



PROGRAMMABLE CURRENT AMPLIFIER

CA5351

INSTRUCTION MANUAL

NF Corporation

DA00082422-001

PROGRAMMABLE CURRENT AMPLIFIER

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Preface

Thank you for purchasing the “**CA5351 PROGRAMMABLE CURRENT AMPLIFIER**”. For safe and correct use of this product, 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. Panel operations and basic operation

This chapter describes the functions of the keys and knob on the panel, the operating procedures of the screen, and the basic operating procedures of the instrument.

Refer to this chapter as you use the instrument.

4. Advanced operation

This chapter describes a wide range of operations.

5. Remote control

This chapter describes remote control via USB, LAN, and GPIB interfaces.

6. Troubleshooting

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

7. Maintenance

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

8. 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.

This product is a Class I product (with protective conductor terminal) that conforms to the JIS and IEC insulation standards.

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

This instruction manual contains information for the safe operation and use of this product.

Be sure to read this instruction before using this product.

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.

- **Be certain that the product is properly grounded.**

This product uses a line filter which may cause electric shock if the product is not grounded.

To prevent electric shock accidents, connect the product to an earth ground so that the ground resistance is 100 Ω or less.

This product is automatically grounded by connecting a 3-pin power plug to a power outlet with a protective ground contact.

This product does not come with an accessory 3-pin to 2-pin power adapter. If you must use your own adapter, be sure to connect the ground line of the adapter to suitable ground near the power outlet.

If there is a ground terminal on the rear panel, you may connect the terminal to the ground via a cable thicker than the power supply plug.

- **Check the power supply voltage.**

This instrument operates on the power source voltage described in “**Grounding and power connections**”.

Before plugging in the power cord, confirm that the outlet voltage conforms to the rated power supply of this product.

- **Observe the fuse rating.**

Using an unspecified fuse could cause a fire. Use the rated fuse specified in “**Grounding and power connections**”.

Also, when replacing the fuse, unplug the power cord from a power outlet.

- **If you think something is wrong, ...**

If smoke or an unusual odor or sound comes from the instrument, immediately remove the power cord from the socket and cease use of the instrument.

If any such abnormality occurs, take measures to prevent the use of the instrument until repairs have been completed and promptly contact the NF Corporation or its authorized agent.

- **Do not use this product in explosive atmosphere.**

An explosion or other hazards may occur.

- **Do not open the product case.**

To prevent exposure of high voltages, never remove the cover of the instrument.

Only technicians certified by the NF Corporation are authorized to inspect and touch anything inside the product case.

- **Do not modify this product.**

Never modify this product 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 product when it is wet may result in electrical shock or fire. If the instrument becomes wet, immediately unplug the power cord and contact the NF Corporation or its authorized agent.

- **If lightning occurs nearby, turn off the power switch and unplug the power cord.**

A lightning strike may cause electrical shock, fire, or instrument malfunction.

- **Electromagnetic compatibility**

This product is a CISPR 11 Group 1 Class A compliant instrument. 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 and television broadcasts.

● **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.



Electric Shock Danger Symbol

This symbol indicates a location that presents a risk of electric shock under specific conditions.



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 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**

| Indicates that the “on” position of the power switch.

○ Indicates that the “off” position of the power switch.

 Indicates that connected to the product case.

 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 42Vpk or less. This product is grounded when in use, so the electrical potential of the instrument enclosure is equal to the ground potential.

● **Disposal of this product**

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

- a) Use the services of an industrial waste disposal contractor for disposal of the entire product.
- b) This product does not use batteries.
- c) This product does not contain mercury.

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1. Introduction

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1.1 Features

The “**CA5351 PROGRAMMABLE CURRENT AMPLIFIER**” is the current input type preamplifier that converts an input current signal from a photo multiplier or a photo diode into a voltage signal.

The instrument has both high gain and a wide frequency bandwidth, and gain of the amplifier can be varied over a wide range from 10^3 (V/A) to 10^{10} (V/A).

Besides, the instrument is equipped with a filter with rise time from $1\mu\text{s}$ to 300ms, which can remove unnecessary noise components and improve SN ratio (signal-to-noise ratio) of a signal.

Furthermore, the instrument is also equipped with a current suppression function (± 8 nA to ± 8 mA) for cancelling dark current of a sensor.

The instrument also has LAN, GPIB, and USB interfaces, by which the gain and other settings can be changed from an external controller such as a personal computer.

Therefore, an automatic measurement system can be easily built.

■ High sensitivity and wide bandwidth

A frequency bandwidth is DC to 14 kHz (response speed is $25\mu\text{s}$) when the gain is 10^{10} (V/A).

A frequency bandwidth is DC to 500 kHz (response speed is $0.7\mu\text{s}$) when the gain is 10^6 (V/A).

■ Stable against additional input capacitance

The instrument will operate stably without any concerns of oscillation against additional input capacitance.

Besides, an overshoot and ringing will not occur in a pulse response.

■ Variable Gain

The gain can be set in the range of 10^3 (V/A) to 10^{10} (V/A) with a step by 10 times (8 ranges).

■ Variable Filter

The instrument is equipped with a filter (low pass filter) with the rise time in the range of $1\mu\text{s}$ to 300 ms by 1-3 sequence in 12 ways. It can remove noise components and improve the SN ratio (signal-to-noise ratio).

■ Current suppression

The instrument is equipped with current suppression in the range of ± 8 nA to ± 8 mA covering 7 ranges for cancelling dark current of a sensor.

■ Remote control

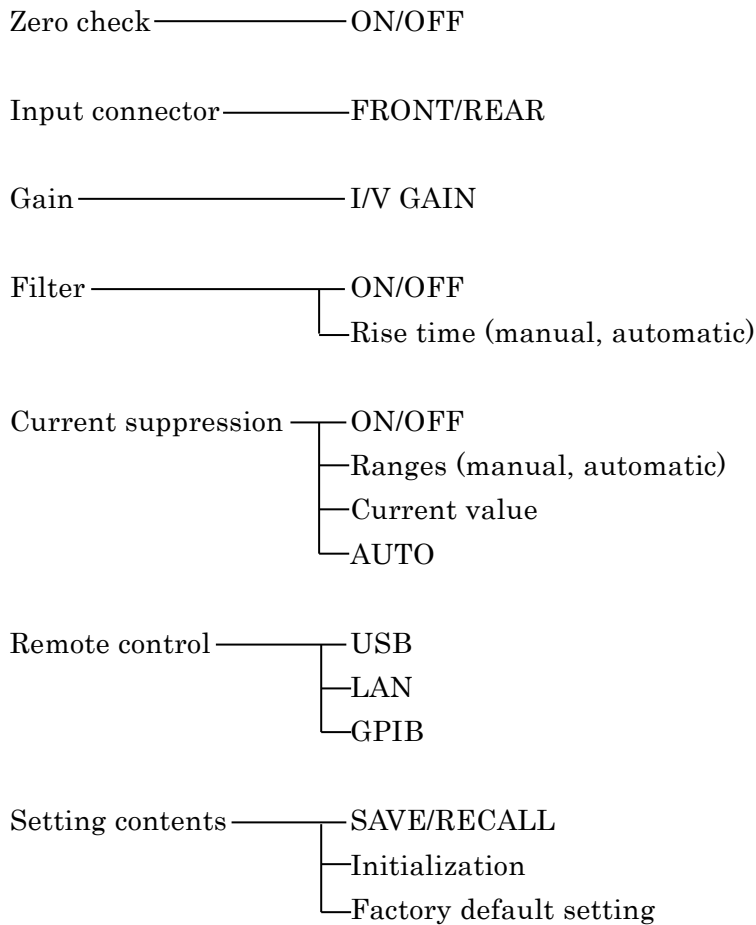
An automatic measurement system can be easily built because the instrument is equipped with LAN, GPIB, and USB interfaces as standard features.

1.2 Applications

- High sensitivity detection of output current signals from photomultipliers or photo diodes
- Measurement of tiny electrical current signals from electrochemical cells
- Material research of dielectric substances

1.3 List of Functions

The outline of the functional tree of the **CA5351** are shown below.



1.4 Operating principles

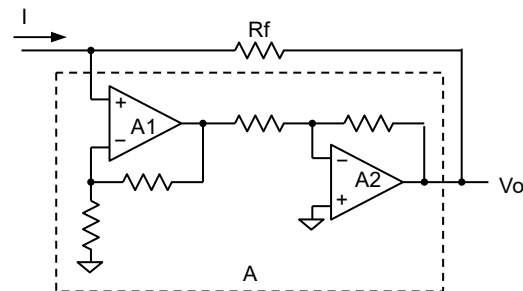
This instrument has an I/V conversion amplifier with the feedback resistor “Rf” connected to the inverting amplifier “A” as shown in the figure below. In the amplifier “A”, the non-inverting amplifier with low-noise FET front end that is used in the initial stage “A1” and the inverting amplifier that is used in the rear stage “A2” are cascade-connected.

The input impedance of the amplifier “A” is pure resistance and constant because it can obtain constant gain within the usage frequency bandwidth. Therefore, if large capacitance is added to the input, this instrument will operate stably without any concerns of oscillation.

Conversion gain (I/V GAIN) is

$$\left| \frac{-V_o}{I} \right| = \frac{I \times R_f}{I} = R_f \text{ (V/A)}.$$

Therefore, the gain is the same as the value of the feedback resistor “Rf”.



In this section, the block diagram of the **CA5351** are presented and the main functions are explained.

■ Zero check (ZERO CHECK)

It disconnects the input connection and cuts off an input current. It can be used to check whether there is a current output from a sensor, or an output offset from the **CA5351** itself.

■ I/V conversion amplifier (I-V)

A current signal input is converted to a voltage signal.

■ Equalizer Amplifier (EQ)

It corrects gain errors caused by the I/V conversion amplifier.

■ Filter (FILTER)

The instrument is equipped with the filter (low pass filter) with the rise time in the range of 1 μ s to 300 ms by 1-3 sequence. It can remove noise components and extract required signal components.

■ Current suppression (CURRENT SUPPRESS)

The instrument is equipped with the current suppression for canceling dark current of a sensor. Because it is possible to set huge gain of the I/V conversion amplifier by canceling dark current of a sensor, even tiny change in current can be detected with high sensitivity.

■ System controller (MAIN CPU, PANEL/DISPLAY, and REMOTE CONTROL)

The system controller sets and controls the analog unit according to user operations, and it displays various information on the LCD. Besides, it can also communicate with a host controller.

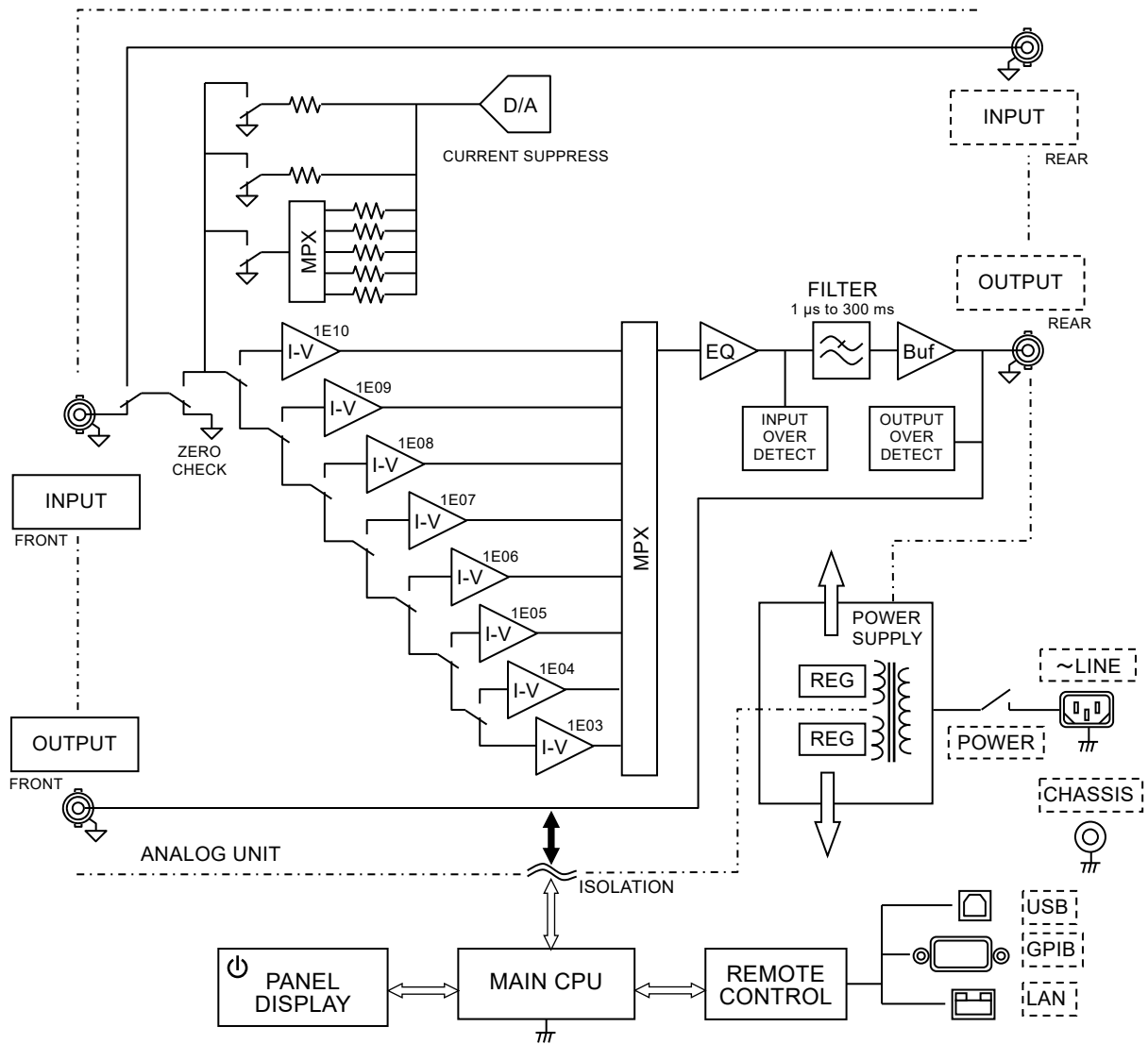


Figure 1-1 Block diagram of the CA5351



2. Preparation before use

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2.1 Inspection

■ Safety check

Before using the **CA5351**, 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 Package Contents**” are supplied.

