — | P5-37 |
| :SYST:REM:LAN:MASK | Sets subnet mask | R/W | — | P5-37 |
| :SYST:REM:LAN:GATE | Sets default gateway | R/W | — | P5-38 |
| :SYST:RST | Initialize settings and the configuration memory | W | — | P5-38 |
| **TRIGger subsystem** | | | | |
| :TRIG:DEL | Sets trigger delay time | R/W | — | P5-38 |
| :TRIG | Executes trigger (starts recording) | W | — | P5-38 |
| :TRIG:SOUR | Sets trigger source | R/W | — | P5-38 |

Note: The commands with respect to B IN are only applicable to the **LI5502**.

## 5.2.2  Command tree

The subsystem command tree for the **LI5501 / LI5502** is shown below.

Brackets ([ ]) in the tree indicate optional keywords.

```
<Root>                                                      Command tree 1/2
   ├─ABORt
   │
   ├─CALCulate[1] ─┬─ OFFSet
   │               ├─ MULTiplier
   │               └─ FORMat
   ├─CALCulate2 ───┬─ OFFSet
   │               └─ FORMat
   ├─CALCulate3 ───┬─ OFFSet
   │               └─ MULTiplier
   ├─CALCulate4 ──── OFFSet
   ├─DATA ─────────┬─ COUNt?
   │               ├─ DATA?
   │               ├─ DELete
   │               ├─ FEED ──────────────── CONTrol
   │               │
   │               ├─ POINts
   │               └─ PERiod
   ├─FETCh?
   ├─INITiate ───────── [IMMediate]
   ├─INPut[1] ───────── OFFSet ──────┬─ AUTO ─────── ONCE
   │                                 └─ RST
   │  INPut2 ────────── OFFSet ──────┬─ AUTO ─────── ONCE
   │                                 └─ RST
   ├─INPut3 ─────────── TYPE
   ├─MEMory ─────────── STATe ─────────── DELete
   ├─OUTPut[1] ──────── [STATe]
   ├─OUTPut2 ────────── [STATe]
   ├─ROUTe ──────────── [TERMinals]
   └─[SENSe] ─────────┬─ DREServe[1]
                      ├─ DREServe2
                      ├─ FREQuency[1] ─────┬─ MULTiplier
                      │                    └─ SMULtiplier
                      ├─ FREQuency2 ──── MULTiplier
                      ├─ FILTer[1] ─────── [LPASs] ───┬─ SLOPe
                      │                               ├─ TCONstant
                      │                               └─ MOV
                      ├─ FILTer2 ───────── [LPASs] ───┬─ SLOPe
                      │                               ├─ TCONstant
                      │                               └─ MOV
                      ├─ PHASe[1] ─────────── AUTO ─────── ONCE
                      │
                      ├─ PHASe2 ───────────── AUTO ─────── ONCE
                      │
                      ├─ ROSCillator ──── SOURce
                      ├─ VOLTage[1] ──── AC ─────── RANGe ─────── [UPPer]
                      └─ VOLTage2 ────── AC ─────── RANGe ─────── [UPPer]
```

Command tree 2/2

```
SOURce ──── FREQuency ──┬─ [CW]
                        └─ MULTiplier
          ─ VOLTate ──── [LEVel] ──── [IMMediate] ──┬─ [AMPLitude]
                                                     └─ OFFSET
          ─ OUTPut
          ─ PHASe
                              ──── INITiate
          ─ TYPE

STATus ──── OPERation ──┬─ [EVENt]
                        ├─ CONDition
                        ├─ ENABle
                        ├─ NTRansition
                        └─ PTRansition
          └ QUEStionable ──┬─ [EVENt]
                           ├─ CONDition
                           ├─ ENABle
                           ├─ NTRansition
                           └─ PTRansition

SYSTem ──┬─ ERRor?
         ├─ FAN ──────── CONTrol
         ├─ REMote ──── LAN ──┬─ IPADdress
         │                    ├─ MASK
         │                    └─ GATE
         └ RST

TRIGer ──┬─ DELay
         ├─ [IMMediate]
         └─ SOURce
```

# 5.3 Commands

## 5.3.1 Overview

Commands of the **LI5501 / LI5502** are classified into common commands compliant with the IEEE488.2 standard and subsystem commands corresponding to device-specific functions.

### 5.3.1.1 Notation

For convenience, the following notations are used in this manual.

< >　　　　Parameters or parameter formats are enclosed in angle brackets (< >).

[ ]　　　　Brackets ([ ]) are used to enclose options, which can be omitted.

{abc|xyz}

A vertical bar (|) indicates that either "abc" or "xyz" can be used.

[abc|xyz]

Square brackets indicate that either "abc" or "xyz" can be used, which can be omitted.

Uppercase and lowercase letters

Keywords written in uppercase and lowercase letters are long-form expressions; keywords written in uppercase letters only are short-form expressions.

### 5.3.1.2 SCPI commands

The program messages of the **LI5501 / LI5502** consist of the common commands and subsystem commands. Here, these command formats and the subsystem command tree are explained.

■ **Common commands**

The common commands are for control of the general instrument functions.
The command syntax is illustrated in **"Figure 5-1"**.
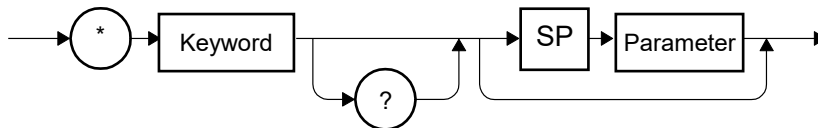


**Figure 5-1　Common command syntax**

The keyword in **"Figure 5-1"** are composed of three alphabetic characters. In this figure, SP represents a space (ASCII code 32).

■ **Subsystem commands**

The subsystem commands are for executing specific instrument functions. They consist of a root keyword, one or more lower-level keywords, a parameter, and a suffix. Examples of a command and query are shown below.

    :OUTPut:STATe ON
    :OUTPut:STATe?

"OUTPut" is a root-level keyword that is concatenated with a second-level keyword and "ON" is a parameter.

■ **Subsystem command syntax**

The subsystem command syntax is illustrated in **"Figure 5-2"**.
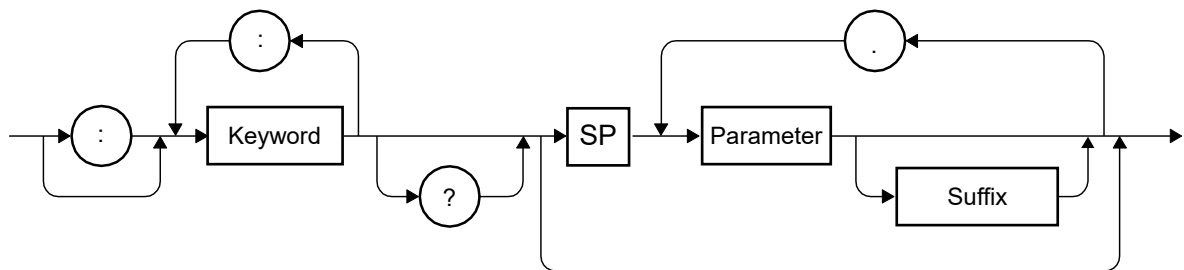


**Figure 5-2  Subsystem command syntax**

[Keywords]

The keyword in **"Figure 5-2"** is a text strings of up to 12 characters that begins with a letter of the alphabet. The remaining characters are uppercase or lowercase alphabetic characters, underscore characters, or numerals.

Most of the keywords shown in **"5.3.3 Commands description"** are composed of a mixture of uppercase and lowercase characters. Here, uppercase characters indicate short-form expressions and the mixture of uppercase and lowercase characters indicates long-form keywords. For convenience and explanation, uppercase and lowercase characters are used in keywords, but actual commands are case insensitive. The **"Table 5-3"** shows an example for the keyword "OUTPut".

**Table 5-3  Keywords that can be interpreted or not**

| Keyword | Description |
|---|---|
| OUTPUT | Can be used as the long form |
| OUTP | Can be used as the short form |
| OutpUt | Keywords are case insensitive. This can be used as the long form. |
| oUTP | Keywords are case insensitive. This can be used as the short form. |
| OUTPU | This cannot be used, because it does not correspond to either the long form or short form. |
| OU | This cannot be used, because it does not correspond to either the long form or short form. |

[Keyword separators]

The colons that appear in **"Figure 5-2"** are interpreted as keyword separators. The keyword separator serves to separate upper-level keyword and lower-level keyword in the command tree.

The colon that appears at the beginning of the subsystem commands is interpreted as a root specifier. The root specifier sets the current path as the root.

[Keyword omission]

For the commands shown in **"5.3.3 Commands description"**, a keyword enclosed in square brackets ([ ]) can be omitted. When the keyword is omitted, the instrument assumes that it has been received and analyzed.

Taking the ":OUTPut[:STATe]" command for example, either the following commands can be used.

:OUTPut:STATe
:OUTPut

[Parameters]

The parameter formats are described below.

### (1)  Numerical parameters (<NRf>, <NR1>, <NR2>, and <NR3>)

The numerical parameter formats include integer (<NR1>), real number (floating-point) (<NR2>), and real umber (exponent) (<NR3>). <NRf> is a generic expression that includes <NR1>, <NR2>, and <NR3>. The syntax for numerical parameters is illustrated below.
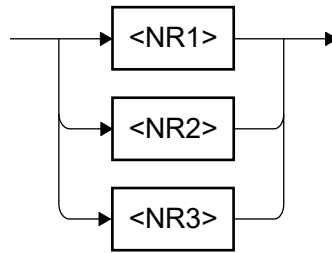


**Figure 5-3  Numerical parameter syntax (<NRf>)**
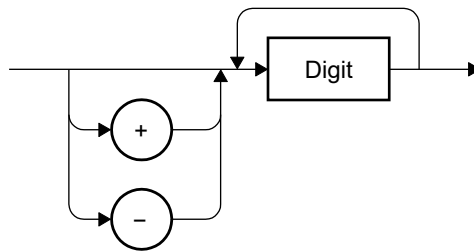


**Figure 5-4  Numerical parameter syntax (<NR1>)**
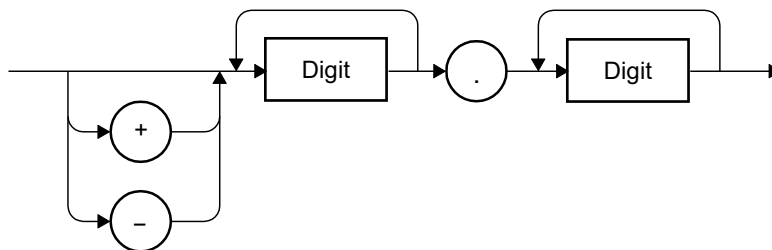


**Figure 5-5  Numerical parameter syntax (<NR2>)**
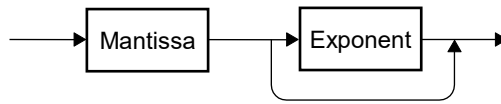
**Figure 5-6  Numerical parameter syntax (<NR3>)**

Here, the syntax for the mantissa and the exponent of **"Figure 5-6"** is illustrated below.
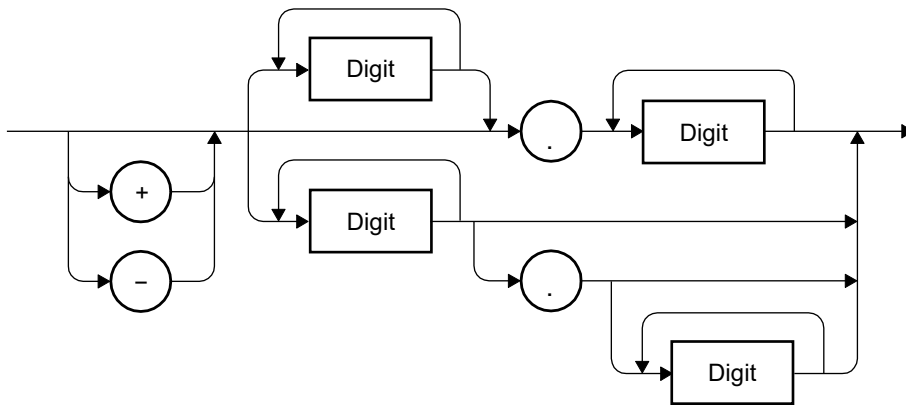


**Figure 5-7  Mantissa syntax**
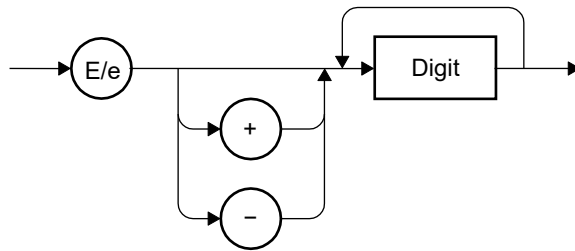


**Figure 5-8  Exponent syntax**

**(2) Discrete parameters (<DISC>)**

The syntax for discrete parameters is illustrated below.
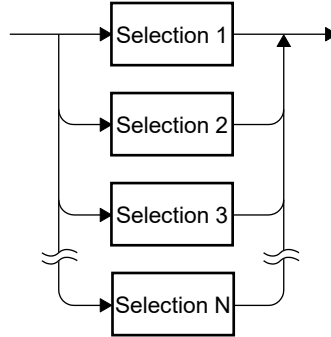


**Figure 5-9  Discrete parameter syntax (<DISC>)**

**(3) Boolean parameters (<BOL>)**

The syntax for Boolean parameters is illustrated below.

The Boolean parameter value of "0" is interpreted as "false" (OFF) and all the other values are interpreted as "true" (ON).
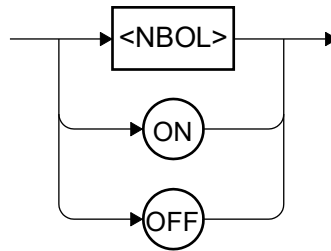


**Figure 5-10  Boolean parameter syntax (<BOL>)**

**(4) Text string parameters (<STR>)**

The syntax for text string parameters is illustrated below.
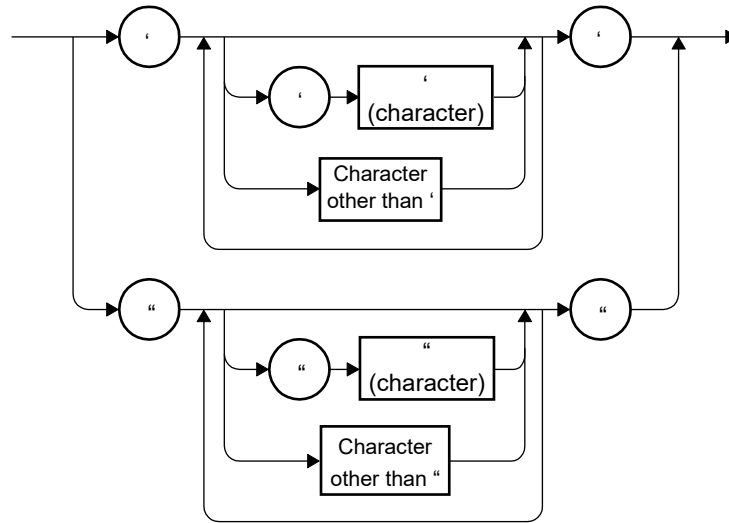


**Figure 5-11  Text string parameters (<STR>)**

[Parameter separators]

The parameter separator will be used between two parameters when two or more parameters are used in command.

[Query parameters]

Query parameters are specified after the "?" of a query.

[Suffixes]

In some commands, it is possible to set a value by specifying an SI suffix and unit. The syntax for suffixes is illustrated below.
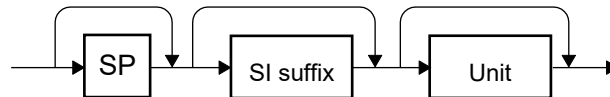


**Figure 5-12  Suffix syntax**

■ **Program message syntax**

The controller can send a combination of two or more common commands and subsystem commands to the instrument in a single program message. The program message syntax is illustrated below.
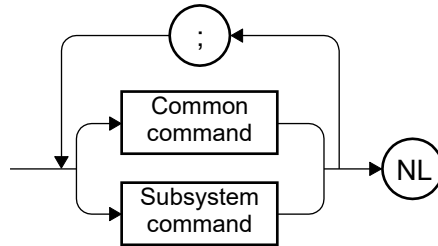
**Figure 5-13  Program message syntax**

Commands are separated by a semicolon.

■ **Response message syntax**

Response messages are used by the instrument to send data in response to a query.

[Response message syntax]

The syntax for response messages is illustrated below.
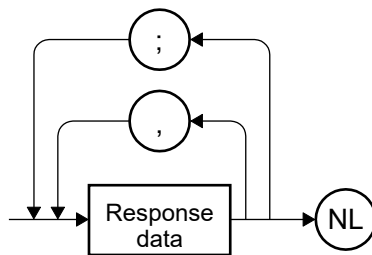
**Figure 5-14  Response message syntax**

In response messages, commas and semicolons are used as separators. When multiple values are returned by a single command, a response message will be delineated by commas. When a single program message contains multiple queries, a response message will be delineated semicolons.

[Response message data]

The response message data types are described below.