Table 2-1 Packing list

CA5351 Main unit	1
Accessories	
Instruction manual	1
Power cord set (2 m, with three-pin plug)	1
Fuse [Note1] (Time lag, $\phi 5.2 \times 20$ mm)	1

[Note1] Spare fuse

One operating fuse and one spare fuse are in the fuse holder.

WARNING

There are locations of high-voltage inside this product. Do not remove the cover of this instrument.

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

2.2 Installation

2.2.1 General cautions

⚠ CAUTION

Attention should be given to the following items to reduce the possibility of damage to the **CA5351**.

- The instrument has a fan for forced-air cooling.
The instrument has air exhaust vents on the rear panel and air intake vents on the side panels. Do not cover these air vents.
If you notice that the fan is not moving, immediately disconnect the instrument from the power source and contact the NF Corporation or its authorized agent. Continued use of the instrument while the fan is stopped may increase damage to the instrument and make repair difficult.
 - Do not use this instrument while it is positioned such that it is resting on a surface with a side or the rear facing down. Doing so creates the risk of the instrument tipping over. The instrument must be placed on a level surface such as a desk with the bottom side facing down and so that all four feet are contacted on the surface when in use.
-

2.2.2 Installation environment

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

Operation: 0 to +40 °C, 5 to 85 %RH
(absolute humidity is 1 to 25g/m³, non-condensing)

Storage: -10 to +50 °C, 5 to 95 %RH
(absolute humidity is 1 to 29g/m³, non-condensing)

- Place the instrument in a location of altitude 2 000 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 an output voltage.

 **CAUTION**

Avoid installation in the following locations.

- Where there is flammable gas
There is a risk of explosion. 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 vapors, a lot of dust and particles, salty air and oily smoke, and metal powder, etc.
Corrosion, malfunction or a failure may occur.
 - Where there is a lot of vibration
Noise may increase or malfunction or a failure may occur.
 - Near an electromagnetic field source, high-voltage equipment, power line, or pulse noise source
Noise may increase or malfunction may occur.
-

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

2.2.3 Rack mounting

The **CA5351** can be installed in a 19-inch IEC rack, an EIA standard rack or a JIS standard rack by using optional rack mounting kits. The rack mounting kits are available for inch-racks (EIA) and millimeter racks (JIS).

Model name	Product name
PA-001-3512	Rack mounting kit (EIA for one unit)
PA-001-3513	Rack mounting kit (EIA for two units)
PA-001-3514	Rack mounting kit (JIS for one unit)
PA-001-3515	Rack mounting kit (JIS for two units)

For the assembly and dimensions of rack mount kits, refer to the list below.

Firstly, assemble the rack mounting kit and attach the kit to the instrument, and then install the instrument in the rack.

Figure 2-1 Rack mounting kit assembly diagram (EIA for one unit)

Figure 2-2 Rack mounting kit assembly diagram (EIA for two units)

Figure 2-3 Rack mounting kit assembly diagram (JIS for one unit)

Figure 2-4 Rack mounting kit assembly diagram (JIS for two units)

Figure 2-5 Rack mounting kit dimensions (EIA for one unit)

Figure 2-6 Rack mounting kit dimensions (EIA for two units)

Figure 2-7 Rack mounting kit dimensions (JIS for one unit)

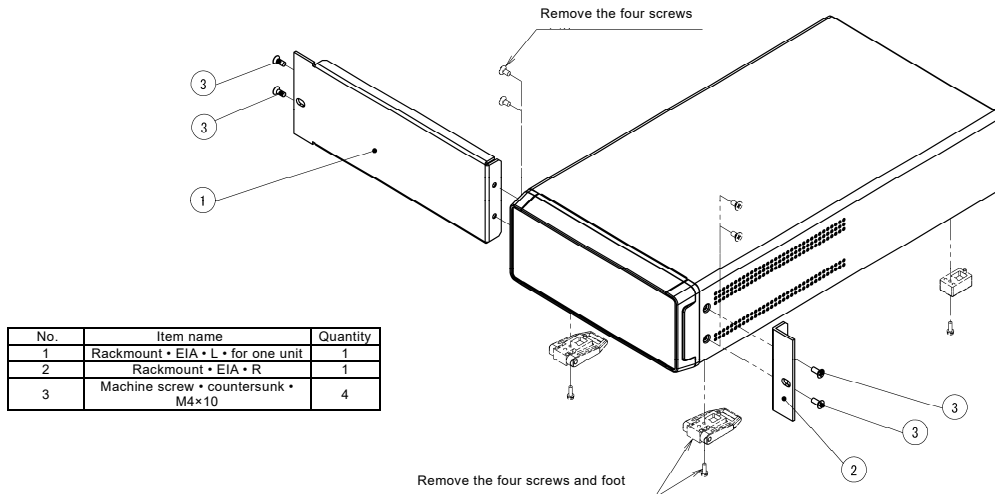
Figure 2-8 Rack mounting kit dimensions (JIS for two units)

WARNING

When mounting the instrument in the rack, be sure to use a rack rail or other means and support the instrument. Failure to do so may result in injury to the user or damage to the instrument from falling.

CAUTION

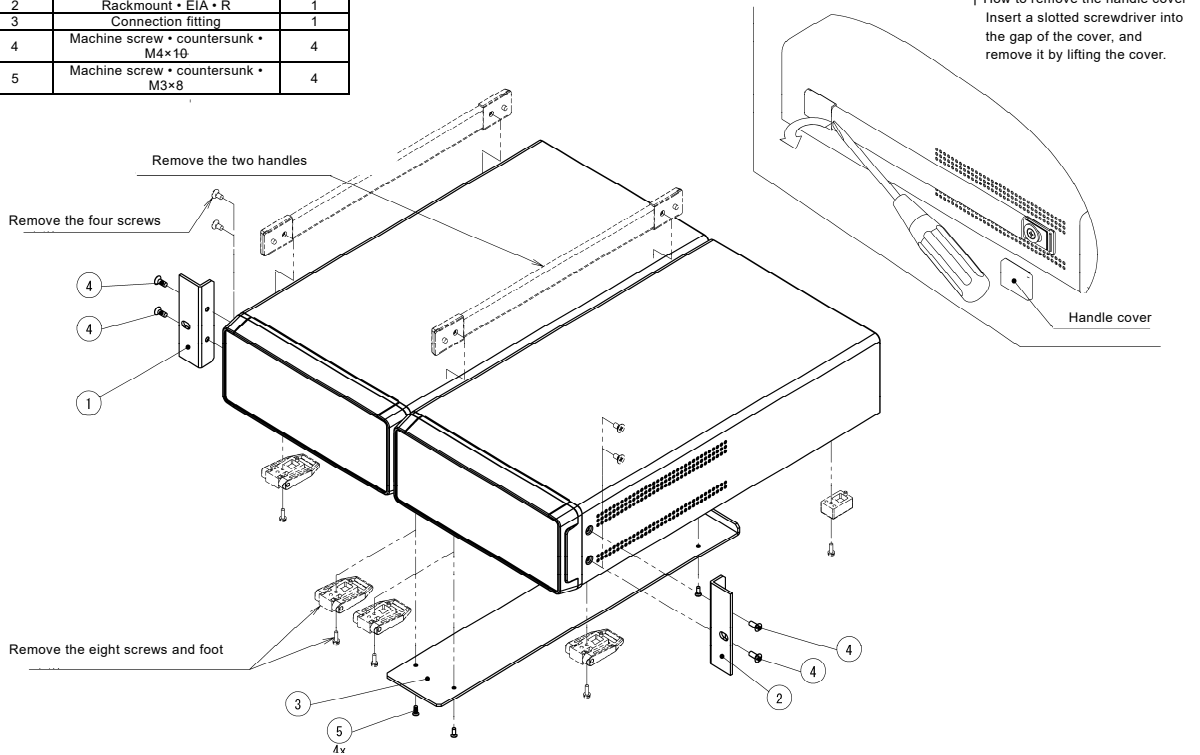
- Make sure that there are sufficient air vents in the rack or that a cooling fan is installed.
- The instrument has air intake vents on the side panels.
Make sure that there is at least 20 mm of distance between the sides of the instrument and the inner walls of the rack.
- The instrument has air exhaust vents on the rear panel.
Make sure that there is at least 50 mm between the rear of the instrument and the inner wall of the rack.
If the ambient temperature exceeds the specification or the air exhaust vent is blocked, the performance of the instrument may decrease or the instrument may be damaged.



Caution
 When storing the main unit in a rack, do not hold with rack mount adapter alone.
 Be sure to provide L bracket or shelf on the rack side and hold the main unit.

Figure 2-1 Rack mounting kit assembly diagram (EIA for one unit)

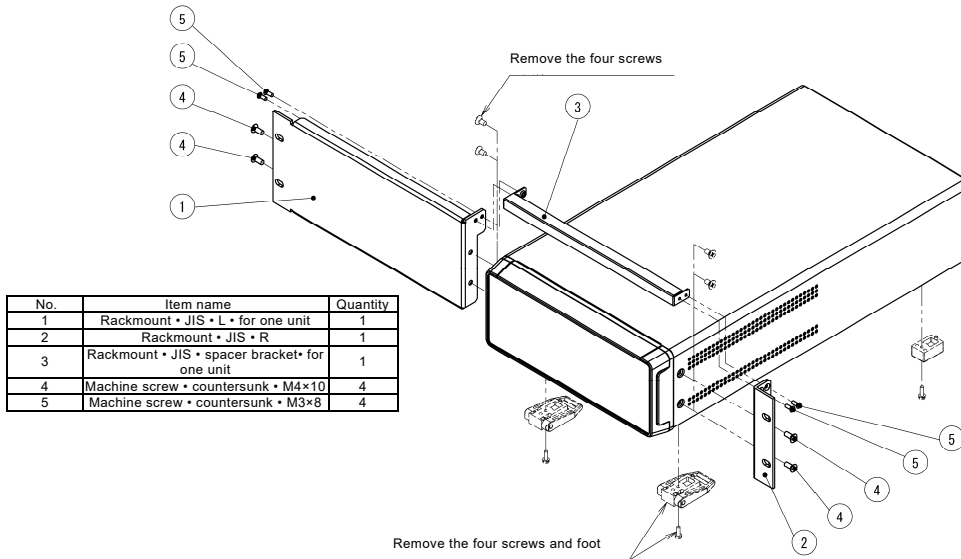
No.	Item name	Quantity
1	Rackmount • EIA • L	1
2	Rackmount • EIA • R	1
3	Connection fitting	1
4	Machine screw • countersunk • M4×10	4
5	Machine screw • countersunk • M3×8	4



Caution
 When storing the main unit in a rack, do not hold with rack mount adapter alone.
 Be sure to provide L bracket or shelf on the rack side and hold the main unit.

Figure 2-2 Rack mounting kit assembly diagram (EIA for two units)

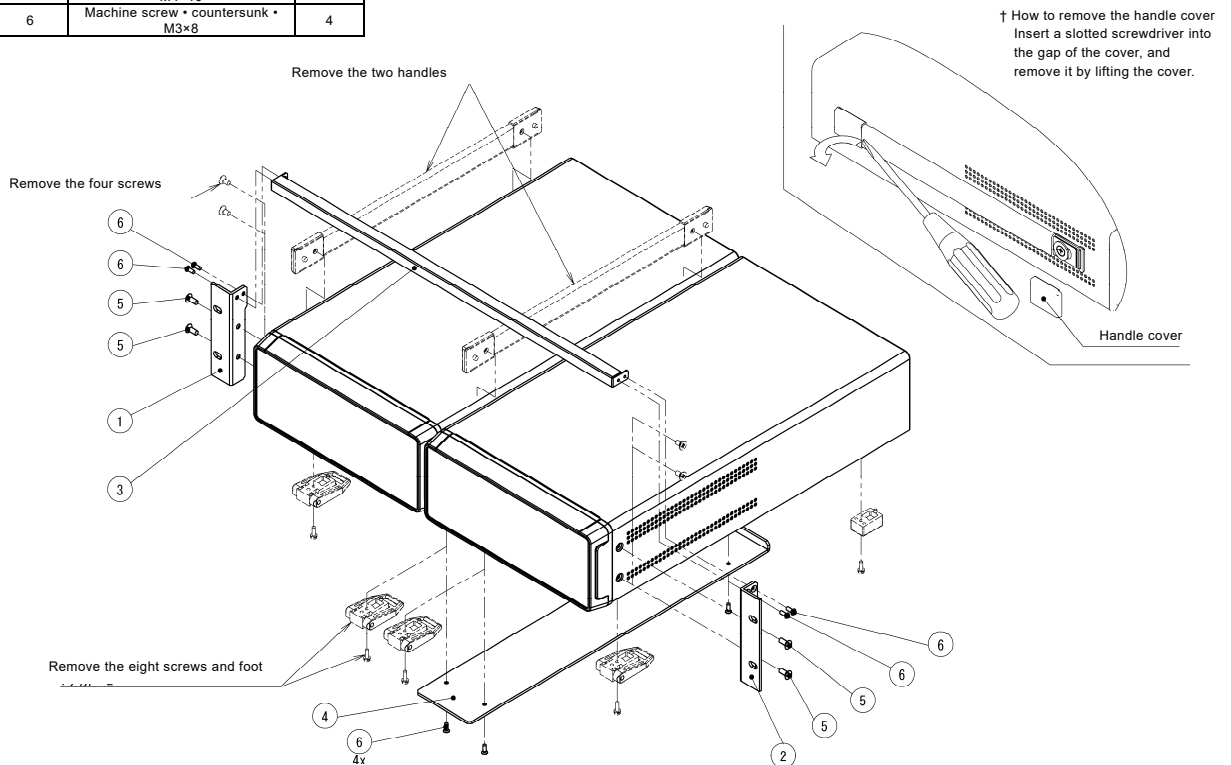
2.2 Installation



Caution
When storing the main unit in a rack, do not hold with rack mount adapter alone.
Be sure to provide L bracket or shelf on the rack side and hold the main unit.

Figure 2-3 Rack mounting kit assembly diagram (JIS for one unit)

No.	Item name	Quantity
1	Rackmount • EIA • L	1
2	Rackmount • EIA • R	1
3	Rackmount • JIS • spacer bracket• for two units	1
4	Connection fitting	1
5	Machine screw • countersunk • M4×10	4
6	Machine screw • countersunk • M3×8	4



Caution
When storing the main unit in a rack, do not hold with rack mount adapter alone.
Be sure to provide L bracket or shelf on the rack side and hold the main unit.

Figure 2-4 Rack mounting kit assembly diagram (JIS for two units)

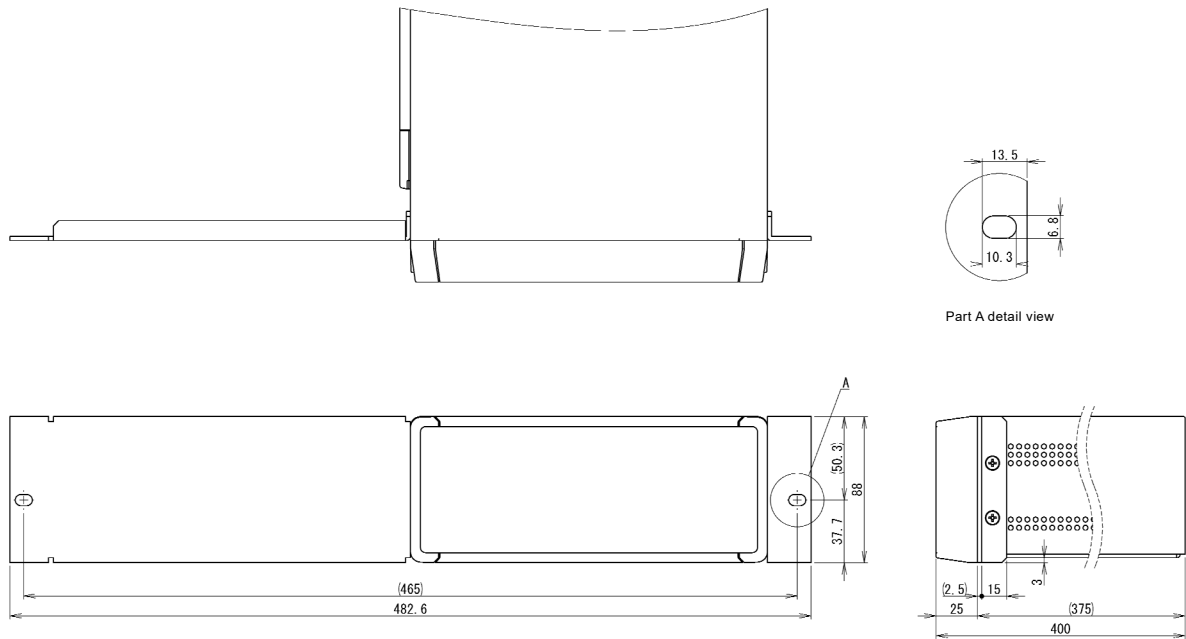


Figure 2-5 Rack mounting kit dimensions (EIA for one unit)

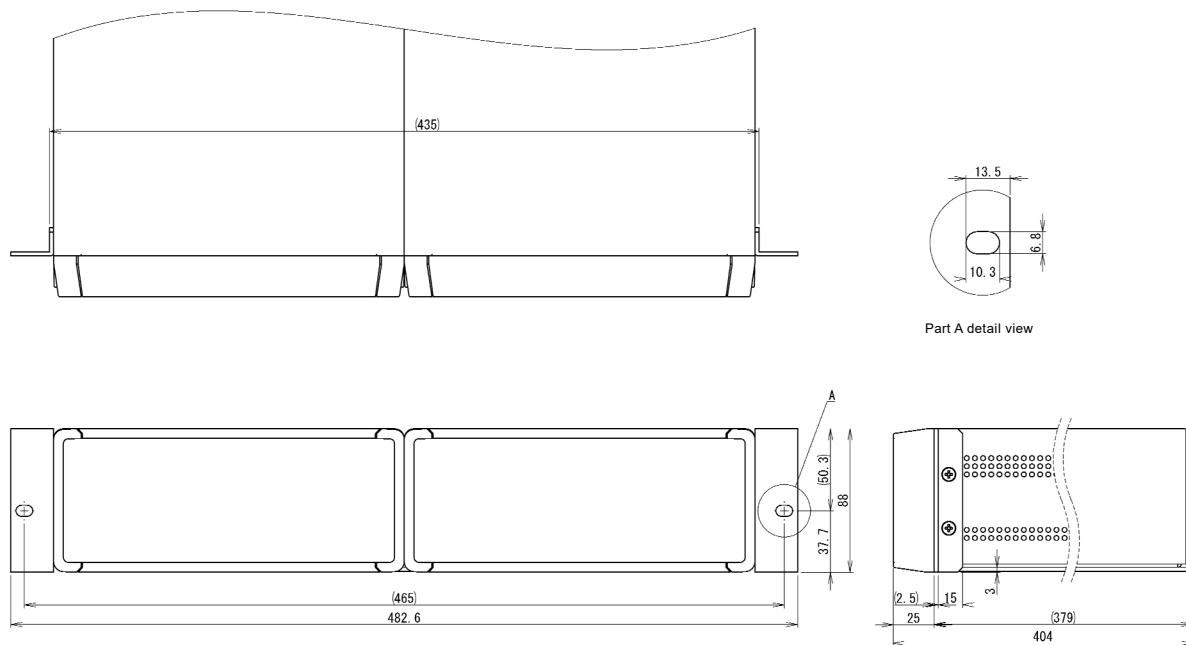


Figure 2-6 Rack mounting kit dimensions (EIA for two units)

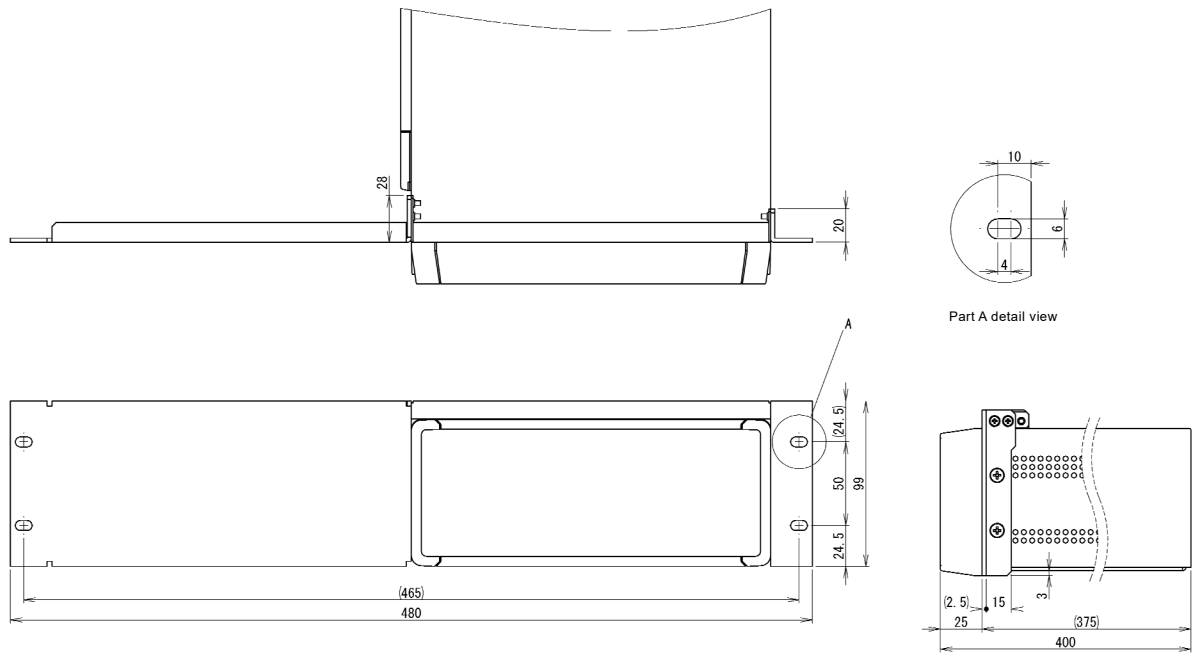


Figure 2-7 Rack mounting kit dimensions (JIS for one unit)

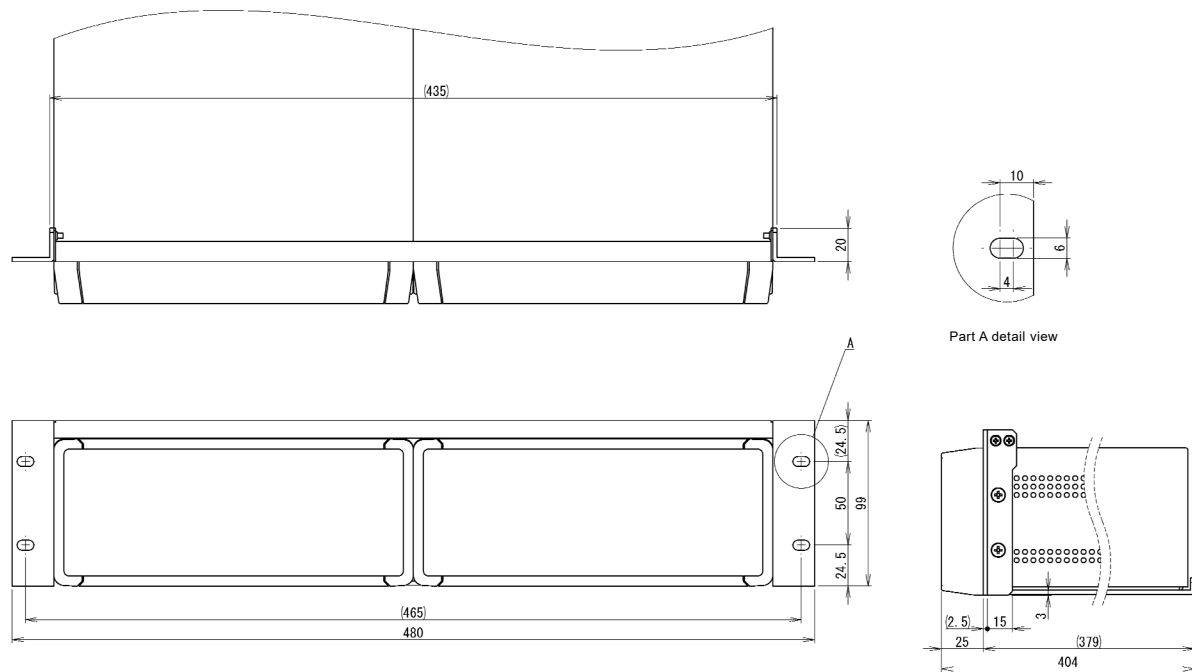


Figure 2-8 Rack mounting kit dimensions (JIS for two units)

2.3 Grounding and power connections

- The instrument must be grounded.