**(1) Numerical response data (<NR1>, <NR2>, and <NR3>)**

The syntax for numerical response data is illustrated below.
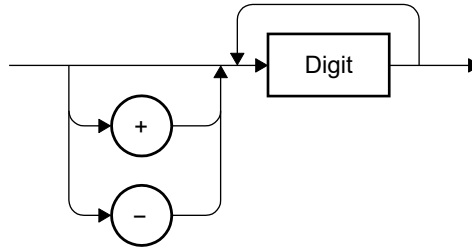


**Figure 5-15  Integer response data syntax (<NR1>)**
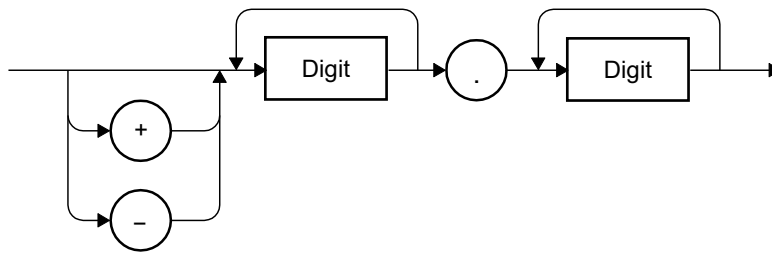


**Figure 5-16  NR2 numerical response data syntax (<NR2>)**
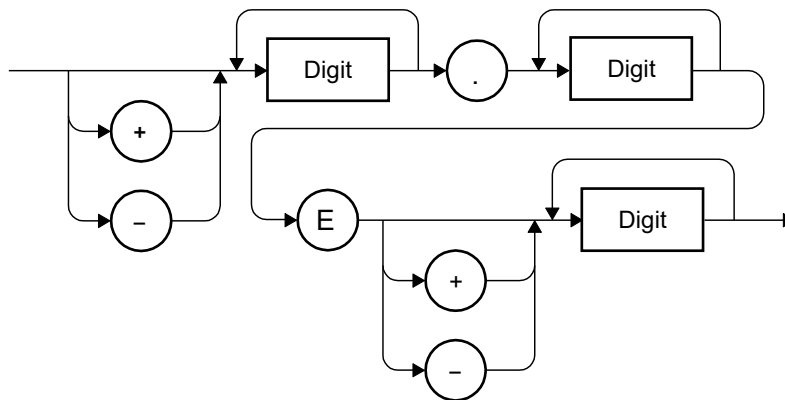


**Figure 5-17  NR3 numerical response data syntax (<NR3>)**

**(2) Discrete response data (<DISC>)**

The syntax for discrete response data is illustrated below.
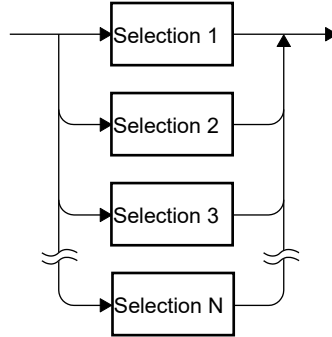


**Figure 5-18  Discrete response data syntax (<DISC>)**

**(3) Numerical Boolean response data (<NBOL>)**

The syntax for numerical Boolean response data is illustrated below.
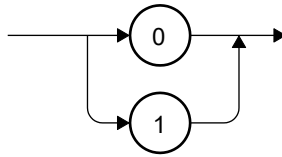


**Figure 5-19  Numerical Boolean response data syntax (<NBOL>)**

**(4) Text string response data (<STR>)**

The syntax for text string response data is illustrated below.
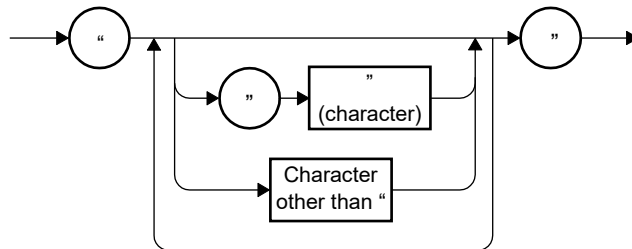


**Figure 5-20  Text string response data syntax (<STR>)**

**(5) Defined-length arbitrary block response data (<DBLK>)**

The syntax for defined-length arbitrary block response data is illustrated below.
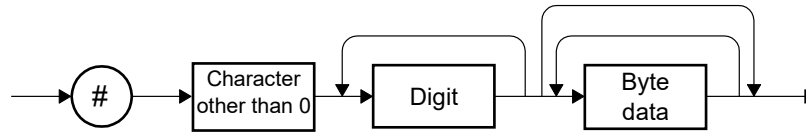


**Figure 5-21  Defined-length arbitrary block response data syntax (<DBLK>)**

## 5.3.2  Sequential commands

The commands of the **LI5501 / LI5502** are all sequential commands. After execution of a command is completed, the next command will be executed. There are no overlapping commands.

## 5.3.3 Commands description

This section describes the commands in detail.

Supplement: "4 digits (1 p ($10^{-12}$) when <10 n ($10^{-9}$))" in the resolution of the tables means that the resolution is usually 4 digits, but 1 p ($10^{-12}$) when a setting value is less than 10 n ($10^{-9}$).

### 5.3.3.1 *CLS

| Explanation | Clears the event register and error queue |
|---|---|
| Comments | Targets for the clear operation:<br>• Status byte register<br>• Standard event status register<br>• Operation status event register<br>• Error queue |

### 5.3.3.2 *ESE <value>
### *ESE?

| Explanation | Sets and queries the standard event status enable register | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Standard event status enable register |
| | | | Range: 0 to 255<br>Resolution: 1<br>Default: 0 |
| Response format | <NR1> | | |
| Comments | It is initialized when the power is turned on. Not initialized by the "*RST" command | | |

### 5.3.3.3 *ESR?

| Explanation | Queries the standard event status register |
|---|---|
| Response format | <NR1> |
| Comments | The standard event status register will be cleared when the *ESR? query or the *CLS command is received. |

### 5.3.3.4 *IDN?

| Explanation | Queries the instrument-specific information | | |
|---|---|---|---|
| Response format | <corporation>,<model>,<serial>,<ver> | | |
| | <corporation> | <STR> | Company name (NF Corporation) |
| | <model> | <STR> | Model name (LI5501 / LI5502) |
| | <serial> | <STR> | Serial number |
| | <ver> | <STR> | Firmware version |
| Comments | The response is returned without including double quotation marks.<br>NF Corporation,LI5501 / LI5502,1234567,Ver1.00 | | |

### 5.3.3.5 *OPC
### *OPC?

| Explanation | *OPC: Sets the OPC bit to "1" when all previous commands have ended<br>*OPC?: Sets "1" to the output buffer when all previous commands have ended |
|---|---|
| Response format | <NR1> |
| Comments | — |

### 5.3.3.6 *RCL <value>

| Explanation | Executes a read from the configuration memory (internal memory) | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Configuration memory number |
| | | | Range:        0 to 15 |
| | | | Resolution:   1 |
| Comments | The No.0 memory is resume memory and settings are not changed. Contents of the No.15 memory is the factory default setting. | | |

### 5.3.3.7 *RST

| Explanation | Initializes settings |
|---|---|
| Comments | Refer to **"Table 4-1  Setting items and initial values"** what contents to be initialized. |

### 5.3.3.8 *SAV <value>

| Explanation | Executes a save to the configuration memory (internal memory) | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Configuration memory number |
| | | | Range:        1 to 14 |
| | | | Resolution:   1 |
| Comments | Refer to **"Table 4-1  Setting items and initial values"** what contents to be saved. | | |

### 5.3.3.9 *SRE <value>
####      *SRE?

| Explanation | Sets and queries the service request enable register | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Service request enable register |
| | | | Range:        0 to 255 |
| | | | Resolution:   1 |
| | | | Default:      0 |
| Response format | <NR1> | | |
| Comments | It is initialized when the power is turned on. Not initialized by the "*RST" command | | |

### 5.3.3.10 *STB?

| Explanation | Queries the status byte register |
|---|---|
| Response format | <NR1> |
| Comments | Refer to **"5.4.2 Status byte"** about status bytes. |

### 5.3.3.11 *TST?

| Explanation | Executes the self-diagnostic test and queries its results |
|---|---|
| Response format | <NR1> |
| Comments | It is the SCPI command. "0" is always returned. |

### 5.3.3.12 *WAI

| Explanation | Standby for end of overlapping command execution |
|---|---|
| Comments | There are no overlapping commands for the **LI5501 / LI5502**. |

### 5.3.3.13    :ABORt

| Explanation | Stops recording to the measurement data buffer and makes the triggering system idle |
|---|---|
| Comments | — |

### 5.3.3.14    :CALCulate1:FORMat <value>
### :CALCulate1:FORMat?

| Explanation | Sets and queries the measurement parameter to be output to the DATA1 | | |
|---|---|---|---|
| Parameter | <value> | <DISC> | Measurement parameters |
| | | | REAL: $\quad X_A$ (= $R_A \cos \theta_A$) |
| | | | MLINear: $\quad R_A$ (= $\sqrt{X_A{}^2 + Y_A{}^2}$ ) |
| | | | IMAGinary: $\quad Y_A$ (= $R_A \sin \theta_A$) |
| | | | PHASe: $\quad \theta_A$ |
| | | | REAL2: $\quad X_B$ (= $R_B \cos \theta_B$) |
| | | | MLINear2: $\quad R_B$ (= $\sqrt{X_B{}^2 + Y_B{}^2}$ ) |
| | | | IMAGinary2: $\quad Y_B$ (= $R_B \sin \theta_B$) |
| | | | PHASe2: $\quad \theta_B$ |
| | | | MLINear3: $\quad R_A / R_B$ (amplitude ratio of A IN to B IN) |
| | | | PHASe3: $\quad \theta_A - \theta_B$ (phase difference between A IN and B IN) |
| Response format | <DISC> | | |
| Comments | Example) When setting parameter to $X_A$, enter ":CALCulate1:FORMat REAL". | | |

### 5.3.3.15    :CALCulate1:MULTiplier <value>
### :CALCulate1:MULTiplier?

| Explanation | Sets and queries EXPAND multiplier on the A IN side | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Multiplier [times] |
| | | | Range: $\quad$ 1 to 1000 |
| | | | Resolution: $\quad$ 1 |
| Response format | <NR1> | | |
| Comments | The EXPAND multiplier only affects X, Y, and R parameters.<br>It does not affect the other parameters.<br>1-2-5 sequence is recommended. | | |

### 5.3.3.16    :CALCulate1:OFFSet <value>
### :CALCulate1:OFFSet?

| Explanation | Sets and queries the offset value for the X output on the A IN side | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Offset [%] |
| | | | Range: $\quad$ −120.00 to +120.00 |
| | | | Resolution: $\quad$ 0.01 |
| Response format | <NR2> | | |
| Comments | — | | |

### 5.3.3.17 :CALCulate2:FORMat <value>

#### :CALCulate2:FORMat?

| Explanation | Sets and queries the measurement parameter to be output to the DATA2 | | |
|---|---|---|---|
| Parameter | <value> | <DISC> | Measurement parameters |
| | | | REAL: $\quad$ $X_A$ (= $R_A \cos \theta_A$) |
| | | | MLINear: $\quad$ $R_A$ (= $\sqrt{X_A{}^2 + Y_A{}^2}$ ) |
| | | | IMAGinary: $\quad$ $Y_A$ (= $R_A \sin \theta_A$) |
| | | | PHASe: $\quad$ $\theta_A$ |
| | | | REAL2: $\quad$ $X_B$ (= $R_B \cos \theta_B$) |
| | | | MLINear2: $\quad$ $R_B$ (= $\sqrt{X_B{}^2 + Y_B{}^2}$ ) |
| | | | IMAGinary2: $\quad$ $Y_B$ (= $R_B \sin \theta_B$) |
| | | | PHASe2: $\quad$ $\theta_B$ |
| | | | MLINear3: $\quad$ $R_A$ / $R_B$ (amplitude ratio of A IN to B IN) |
| | | | PHASe3: $\quad$ $\theta_A - \theta_B$ (phase difference between A IN and B IN) |
| Response format | <DISC> | | |
| Comments | — | | |

### 5.3.3.18 :CALCulate2:OFFSet <value>

#### :CALCulate2:OFFSet?

| Explanation | Sets and queries the offset value for the Y output on the A IN side | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Offset [%] |
| | | | Range: $\quad$ −120.00 to +120.00 |
| | | | Resolution: $\quad$ 0.01 |
| Response format | <NR2> | | |
| Comments | — | | |

### 5.3.3.19 :CALCulate3:MULTiplier <value>

#### :CALCulate3:MULTiplier?

| Explanation | Sets and queries EXPAND multiplier on the B IN side | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Multiplier [times] |
| | | | Range: $\quad$ 1 to 1000 |
| | | | Resolution: $\quad$ 1 |
| Response format | <NR1> | | |
| Comments | The EXPAND multiplier only affects X, Y, and R parameters. It does not affect the other parameters. 1-2-5 sequence is recommended. | | |

### 5.3.3.20 :CALCulate3:OFFSet <value>

#### :CALCulate3:OFFSet?

| Explanation | Sets and queries the offset value for the X output on the B IN side | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Offset [%] |
| | | | Range: $\quad$ −120.00 to +120.00 |
| | | | Resolution: $\quad$ 0.01 |
| Response format | <NR2> | | |
| Comments | — | | |

### 5.3.3.21   :CALCulate4:OFFSet <value>

### :CALCulate4:OFFSet?

| Explanation | Sets and queries the offset value for the Y output on the B IN side | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Offset [%] |
| | | | Range:          −120.00 to +120.00 |
| | | | Resolution:     0.01 |
| Response format | <NR2> | | |
| Comments | — | | |

### 5.3.3.22   :DATA:COUNt?

| Explanation | Queries the number of data sampling points recorded in the measurement data buffer |
|---|---|
| Response format | <NR1> |
| Comments | — |

### 5.3.3.23   :DATA:DATA?

| Explanation | Queries the contents of the measurement data buffer (measurement values) |
|---|---|
| Response format | <DBLK> |
| Comments | — |

### 5.3.3.24   :DATA:DELete

| Explanation | Clears the measurement data buffer |
|---|---|
| Comments | — |

### 5.3.3.25　:DATA:FEED <value>
### 　　　　　:DATA:FEED?

| Explanation | Sets and queries measurement data parameters recorded in the measurement data buffer | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Measurement data parameters |
| | | | Weight: |
| | | | 　　1:　STATUS |
| | | | 　　2:　FREQ-H (upper bits of reference signal frequency) |
| | | | 　　4:　FREQ-L (lower bits of reference signal frequency) |
| | | | 　　8:　$X_A$ (X value on A IN side) |
| | | | 　16:　$Y_A$ (Y value on A IN side) |
| | | | 　32:　$R_A$ (R value on A IN side) |
| | | | 　64:　$\theta_A$ (θ value on A IN side) |
| | | | 　128:　$X_B$ (X value on B IN side) |
| | | | 　256:　$Y_B$ (Y value on B IN side) |
| | | | 　512:　$R_B$ (R value on B IN side) |
| | | | 1024:　$\theta_B$ (θ value on B IN side) |
| | | | 2048:　RATIO (amplitude ratio of A IN to B IN) |
| | | | 4096:　PHASE (phase difference between A IN and B IN) |
| Response format | <NR1> | | |
| Comments | Example) When selecting $R_A$ and $\theta_A$, enter ":DATA:FEED 96". <br> Refer to **"6.1.1 Setting of measurement data parameters"** about STATUS. | | |

### 5.3.3.26　:DATA:FEED:CONTrol <value>
### 　　　　　:DATA:FEED:CONTrol?

| Explanation | Sets and queries whether or not to be recorded in the measurement data buffer | | |
|---|---|---|---|
| Parameter | <value> | <DISC> | Whether recording or not |
| | | | ALWays:　Records measurement data |
| | | | NEVer:　　Does not record measurement data |
| Response format | <DISC> | | |
| Comments | — | | |

### 5.3.3.27　:DATA:POINts <value>
### 　　　　　:DATA:POINts?

| Explanation | Sets and queries the measurement data buffer size | | |
|---|---|---|---|
| Parameter | <value> | <DISC> | Size [points] |
| | | | Range: 1 to 65536 or INFinity |
| Response format | <NR1> or <DISC> | | |
| Comments | "INFinity" indicates that recording continues until the measurement buffer is full. | | |

### 5.3.3.28  :DATA:PERiod <value>

### :DATA:PERiod?

| Explanation | Sets and queries recording interval to the measurement data buffer | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Recording interval [s] |
| | | | Range:          0.4 μs to 26.2 ms |
| | | | Resolution:      0.4 μs |
| | | | Suffix "U" ($10^{-6}$) and "M" ($10^{-3}$) and unit "S" are available. |
| Response format | <NR2> | | |
| Comments | It takes 0.4 μs per measured data parameter. | | |

### 5.3.3.29  :FETCh?

| Explanation | Queries the latest measurement data |
|---|---|
| Response format | <NR1> |
| Comments | Query the measurement data set by the ":DATA:FEED" command. |

### 5.3.3.30  :INITiate[:IMMediate]

| Explanation | When recording to the measurement data buffer is enabled and the triggering system is idle, the system transitions to the awaiting trigger state. |
|---|---|
| Comments | If the measurement data buffer is full during recording, the system becomes the idle state. It cannot become the awaiting trigger state, while the measurement data if full. Clear the buffer if necessary. |

### 5.3.3.31  :INPut[1]:OFFSet:AUTO:ONCE

| Explanation | Automatically adjusts the PSD input offset on the A IN side only once |
|---|---|
| Comments | — |

### 5.3.3.32  :INPut[1]:OFFSet:RST

| Explanation | The PSD input offset amount on the A IN side is restored to the factory default setting. |
|---|---|
| Comments | — |

### 5.3.3.33  :INPut2:OFFSet:AUTO:ONCE

| Explanation | Automatically adjusts the PSD input offset on the B IN side only once |
|---|---|
| Comments | — |

### 5.3.3.34  :INPut2:OFFSet:RST

| Explanation | The PSD input offset amount on the B IN side is restored to the factory default setting. |
|---|---|
| Comments | — |

### 5.3.3.35    :INPut3:TYPE <value>
### :INPut3:TYPE?

| Explanation | Sets and queries the reference signal waveform | | |
|---|---|---|---|
| Parameter | <value> | <DISC> | Edge |
| | | | SINusoid:    Sine wave (edge: rising slope intersects 0 V) |
| | | | TPOS:    TTL level rising edge |
| | | | TNEG:    TTL level falling edge |
| Response format | <DISC> | | |
| Comments | — | | |

### 5.3.3.36    :MEMory:STATe:DELete <value>

| Explanation | Clears contents of designated configuration memory | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Memory number |
| | | | Range: 1 to 14 |
| Response format | <NR1> | | |
| Comments | — | | |

### 5.3.3.37    :OUTPut[1][:STATe] <value>
### :OUTPut[1][:STATe]?

| Explanation | Sets and queries the output state of the DATA1 terminal | | |
|---|---|---|---|
| Parameter | <value> | <BOL> | Output state |
| | | | ON │ 1:    Enables output of the DATA1 terminal |
| | | | OFF │ 0:    Disables output of the DATA1 terminal |
| Response format | <NBOL> | | |
| Comments | — | | |

### 5.3.3.38    :OUTPut2[:STATe] <value>
### :OUTPut2[:STATe]?

| Explanation | Sets and queries the output state of the DATA2 terminal | | |
|---|---|---|---|
| Parameter | <value> | <BOL> | Output state |
| | | | ON │ 1:    Enables output of the DATA2 terminal |
| | | | OFF │ 0:    Disables output of the DATA2 terminal |
| Response format | <NBOL> | | |
| Comments | — | | |

### 5.3.3.39    :ROUTe[:TERMinals] <value>
### :ROUTe[:TERMinals]?

| Explanation | Sets and queries the reference signal source | | |
|---|---|---|---|
| Parameter | <value> | <DISC> | Reference signal source |
| | | | RINPut:    Input signal to the REF IN terminal |
| | | | IOSC:    Internal oscillator |
| Response format | <DISC> | | |
| Comments | — | | |

### 5.3.3.40　[:SENSe]:DREServe[1] <value>
### [:SENSe]:DREServe[1]?

| Explanation | Sets and queries the dynamic reserve on the A IN side | | |
|---|---|---|---|
| Parameter | <value> | <DISC> | Dynamic reserve |
| | | | HIGH:　　　High dynamic reserve (when noise level is high)<br>MEDium:　　Medium dynamic reserve<br>LOW2:　　　Low dynamic reserve<br>LOW1:　　　Lower dynamic reserve (when noise level is low) |
| Response format | <DISC> | | |
| Comments | — | | |

### 5.3.3.41　[:SENSe]:DREServe2 <value>
### [:SENSe]:DREServe2?

| Explanation | Sets and queries the dynamic reserve on the B IN side | | |
|---|---|---|---|
| Parameter | <value> | <DISC> | Dynamic reserve |
| | | | HIGH:　　　High dynamic reserve (when noise level is high)<br>MEDium:　　Medium dynamic reserve<br>LOW2:　　　Low dynamic reserve<br>LOW1:　　　Lower dynamic reserve (when noise level is low) |
| Response format | <DISC> | | |
| Comments | — | | |

### 5.3.3.42　[:SENSe]:FILTer[1][:LPASs]:MOV <value>
### [:SENSe]:Filter[1][:LPASs]:MOV?

| Explanation | Sets and queries the averaging time of the moving average filter on the A IN side | | |
|---|---|---|---|
| Parameter | <value> | <NRf><br><DISC> | Averaging time [s] |
| | | | Range: OFF, AUTO, or| $1E{-}6$ to 100 (1-2-5 sequence)<br>Suffix "U" ($10^{-6}$) and "M" ($10^{-3}$) and unit "S" are available. |
| Response format | <DISC> | | |
| Comments | If an arbitrary number is entered, it will be rounded to the nearest value. | | |

### 5.3.3.43　[:SENSe]:FILTer[1][:LPASs]:SLOPe <value>
### [:SENSe]:Filter[1][:LPASs]:SLOPe?

| Explanation | Sets and queries the attenuation slope of the time constant filter on the A IN side | |
|---|---|---|
| Parameter | <value> | <NRf> | Attenuation slope [dB/oct] |
| | | | Range: 6 \| 12 \| 18 \| 24 |
| Response format | <NR1> | | |
| Comments | — | | |

### 5.3.3.44 [:SENSe]:FILTer[1][:LPASs]:TCONstant <value>
### [:SENSe]:Filter[1][:LPASs]:TCONstant?

| Explanation | Sets and queries the time constant of the time constant filter on the A IN side | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Time constant [s] |
| | | | Range: 1E−6 to 10E+3 (1-2-5 sequence) |
| Response format | <NR3> | | |
| Comments | — | | |

### 5.3.3.45 [:SENSe]:FILTer2[:LPASs]:MOV <value>
### [:SENSe]:Filter2[:LPASs]:MOV?

| Explanation | Sets and queries the averaging time of the moving average filter on the B IN side | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Averaging time [s] |
| | | <DISC> | Range: OFF, AUTO, or 1E−6 to 100 (1-2-5 sequence) |
| | | | Suffix "U" ($10^{-6}$) and "M" ($10^{-3}$) and unit "S" are available. |
| Response format | <DISC> | | |
| Comments | If an arbitrary number is entered, it will be rounded to the nearest value. | | |

### 5.3.3.46 [:SENSe]:FILTer2[:LPASs]:SLOPe <value>
### [:SENSe]:Filter2[:LPASs]:SLOPe?

| Explanation | Sets and queries the attenuation slope of the time constant filter on the B IN side | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Attenuation slope [dB/oct] |
| | | | Range: 6 \| 12 \| 18 \| 24 |
| Response format | <NR1> | | |
| Comments | — | | |

### 5.3.3.47 [:SENSe]:FILTer2[:LPASs]:TCONstant <value>
### [:SENSe]:Filter2[:LPASs]:TCONstant?

| Explanation | Sets and queries the time constant of the time constant filter on the B IN side | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Time constant [s] |
| | | | Range: 1E−6 to 10E+3 (1-2-5 sequence) |
| Response format | <NR3> | | |
| Comments | — | | |

### 5.3.3.48 [:SENSe]:FREQuency[1]?

| Explanation | Queries the frequency |
|---|---|
| Response format | <NR2> value |
| | Range: 9.5E−3 to 1.05E+6, Resolution: 7digits, Unit: Hz |
| Comments | — |

### 5.3.3.49 [:SENSe]:FREQuency[1]:MULTiplier <value>
### [:SENSe]:FREQuency[1]:MULTiplier?

| Explanation | Sets and queries the harmonic order "n" when measuring a harmonic on the A IN side | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Harmonic order "n" |
| | | | Range: 1 to 63 |
| Response format | <NR1> | | |
| Comments | — | | |

### 5.3.3.50 [:SENSe]:FREQuency[1]:SMULtiplier <value>
### [:SENSe]:FREQuency[1]:SMULtiplier?

| Explanation | Sets and queries the subharmonic order "m" common to the A IN and B in side when measuring subharmonics | | |
|---|---|---|---|
| Parameter | <value> | <NR1> | Subharmonic order "m" |
| | | | Range: 1 to 64 |
| Response format | <NR1> | | |
| Comments | — | | |

### 5.3.3.51 [:SENSe]:FREQuency2:MULTiplier <value>
### [:SENSe]:FREQuency2:MULTiplier?

| Explanation | Sets and queries the harmonic order "n" measuring a harmonic on the B IN side | | |
|---|---|---|---|
| Parameter | <value> | <NR1> | Harmonic order "n" |
| | | | Range: 1 to 63 |
| Response format | <NR1> | | |
| Comments | — | | |

### 5.3.3.52 [:SENSe]:PHASe[1] <value>
### [:SENSe]:PHASe[1]?

| Explanation | Sets and queries the phase shift amount on the A IN side | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Phase shift amount [°] |
| | | | Range: −180.000 to +179.999<br>Resolution: 0.001 |
| Response format | <NR2> | | |
| Comments | — | | |

### 5.3.3.53 [:SENSe]:PHASe[1]:AUTO:ONCE

| Explanation | Automatically adjusts the phase shift amount so that the A IN side θ becomes zero |
|---|---|
| Comments | When this adjustment is done, signal amplitude can be determined from the parameter "X" and phase change can be determined from the parameter "Y". |

### 5.3.3.54 [:SENSe]:PHASe2 <value>

#### [:SENSe]:PHASe2?

| Explanation | Sets and queries the phase shift amount on the B IN side | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Phase shift amount [°] |
| | | | Range: −180.000 to +179.999 <br> Resolution: 0.001 |
| Response format | <NR2> | | |
| Comments | — | | |

### 5.3.3.55 [:SENSe]:PHASe2:AUTO:ONCE

| Explanation | Automatically adjusts the phase shift amount so that the B IN side θ becomes zero |
|---|---|
| Comments | When this adjustment is done, signal amplitude can be determined from the parameter "X" and phase change can be determined from the parameter "Y". |

### 5.3.3.56 [:SENSe]:ROSCillator:SOURce <value>

#### [:SENSe]:ROSCillator:SOURce?

| Explanation | Sets and queries the reference frequency source for frequency synthesis | | |
|---|---|---|---|
| Parameter | <value> | <DISC> | Reference frequency source |
| | | | INTernal: Internal <br> EXTernal: External (10 MHz IN terminal) |
| Response format | <DISC> | | |
| Comments | — | | |

### 5.3.3.57 [:SENSe]:VOLTage[1]:AC:RANGe[:UPPer] <value>

#### [:SENSe]:VOLTage[1]:AC:RANGe[:UPPer]?

| Explanation | Sets and queries the voltage sensitivity on the A IN side | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Voltage sensitivity [V] |
| | | | When the dynamic reserve is HIGH <br>    Range: 5E-6 to 1 (1-2-5 sequence) <br> When the dynamic reserve is MED <br>    Range: 1E-6 to 1 (1-2-5 sequence) <br> When the dynamic reserve is LOW2 <br>    Range: 100E-9 to 100E-3 (1-2-5 sequence) <br> When the dynamic reserve is LOW1 <br>    Range: 10E-9 to 10E-3 (1-2-5 sequence) <br> Suffix "N" ($10^{-9}$), "U" ($10^{-6}$), and "M" ($10^{-3}$) and unit "V", "MAX", and "MIN" are available. |
| Response format | <NR2> | | |
| Comments | If the voltage sensitivity is out of range due to changing the dynamic reserve, it is automatically set to the nearest value within the range. | | |

### 5.3.3.58 [:SENSe]:VOLTage2:AC:RANGe[:UPPer] <value>
### [:SENSe]:VOLTage2:AC:RANGe[:UPPer]?

| Explanation | Sets and queries the voltage sensitivity on the B IN side | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Voltage sensitivity [V] |
| | | | When the dynamic reserve is HIGH<br>    Range: 5E-6 to 1 (1-2-5 sequence)<br>When the dynamic reserve is MED<br>    Range: 1E-6 to 1 (1-2-5 sequence)<br>When the dynamic reserve is LOW2<br>    Range: 100E-9 to 100E-3 (1-2-5 sequence)<br>When the dynamic reserve is LOW1<br>    Range: 10E-9 to 10E-3 (1-2-5 sequence)<br>Suffix "N" ($10^{-9}$), "U" ($10^{-6}$), and "M" ($10^{-3}$) and unit "V", "MAX", and "MIN" are available. |
| Response format | <NR2> | | |
| Comments | If the voltage sensitivity is out of range due to changing the dynamic reserve, it is automatically set to the nearest value within the range. | | |

### 5.3.3.59 :SOURce:FREQuency[:CW] <value>
### :SOURce:FREQuency[:CW]?

| Explanation | Sets and queries the internal oscillator frequency | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Frequency [Hz] |
| | | | Range:        9.5E-3 to 1.05E+6<br>Resolution:      6 digits<br>Suffix "M" ($10^{-3}$), "K" ($10^{3}$), and "MA" ($10^{6}$) and unit "HZ", "MAX", and "MIN" are available. |
| Response format | <NR2> | | |
| Comments | — | | |

### 5.3.3.60 :SOURce:FREQuency:MULTiplier <value>
### :SOURce:FREQuency:MULTiplier?

| Explanation | Sets the oscillator output frequency to "n" times the internal oscillator frequency and queries the harmonic order "n" | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Harmonic order "n" |
| | | | Range: 1 to 63 |
| Response format | <NR1> | | |
| Comments | — | | |

### 5.3.3.61 :SOURce:OUTPut <value>
### :SOURce:OUTPut?

| Explanation | Sets and queries the output state of the OSC OUT terminal | | |
|---|---|---|---|
| Parameter | <value> | <BOL> | Output state |
| | | | ON \| OFF |
| Response format | <NBOL> | | |
| Comments | Only AC waveforms can be turned on and off.<br>The DC offset is not affected. | | |

### 5.3.3.62 :SOURce:PHASe <value>

#### :SOURce:PHASe?

| Explanation | Sets and queries the phase of the internal oscillator | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Phase [°] |
| | | | Range:         −180.000 to +179.999 |
| | | | Resolution:    0.001 |
| Response format | <NR2> | | |
| Comments | — | | |

### 5.3.3.63 :SOURce:PHASe:INITiate <value>

| Explanation | Executes phase synchronization of the internal oscillator |
|---|---|
| Comments | — |

### 5.3.3.64 :SOURce:TYPE <value>

#### :SOURce:TYPE?

| Explanation | Sets and queries the wave form of the internal oscillator | | |
|---|---|---|---|
| Parameter | <value> | <DISC> | Waveform |
| | | | SINusoid:       Sine wave |
| | | | TTL:            TTL-level square wave |
| Response format | <DISC> | | |
| Comments | — | | |

### 5.3.3.65 :SOURce:VOLTage[:LEVel][:IMMediate][:AMPLitude] <value>

#### :SOURce:VOLTage[:LEVel][:IMMediate][:AMPLitude]?

| Explanation | Sets and queries the output amplitude of the internal oscillator | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Amplitude [Vrms] |
| | | | Range:         0.000 to 1.000 |
| | | | Resolution:    0.001 |
| Response format | <NR2> | | |
| Comments | — | | |

### 5.3.3.66 :SOURce:VOLTage[:LEVel][:IMMediate]:OFFSet <value>

#### :SOURce:VOLTage[:LEVel][:IMMediate]:OFFSet?

| Explanation | Sets and queries the DC offset voltage of the internal oscillator | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Offset voltage [VDC] |
| | | | Range:         −5.000 to +5.000 |
| | | | Resolution:    0.005 |
| Response format | <NR2> | | |
| Comments | — | | |

### 5.3.3.67　:STATus:OPERation:CONDition?

| Explanation | Queries the operation status condition register |
|---|---|
| Response format | <NR1> |
| Comments | — |

### 5.3.3.68　:STATus:OPERation:ENABle <value>

### :STATus:OPERation:ENABle?

| Explanation | Sets and queries the operation status event enable register | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Operation status event enable register |
| | | | Range:　　　0 to 65535 |
| | | | Resolution:　1 |
| | | | Default:　　0 |
| Response format | <NR1> | | |
| Comments | It is initialized when the power is turned on. Not initialized by the "*RST" command | | |

### 5.3.3.69　:STATus:OPERation[:EVENt]?

| Explanation | Queries the operation status event register |
|---|---|
| Response format | <NR1> |
| Comments | It will be cleared if the event register is queried or the "*CLS" command is received. |

### 5.3.3.70　:STATus:OPERation:NTRansition <value>

### :STATus:OPERation:NTRansition?

| Explanation | Sets and queries the negative operation status transition filter | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Negative operation status transition filter |
| | | | Range:　　　0 to 65535 |
| | | | Resolution:　1 |
| | | | Default:　　0 |
| Response format | <NR1> | | |
| Comments | It is initialized when the power is turned on. Not initialized by the "*RST" command | | |

### 5.3.3.71　:STATus:OPERation:PTRansition <value>

### :STATus:OPERation:PTRansition?

| Explanation | Sets and queries the positive operation status transition filter | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Positive operation status transition filter |
| | | | Range:　　　0 to 65535 |
| | | | Resolution:　1 |
| | | | Default:　　0 |
| Response format | <NR1> | | |
| Comments | It is initialized when the power is turned on. Not initialized by the "*RST" command | | |

### 5.3.3.72    :STATus:QUEStionable:CONDition?

| Explanation | Queries the questionable condition register |
|---|---|
| Response format | <NR1> |
| Comments | — |

### 5.3.3.73    :STATus:QUEStionable:ENABle <value>
###             :STATus:QUEStionable:ENABle?

| Explanation | Sets and queries the questionable event enable register | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Questionable event enable register |
| | | | Range:           0 to 65535 |
| | | | Resolution:     1 |
| | | | Initial value:   0 |
| Response format | <NR1> | | |
| Comments | It is initialized when the power is turned on. Not initialized by the "*RST" command | | |

### 5.3.3.74    :STATus:QUEStionable[:EVENt]?

| Explanation | Queries the questionable event register |
|---|---|
| Response format | <NR1> |
| Comments | It is cleared when querying the event register or the "*CLS" command is received. |

### 5.3.3.75    :STATus:QUEStionable:NTRansition <value>
###             :STATus:QUEStionable:NTRansition?

| Explanation | Sets and queries the questionable status negative transition filter | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Negative transition filter |
| | | | Range:           0 to 65535 |
| | | | Resolution:     1 |
| | | | Initial value:   0 |
| Response format | <NR1> | | |
| Comments | It is initialized when the power is turned on. Not initialized by the "*RST" command | | |

### 5.3.3.76    :STATus:QUEStionable:PTRansition <value>
###             :STATus:QUEStionable:PTRansition?

| Explanation | Sets and queries the questionable status positive transition filter | | |
|---|---|---|---|
| Parameter | <value> | <NRf> | Positive transition filter |
| | | | Range:           0 to 65535 |
| | | | Resolution:     1 |
| | | | Initial value:   0 |
| Response format | <NR1> | | |
| Comments | It is initialized when the power is turned on. Not initialized by the "*RST" command | | |

### 5.3.3.77 :SYSTem:FAN:CONTrol <value>

### :SYSTem:FAN:CONTrol?

| Explanation | Sets and queries the internal fan setting | | |
|---|---|---|---|
| Parameter | <value> | <DISC> | Fan control |
| | | | ON:        Always on<br>OFF:      Always off<br>AUTO:    When the CPU temp. exceeds about 60 °C, it is turned on and when the CPU temp. falls below about 55 °C, it is turned off. |
| Response format | <DISC> | | |
| Comments | — | | |

### 5.3.3.78 :SYSTem:ERRor?

| Explanation | Queries remote errors | | |
|---|---|---|---|
| Response format | <code>,<message> | | |
| | <code> | <NR1> | Error code |
| | <message> | <STR> | Error message |
| Comments | • <message> includes double quotation marks.<br>• The error queue can hold up to 16 error messages and the message can be read one by one in order of oldest first.<br>• If there are more than 16 error messages, the last message in the error queue will be replaced by "Queue overflow" and a new error will not be added until there is a room in the error queue.<br>• The error queue will be cleared when the "*CLS" command is received. | | |

### 5.3.3.79 :SYSTem:REMote:LAN:IPADdress <value>

### :SYSTem:REMote:LAN:IPADdress?

| Explanation | Sets and queries the IP address | | |
|---|---|---|---|
| Parameter | <value> | <STR> | IP address |
| | | | Range:    0 to 255<br>            XXX. XXX. XXX. XXX<br>Example) 192. 168. 0. 2 |
| Response format | <STR> | | |
| Comments | — | | |

### 5.3.3.80 :SYSTem:REMote:LAN:MASK <value>

### :SYSTem:REMote:LAN:MASK?

| Explanation | Sets and queries the subnet mask | | |
|---|---|---|---|
| Parameter | <value> | <STR> | Subnet mask |
| | | | Range:    0 to 255<br>            XXX. XXX. XXX. XXX<br>Example) 255. 255. 255. 0 |
| Response format | <STR> | | |
| Comments | — | | |

### 5.3.3.81  :SYSTem:REMote:LAN:GATE &lt;value&gt;

#### :SYSTem:REMote:LAN:GATE?

| Explanation | Sets and queries the default gateway | | |
|---|---|---|---|
| Parameter | &lt;value&gt; | &lt;STR&gt; | Default gateway |
| | | | Range:   0 to 255<br>XXX. XXX. XXX. XXX<br>Example) 192. 168. 0. 1 |
| Response format | &lt;STR&gt; | | |
| Comments | — | | |

### 5.3.3.82  :SYSTem:RST

| Explanation | Initializes settings<br>Unlike the "*RST" command, this command also clears contents of the configuration memories from No.1 to 14. |
|---|---|
| Comments | — |