WARNING

There is a risk of electrical shock if the instrument is not grounded.
To prevent electrical shock, connect it to an earth ground so that the ground resistance is 100 Ω or less.

The instrument is automatically grounded by connecting a 3-pin power plug to a power outlet with a protective ground contact.

The instrument does not come with an accessory 3-pin to 2-pin power adapter. If you must use your own adapter, be sure to connect the ground line of the adapter (green line) to suitable ground near the power outlet.

■ Power supply specifications

Power supply voltage range	AC 100 V \pm 10 %/AC 120 V \pm 10 %/AC 230 V +10 % to -14 %, however 250 V or less
Frequency range	50 Hz/60 Hz \pm 2 Hz
Overvoltage category	II
Power consumption	40 VA or less

The instrument has a voltage selector switch on the rear panel. Confirm that the voltage of the switch conforms to the outlet voltage.

When changing a power supply voltage, after unplugging the power cord, turn the switch slowly and until hearing a clicking sound so that the direction of the switch becomes the intended voltage.

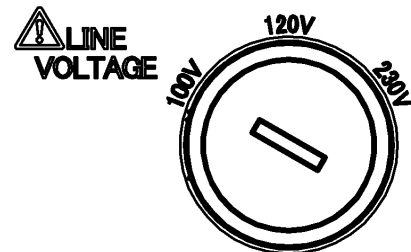


Figure 2-9 Voltage selector switch

CAUTION

The voltage of the switch is set depending on destination.
Set the switch to the point where you can hear a clicking sound so that the switch is not in an invalid position.
After confirming the voltage of the switch, connect the power cord.

■ **Connecting the power supply**

- 1) Confirm that a commercial power supply voltage to which the instrument is connected is within the specified voltage range of the instrument.
- 2) Set the power switch on the rear panel to the off position.
- 3) Insert the power cord in the power inlet on the rear panel.
- 4) Plug the power cord into a ground-protected power outlet.

 **CAUTION**

The power cord set that comes with the instrument is intended for use only with this instrument.

The power cord set should not be used with any other products or for any other purposes.

When connecting the instrument to the commercial power supply, be sure to use only the power cord that is provided with the instrument.

If the power to the instrument is turned off, wait at least 5 seconds before turning it back on again.

■ **In an emergency, the power cord can be used to disconnect the instrument from the commercial power supply.**

 **WARNING**

Confirm that there is sufficient space around the power inlet of the instrument to ensure that the power cord can be removed easily. Alternatively, plug the power cord into a power outlet that is easily accessible and has sufficient space around it to allow easy removal of the power plug.

If smoke or an unusual odor or sound is emitted from the instrument, immediately unplug the power cord and do not use the instrument again until it has been repaired.

■ **Be sure to conform to the fuse ratings**

The fuse ratings of the **CA5351** are shown below.

When power supply voltage is 100 V or 120 V : Time-lag 1 A

When power supply voltage is 230 V : Time-lag 0.5 A

Both of their voltage ratings are 250 V and sizes are $\phi 5.2 \times 20$ mm.

When replacing the fuse, unplug the power cord, and then open the fuse holder by slotted driver etc. An operating fuse and a spare fuse are inserted in the fuse holder. After replacing the fuse, push into the fuse holder to the original position securely.

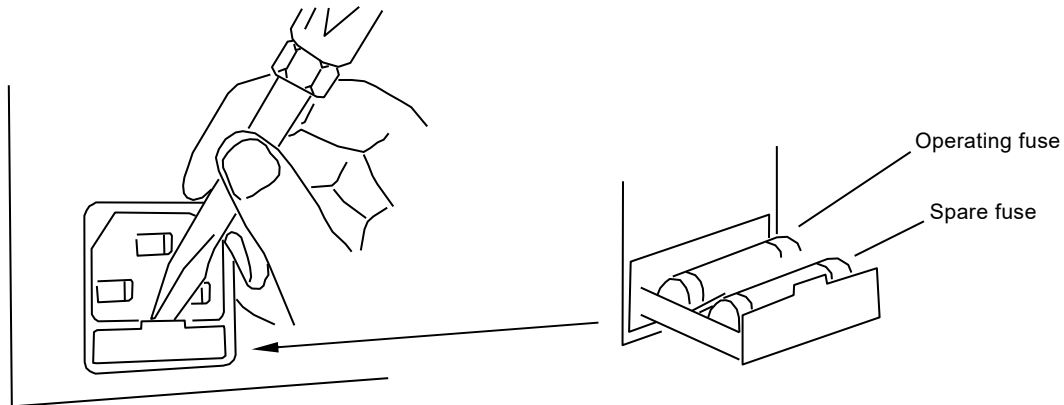


Figure 2-10 Fuse replacement

⚠ WARNING

Confirm that the voltage of the voltage selector switch and the fuse rating are suitable for the commercial power supply voltage before connecting to the power supply.
Change the voltage of the switch and replace the fuse after unplugging the power cord from the power inlet of the instrument or a power outlet.

⚠ WARNING

There are locations of high-voltage inside this product. Do not remove the cover of this instrument.

2.4 Quick operation check

In this section, methods of a quick operation check after storing the instrument for a long time are explained.

For more detailed check methods → Refer to “7. Maintenance”.

2.4.1 Display check at power on

Turn on the power switch of the **CA5351** and press the standby switch. After the startup screen is displayed, the main screen will be displayed, and then the instrument will be operational.

About the display when power is turned on → Refer to “3.2 Display at power “ON” and initial settings”.

For the details of error messages → Refer to “6.1 Error messages”.

WARNING

If smoke or an unusual odor or sound is emitted from the instrument, immediately unplug the power cord from an outlet and do not use the instrument again until it has been repaired.

2.4.2 Self-diagnostic test execution

The self-diagnostic test can be performed as shown in the following procedures. For more details, refer to “4.1.6 SELFTEST (self-diagnostic test execution screen)”.

1. Press the **UTILITY** key on the front panel and the utility screen will be displayed.
2. Move the cursor over the “**SELFTEST**” and press the **ENTER** key by pressing the up and down keys or turning the knob.
3. After moving the cursor over the “**OK**”, press the **ENTER** key with no connection to the output connector.
4. The self-diagnostic test will be completed in a few seconds and the result will be displayed.
5. When “Pass” is displayed on the screen, the instrument will work normally. If “Fail” is displayed, refer to “6.1.2 Errors that occur during panel operations”

That is all the quick operation check is completed.

2.5 Calibration

It is recommended to perform calibration for the **CA5351** 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.

When calibration is necessary, please contact the NF Corporation or its authorized agent.

Please understand that there is a charge for calibration and adjustments.

When the instrument is used for important measurements or tests, it is recommended that the performance test described in **“7.6 Performance test”** be performed immediately before the measurements 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.

3. Panel operations and basic operation

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3.1 Function and use of each part of the panels

This section describes the names and functions of each part of the front panel and rear panel of the **CA5351**.

3.1.1 Front panel

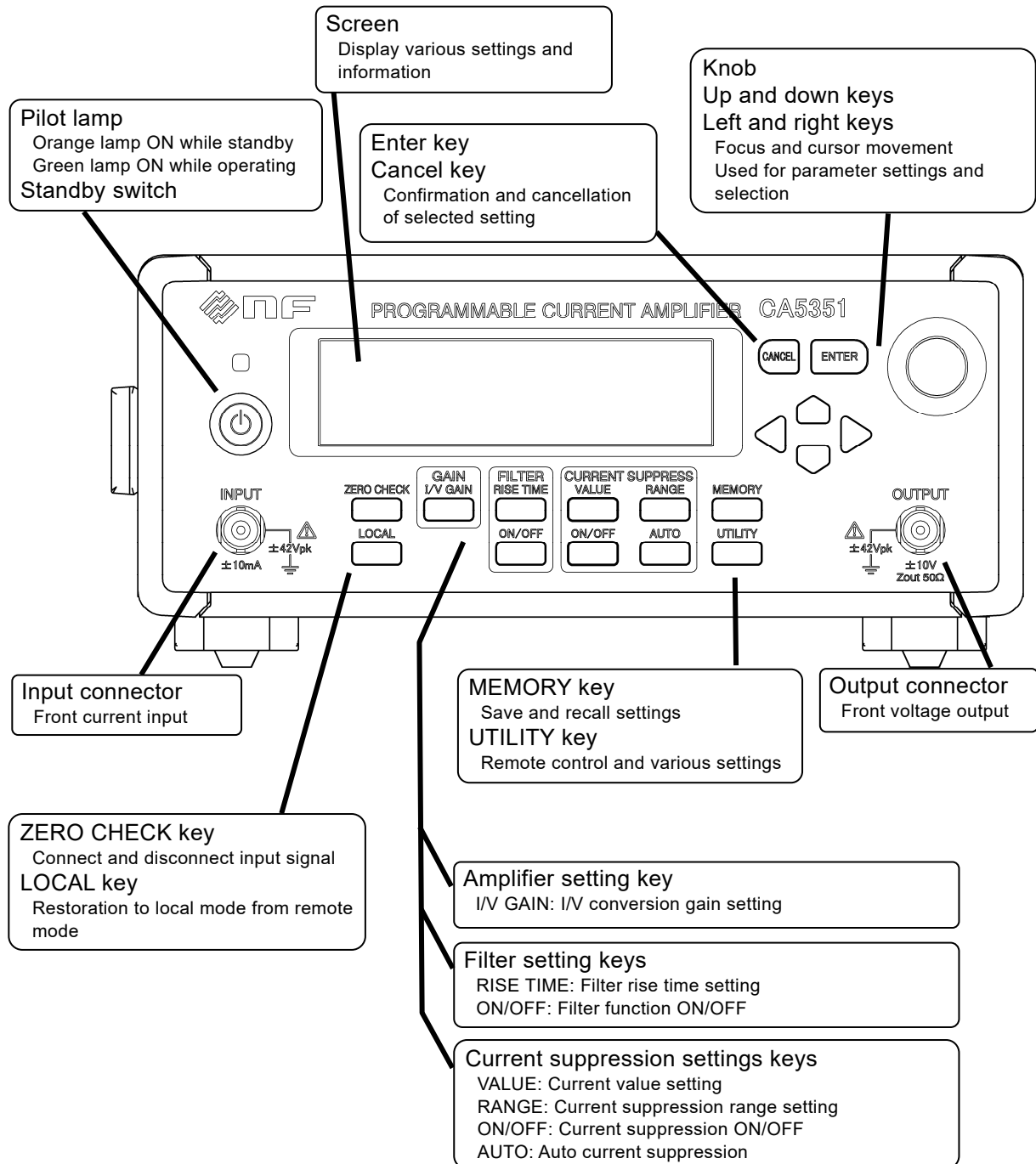


Figure 3-1 Front panel

3.1.2 Rear panel

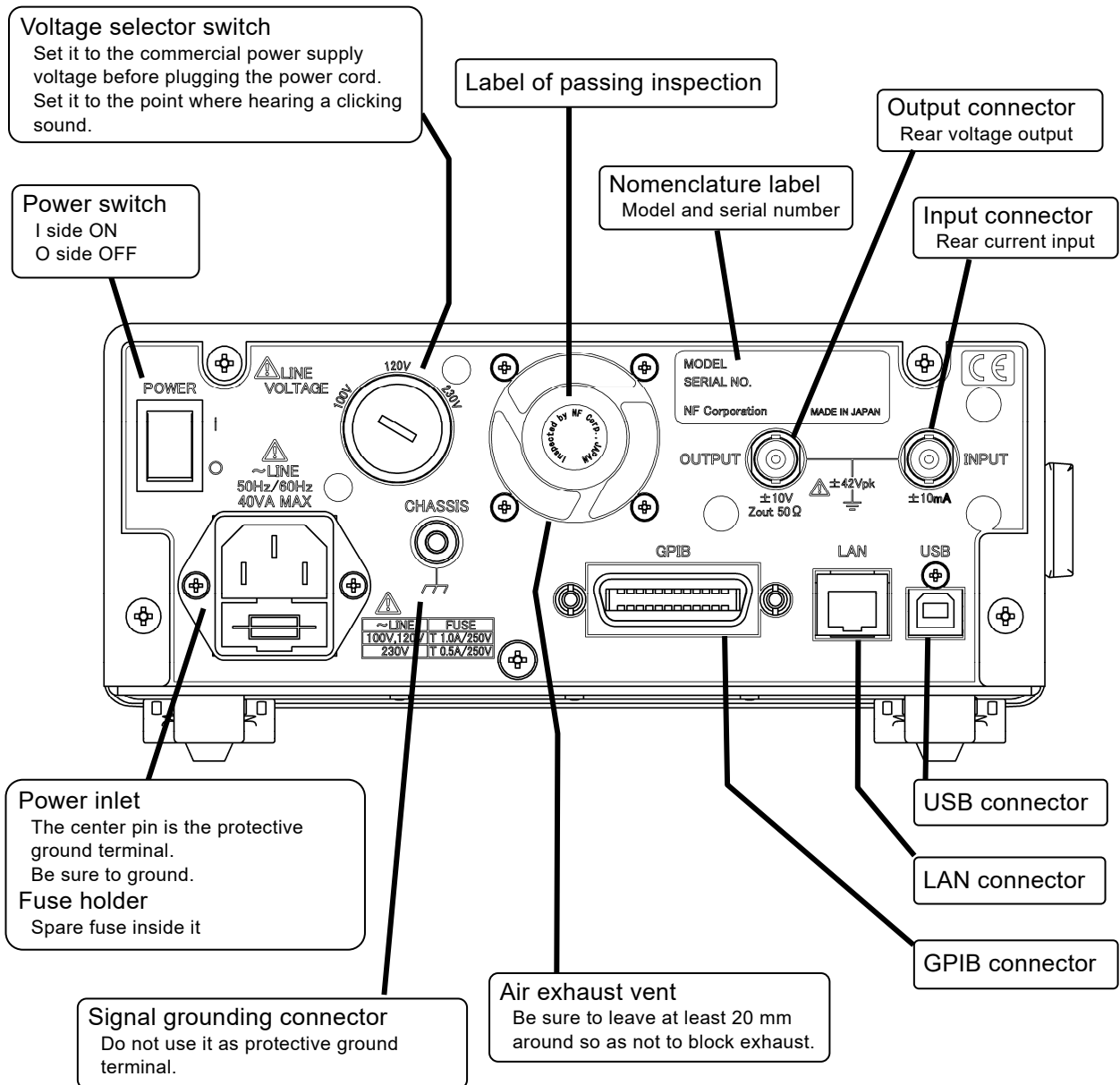


Figure 3-2 Rear panel

3.2 Display at power “ON” and initial settings

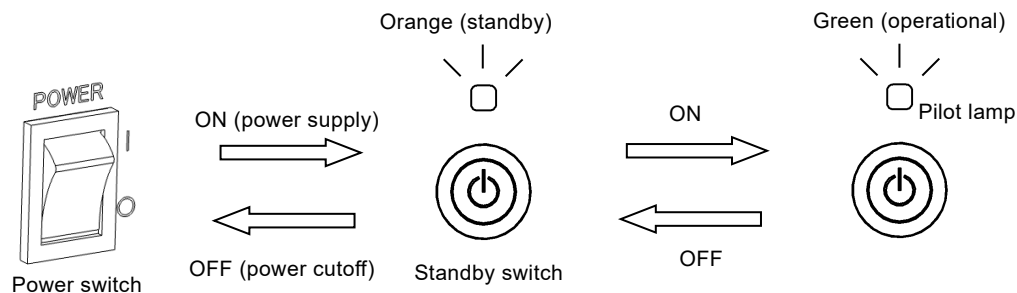
3.2.1 What to check before turning the power on

Before turning the instrument power switch on, read “**2.3 Grounding and power connections**” and check the instrument grounding and the voltage of the voltage selector switch.

3.2.2 Display at power “ON”

When the power switch is turned on, the pilot lamp will light up orange and the instrument will become the standby state. When the standby switch is turned on in this state, the pilot lamp will light up green and the instrument will be operational.

When the standby switch is turned off in the operational state, the pilot lamp will light up orange and the instrument will become the standby state. Moreover, when the power switch is turned off, power supply will be blocked.



When the instrument becomes the operational state, the startup screen will be displayed.

During that time, a system check is performed and settings are read.

If an abnormality occurs, an error message will be displayed.

For more details → Refer to “6.1.1 Errors that occur when the instrument power is turned on”.



Startup screen

If a serious error is detected, the instrument will no longer operate with the error message displayed.

If settings are lost, the error message will be displayed. However, the instrument will initialize all contents of the configuration memory to the factory default setting, and then it will be operational.

Contents of initialization → Refer to “3.2.3 Initial settings”

If the resume memory has no errors, settings will return to the state when the power was turned off most recently.

The behavior when the power is turned on can be set in the “**POWER ON STATE**” on the “**UTILITY**” screen.

3.2.3 Initial settings

The **CA5351** will be initialized to the factory default setting at the following conditions below.

■ When shipped from a factory

All of the settings are initial values. The contents of the configuration memory are the factory default setting.

Push the **UTILITY** key and the “**UTILITY**” screen will be displayed. Focus on the “**Exec**” on the right of “**INITIALIZE**” and push the **ENTER** key, and then initialization execution screen will be displayed. Focus on the “**OK**” and push the **ENTER** key to reset to the factory default setting. However, maintenance information will not be changed.

■ When the initialization is executed

All settings other than configuration memory, interface settings, and display settings will be initialized.

• Panel operation

When moving the cursor over the “**Exec**” on the right of “**RESET**” and pushing the **ENTER** key

• Remote control command

By *RST command

■ When the power is turned on, if the resume memory storing the last settings has an error

Abnormal parts will be initialized.

If all settings are normal, these settings will be returned to the last settings.

Refer to “**Table3-1 Initial settings**” for the items to be initialized and initial values.

The table shows the relationship between each parameter and the automatic setting functions, configuration memory, and resume memory.

Table 3-1 Initial settings

Setting item	Parameter range	Initial value	*RST	Configuration memory	Resume memory
<Input>					
Zero check	ON, OFF	ON	←	×	✓
Input select	FRONT, REAR	FRONT	←	✓	✓
<Gain>					
I/V GAIN	1E03, 1E04, 1E05, 1E06, 1E07, 1E08, 1E09, 1E10	1E04	←	✓	✓
<Filter>					
AUTO filter	AUTO, OFF	AUTO	←	✓	✓
Rise time	1 μs, 3 μs, 10 μs, 30 μs, 100 μs, 300 μs, 1 ms, 3 ms, 10 ms, 30 ms, 100 ms, 300 ms	1 μs	←	✓	✓
ON/OFF	ON, OFF	ON	←	✓	✓
<Current suppression>					
Current value	±0 to ±8.000 mA	0.000 nA	←	✓	✓
AUTO range	AUTO, OFF	OFF	←	✓	✓
Range	8 nA, 80 nA, 800 nA, 8 μA, 80 μA, 800 μA, 8 mA	8 nA	←	✓	✓
ON/OFF	ON, OFF	OFF	←	✓	✓
<Display>					
Backlight	OFF, 1, 2, 3	2	×	×	✓
Color	DARK, GRAY, LIGHT	DARK	×	×	✓
<Remote control>					
Interface	USB, LAN, GPIB	USB	×	×	▲
LAN IP address	0.0.0.0 to 255.255.255.255	192.168.0.2	×	×	▲
LAN subnet mask	0.0.0.0 to 255.255.255.255	255.255.255.0	×	×	▲
LAN default gateway	0.0.0.0 to 255.255.255.255	0.0.0.0	×	×	▲
GPIB address	0 to 30	2	×	×	▲
command	SCPI, 5350	SCPI	×	×	▲
<Power on setting>					
Power on state	STBY, STBY&ZERO, Last-STAT, Last-STAT&ZERO	Last-STAT&Zero	×	×	▲
<Configuration memory>					
contents	—	Initial value	×	—	—
Memory name	—	Initial value	×	—	—

■ **Notes**

Initial value: Factory default setting

*RST : When RESET panel operation or the *RST remote command is executed

← : Same as left (initial value)

✓ : With function

× : No function

▲ : With function but incompatible with remote control

3.3 I/O connectors

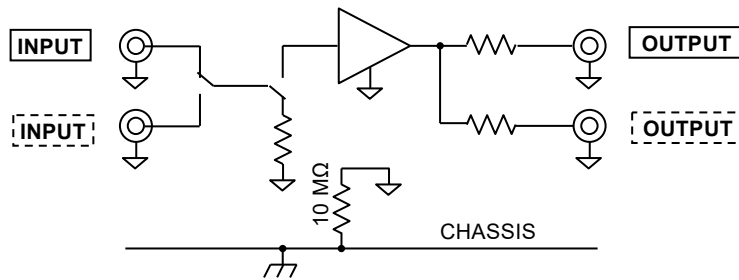


Figure 3-3 I/O connectors

The input and output connectors of the **CA5351** are isolated from the enclosure of the instrument with high resistance (10 MΩ). The withstanding voltage is 42 Vpk (DC + ACpeak).

⚠ WARNING

For avoiding electric shock, ensure that voltage exceeding 42 Vpk (DC + AC peak) must not be applied between the outer conductors of the BNC connectors and enclosure of the instrument.

If doing so, the internal voltage limiter will become active and will try to limit that voltage. However, if that voltage is too large, the instrument may be damaged by fire.

⚠ CAUTION

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

⚠ CAUTION

Do not apply current exceeding the non-destructive maximum input current value to the input connectors. Doing so may damage the instrument.

⚠ CAUTION

When there is an electric potential difference between the enclosure of the instrument and the outer conductors of the BNC connectors, do not short-circuit the inner conductors of the BNC connectors and the enclosure. Doing so may damage the instrument.

■ Input connectors (INPUT)

The input connectors of the **CA5351** are located on the front panel and rear panel. Select and use either of them. You cannot use both of them simultaneously.

Turning on the “**ZERO CHECK**” will disconnect the input connector (the selected one) from the internal amplifier. Use this when checking whether there is input current or an offset of the **CA5351** itself.

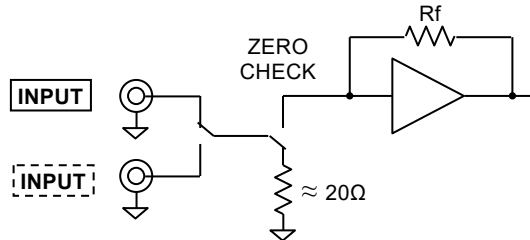


Figure 3-4 Input connectors

Methods of selecting the input connectors → “4.1.2 INPUT (input select screen)”

■ Output connectors (OUTPUT)

The output connectors are located on the front panel and rear panel. Output impedance of each connector is 50 Ω (approximate value) and the same signals are outputted from the front and rear connectors. However, the output voltages of each connector will differ if load current flows. Therefore, it is recommended to use only one of the output connectors and keep the other one open.

The maximum output current is ±10 mA as the total of both the connectors.

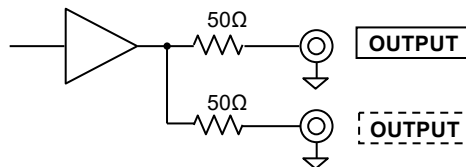


Figure 3-5 Output connectors

When current is flowed into the input connector of the **CA5351**, negative voltage will be outputted from the output connectors. Thus, an output signal owns the opposite polarity of an input signal.

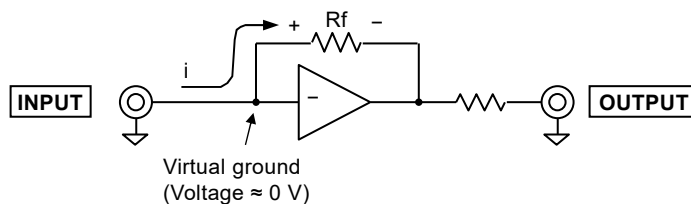


Figure 3-6 Output polarity

3.4 I/O connections

To get the best low-noise performance of the **CA5351**, it is important how the input and output are shielded and the instrument is connected and installed. Connect and install the instrument as the following methods.

- Install the **CA5351** as close as possible to a sensor or source of a signal, and keep a connection cable to the input connector as short as possible.
- When there are instruments with built-in transformers (both a commercial power supply transformer or switching transformer) nearby, keep a sensor and the **CA5351** away from them as far as possible. Besides, keep the I/O cables of the **CA5351** away from them as far as possible.
- Install the instrument in a place of as little vibration as possible. When it is used for detecting tiny signals, it may be affected by microphonic noise generated by vibration of cables.
- Use shielded cables such as coaxial cables. Besides, ensure that input and output cables should be separated from each other to avoid coupling. Coupling between input and output cables may cause instability such as self-oscillation.

3.4.1 Connection of optical sensor (photodiode), etc.

Ensure to place a sensor in a shielded box.