### 5.3.3.83  :TRIGger:DELay &lt;value&gt;

#### :TRIGer:DELay?

| Explanation | Sets and queries the trigger delay time | | |
|---|---|---|---|
| Parameter | &lt;value&gt; | &lt;NRf&gt; | Delay time [s] |
| | | | Range: 0 to 1.67 s (1.6777212 s) |
| Response format | &lt;NR2&gt; | | |
| Comments | — | | |

### 5.3.3.84  :TRIGger[:IMMediate]

| Explanation | When the measurement data buffer is enabled, measurement data is recorded in the buffer by a trigger. |
|---|---|
| Comments | — |

### 5.3.3.85  :TRIGger:SOURce &lt;value&gt;

#### :TRIGer:SOURce?

| Explanation | Sets and queries the trigger source | | |
|---|---|---|---|
| Parameter | &lt;value&gt; | &lt;DISC&gt; | Trigger source |
| | | | EXTernal:   By external signal<br>BUS:   By communication<br>   Use the ":TRIGger[:IMMediate]" command. |
| Response format | &lt;DISC&gt; | | |
| Comments | — | | |

# 5.4 Status system

## 5.4.1 Overview of status system

The status system of the **LI5501 / LI5502** is illustrated in **"Figure 5-22"**.
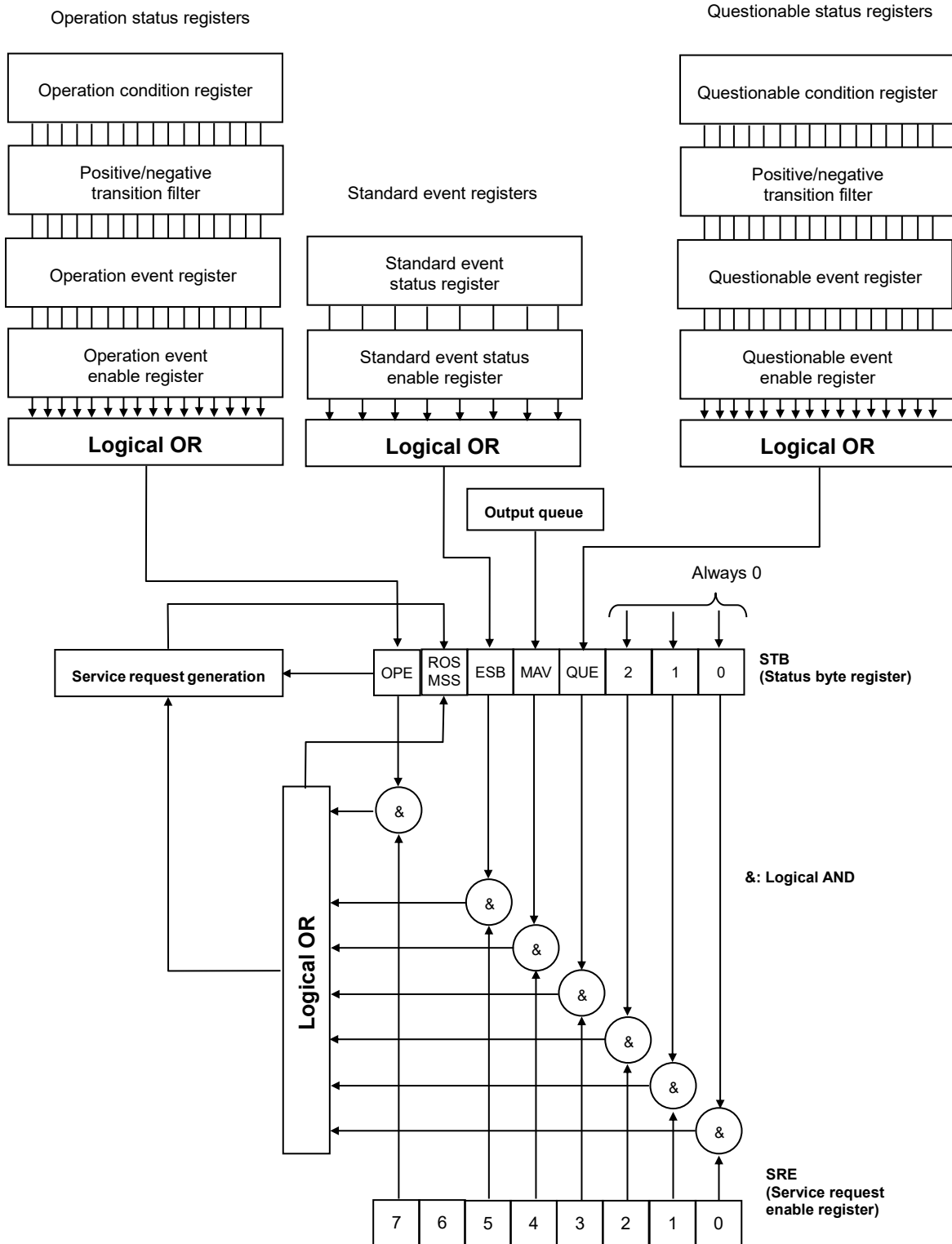


**Figure 5-22  Status system**

## 5.4.2 Status byte

The definition of the status byte register is described in **"Table 5-4"**. The status byte can be read by serial polling. In this case, bit "6" is RQS (Request service).

**Table5-4  Definitions of the status byte register**

| Bit | | Weight | Condition for setting to "1" | Condition for setting to "0" |
|-----|---|--------|------------------------------|------------------------------|
| OPE | 7 | 128 | When any of the effective bits of the operation status event register is set to "1" | When all of the effective bits of the operation status event register are set to "0" |
| RQS/ MSS | 6 | 64 | When SRQ is sent | · When the device clear is received<br>· When RQS reads the status byte by serial polling |
| ESB | 5 | 32 | When one of the effective bits of the standard event status register becomes "1" | When all of the effective bits of the standard event status register become "0" |
| MAV | 4 | 16 | When a response to the query has been prepared and can be output | When all of responses have been output and there are no more responses to be output |
| QUE | 3 | 8 | – | Always "0" (not used) |
| – | 2 | 4 | – | Always "0" (not used) |
| – | 1 | 2 | – | Always "0" (not used) |
| – | 0 | 1 | – | Always "0" (not used) |

■ **Relevant commands and queries**

**\*STB?**

This command can query contents of the status byte register.

Bit "6" is MSS (Master Summary Status).

**\*SRE, \*SRE?**

These commands can set and query the service request enable register.

Immediately after the power is turned on, the register will have been cleared to zero.

The status byte register bits will become effective when the corresponding bits in the service request enable register are set to "1". The service request will be issued when any one of the effective bits is set to "1".

Parameters for setting and response messages to each register are the sums of all the weights of the bits that have the value of "1".

■ **Checking status when making a query**

Normally, a correct response message can be received after a query has been sent, and it is not necessary to check the MAV bit of the status byte. If it is necessary to proceed with processes while the MAV bit is being checked, first check that the MAV bit of the status byte is "1" by serial polling after the query is sent and then read the response message. Then confirm that the MAV bit has changed to "0" and proceed with the next operation.

### 5.4.3 Standard event status

The structure of the standard event status is illustrated in **"Figure 5-23"**, and the details of the status are described in **"Table 5-5"**. If the bits of the standard event status enable register are set to "1", the corresponding bits of the standard event status register will be enabled, and if any of the enabled bits become the value "1", the ESB bit of the status byte register will be set to "1".
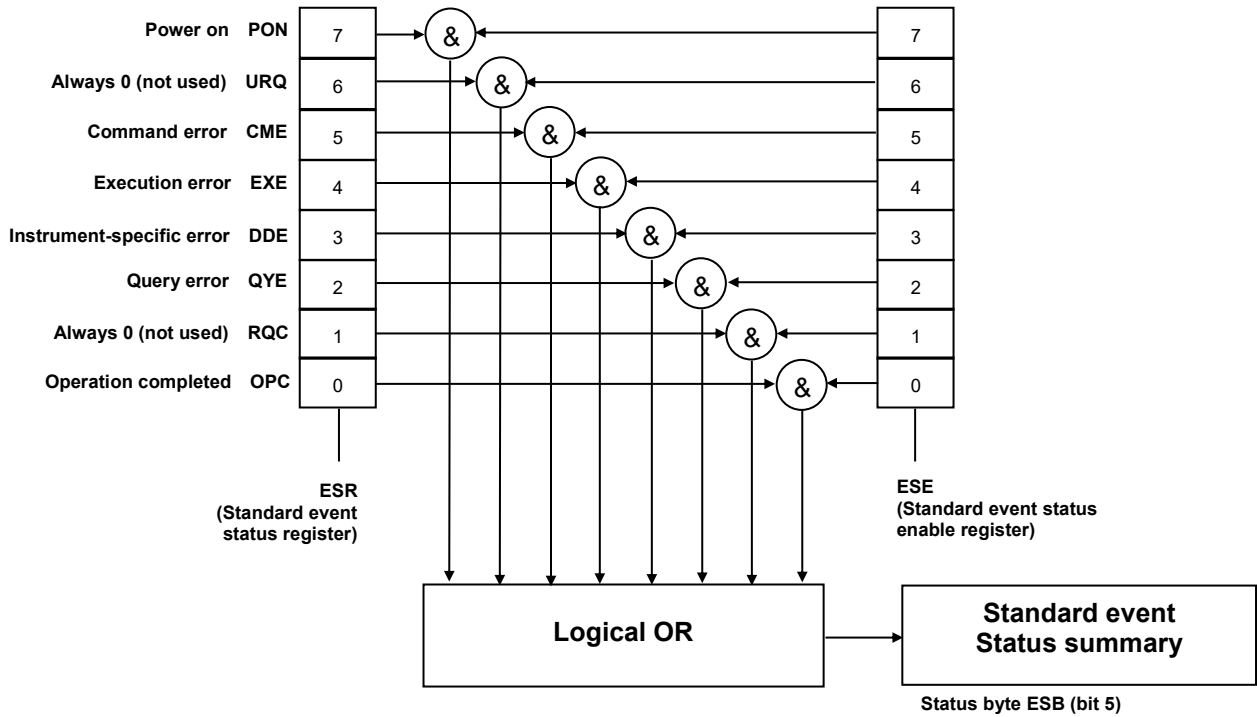


**Figure 5-23  Structure of the standard event status**

**Table5-5  Contents of the standard event status register**

| Bit | | Weight | Content |
|---|---|---|---|
| PON | 7 | 128 | Power-on<br>This bit will be set to "1" when the power is turned on. It will remain "0" until the power is turned on again when this register is read and the value is cleared to "0". |
| URQ | 6 | 64 | User's request<br>Always "0" (not used) |
| CME | 5 | 32 | Command error<br>This bit will be set to "1" if there is a syntax error in a remote command. |
| EXE | 4 | 16 | Execution error<br>This bit will be set to "1" if a parameter is out of range or there is a conflict in setting. |
| DDE | 3 | 8 | Instrument-specific error<br>This bit will be set to "1" if the error queue is overflowed. |
| QYE | 2 | 4 | Query error<br>This bit will be set to "1" if a read attempt is made when there is no data in the output buffer or if the data in the output buffer has been lost. |
| RQC | 1 | 2 | Request control<br>Always "0" (not used) |
| OPC | 0 | 1 | Operation completed<br>This bit will be set to "1" when processing for all commands up to the *OPC command has been completed. |

■ **Relevant commands and queries**

**\*ESR?**

This command can query contents of the standard event status register.

The register will be cleared to "0" if it is queried. The "*CLS" command also can clear the register.

The register will have been cleared to "0" immediately after the power is turned on, but the PON bit will have been set to "1".

**\*ESE, \*ESE?**

These commands can set and query the standard event status enable register.

Set the value "0" to clear the register to "0".

There are no other clear commands.

The register will have been cleared to "0" immediately after the power is turned on.

Parameters for setting and response messages to each register are the sums of all the weights of the bits that have the value of "1".

### 5.4.4 Operation status

The structure of the operation status is illustrated in **"Figure 5-24"**.
The operation condition register (OPCR) indicates a status of the **LI5501 / LI5502** as shown in **"Table 5-6"**. The transition filter can detect changes in the conditions and generates events. Generating an event requires settings of the transition filter. The operation status event register can store generated events. If the operation status event enable register bits are set to "1", the corresponding bits of the operation status event register will be enabled. If the value of any of the enabled bits is set to "1", the OPE bit of the status byte will be set to "1".

**OPCR (Operation status condition register)**
**OPTR (Positive transition filter)**
**ONTR (Negative transition filter)**

| Label | OPCR | OPTR | ONTR | OPER | | OPEE |
|---|---|---|---|---|---|---|
| Always 0 (not used) | 15 | 15 | 15 | 15 | & | 15 |
| Always 0 (not used) | 14 | 14 | 14 | 14 | & | 14 |
| Always 0 (not used) | 13 | 13 | 13 | 13 | | 13 |
| Out of sync ULOC | 12 | 12 | 12 | 12 | | 12 |
| Always 0 (not used) | 11 | 11 | 11 | 11 | | 11 |
| Buffer is full BUF | 10 | 10 | 10 | 10 | | 10 |
| Always 0 (not used) | 9 | 9 | 9 | 9 | | 9 |
| PSD adjusting BPSD | 8 | 8 | 8 | 8 | | 8 |
| PSD adjusting APSD | 7 | 7 | 7 | 7 | | 7 |
| Always 0 (not used) | 6 | 6 | 6 | 6 | | 6 |
| Awaiting trigger WTRG | 5 | 5 | 5 | 5 | | 5 |
| Recording MEAS | 4 | 4 | 4 | 4 | | 4 |
| Always 0 (not used) | 3 | 3 | 3 | 3 | | 3 |
| Always 0 (not used) | 2 | 2 | 2 | 2 | | 2 |
| Always 0 (not used) | 1 | 1 | 1 | 1 | & | 1 |
| Always 0 (not used) | 0 | 0 | 0 | 0 | & | 0 |

**OPER (Operation status event register)**

**OPEE (Operation status event enable register)**

**Logical OR**
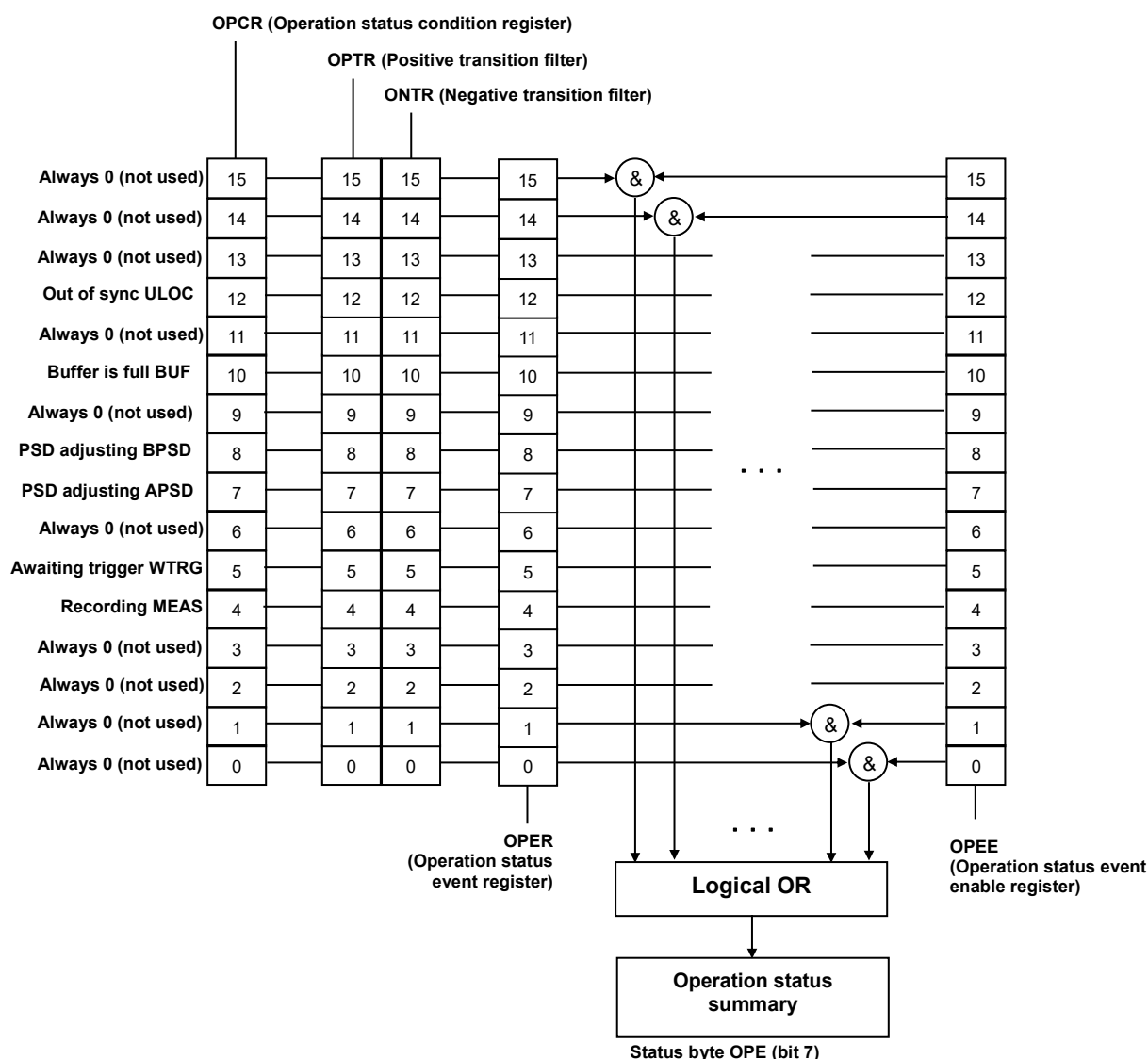
**Operation status summary**

**Status byte OPE (bit 7)**

**Figure 5-24  Structure of the operation status**

**Table5-6  Contents of the operation status condition register**

| Bit | | Weight | Content |
|---|---|---|---|
| — | 15 | 32768 | Always "0" (not used) |
| — | 14 | 16384 | Always "0" (not used) |
| — | 13 | 8192 | Always "0" (not used) |
| ULOC | 12 | 4096 | Not synchronized with external reference frequency (10 MHz) |
| — | 11 | 2048 | Always "0" (not used) |
| BUF | 10 | 1024 | The buffer is full. |
| — | 9 | 512 | Always "0" (not used) |
| BPSD | 8 | 256 | Adjusting DC offset to zero on the B in side |
| APSD | 7 | 128 | Adjusting DC offset to zero on the A in side |
| — | 6 | 64 | Always "0" (not used) |
| WTRG | 5 | 32 | Awaiting trigger |
| MEAS | 4 | 16 | Recording |
| — | 3 | 8 | Always "0" (not used) |
| — | 2 | 4 | Always "0" (not used) |
| — | 1 | 2 | Always "0" (not used) |
| — | 0 | 1 | Always "0" (not used) |

Note: When an external trigger is used, the MEAS bit is always "0".