(1) No-bias type sensor

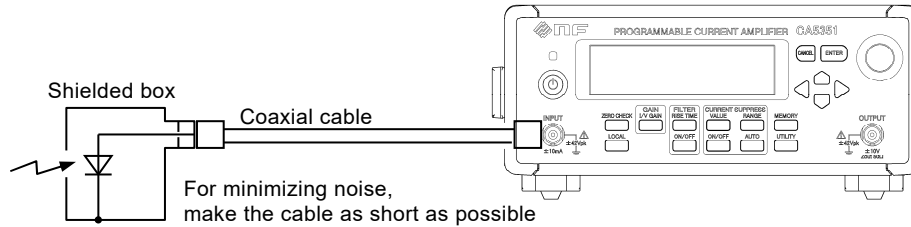


Figure 3-7 Connection of sensor without bias type

(2) Reverse bias type sensor

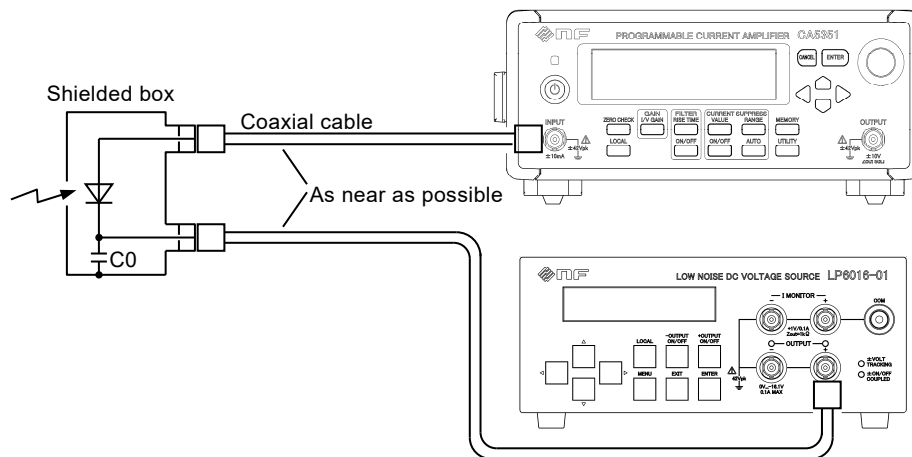


Figure 3-8 Connection of reverse bias type sensor

Apply a positive bias voltage to the cathode of the sensor shown in “**Figure 3-8 Connection of reverse bias type sensor**” using a low-noise voltage source (Our product Model LP6016-01, etc.).

The “C0” in “**Figure 3-8 Connection of reverse bias type sensor**” is the capacitor for bypassing noise from outside. Use a capacitor with sufficiently large electrostatic capacitance (for example: about 0.1 μF) as the “C0” if needed.

Position the coaxial cables for current input and bias output as parallel as possible and as close as possible. If a loop area formed with the two cables becomes large, electromagnetic induction noise due to external magnetic flux will occur easily.

Output voltage of the **CA5351** may be saturated when a sensor with large dark current is used as an input signal. The current suppression function can cancel such dark current, thereby larger the “**I/V GAIN**” can be used.

About current suppression → Refer to “**3.7.4 Current suppression settings**”.

(3) Example of connection with photomultiplier (PMT)

Because a large bias voltage (100 V or more) is required, a dedicated bias voltage source is necessary.

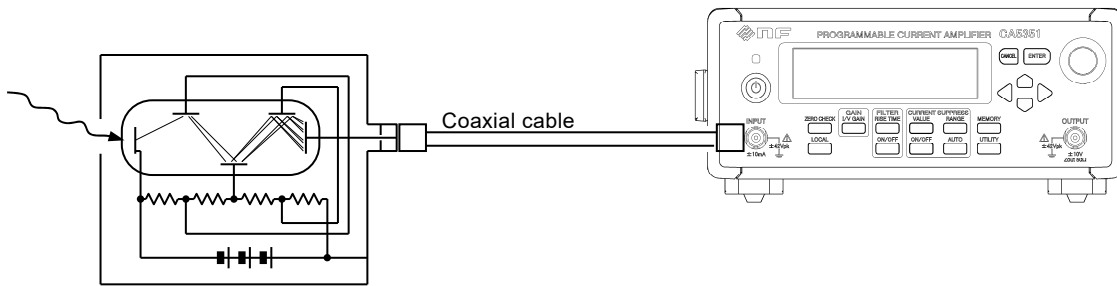


Figure 3-9 Example of connection of photomultiplier

For either of the connections, it is important to make the input cable as short as possible to get the best low-noise performance.

3.4.2 Connection to lock-in amplifier, etc.

When connecting the output connector of the **CA5351** to measurement equipment like a lock-in amplifier or digitizer, it is necessary to pay attention to noise current by a ground loop.

Because the I/O of the **CA5351** are isolated from the enclosure of the instrument, it is less susceptible to effect of a ground loop. However, it is necessary to pay careful attention to grounding of a sensor and the equipment connected to the output of the **CA5351**.

(1) When signal source is grounded

When the signal source is grounded, do not ground the input of the measurement equipment (lock-in amplifier, etc.) which is connected to the output of the **CA5351**. Because a ground loop is formed and noise current flow through it, common mode noise may occur easily.

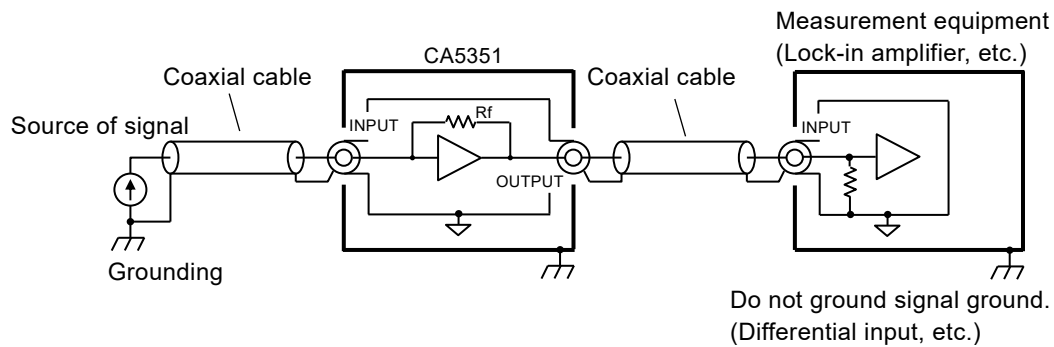


Figure 3-10 When signal source is grounded

(2) When signal source cannot be grounded

When the signal source cannot be grounded as shown in “**Figure 3-11 When signal source cannot be grounded**”, ground the outer conductor of the coaxial cable at the input of the measurement equipment. If the measurement equipment is used without grounding, high voltage will occur because of electrical charge accumulated in the outer conductor of the coaxial cable, which may cause electric shock or damage to the instrument. Besides, noise may be easily mixed in the signal by electrostatic induction.

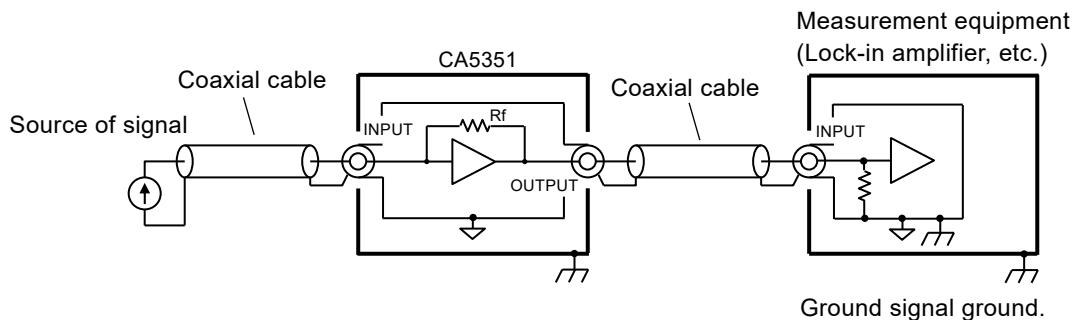
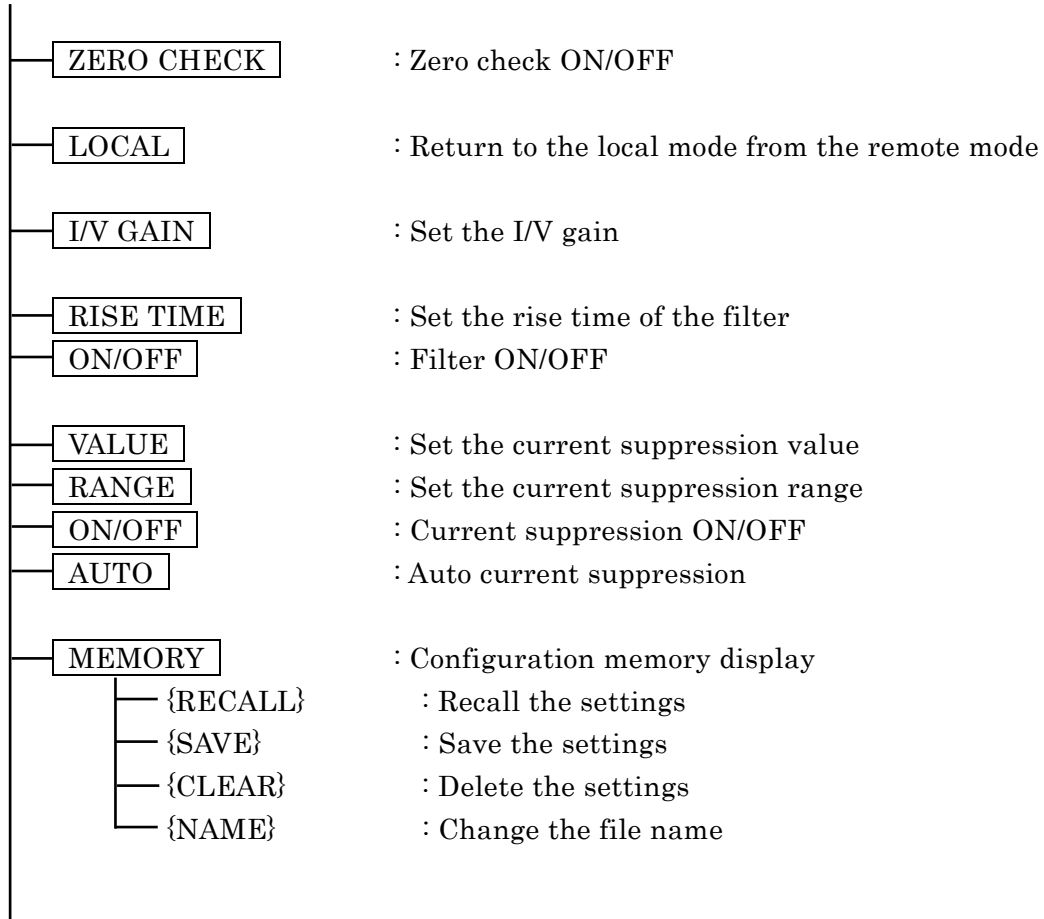


Figure 3-11 When signal source cannot be grounded

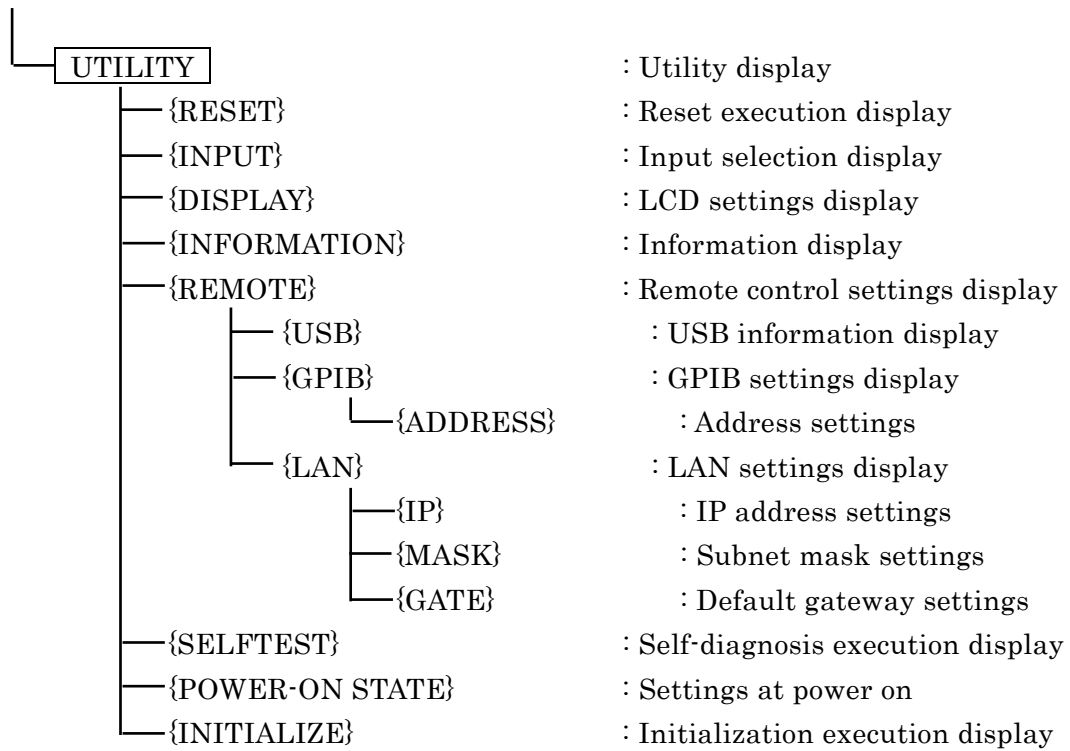
3.5 Operation tree

The operation tree for operating the **CA5351** from its panels is presented below.

Front panel



(Continued)

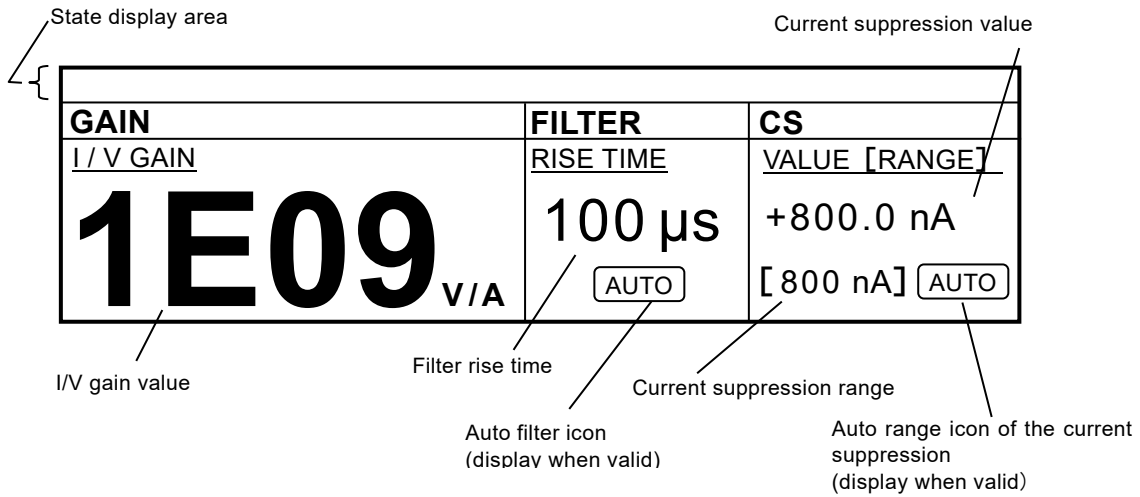


3.6 Basic operation

3.6.1 Outline of main screen

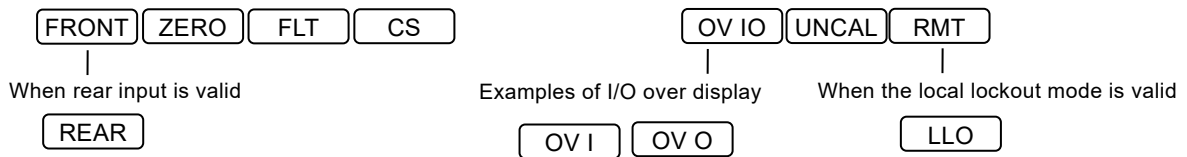
■ Main screen

The figure below describes contents of the main screen.



■ State display area

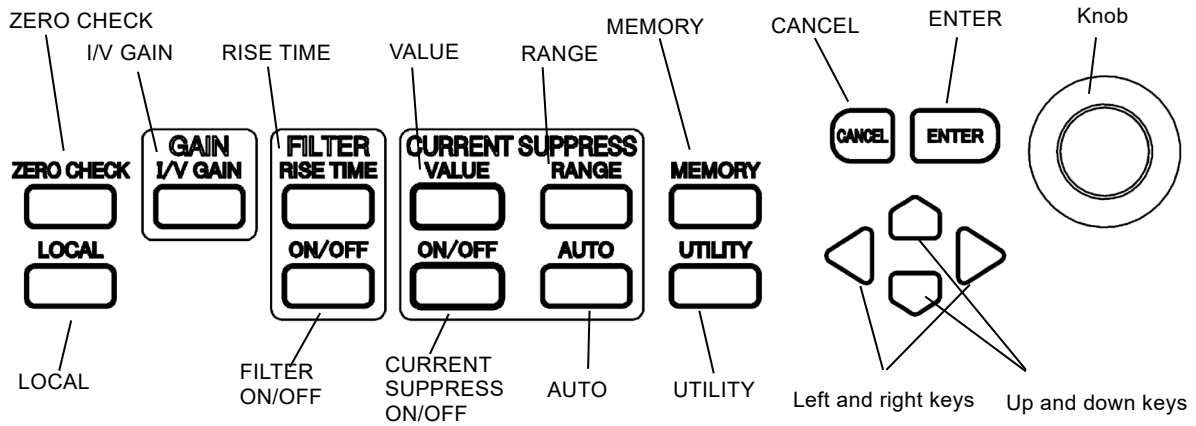
The figure and chart below describe icons displayed on the state display area.



State	Description
FRONT /REAR	Display the current input terminal FRONT or REAR is definitely displayed.
ZERO	Display Zero check ON/OFF Zero check is ON when the icon is displayed.
FLT	Display the filter functions ON/OFF The filter function is ON when the icon is displayed and the filter function is OFF when the icon is hidden.
CS	Display the current suppression functions ON/OFF The current suppression is ON when the icon is displayed and the current suppression is OFF when the icon is hidden.
OV IO, etc.	Display over levels of signals Detect saturation of the current amplifier and the output connectors
UNCAL	The instrument is in uncalibrated state. The calibration information of the instrument was lost and the specifications cannot be maintained due to some trouble. Please contact the NF Corporation or its authorized agent as it is malfunction.
RMT /LLO	The instrument is in the remote mode when RMT is displayed. The instrument is in the local lockout mode when LLO is displayed.

3.6.2 Basic key operation

The figure and chart below describe the keys of the front panel.



Key name	Function
ZERO CHECK	Zero check ON/OFF
LOCAL	Return to the local mode from the remote mode
I/V GAIN	The shortcut to I/V gain setting
RISE TIME	The shortcut to rise time setting AUTO filter ON/OFF by pressing and holding this key
FILTER ON/OFF	Filter function ON/OFF
VALUE	The shortcut to the current suppression value
RANGE	The shortcut to the current suppression range Auto range of the current suppression ON/OFF by pressing and holding this key
CURRENT SUPPRESS ON/OFF	The current suppression ON/OFF
AUTO	Execute the auto current suppression
MEMORY	Move to the display of the configuration memory
UTILITY	Move to the utility display Recovery from display OFF
ENTER	Decision to execute a setting Move to a lower hierarchy of an operation screen Move to a focus state from a non-focus state Move to a setting change state from a focus state
CANCEL	Move to a higher hierarchy of an operation screen or return to an original operation screen Move to a focus state from a setting change state Move to a non-focus state from a focus state
Knob	Move the focus and change setting values Turn clockwise to turn up and counterclockwise to turn down
Up and down keys	Move the focus up and down and change setting values
Left and right keys	Move the focus to left and right Select a digit





■ Display of main screen

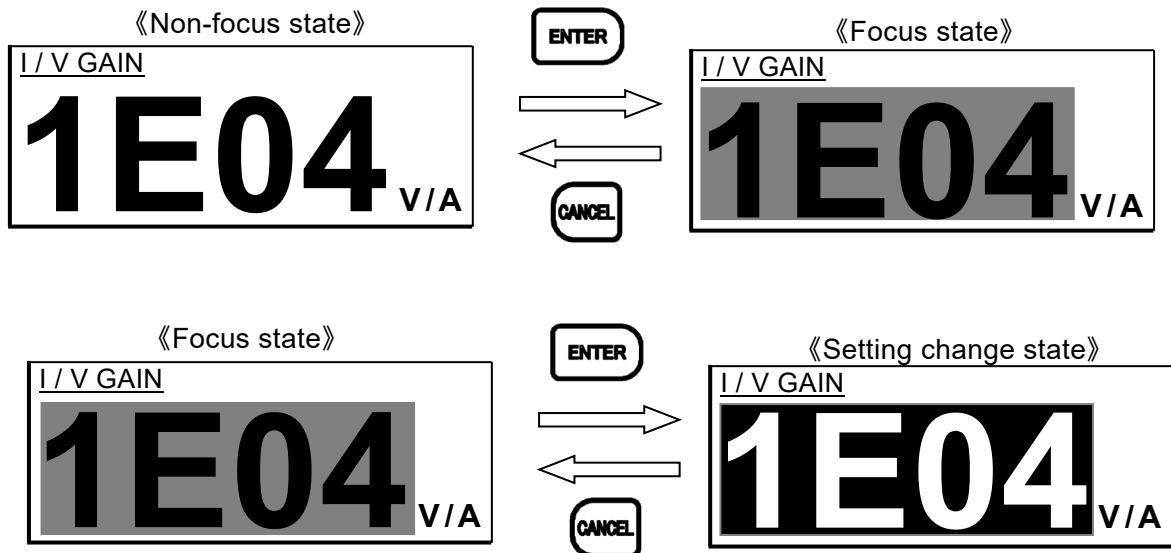
The main screen as shown below will be displayed after the instrument is turned on.

FRONT	ZERO	FLT
GAIN		FILTER
I / V GAIN		RISE TIME
1E04 _{V/A}		1 μ s
		<input type="button" value="AUTO"/>
		CS
		VALUE [RANGE]
		+0.000 nA
		[8 nA] <input type="button" value="AUTO"/>

■ Selection of setting item

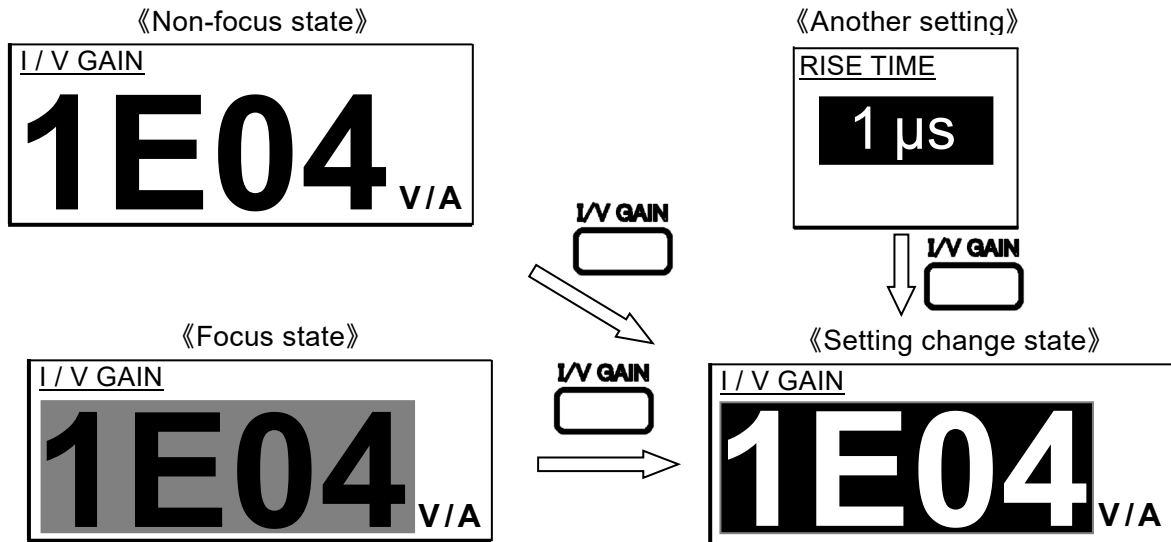
• Move of focus

Press the **ENTER** key at the main screen to show a focus. Turn the Knob, use the   (up and down keys), and the   (left and right keys), and then move the focus to an item to be changed. After focusing on the item, the instrument will become the setting change state when the **ENTER** key is pressed. When the **CANCEL** key is pressed, the setting change state will move to the focus state. Furthermore, when the **CANCEL** key is pressed, the focus state will move to the non-focus state.





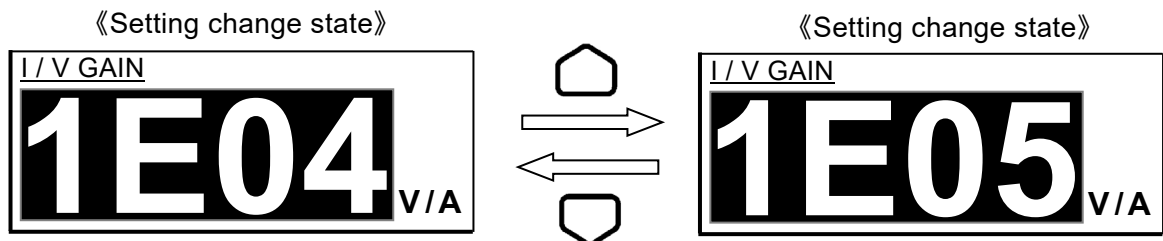
- **Shortcut key**

When the **I/V GAIN**, **RISE TIME**, **VALUE**, or **RANGE** key is pressed, the instrument will move to the setting change state corresponding to the key pressed.



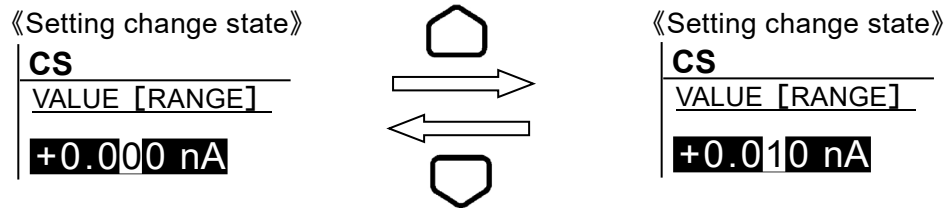
- **Change setting**

In the case of the “**I/V GAIN**”, 1E03 V/A, 1E04 V/A, ..., and 1E10 V/A can be set. You can change the “**I/V GAIN**” value turning the knob or using the   (up and down keys). Once the value is changed, it will be reflected immediately.