■ **Relevant commands and queries**

**:STATus:OPERation:CONDition?**

This command can query contents of the operation status condition register.

The register will not be cleared to "0" if it is queried

The status of the instrument is always indicated.

**:STATus:OPERation[:EVENt]?**

This command can query the operation status event register.

The register will be cleared to "0" if it is queried.

The register can also be cleared by the "*CLS" command.

The register will have been cleared to "0" immediately after the power is turned on.

**:STATus:OPERation:ENABle , STATus:OPERation:ENABle?**

This command can set and query the operation status event enable register.

Set the value "0" to clear the register to "0".

There are no other clear commands.

The register will have been cleared to "0" immediately after the power is turned on.

**:STATus:OPERation:NTRansition, STATus:OPERation:NTRansition?**

**:STATus:OPERation:PTRansition, STATus:OPERation:PTRansition?**

These commands can set and query the operation status transition filters.

The relationships between a transition filter setting and event register transition are shown in **"Table 5-7"**.

**Table5-7  Transition filter settings and the event register transitions**

| Positive transition filter bit | Negative transition filter bit | Condition register transition for changing the event register to "1" |
|---|---|---|
| "1" | "0" | "0" → "1" |
| "0" | "1" | "1" → "0" |
| "1" | "1" | "0" → "1" or "1" → "0" |
| "0" | "0" | Event register cannot be changed to "1". |

Parameters for setting and response messages to each register are the sums of all the weights of the bits that have the value of "1".

## 5.4.5  Questionable status

The structure of the questionable status is illustrated in **"Figure 5-25"**.
The questionable condition register indicates an abnormal staus of the **LI5501 / LI5502** as shown in **"Table 5-7"**. The transition filter can detect changes in the conditions and generates events. Generating an event requires settings of the transition filter. The questionable event register can store generated events. If the event enable register bits are set to "1", the corresponding bits of the event register will be enabled. If the value of any of the enabled bits is set to "1", the QUE bit of the status byte will be set to "1".
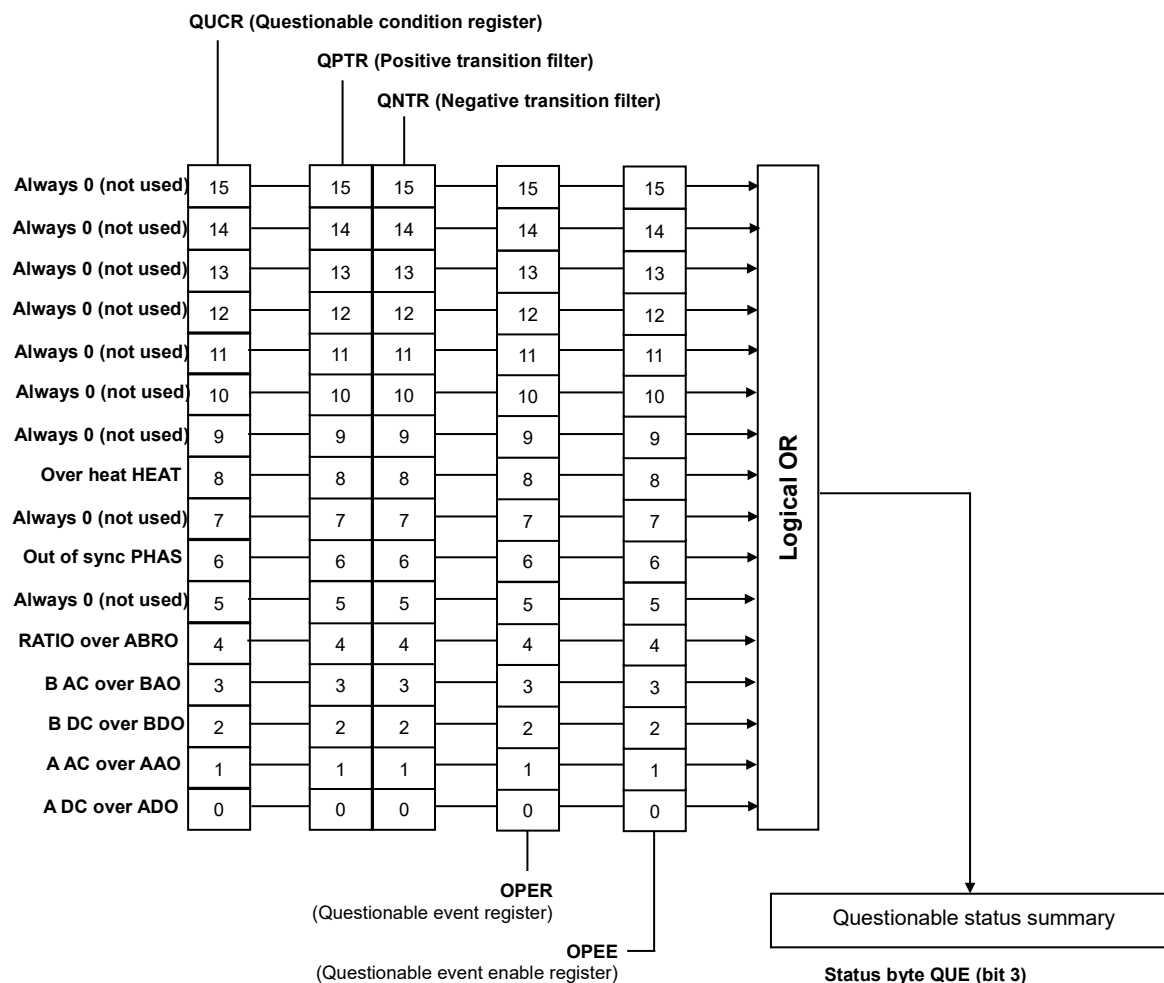


**Figure 5-25  Structure of the questionable status**

**Table5-8  Contents of the questionable condition register**

| Bit | | Weight | Content |
|---|---|---|---|
| — | 15 | 32768 | Always "0" (not used) |
| — | 14 | 16384 | Always "0" (not used) |
| — | 13 | 8192 | Always "0" (not used) |
| — | 12 | 4096 | Always "0" (not used) |
| — | 11 | 2048 | Always "0" (not used) |
| — | 10 | 1024 | Always "0" (not used) |
| — | 9 | 512 | Always "0" (not used) |
| HEAT | 8 | 256 | Overheated state |
| — | 7 | 128 | Always "0" (not used) |
| PHAS | 6 | 64 | Not synchronized with external reference signal |
| — | 5 | 32 | Always "0" (not used) |
| ABRO | 4 | 16 | Saturation in ratio operation |
| BAO | 3 | 8 | Saturation in the previous PSD stage on the B IN side |
| BDO | 2 | 4 | Saturation after PSD stage on the B in side[*] |
| AAO | 1 | 2 | Saturation in the previous PSD stage on the A IN side |
| ADO | 0 | 1 | Saturation after PSD stage on the A in side[*] |

*Saturation in the time constant filter, DC GAIN, moving average filter, EXPAND, or operational parts

■ **Relevant commands and queries**

**:STATus:QUEStionable:CONDition?**

This command can query contents of the questionable condition register.

The register will not be cleared to "0" if it is queried.

The status of the instrument is always indicated.

**:STATus:QUEStionable[:EVENt]?**

This command can query the questionable event register.

The register will be cleared to "0" if it is queried.

The register can also be cleared by the "*CLS" command.

The register will have been cleared to "0" immediately after the power is turned on.

**:STATus:QUEStionable:ENABle, STATus:QUEStionable:ENABle?**

This command can set and query the questionable event enable register.

Set the value "0" to clear the register to "0".

There are no other clear commands.

The register will have been cleared to "0" immediately after the power is turned on.

**:STATus:QUEStionable:NTRansition, STATus:QUEStionable:NTRansition?**
**:STATus:QUEStionable:PTRansition, STATus:QUEStionable:PTRansition?**

This command can set and query the questionable transition filter.

The relationships between a transition filter setting and event register transition are shown in **"Table 5-9"**.

**Table5-9  Transition filter settings and the event register transitions**

| Positive transition filter bit | Negative transition filter bit | Condition register transition for changing the event register to "1" |
|---|---|---|
| "1" | "0" | "0" → "1" |
| "0" | "1" | "1" → "0" |
| "1" | "1" | "0" → "1" or "1" → "0" |
| "0" | "0" | Event register cannot be changed to "1". |

Parameters for setting and response messages to each register are the sums of all the weights of the bits that have the value of "1".

## 5.5   Error messages

In this section, primary errors that occur in the remote control are described.

**Table5-10  Error messages  1/2**

| Error number | Error message | Description |
|---|---|---|
| 0 | No error | No abnormality |
| –100 | Command error | There is an abnormality in the command (no detailed classification). |
| –101 | Invalid character | There is an abnormality in the text data. |
| –102 | Syntax error | The command or data that cannot be recognized has been received. |
| –103 | Invalid separator | There is an abnormality in the command separators. |
| –104 | Data type error | The parameter format is inappropriate. |
| –108 | Parameter not allowed | There are too many parameters or there are parameters where it cannot be used. |
| –109 | Missing parameter | Not enough parameters |
| –110 | Command header error | There is an abnormality in the command header (no detailed classification). |
| –113 | Undefined header | The command header is undefined. |
| –115 | Unexpected number of parameters | There is an abnormality in the number of parameters. |
| –120 | Numeric data error | There is an abnormality in the numerical data (no detailed classification). |
| –123 | Exponent too large | The exponent is too large (greater than 32000). |
| –124 | Too many digits | A number has too many digits (more than 255-digit). |
| –130 | Suffix error | There is an abnormality in the SI prefix or unit (no detailed classification). |
| –134 | Suffix too long | The SI prefix or unit is too long (more than 7 characters). |
| –140 | Character data error | There is an abnormality in the text data (no detailed classification). |
| –144 | Character data too long | The text data is too long. |
| –150 | String data error | There is an abnormality in the string data (no detailed classification). |
| –200 | Execution error | The command could not be executed (no detailed classification). |
| –221 | Settings conflict | The command cannot be executed because of constraint conflicts among multiple settings. |
| –222 | Data out of range | The data is outside of the valid range. |
| –224 | Illegal parameter value | The parameters are incorrect (inappropriate other than "Data type error"). |

**Table5-10  Error message  2/2**

| Error number | Error message | Description |
|---|---|---|
| –310 | System error | An instrument-specific internal error has occurred. (memory contents were lost, etc.) |
| –350 | Queue overflow | The error queue has overflowed and cannot accommodate new errors. (more than 16 error queues) |
| –363 | Input buffer overrun | The input buffer has been overflowed. |
| –430 | Query DEADLOCKED | The buffer was full and the processing cannot proceed. The output buffer will be cleared. |
| –440 | Query UNTERMINATED after indefinite response | There was a query following "*IDN?" in the text string ("*IDN?" must be the last query in received text string.). |

Errors relevant to the remote control are stored in the error queue and can be read one at a time in order of oldest first with the ":SYSTem:ERRor?" query. If a read operation is executed after all of the errors have been read, "0, "No error"" will be returned. The error queue can be cleared with the "*CLS" command.
If a problem occurs that results in data remaining in the input buffer or output buffer, the buffers can be cleared with the device clear messages (DCL, SDC).

A error other than those described above may occur in some situations. In such case, check the error message for a summary.

# 6. Advanced settings

# 6.1 Measurement data buffer

The **LI5501 / LI5502** can acquire measurement data in two ways: Streaming, which uses the internal memory and can acquire a large amount of data, and Querying, which queries the latest measurement data with the ":FETCh?" command.

This section describes setting items for these data acquisition ways.

## 6.1.1 Setting of measurement data parameters

Up to 7 measurement data (7 words) parameters to be obtained can be selected from the **"Table 6-1"**.

**Table6-1 Measurement data parameters**

| Weight | Parameter | Description | Bit length | |
|--------|-----------|-------------|-----------|----------|
| | | | Streaming | Querying |
| 1 | STATUS | Status | 16 bits | 16 bits |
| 2 | FREQ-H | Upper bits of reference signal frequency | 16 bits | 16 bits |
| 4 | FREQ-L | Lower bits of reference signal frequency | 16 bits | 20 bits |
| 8 | $X_A$ | X value on the A IN side | 16 bits | 18 bits |
| 16 | $Y_B$ | Y value on the A IN side | 16 bits | 18 bits |
| 32 | $R_A$ | R value on the A IN side | 16 bits | 20 bits |
| 64 | $\theta_A$ | θ value on the A IN side | 16 bits | 20 bits |
| 128 | $X_B$ | X value on the B IN side | 16 bits | 18 bits |
| 256 | $Y_B$ | Y value on the B IN side | 16 bits | 18 bits |
| 512 | $R_B$ | R value on the B IN side | 16 bits | 20 bits |
| 1024 | $\theta_B$ | θ value on the B IN side | 16 bits | 20 bits |
| 2048 | RATIO | Amplitude ratio of $R_A$ to $R_B$ | 16 bits | 20 bits |
| 4096 | PHASE | Phase difference between $\theta_A$ and $\theta_B$ | 16 bits | 20 bits |

The "STATUS" descriptions are shown in below.

| Weight | STATUS | Description |
|--------|--------|-------------|
| 1 | —— | Indefinite |
| 2 | —— | Indefinite |
| 4 | —— | Indefinite |
| 8 | RATIO over | Saturation in ratio operation |
| 16 | MOV over (B) | Saturation in the MOV filter or EXPAND on the B IN side |
| 32 | MOV over (A) | Saturation in the MOV filter or EXPAND on the A IN side |
| 64 | LPF over (B) | Saturation in the TC filter or DC GAIN on the B IN side |
| 128 | LPF over (A) | Saturation in the TC filter or DC GAIN on the A IN side |
| 256 | ADC over (B) | Saturation in the previous PSD stage on the B IN side |
| 512 | ADC over (A) | Saturation in the previous PSD stage on the A IN side |
| 1024 | —— | Indefinite |
| 2048 | —— | Indefinite |
| 4096 | —— | Indefinite |
| 8192 | —— | Indefinite |
| 16384 | OSC over | Overvoltage at the oscillator output |
| 32768 | UNLOCK | No synchronization |

## 6.1.2  Format

### 1)Streaming

Measured data is read in order of ascending weight of parameters.

The data is sent in blocks of one measurement data without a comma or message terminator.

The measured value can be obtained using the following formula after converting signed 4-digit hexadecimal (16 bits) to signed 16-bit integer format (−32,768 to 32,767).

Measured value = Measured data $\times 2^{-15} \times 1.2 \times$ full-scale of a meter (See below.)

The actual value of parameter received in integer format can be determined by the bit length recorded in the measurement data buffer using the following formula.

| Parameter | Formula |
|---|---|
| R | Measured value = Measured data $\times 2^{-15} \times 1.2 \times$ (Sensitivity / EXPAND) |
| X <br> Y | Measured value = Meter value × (Sensitivity / EXPAND) <br> Meter value = Measured data $\times 2^{-15} \times 1.2$ |
| RATIO | Measured value = Measured data $\times 2^{-15} \times (5 / 3) \times 2.4 \times$ Sensitivity ratio <br> Sensitivity ratio = <br> (A IN Sensitivity / B IN Sensitivity) × (A IN EXPAND / B IN EXPAND) |
| θ <br> PHASE | Measured value = Measured data $\times 2^{-15} \times 180°$ |
| Frequency | Frequency = $(A \times 2^{16} + B) \times 2^{-33} \times 2.5$ MHz <br> Measured frequency data is transferred after divided unsigned 8-digit hexadecimal data (32 bits) into A: FREQ-H and B: FREQ-L. <br> This is converted to an unsigned 16-bit integer format (0 to 65,535) and the measurement value can be calculated from it. |

If the sensitivity setting when querying measured data is different from the setting when recording the data, correct measurement results cannot be obtained.

## 2)Querying

Measured data can be read by the ":FETCh?" command in order of ascending weight of parameters.

Each value is separated by commas.

The actual value of parameter received in integer format can be determined by the bit length recorded in the measurement data buffer using the following formula.

| Parameter | Formula |
|---|---|
| R | Measured value = Measured data × $2^{-19}$ × 1.2 × (Sensitivity / EXPAND) |
| X<br><br>Y | Measured value = Meter value × (Sensitivity / EXPAND)<br>Meter value = Measured data × $2^{-17}$ × 1.2<br>If a calculated meter value is greater than or equal to 1.2, subtract 2.4 to obtain a range of −1.2 to 1.2. |
| RATIO | Measured value = Measured data × $2^{-19}$ × 2.4 ×Sensitivity ratio<br>Sensitivity ratio =<br>(A IN Sensitivity / B IN Sensitivity) × (A IN EXPAND / B IN EXPAND) |
| θ<br>PHASE | Measured value = Measured data × $2^{-19}$ × 180°<br>If a calculated value is greater than or equal to 180, subtract 360 to obtain a range of −180.000 to +179.999. |
| Frequency | Frequency = (A × $2^{20}$ + B) × $2^{-37}$ × 2.5 MHz<br>A measured frequency data is transferred after divided into A: FREQ-H and B: FREQ-L. |

If the sensitivity setting when querying measured data is different from the setting when recording the data, correct measurement results cannot be obtained.

### 6.1.3 Triggering system

This section describes settings for continuous data acquisition using the measurement data buffer.

**1) Sampling interval**

This is the sampling interval for data acquisition.

- Range: 0.4 µs to 26.2 ms

**2) Buffer size**

This is the number of samples per trigger.

- Range: 1 to 65536 or INF (continuous)

**3) Trigger source**

Select the trigger source from the remote control command by computer (BUS) or external signal (EXT) to the trigger pin in the power supply terminal.

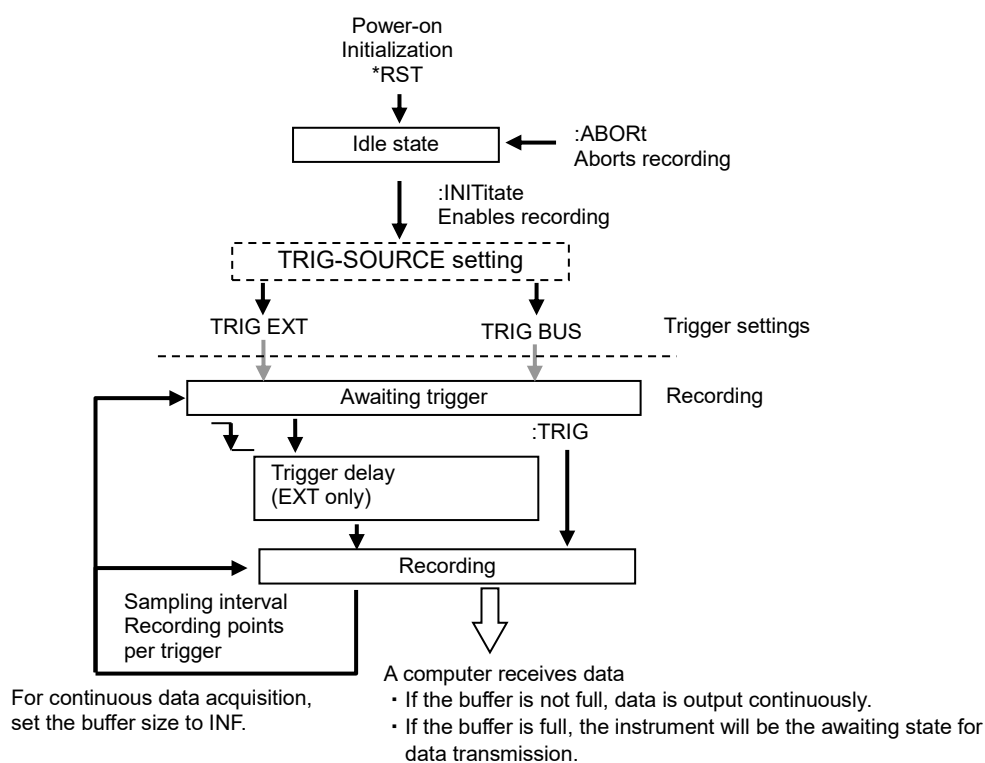When the trigger source is EXT, the instruments is triggered by falling edge of an external signal.

- Trigger source: BUS or EXT

**4) Trigger delay**

When the trigger source is EXT, set the trigger delay.

When the trigger source is BUS, adjust a timing on a computer side.

- Range: 0 to 1.67 s

```
                        Power-on
                        Initialization
                        *RST
                            │
                            ▼
                    ┌──────────────┐        :ABORt
                    │  Idle state  │ ◄────  Aborts recording
                    └──────────────┘
                            │  :INITitate
                            │  Enables recording
                            ▼
                ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
                   TRIG-SOURCE setting
                └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
                    │                   │
                    ▼                   ▼
                TRIG EXT            TRIG BUS        Trigger settings
            ─ ─ ─ ─│─ ─ ─ ─ ─ ─ ─ ─ ─ ─│─ ─ ─ ─
                   ▼                    ▼
            ┌──────────────────────────────┐
        ┌──►│      Awaiting trigger        │      Recording
        │   └──────────────────────────────┘
        │       │  │              │  :TRIG
        │       │  ▼              │
        │   ┌──────────────┐      │
        │   │ Trigger delay│      │
        │   │  (EXT only)  │      │
        │   └──────────────┘      │
        │          │              │
        │          ▼              ▼
        │   ┌──────────────────────────────┐
        │   │          Recording           │
        │   └──────────────────────────────┘
        │      Sampling interval    │
        │      Recording points     ▽
        └──────per trigger
```

For continuous data acquisition, set the buffer size to INF.

A computer receives data
- If the buffer is not full, data is output continuously.
- If the buffer is full, the instrument will be the awaiting state for data transmission.

## 6.1.4  Sample programs of data acquisition

Sample programs using the measurement data buffer are shown below.

Example 1) Records measurement data at arbitrary timing and then reads them together

```
Send (":ABOR")
    ' If recording is in progress, it is aborted.
Send (":DATA:FEED 96")
    ' Sets the measurement data set for recording
Send (":DATA:POIN 1")
    ' Sets the number of samples per trigger
Send (":DATA:FEED:CONT ALW")
    ' Enables recording into the measurement data buffer
Send (":TRIG:SOUR BUS")
    ' Sets the trigger source to the remote control command
Send (":INIT")
    ' Transition to the awaiting trigger state

Send (":TRIG")
    ' Applies the trigger to repeatedly record measurement data
    ' If the measurement data buffer becomes full during recording,
      the trigger system enters the idle state and further triggers are not accepted.

Send (":DATA:DATA?")
    ' Requests sending measurement data
Receive (MLIN_1, PHAS_1, MLIN_2, PHAS_2, MLIN_3, PHAS_3, ...)
    ' Reads out measurement data from the measurement data buffer
```

Example 2) Reads out measurement data while recording it

Send (":ABOR")
 ' If recording is in progress, it is aborted.
Send (":DATA:FEED 96")
 ' Sets the measurement data set for recording
Send (":DATA:POIN INF")
 ' Sets the number of samples per trigger
Send (":DATA:FEED:CONT ALW")
 ' Enables recording into the measurement data buffer
Send (":DATA:PER 1E-3")
 ' Sets the recording cycle of measurement data
Send (":TRIG:SOUR BUS")
 ' Sets the trigger source to the remote control command
Send (":INIT")
 ' Transition to the awaiting trigger state
Send (":TRIG")
 ' Applies the trigger to repeatedly record measurement data
 ' If the measurement data buffer becomes full during recording,
  the trigger system enters the idle state and further triggers are not accepted.


Send (":DATA:COUNt?")
 ' Queries the number of data sampling points recorded in the buffer
 ' The number of samples requested by computer is less than or equal to
  recorded number of samples.
Send (":DATA:DATA?")
 ' Requests sending measurement data
Receive (MLIN_1, PHAS_1, MLIN_2, PHAS_2, MLIN_3, PHAS_3, ... )
 ' Receives data on requested number of samples
 ' If readout is faster than recording, the buffer doesn't become full
  and recording can continue.
 ' If the buffer becomes full, no more data will be recorded.

Send (":DATA:FEED:CONT NEV")
 ' Stops recording after acquiring necessary data

## 6.2　Configuration memory

There are 16 sets of the configuration memory from No.0 to 15.

The No.1 to 14 memories are for user's memory. Frequently used settings can be saved to the memories and recalled when needed.

The No.15 memory is factory default settings memory. The factory default settings can be recalled.

The No.0 memory is the RESUME memory. The current settings are always saved to the memory during power-on and saved even when the power is turned off.

The MODE switch on the rear panel is used to recall settings stored in the configuration memory.

MODE Switch

"0" to "9" and "A" to "F" on the MODE switch correspond to the configuration memory numbers "0" to "9" and "10" to "15" respectively.

The table below summarizes the configuration memory.

| Memory number | Function | User operation | | | |
|---|---|---|---|---|---|
| | | Save | Recall | *RST | :SYS:RST |
| 0 | RESUME | Always | ―――― | Initialized | Initialized |
| 1 to 14 | User's memory | By command | By command or switch | Unchanged | Initialized |
| 15 | Factory default settings | ―――― | By command or switch | ―――― | ―――― |

The RESUME memory can be initialized by the "*RST" command.

The RESUME and user's memory can be initialized by the ":SYS:RST" command.

### 6.2.1　Recall settings

**1)MODE switch**

The number set on the MODE switch is recalled at startup.

If the MODE switch is changed during power-on, settings stored in the memory number will be recalled.

If the mode switch is set to "0" when the power is turned on, the settings at the time the power is previously turned off are recalled.

**2)Recall settings by remote control**

Settings stored in specified memory number can be recalled by remote control.

### 6.2.2　Save settings

**1)Save current settings**

Current settings (contents of the RESUME memory) can be saved to a specified user's memory.

## 6.3 FAN control

This instrument contains electronic components that generate a lot of heat in small enclosure. Ambient temperature above 40 °C will shorten the life of the instrument. Therefore, the cooling fan is equipped with the instrument.
In acoustic or vibration measurement, the cooling fan may affect the measurement system, so turn it off if necessary.

The fan control can be set to always ON, always OFF, or AUTO. For details, refer to **"5.3.3.77 :SYSTem:FAN:CONTrol <value>"**.
In "AUTO" setting, the fan is automatically controlled according to measured temperature of the CPU inside the instrument. The fan will be turned on when the measured temperature exceeds about 60 °C and turned off when the temperature drops below about 55 °C.
The ventilation holes are provided on the sides of the instrument, and the airflow direction is as shown in the figure below.
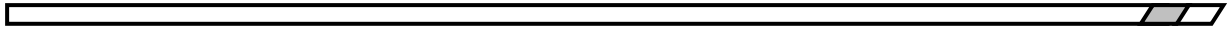The life of the fan in continuous operation is about 30,000 hours.
When the fan is turned on, dust or foreign matter may be absorbed into the enclosure, resulting in corrosion and failure. Periodic maintenance (cleaning) is recommended.



---
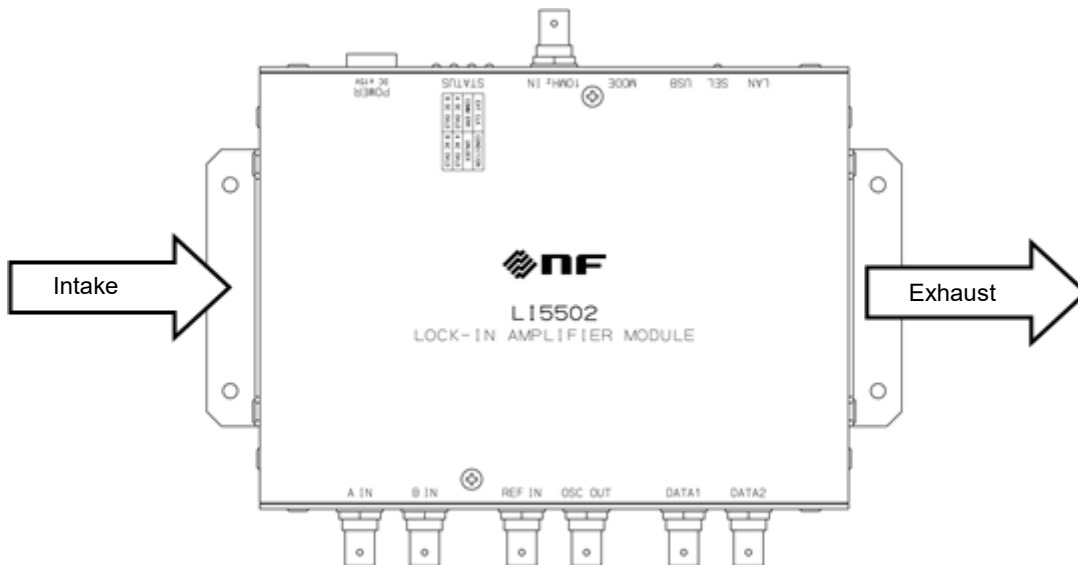
⚠ **CAUTION**

As an internal temperature of the instrument becomes hot, the enclosure and metal parts of the connectors also become hot.

---

(Blank)

# 7.   Troubleshooting

## 7.1 Error messages

To check operational status of the instrument, check the LEDs on the rear panel or use the remote command. Refer to **"5.4 Status system"** and **"5.5 Error messages"** about the status system and error messages due to communication.

Main errors that occur during normal measurement are described in this section, along with their causes and how to deal with them.

If the instrument requires repair, please contact the NF Corporation or its authorized agent.

When requesting repair, please provide the error message and symptom.

An error message that are not described in this manual may also appear during unusual operations such as updating the instrument firmware. If other manuals are provided, refer to them as well.

## 7.2 Abnormalities during measurement

In addition to error detection by remote control, LEDs on the rear panel can be used to detect abnormalities.

| LED name and Color | Description and cause | Handling |
|---|---|---|
| CONDITION Green | ・The LED does not light up.<br>・The LED blinks during startup. The calibration data was lost and the specified performance cannot be maintained. | ・Review the power supply voltage.<br>・Contact the NF Corporation or its authorized agent and request a repair. |
| EXT-CLK Green | ・The LED blinks. When the external 10 MHz setting is enabled, no external 10 MHz signal is applied. | ・Input a specified 10 MHz signal to the 10MHz IN terminal.<br>・Check if the input 10 MHz input signal can be driven.<br>・The instrument can work with the internal reference clock even when the LED is blinking. |
| UNLOCK Orange | ・The LED lights up. The instrument is not synchronized with a reference signal | ・An external reference signal is not connected.<br>・The related settings are not appropriate.<br>・The amplitude of the input signal is too low or out of the frequency range. |
| COMM ERR Orange | ・The LED lights up. Communication failure occurred. The data buffer is full. | ・Change data buffer settings. |
| A AC OVLD Orange | ・The LED lights up. Saturation in the previous PSD stage on the A IN side | ・Check input signal amplitude on the A IN side.<br>・Review the dynamic reserve setting on the A IN side. |
| A DC OVLD Orange | ・The LED lights up. Saturation after the PSD on the A IN side | ・Review settings of the time constant filter, DC GAIN, OFFSET, and EXPAND on the A IN side. |
| B AC OVLD* Orange | ・The LED lights up. Saturation in the previous PSD stage on the B IN side | ・Check input signal amplitude on the B IN side.<br>・Review the dynamic reserve setting on the B IN side. |
| B DC OVLD* Orange | ・The LED lights up. Saturation after the PSD on the B IN side | ・Review settings of the time constant filter, DC GAIN, OFFSET, and EXPAND on the B IN side. |

*B AC/DC OVLD are **LI5502** only.

(Blank)

# 8. Maintenance

# 8.1   Introduction

The maintenance items required to keep the instrument in good condition for use are listed below.

- Operational inspection       Check whether the instrument is functioning properly.

- Performance test             Check whether the instrument is operating at the rated performance levels.

- Adjustment and calibration   If the instrument does not meet the specifications, the NF Corporation will adjust and calibrate the instrument to restore performance.

- Repair                       If adjustment and calibration fail to improve performance, the NF Corporation will investigate the cause, locate the failure, and repair the instrument.

This instruction manual describes how you can easily check for proper operation of the instrument and performance test methods.
For more advanced inspection, adjustment, calibration, and repair, contact the NF Corporation or its authorized agent.

### ⚠ WARNING

There are high temperature locations and Precision electronic components inside the instrument. Do not remove the cover.
Inspection of the interior of the instrument should not be performed by anyone other than service technicians that have been trained to avoid hazards.

## 8.2    Daily maintenance

Before use, install the instrument in a location that satisfies the installation conditions.
**Installation conditions → Refer to "2.2.2 Installation environment"**
Clean the outside of the instrument using a soft cloth as necessary. To remove stubborn soiling, use a cloth that has been dampened with a mild detergent solution and squeezed well to remove excess liquid. Do not use organic solvents such as paint thinner or benzene, or a chemically-treated cloth. Doing so may result in degradation, a cloudy appearance, or peeling of paint.

## 8.3    Storage, repacking, and transport

The **LI5501 / LI5502** should be stored in a location that satisfies the storage conditions.
**Storage conditions → Refer to "2.2.2 Installation environment"**.
When packing the instrument for transportation, etc., use a box that is sufficiently strong and large enough to provide a surplus of space. Fill the box with packing materials that can withstand the weight of the instrument so that it is fully protected.
Make sure that the package is handled with care to avoid strong shock during transport.

## 8.4    Checking the version number

Because the instrument continues to be improved, instruments may have the same model name but may have different firmware versions. Instruments that have different firmware versions may differ in operation. When a problem arises, be sure to include the firmware version number with description of the problem.

Use the "*IDN?" command to check the firmware version number.

### ■ Serial number

If the serial number cannot be checked by the "*IDN?" command, check the nomenclature label on the bottom of the instrument.

MODEL
SERIAL NO.

NF Corporation          MADE IN JAPAN
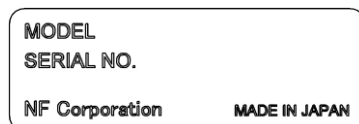
Nomenclature label

Label of
passing inspection

## 8.5 Performance tests

### 8.5.1 Introduction

The performance tests are a part of preventive maintenance and is performed to prevent degradation of instrument performance. The tests should be done for acceptance inspection, periodic inspections, and whenever it is necessary to check the performance, such as after repair.

The simple performance tests described here can be performed using commercially available standards and measurement instruments. For advanced tests, please contact the NF Corporation or its authorized agent. This is available for a charge.

If the performance tests indicate that the instrument does not satisfy the specifications, calibration or repair is required. In that case, please contact the NF Corporation or its authorized agent.

**1) Test environment**

The performance tests should be performed under the following conditions.
- ・Ambient temperature       23 ± 5 °C
- ・Ambient humidity       20 to 70 %RH, no condensation
- ・Power supply requirements       ± 15 VDC, 1 A or more
- ・Warm-up time       20 minutes or more

**2) Preparation for tests**

Before doing the tests, initialize the settings.

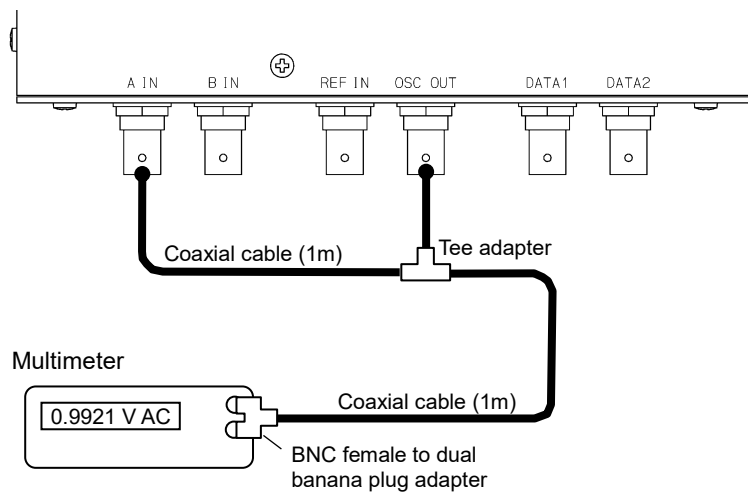To initialize the settings, set the MODE switch to "F" and power-on.

## 3) Test equipment

The measurement instruments needed for the tests are listed as below.

| Product | Required specifications | Example model |
|---------|-------------------------|---------------|
| Function generator | Waveform: Sine wave<br>Frequency: 1 mHz to 1.05 MHz<br>Amplitude: 10 mVrms to 7 Vrms<br>TTL output synchronized with sine wave | WF1947<br>(NF Corp.) |
| Digital multimeter | AC voltmeter (true rms)<br>  (100 mV to 1 V range)<br>   Accuracy: ± 0.1 % (10 Hz to 20 kHz)<br>DC voltmeter<br>  (100 mV to 100 V range)<br>   Accuracy: ± 0.04 % | 34401A<br>(Keysight) |
| Oscilloscope | Bandwidth: 10 MHz or more<br>Time / division: 10 s / division or faster<br>For monitoring | TBS2072B<br>(Tektronix) |
| Others | | |
|   Coaxial cables | 50 Ω, BNC, equivalent to RG58/U | |
|   Shorted plug | BNC shorted plug or 50 Ω BNC terminator | |
|   Adapter | BNC, Tee adapter | |

## 8.5.2  Voltage measurement accuracy

In the following descriptions, the **LI5502** is shown in the connection diagrams as a representative.

| | |
|---|---|
| **LI5502** settings: | Set the reference signal source to INT OSC (internal oscillator). Set the frequency to 1 kHz. Set the time constant to 100 ms. Set the attenuation slope to 24 dB/oct. Set the measurement parameter to R. Turn on the oscillator output. The amplitude, dynamic reserve, and sensitivity are shown in the following table. Perform the test for each input. |
| Measurement Instrument settings: | Set the multimeter to AC voltage measurement mode. |
| Connections: | Connect a coaxial cable from one side of a tee adapter at the OSC OUT terminal to the A IN terminal. Connect another coaxial cable from the other side of the adapter to the multimeter. |
| Measurement method: | Set the following specified amplitude, dynamic reserve, and sensitivity and read the measured value and multimeter. |
| Judgement (passing range): | See the table below. |

judgement

| Input | Dynamic reserve | Sensitivity [rms] | Internal oscillator amplitude [rms] | R: Measured value [rms] S: DMM reading [rms] R / S | Passing range (R / S) |
|---|---|---|---|---|---|
| A IN | HIGH | 1 V | 1 V | _ . _ _ _ _ V<br>_ . _ _ _ _ V     _ . _ _ _ | 0.995 to 1.005 * |
| | MED | 1 V | 1 V | _ . _ _ _ _ V<br>_ . _ _ _ _ V     _ . _ _ _ | 0.995 to 1.005 |
| | LOW2 | 100 mV | 100 mV | _ _ _ . _ mV<br>_ _ _ . _ mV     _ . _ _ _ | 0.995 to 1.005 * |
| | LOW1 | 10 mV | 10 mV | _ _ . _ _ mV<br>_ _ . _ _ mV     _ . _ _ _ | 0.995 to 1.005 * |
| B IN | HIGH | 1 V | 1 V | _ . _ _ _ _ V<br>_ . _ _ _ _ V     _ . _ _ _ | 0.995 to 1.005 * |
| | MED | 1 V | 1 V | _ . _ _ _ _ V<br>_ . _ _ _ _ V     _ . _ _ _ | 0.995 to 1.005 |
| | LOW2 | 100 mV | 100 mV | _ _ _ . _ mV<br>_ _ _ . _ mV     _ . _ _ _ | 0.995 to 1.005 * |
| | LOW1 | 10 mV | 10 mV | _ _ . _ _ mV<br>_ _ . _ _ mV     _ . _ _ _ | 0.995 to 1.005 * |

*These are supplementary values, not guaranteed values.

These values are generally in this range, but if these are significantly out of range, the instrument may be malfunctioning.

### 8.5.3  Analog outputs voltage accuracy

| | |
|---|---|
| **LI5502** settings: | Set the reference signal source to INT OSC (internal oscillator).<br>Set the frequency to 1 kHz.<br>Set the internal oscillator amplitude to 0 V.<br>Set the time constant to 100 ms.<br>Set the attenuation slope to 24 dB/oct.<br>Set the measurement parameter of DATA1 to X and that of DATA2 to Y.<br>Set the offset values for both X and Y as shown in the table below. |
| Measurement Instrument settings: | Set the multimeter to DC voltage measurement mode. |
| Connections: | Connect a shorted plug or 50Ω terminator to the A IN terminal.<br>Connect the DATA1 or DATA2 terminal to the digital multimeter with a coaxial cable. |
| Measurement method: | Set the following specified offset value and read the measurement value on the multimeter. |
| Judgement (passing range): | See the table below. |
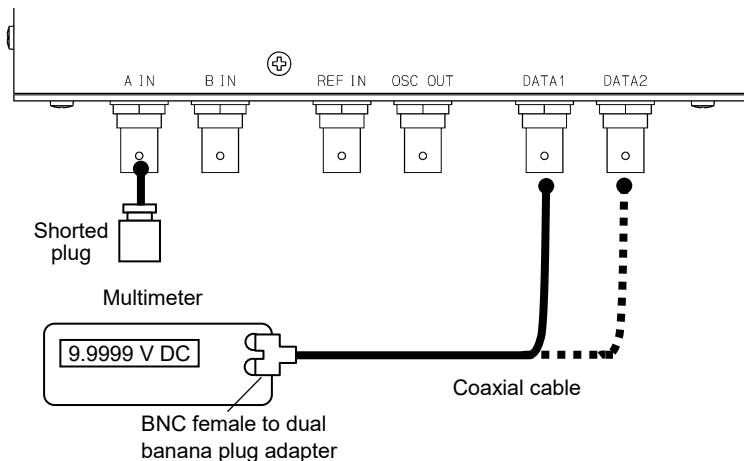


Judgement

| Offset values (X and Y) | DMM reading<br>Passing range (± 10 V ± 60 mV at ± 100% and ± 10 mV at 0%) | |
|---|---|---|
| | DATA1 (X) | DATA2 (Y) |
| +100% | + _ _ . _ _ _ V | + _ _ . _ _ _ V |
| 0% | _ _ _ . _ _ mV | _ _ _ . _ _ mV |
| −100% | − _ _ . _ _ _ V | − _ _ . _ _ _ V |

## 8.5.4  Phase accuracy

### 1)  Relative to external reference signal

|  |  |
|---|---|
| **LI5502** settings: | Set the reference signal source to REF IN (external reference). |
|  | Set the reference signal waveform to SIN. |
|  | Set the sensitivity to 1 V and dynamic reserve to MED. |
|  | Set the measurement parameter to θ. |
|  | Set the time constant to 100 ms. |
|  | Set the attenuation slope to 24 dB/oct. |
| Measurement | Set the wave form to a sine wave. |
| Instrument | Set the frequency to 1 kHz and the amplitude to 1 Vrms. |
| settings: |  |
| Connections: | Connect a coaxial cable from one side of a tee adapter at the function generator output terminal to the A IN terminal. |
|  | Connect another coaxial cable from the other side of the adapter to the REF IN terminal. |
| Measurement method: | Read the measured θ value by remote control. |
| Judgement (passing range): | See the table below. |



Use same length and characteristics cables.
Shorter cables are preferable.

Judgement

| Input | Frequency | θ | Passing range * |
|---|---|---|---|
| A IN | 1 kHz | _ _ _ . _ _ ° | −1 to +1 ° |
| B IN | 1 kHz | _ _ _ . _ _ ° | −1 to +1 ° |

*This is a supplementary value, not guaranteed value.

**2) Relative to the internal oscillator**

| | |
|---|---|
| **LI5502** settings: | Set the reference signal source to INT OSC (internal oscillator). |
| | Set the wave form to a sine wave. |
| | Set the frequency to 1 kHz. |
| | Set the internal oscillator amplitude to 1 Vrms. |
| | Turn on the oscillator output. |
| | Set the measurement parameter to θ. |
| | Set the time constant to 100 ms. |
| | Set the attenuation slope to 24 dB/oct. |
| Measurement Instrument settings: | Only a coaxial cable is used. |
| Connections: | Connect the A IN terminal and OSC OUT terminal with a coaxial cable. |
| Measurement method: | Read the measured θ values by remote control. |
| Judgement (passing range): | See the table below. |



Coaxial cable (1m)
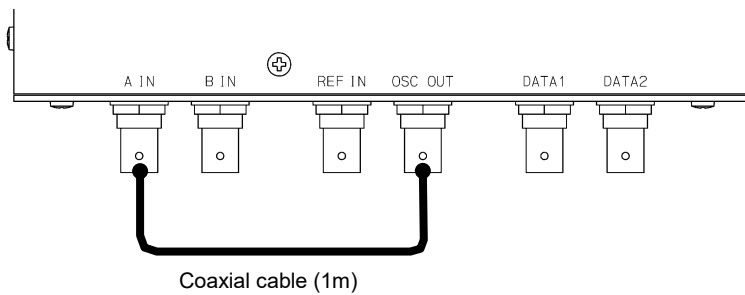
Judgement (same as **1) Relative to external reference signal**)

| Input | Frequency | θ | Passing range * |
|---|---|---|---|
| A IN | 1 kHz | _ _ _ . _ _ ° | −1 to +1 ° |
| B IN | 1 kHz | _ _ _ _ . _ _ ° | −1 to +1 ° |

*This is a supplementary value, not guaranteed value.

## 8.5.5  Amplitude accuracy of the internal oscillator

**LI5502** settings:     Set the reference signal source to INT OSC (internal oscillator).
                         Set the wave form to a sine wave.
                         Set the frequency to 1 kHz.
                         Set the internal oscillator amplitude to 1 Vrms.
                         Turn on the oscillator output.

Measurement          Set the multimeter to AC voltage measurement mode.
Instrument
settings:
Connections:         Connect the OSC OUT terminal to the multimeter with a
                     coaxial cable.
Measurement          Read the measurement value on the multimeter.
method:
Judgement            See the table below.
(passing range):
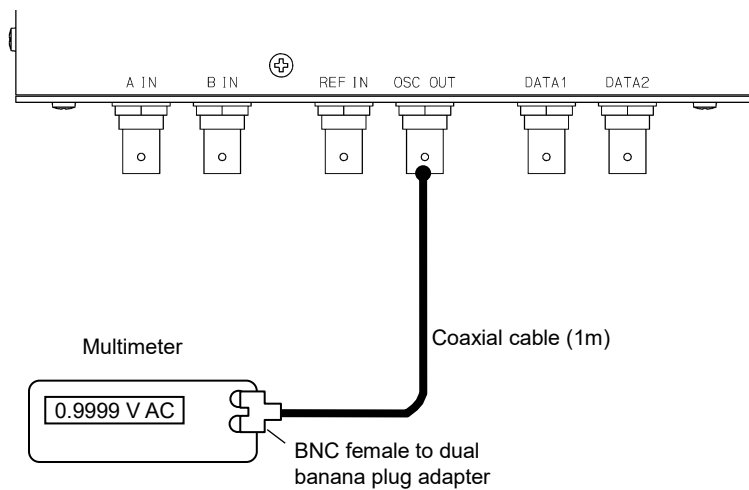


Judgement

| Frequency | Oscillator amplitude | DMM reading [rms] | Passing range |
|-----------|---------------------|-------------------|---------------|
| 1 kHz | 1 Vrms | _ . _ _ _ _ V | 0.955 to 1.045 V |

## 8.6  Calibration

If the performance tests reveal that the instrument fails to satisfy the specifications, the NF Corporation will adjust or calibrate the instrument to restore performance.
If calibration is required, please contact the NF Corporation or its authorized agent.
Adjustment or calibration that is performed outside the warranty period is available for a charge.

# 9. Specifications

## Nominal, typical, supplementary and approximate values

These values imply the supplemental data of this instrument and do not guarantee the instrument performance.

## 9.1    Input section

This section describes specifications of the input terminals such as the signal input terminals and reference signal input terminal.

### 9.1.1  Signal inputs

| | |
|---|---|
| Input connector | BNC |
| No. of channels | LI5501: 1 (Terminal name: A IN) |
| | LI5502: 2 (Terminal names: A IN, B IN) |
| Input type | Single-ended |
| Input impedance | 1 MΩ (nominal value), 20 pF in parallel (supplementary value) |
| Frequency range | DC to 1.05 MHz |
| Voltage gain | 0.2x / 1x / 10x / 100x (AC GAIN) |

Voltage gain temperature drift

$\pm$ 250 ppm / °C (supplementary value)

1 kHz frequency

| | |
|---|---|
| Input-referred noise | 25 nV/√Hz (supplementary value) |

1 kHz frequency, 100x voltage gain, input shorted

| | |
|---|---|
| Harmonic distortion | −70 dBc or less (supplementary value) |

1 Vrms input siganl, 1x voltage gain, 20 Hz to 100 kHz, second and third harmonics respectively

Maximum input voltage (for linear operation)

$\pm$ 5 V

Non-destructive maximum input voltage

$\pm$ 10 V

Impedance between the signal ground and chassis ground

22 Ω (nominal value), $\pm$ 1 V

### 9.1.2  Reference signal input

| | |
|---|---|
| Input connector | BNC |
| No. of channels | 1 (Terminal name: REF IN) |
| Imput impedance | 1 MΩ (nominal value), 20 pF in parallel (supplementary value) |
| Frequency range | DC to 1.05 MHz |
| Input voltage range | Sine wave (SIN): 0.4 to 6 Vp-p |
| | Square wave (TTL): 0 to 5 V |
| | high level 2.6 V or more, low level 0.8 V or less |
| Pulse width (square wave) | 100 ns or more (both high and low levels) |

Non-destructive maximum input voltage

$\pm$ 10 V

### 9.1.3  External reference frequency input

Input connector            BNC

No. of channels            1 (Terminal name: 10MHz IN)

Frequency range            10 MHz ± 0.2 %

Waveform                   Sine wave or square wave (45 to 55 % duty cycle)

Signal level               0.5 to 5 Vp-p

Non-destructive maximum input voltage

                           10 Vp-p

Input impedance            500 Ω (approximate value)

Input coupling             AC

Withstand voltage          ± 42 Vpeak max (DC + AC)

(allowable voltage to enclosure)

Reference frequency source Internal or external

                           If a reference signal for frequency synthesis is applied to the
                           10MHz IN terminal from an external source, the internal
                           oscillator generates the reference signal synchronized with
                           that external 10 MHz frequency. Therefore, measurement can
                           be performed without applying an external reference signal.

## 9.2 Output section

This section describes specifications of the output terminals such as the internal oscillator output terminal and measurement data output terminals.

### 9.2.1 Oscillator output

| | |
|---|---|
| Output connector | BNC |
| No. of channels | 1 (Terminal name: OSC OUT) |
| Output frequency | Synchronization frequency or internal oscillator frequency |
| Waveform | Sine wave or square wave |
| Amplitude | Sine wave: 1 Vrms, 1 mVrms resolution |
| | Square wave: TTL level |
| Amplitude accuracy | ± (4 %＋5 mV) |
| | sine wave, 1 kHz frequency |
| DC offset voltage | ± 5 V (available only with sine wave, |
| | 5 mV resolution, nominal value) |
| Maximum output current | ± 15 mA or more |
| Recommended load | 500 Ω or more (resistor connected to signal ground) |
| Output impedance | 53 Ω (nominal value) |
| Harmonic distortion | −70 dBc or less (supplementary value) |
| | 20 Hz to 100 kHz, no load, sine wave, 1 Vrms amplitude |
| | second and third harmonics respectively, 0 V DC offset |

### 9.2.2 Analog data outputs

| | |
|---|---|
| Output connector | BNC |
| No. of channels | 2 (Terminal names: DATA1, DATA2) |
| Maximum update rate | 312.5 k Samples/s |
| Frequency range | 10 kHz or more |
| Output voltage range | ± 12 V (no load), 16-bit resolution |
| Maximum output current | ± 10 mA or more |
| Output impedance | 440 Ω (nominal value) |
| Output voltage accuracy | ± (0.5 % + 10 mV), relative to measured value |

## 9.3　Analysis function

The instrument works as a dual-phase lock-in amplifier.

The **LI5502** can also measure amplitude ratio and phase difference between two channels.

a) Measurement signal system

　　Frequency range　　　　9.5 mHz to 1.05 MHz

　　No. of channels　　　　LI5501: 1 (A IN)

　　　　　　　　　　　　　LI5502: 2 (A IN, B IN)

b) Phase sensitive detector section

　　Phase sensitive detector　Dual-phase (R cosθ, R sinθ)

　　Orthgonality　　　　　　± 0.001 ° (supplementary value)

　　Dynamic reserve　　　　100 dB or more (supplementary value)

> ● **Dynamic reserve**
> The dynamic reserve is a value that expresses a margin against noise.
> It indicates how much noise is tolerated relative to the full scale of the voltage sensitivity.
> DR = Allowable maximum noise level / Voltage sensitivity (full scale of signal)
> The actual DR value depends on voltage sensitivity, frequency difference between a signal and noise, and settings of the time constant filter.
> To realize 100 dB or more, 100 ms or more time constant and 24 dB/oct attenuation slope or equivalent filter settings are required.

　　Time constant filter

　　　　Time constant (TC)　　1 µs to 10 ks (1-2-5 sequence)

> ● 1-2-5 sequence is a sequence of numbers repeating as "1, 2, 5, 10, 20, 50, …".

　　Attenuation slope (SLOPE)

　　　　　　　　　　　　　6 / 12 / 18 / 24 dB/oct

> ● **Time constant filter**
> It is cascade-connected first-order lowpass filters and eliminates noise and ripples associated with phase detection.
> The filter is realized with a digital filter that demonstrates the same response as an analog filter.
> The time constant corresponds to the response time of the first-order lowpass filter and the attenuation slope corresponds to the number of cascade-connected stages (6 dB/oct per stage) of the filter.
> The greater these settings, the greater the effect of noise rejection and ripple rejection.

Voltage sensitivity See the table below (1-2-5 sequence).

 DR setting  LOW1 / LOW2 / MED / HIGH

      (linked with AC GAIN)

| DR | AC GAIN | Voltage sensitivity | |
|---|---|---|---|
| LOW1 | 100x | 10 nVrms  to | 10 mVrms |
| LOW2 | 10x | 100 nVrms  to | 100 mVrms |
| MED | 1x | 1 µVrms  to | 1 Vrms |
| HIGH | 0.2x | 5 µVrms  to | 1 Vrms |

● **Voltage sensitivity**
The DR setting corresponds to the gain of the analog circuit (AC GAIN) and restricts the range of the voltage sensitivity.
Within this range, the voltage sensitivity (DC GAIN) can be set, which amplifies a digital signal after the PSD.

Voltage measurement accuracy

    ± 0.5 % (1 kHz and 1 Vrms input siganl, DR MED,

    1 Vrms voltage sensitivity)

Moving average filter

 Averaging time  OFF (0.4 µs), 1 µs to 100 s (1-2-5 sequence),

      AUTO (Inverse of reference signal frequency is set

      as averaging time.)

● **Moving average filter (MOV)**
This filter removes noise by moving average of averaging time.
A notch filter can be set with integer multiples of the averaging time as the period.
When the averaging time is equal to inverse of reference signal frequency, ripples associated with PSD is greatly reduced and the output is almost settled in the averaging time, so it is easy to obtain a fast response by setting a small time constant.
However, if signal frequency is high, the ripple suppression effect may not be sufficient.
When the filter is OFF, the minimum averaging time of 0.4 µs is set.

EXPAND    1x to 1000x

● **EXPAND**
The EXPAND function amplifies a signal after the moving average filter.
If this function is used without the moving average filter, lower bits will be missing.
Therefore, it is recommended to use the filter with an appropriate amount of averaging time when using this function.
1-2-5 sequence is recommended.

Phase noise
0.001 °rms (1 kHz, 18 dB/oct or more attenuation slope)
Supplementary value; reference signal is external
1 Vrms sine wave, 100 ms time constant, MOV OFF
When a reference signal is noisy or has high jitter or the
amplitude is less than 1 Vrms, this specification may not be
satisfied.

Phase temperature drift  ± 0.02 ° / °C
Supplementary value when input and reference signal are
both 1 kHz and 1 Vrms sine waves.

Phase measurement accuracy
± 1 °
Supplementary value when input and reference signal are
both 1 kHz and 1 Vrms sine waves.

Phase shift amount  −180.000 ° to +179.999 °, 0.001 ° resolution

PSD offset adjustment  Capable of removing a DC component of ± 25% of full-scale

---

● **About PSD offset adjustment**
When the PSD offset adjustment is executed, the average value of the DC
component for about 420 ms is measured, and then the correction value is set.
By the adjustment execution command, the adjustment is ececuted.
By the adjustment reset command, the correction value returns to the factory
default setting.

---

c) Reference signal system

Signal source          REF IN (external reference) / INT OSC (internal oscillator)

> ● **REF IN**
>   When the internal oscillator cannot be synchronized with external reference signal,
>   the instrument will be UNLOCK state.
>   When the internal oscillator can be synchronized with external reference signal,
>   the instrument will be LOCK state within the specified synchronization time.
> ● **INT OSC**
>   Immediately synchronized with the internal oscillator

Waveform          SINE / TTL POS / TTL NEG

> ● **SINE (SIN)**
>   Frequency-stable waveform that crosses the 0 V only twice per period
>   When using a square wave, use it with 10 to 90 % duty factor.
>   Point where a signal crosses 0 V from below to above is 0°
> ● **TTL POS (TPOS)**
>   Frequency-stable waveform that crosses the threshold level only twice per period
>   The rising edge is 0°.
> ● **TTL NEG (TNEG)**
>   Frequency-stable waveform that crosses the threshold level only twice per period
>   The falling edge is 0°.

Frequency range      9.5 mHz to 1.05 MHz

Synchronization time      2 periods + 50 ms or less (supplementary value)

Frequency resolution      0.3 mHz

Frequency measurement accuracy

     $\pm$ 40 ppm (1 Hz or more, waveform: TTL POS / TTL NEG)

Harmonic measurement

     A reference frequency given to the detector can be set to

     n/m times of reference signal frequency.

     Range of n (harmonic): 1 to 63

     Range of m (sub-harmonic): 1 to 64

     Note:     n/m times of reference signal frequency needs to

               be within the synchronization frequency range.

d) Internal oscillator

Frequency range      9.5 mHz to 1.05 MHz

Frequency resolution      0.1 mHz

Frequency accuracy      $\pm$ 30 ppm (supplementary value)

e) Output section of measurement values

Parameters          LI5501: $X_A$, $Y_A$, $R_A$, $\theta_A$

                                    LI5502: $X_A$, $Y_A$, $R_A$, $\theta_A$, $X_B$, $Y_B$, $R_B$, $\theta_B$, RATIO, PHASE

---

● **Parameters**

X: In-phase component ($= R \cos\theta$)

Y: Quadrature component ($= R \sin\theta$)

R: Signal amplitude, RMS value($= \sqrt{(X^2+Y^2)}$)

$\theta$: Signal phase ($= \tan^{-1} (Y / X)$)

    The subscripts indicate the measured channel (A:CH-A, B:CH-B).

RATIO: Amplitude ratio between the two channels ($R_A / R_B$,)

PHASE: Phase defference between the two channels ($\theta_A - \theta_B$)

---

● **Example of measuring amplitude ratio**

When

    measured $R_A$ is 60 mVrms  at sensitivity is 0.1 Vrms (60% full-scale) and

    measured $R_B$ is 100 mVrms at sensitivity is 0.2 Vrms (50% ful-scale),

the measured amplitude ratio (G) is equalt to 1.2 (= 60 %FS / 50 %FS).

The actual amplitude ratio can be calculated using the above measured value and the ratio of the sensitivity settings.

Taking the above as an example, since the sensitivity ratio is 0.5 (= 0.1/ 0.2), the actual amplitude ratio is 0.6 (= 1.2 (G) × 0.5).

---

Measurement range    X, Y               ± 0 to 120 % relative to voltage sensitivity

                                               Resolution: 18 bits

                       R                  0 to 120 % relative to voltage sensitivity

                                               Resolution: 19 bits

                       RATIO          0 to 200 %

                                                 Resolution: 19 bits

                       $\theta$, PHSAE     −180.000 ° to +179.999 °

                                               Resolution: 0.001 °

Voltage range of analog outputs

                       X, Y              ± 10 VDC

                                               (when ± 100 % relative to voltage sensitivity)

                       R                  10 VDC

                                               (when 100 % relative to voltage sensitivity)

                       RATIO          10 VDC (when 200 % amplitude ratio)

                       $\theta$, PHASE     ± 10 VDC

                                               (when 179.999 ° or −180.000 ° respectively)

Offset                       ± 120.00 % relative to voltage sensitivity for X and Y,

                              0.01% resolution

## 9.4 Digital data output

Output mode                     Querying / Streaming

- **Querying**
  Responds to the command query with ASCII
- **Streaming**
  Outputs binary data continuously
  There are seven 16-bit registers and measured data can be output at a specified sample period.
  The maximum transfer rate is 300k word/s.

Sampling interval           $0.4\ \mu s \times (1\ to\ 65536)$

Output parameters

LI5501:        $X_A$, $Y_A$, $R_A$, $\theta_A$

LI5502:        $X_A$, $Y_A$, $R_A$, $\theta_A$, $X_B$, $Y_B$, $R_B$, $\theta_B$, RATIO, PHASE

LI5501/2:    Reference signal frequency, Status

- **Reference signal frequency**
  When the output mode is Streaming, measured frequency data is divided into upper frequency data (16 bits) and lower frequency data (16 bits).
- **Status**
  Not synchronized with reference signal (UNLOCK)
  Saturation in the previous PSD stage (ADC over)
  Saturation in the time constant filter (LPF over)
  Saturation in the moving average filter (MOV over)
  Saturation in the ratio operation (RATIO over)
  Overvoltage at the oscillator output (OSC over)

## 9.5 Remote control interface

USB                    USB 2.0 full speed, device class CDC

LAN                    10BASE-T / 100BASE-TX, TCP/IP (socket communication)

## 9.6　Miscellaneous specifications

Power supply

　Recommended power supply Voltage

　　　　　　　　　± 15 VDC ± 2%

　　　　　　　　　linear power supply (with dual tracking) recommended

　Operating voltage range　± 14 to 16 VDC

　Current consumption　　approximately +400 mA / ‑110 mA (LI5501)

　　　　　　　　　approximately +480 mA / ‑120 mA (LI5502)

　　　　　　　　　factory default settings, no input signals, no loads

　Connector　　　　　　D-SUB 9pin (equivalent to DELC-J9PAF-20L9 (JAE))

Configuration memory　　16 sets (switchable by MODE switch on the rear panel)

　　　　　　　　　One of them is for resume function and another has factory

　　　　　　　　　default settings.

Resume function　　　　Last operating settings will be restored when the

　　　　　　　　　instrument is restarted.

Environmental conditions

　Operation　　　　　　0 to +50 °C, 5 to 85 %RH

　　　　　　　　　(absolute humidity 1 to 25 g/m³, no condensation)

　　　　　　　　　Altitude of 2000 m or less
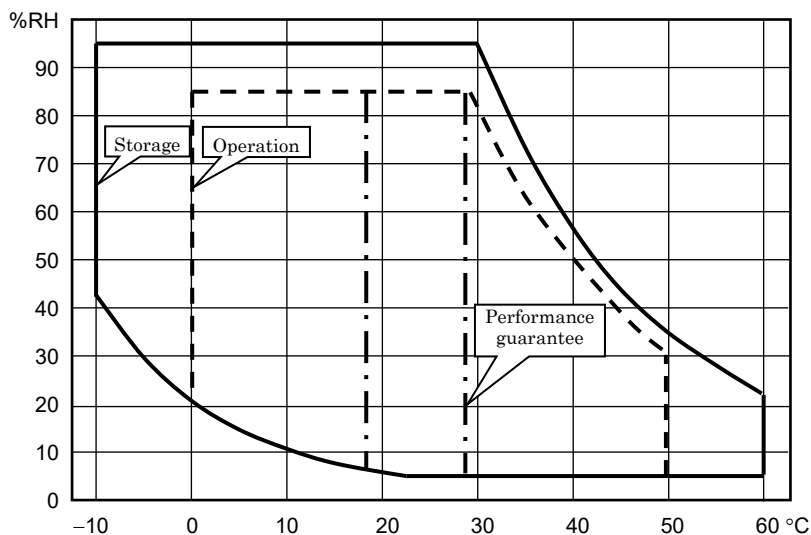
　Performance guarantee　23 ± 5 °C, 5 to 85 %RH

　　　　　　　　　(absolute humidity 1 to 25 g/m³, no condensation)

　　　　　　　　　Altitude of 2000 m or less

　Storage　　　　　　　−10 to +60 °C, 5 to 95 %RH

　　　　　　　　　(absolute humidity 1 to 29 g/m³, no condensation)

| | |
|---|---|
| Pollution degree | 2 (indoor use) |
| Warm-up time | 20 minutes |
| RoHS directive | Directive 2011/65/EU |
| EMC | EN 61326-1, EN 61326-2-1 |
| | Applies to instruments that have a CE marking on the bottom |
| External dimensions | 200 mm (W) × 30 mm (H) × 150 mm (D) |
| | excluding metal fittings and protruding parts |
| Weight | Approximately 700 g |
| | main unit only, excluding accessories and metal fittings |

# 9.7　External dimensions
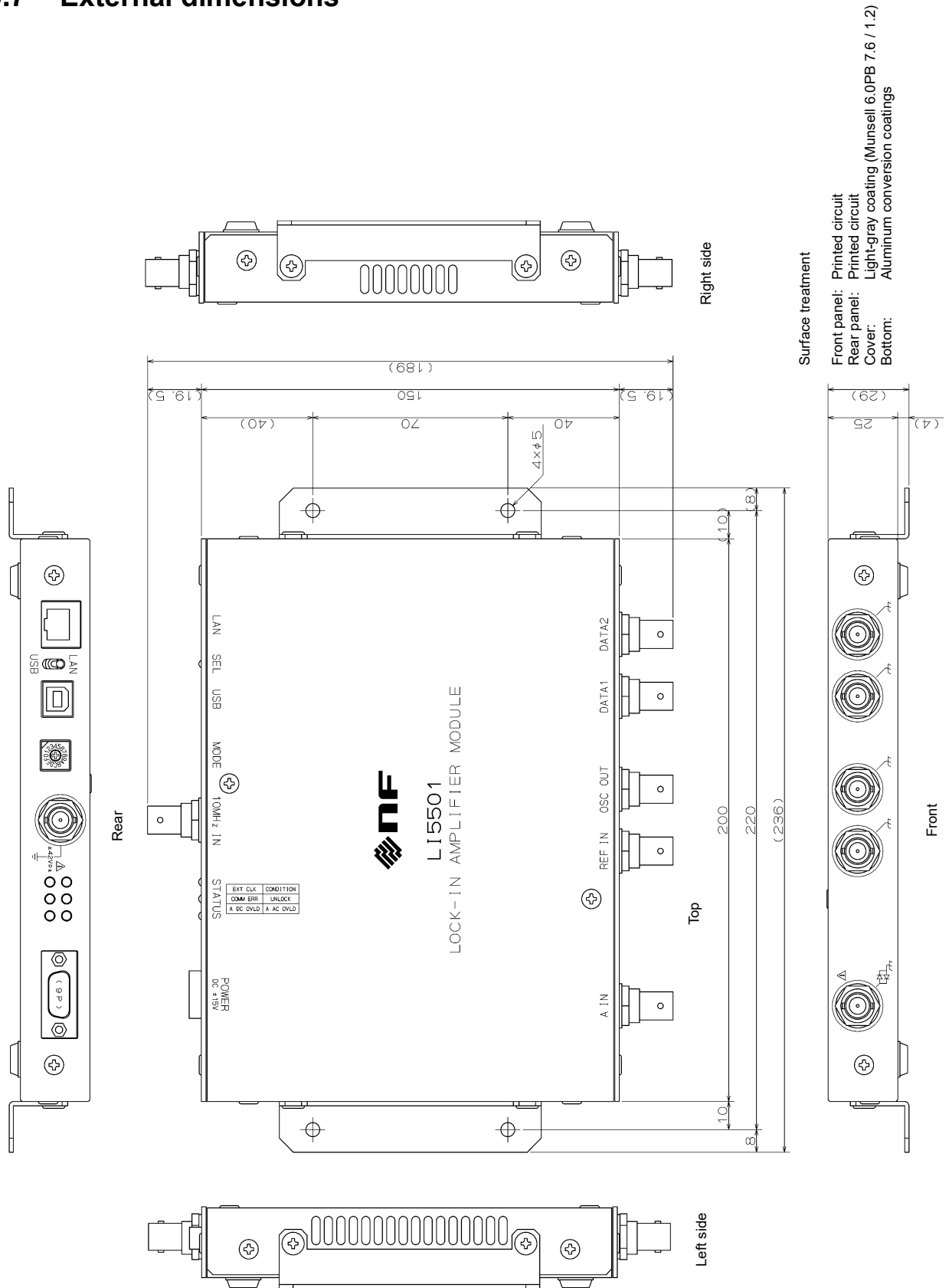


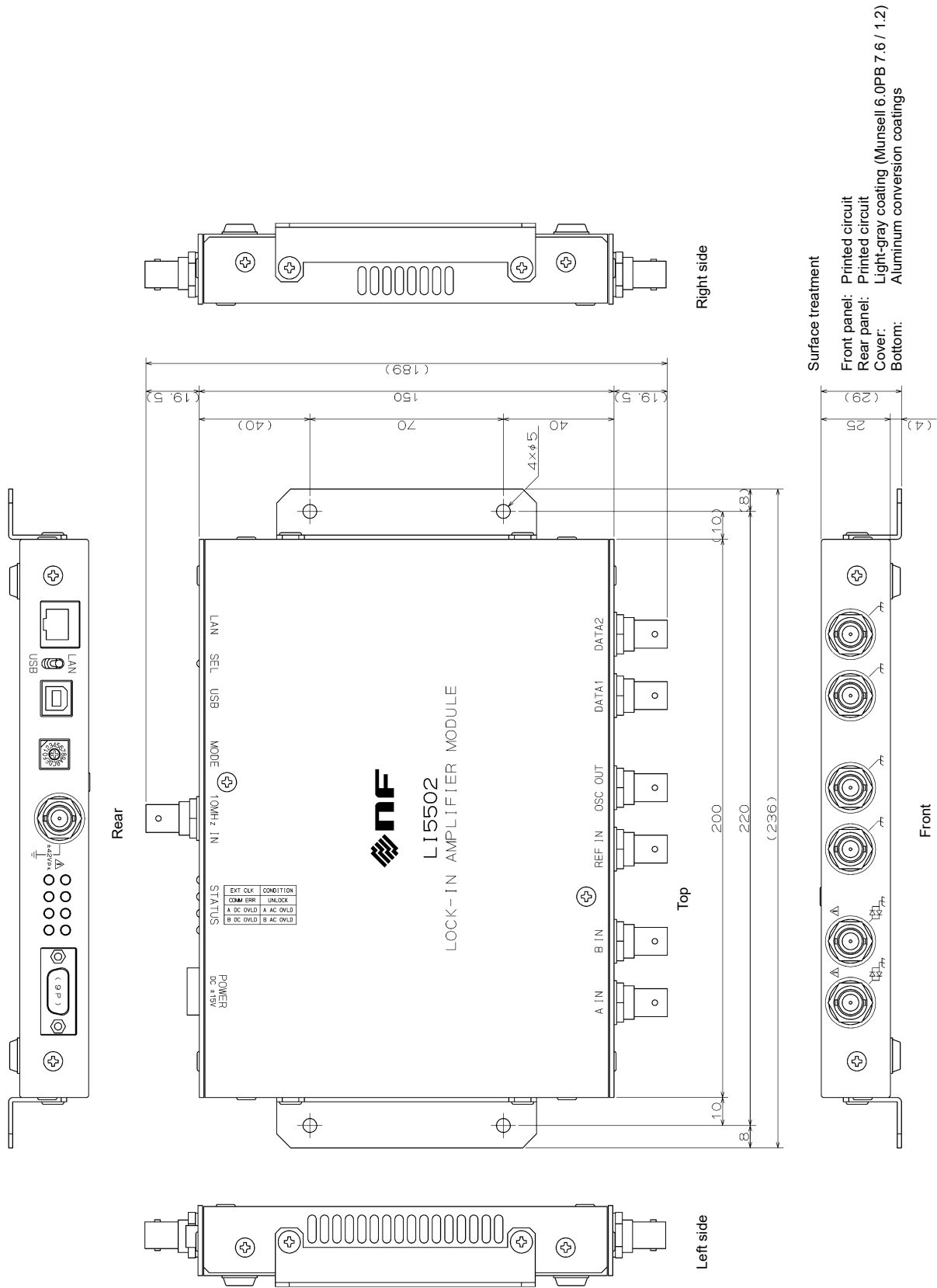**Figure 9-1　External dimensions of the LI5501**

**Figure 9-2  External dimensions of the LI5502**

# ———— 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. In the unlikely event that you experience an issue during use, please contact our company or agency of our company from which you purchased the instrument.

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, NF will repair the defective instrument without any charge for the parts and labor.

For repair service under warranty, the instrument must be returned to either NF or an agent designated by NF. The Purchaser shall prepay all shipping cost, duties and taxes for the instrument to NF from another country, and NF shall pay shipping charges to return the instrument to the purchaser.

This warranty shall not apply when corresponding to following particulars.
- A) Failure caused by improper handling or use of the instrument in a manner that does not conform with the provisions of the Instruction Manual.
- B) Failure or damage caused by transport, dropping, or other handling of the instrument after purchase.
- C) Failure caused by repair, adjustment, or modification of the instrument by a company, organization, or individual not approved by NF.
- D) Failure caused by abnormal voltage or the influence of equipment connected to this instrument.
- E) Failure caused by the influence of supply parts from the customer.
- F) Failure caused by such as corrosion that originate in the use of causticity gas, organic solvent, and chemical.
- G) Failure caused by the insect or small animal that invaded from the outside.
- H) Failure or damage caused by fire, earthquakes, flood damage, lightning, war, or other uncontrollable accident.
- I) Failure caused by the reason that was not able to be foreseen by the science and technology level when shipped from our company.
- J) Replacement and replenishment of consumables such as batteries.

**NF Corporation**

WABUN: (DA00096776-001)

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.

LI5501 / LI5502 INSTRUCTION MANUAL