- **Numerical value input**

When the cursor is on a parameter where a numerical value can be set, the digit can be changed by using the ◀ ▶ (left and right keys) and the value can be changed by using the ⬆ ⬇ (up and down keys). You can increase the value using the ⬆ (up key) or rotating the knob in clockwise direction, or decrease it using the ⬇ (down key) or rotating the knob in counterclockwise direction.



3.6.3 Simple Operation for the first use

This section describes the simple operating method when you use the **CA5351** for the first time. Do not use a remote control interface.

Operate as the following steps

- 1) Initialization
- 2) Connection between sensor (signal source) and the input connector
- 3) Connection between the output connector and measurement equipment
- 4) Disable the Zero check.

- **Initialization**

Push the **UTILITY** key and move to the “UTILITY” screen after the **CA5351** is turned on.

Focus on the “Exec” on the right of the “RESET” and press the **ENTER** key, and then move to the reset execution screen. Focus on the “OK” and press the **ENTER** key, and then the reset will be executed.

- **Connection between sensor (signal source) and the input terminal**

Connect the input connector in the front panel of the **CA5351** and a sensor with a coaxial cable. In the factory default setting of the **CA5351**, the input is selected to the connector located on the front panel. You can check which input connector is used by the icon on the main screen.

- **Connection between the output connector and measurement equipment**

Connect the output connector to measurement equipment with a coaxial cable. Use only one of the output terminals on the front panel or the rear panel. Because the Zero check of the **CA5351** is ON, the signal from the sensor is not be inputted to the internal circuit of the **CA5351**. Therefore, the output voltage is almost 0 V.

- **Turn off the Zero check**

Press the **ZERO CHECK** key to turn off the Zero check.

The voltage signal converted from the input current signal will be outputted from the output connector of the **CA5351**.

3.7 Basic settings

■ Precautions for use

The parts (relays) inside the instrument that switch Zero check state, I/V gain, current suppression range, and the input connector have finite service life. It is possible that relays will deteriorate if the number of switching relays is large. A malfunction may occur despite within the warranty period depending on frequency of switching relays.

3.7.1 Zero check

The Zero check is for disconnecting an inputted signal from the internal circuit. It is used to connect a coaxial cable to the input connector, discharge the cable, check an output offset of the **CA5351**, or check current flowing from a sensor.

The Zero check can be turned on and off by pressing the **ZERO CHECK** key on the panel.

When the Zero check is turned on (the input is disconnected from the internal circuit), the **ZERO** icon will be displayed.

Turn off the Zero check, when amplifying a signal from a sensor. Note that it will not be amplified if the Zero check is turned on.

This function is used for checking an output offset of the **CA5351** or whether there is current flowing from a sensor. When the Zero check is turned on, the inner conductor of the input connector will be disconnected from the inside of the **CA5351** and it is connected to the ground of the outer conductor of the input terminal with low resistance (about 20 Ω).

Therefore, the input of the **CA5351** is turned off while maintaining low load impedance of the sensor. In this state, after the output voltage of the **CA5351** is set to 0 V by adjusting the current suppression value and then turn off the Zero check, the offset generated by the instrument can be cancelled.

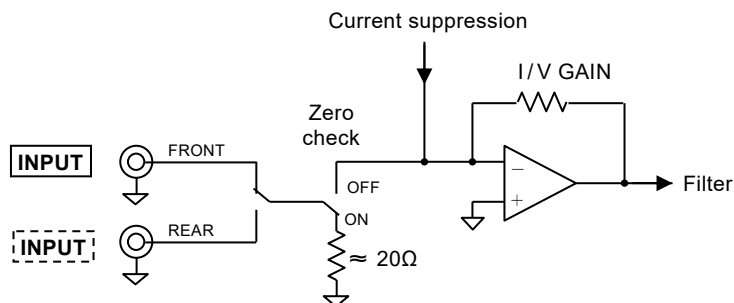


Figure 3-12 Input circuit

3.7.2 Gain settings

Gain of the **CA5351** is the conversion gain (I/V GAIN) of the I/V conversion amplifier.

The range is from 1E03 (10^3) V/A to 1E10 (10^{10}) V/A.

You can change the value of the gain by pressing the **I/V GAIN** key or moving the focus to the “I/V GAIN”, and then pressing the **ENTER** key.

3.7.3 Filter settings

The instrument is equipped with the filter to reject noise from the amplified signal from the I/V conversion amplifier and to improve an SNR.

The filter is Bessel characteristics (2nd order) and a low-pass type. Overshoot does not occur in a pulse response because of Bessel characteristics.

The filter can be set by rise time. Moreover, it is possible that the filter is bypassed for getting the maximum response speed and there is also an auto filter function that automatically sets the optimum filter with respect to the I/V gain value.

1) How to use the filter

You can change the ON/OFF state of the filter by pressing the **ON/OFF** key in the “**FILTER**” frame of the panel.

The **FLT** icon will be displayed when the filter is ON.

Setting the filter to OFF (not use) will disable noise rejection, but response properties will become the fastest. When the fastest response is required, turn off the filter function.

2) Manually settings of filter response (rise time)

Because the setting range is 1 μ s to 300 ms and sequence is 1-3, 12 settings are possible.

You can change the value by pressing the **RISE TIME** key or moving the focus to the “**RISE TIME**” in the “**FILTER**” frame of the panel, and then pressing the **ENTER** key.

《Setting change state》



3) Setting to auto filter

With respect to settings of the rise time, you can choose manual setting or auto setting that automatically sets rise time corresponding to the “**I/V GAIN**” value.

To enable the auto filter, press and hold the **RISE TIME** key in the “**FILTER**” frame of the panel or move the focus to the inactive icon **AUTO** below the rise time and press the **ENTER** key.

To disable the auto filter, press the **RISE TIME** key and change the rise time value, press and hold the **RISE TIME** key again, or move the focus to the active icon “**AUTO**” below the rise time, and then the **ENTER** key.



If the auto filter is enabled while the filter is enabled, the rise time manually set will be changed to the rise time corresponding to the “**I/V GAIN**” value.

Table 3-2 I/V Gain Settings and rise time settings of auto filter

I/V Gain Setting (V/A)	Filter rise time
1E10	100 μ s
1E09	100 μ s
1E08	30 μ s
1E07	10 μ s
1E06	10 μ s
1E05	3 μ s
1E04	1 μ s
1E03	1 μ s

■ Reference material

• Rise time

Rise time is defined as the time taken by the output signal of the **CA5351** to change from 10 % to 90 % of the amplitude when an ideal square-wave (rise time = 0 s) is inputted.

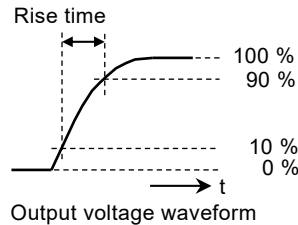


Figure 3-13 Definition of rise time

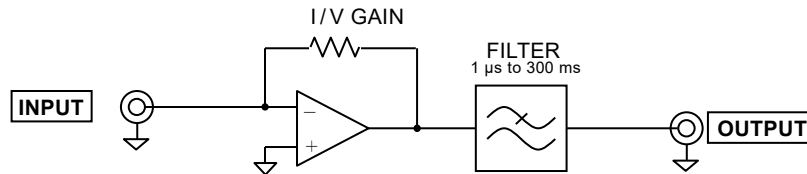


Figure 3-14 Block diagram of the CA5351

A response of the **CA5351** is affected by the rise time decided by the filter as well as response time of the I/V conversion amplifier. When the rise time of the I/V conversion amplifier is t_{IV} and the rise time of the filter is t_{FILT} , total rise time t_{TOTAL} can be calculated from the following expression.

$$t_{TOTAL} = \sqrt{t_{IV}^2 + t_{FILT}^2}$$

The rise time of the I/V conversion amplifier is the following values according to “I/V GAIN” values (rise time is approximate values).

1E10 V/A	≈ 25 μs
1E09 V/A	≈ 5 μs
1E08 V/A	≈ 2 μs
1E07 V/A	≈ 1 μs
1E06 to 1E03 V/A	≈ 0.7 μs

When electrostatic capacitance of a cable and sensor connected to the input connector (**INPUT**) becomes large, the rise time of the I/V conversion amplifier will become large.

The longer of the rise time of the I/V conversion amplifier and the rise time of the filter is the close value of the total rise time of the **CA5351**.

Example 1) When the I/V GAIN is 1E10 V/A (rise time $\approx 25 \mu\text{s}$) and the filter rise time is $1 \mu\text{s}$

$$t_{\text{TOTAL}} = \sqrt{t_{\text{IV}}^2 + t_{\text{FILT}}^2} = \sqrt{(25 \times 10^{-6})^2 + (1 \times 10^{-6})^2} \approx 25 \mu\text{s}$$

Example 2) When the I/V GAIN is 1E10 V/A (rise time $\approx 25 \mu\text{s}$) and the filter rise time is $30 \mu\text{s}$

$$t_{\text{TOTAL}} = \sqrt{t_{\text{IV}}^2 + t_{\text{FILT}}^2} = \sqrt{(25 \times 10^{-6})^2 + (30 \times 10^{-6})^2} \approx 39 \mu\text{s}$$

Example 3) When the I/V GAIN is 1E10 V/A (rise time $\approx 25 \mu\text{s}$) and the filter rise time is $300 \mu\text{s}$

$$t_{\text{TOTAL}} = \sqrt{t_{\text{IV}}^2 + t_{\text{FILT}}^2} = \sqrt{(25 \times 10^{-6})^2 + (300 \times 10^{-6})^2} \approx 301 \mu\text{s}$$

Even if the filter rise time is set shorter than the rise time of the I/V conversion amplifier, responsiveness will not improve as mentioned above. Besides, noise will increase in a high frequency range. Make appropriate filter settings according to the gain of the I/V conversion amplifier and a response signal to be measured and detected.

- **Settling time**

Setting longer filter rise time will reduce a high frequency noise component, thereby the SNR of the signal will be improved. However, settling time will also become longer. Relations between the filter rise time and the settling time are shown below (theoretical values).

Table 3-3 Filter rise time and settling time

Filter rise time	Settling time	
	10 %	1 %
1 μ s	1.19 μ s	1.70 μ s
3 μ s	3.57 μ s	5.11 μ s
10 μ s	11.9 μ s	17.0 μ s
30 μ s	35.7 μ s	51.1 μ s
100 μ s	119 μ s	170 μ s
300 μ s	357 μ s	511 μ s
1 ms	1.19 ms	1.70 ms
3 ms	3.57 ms	5.11 ms
10 ms	11.9 ms	17.0 ms
30 ms	35.7 ms	51.1 ms
100 ms	119 ms	170 ms
300 ms	357 ms	511 ms

- **Relations with frequency characteristics**

The longer the filter rise time is set, the narrower a frequency bandwidth will be. When a high frequency component is required to be passed, set the filter rise time to small value. Relations between the filter rise time and -3 dB cutoff frequency are shown below (theoretical values).

Table 3-4 Filter rise time and frequency bandwidth

Filter rise time	-3 dB cutoff frequency
1 μ s	340 kHz
3 μ s	114 kHz
10 μ s	34 kHz
30 μ s	11.4 kHz
100 μ s	3.4 kHz
300 μ s	1.14 kHz
1 ms	340 Hz
3 ms	114 Hz
10 ms	34 Hz
30 ms	11.4 Hz
100 ms	3.4 Hz
300 ms	1.14 Hz

3.7.4 Current suppression settings

The **CA5351** is equipped with a current source for cancelling dark current of a sensor and removing an offset component of the **CA5351** itself. If the dark current of the sensor is cancelled, the gain of the **CA5351** can be set to larger value, and measurement sensitivity can be improved.

1) How to use the current suppression

You can change the ON/OFF state of the current suppression by pressing the **ON/OFF** key in the “**CURRENT SUPPRESS**” frame of the panel.

The **CS** icon will be displayed when the current suppression is enabled.

2) Manually setting current suppression range

The current suppression range is 8 nA, 80 nA, 800 nA, 8 μA, 80 μA, 800 μA, and 8 mA.

You can change the range by pressing the **RANGE** key in the “**CURRENT SUPPRESS**” frame of the panel or moving the focus to the current suppression range, and then pressing the **ENTER** key.

《Setting change state》

CS
VALUE [RANGE]
+0.000 nA
[8 nA] [AUTO]

3) Manually setting current suppression value

Each current suppression range has the setting resolution of ±8000.

Details of the ranges and current values are shown in “**Table 3-5 Current suppression setting range and resolution**”.

You can change the value by pressing the **VALUE** key in the “**CURRENT SUPPRESS**” frame of the panel or moving the focus to the current suppression value, and then pressing the **ENTER** key.

《Setting change state》

CS
VALUE [RANGE]
+0.000 nA
[8 nA] [AUTO]

Table 3-5 Current suppression value setting range and resolution

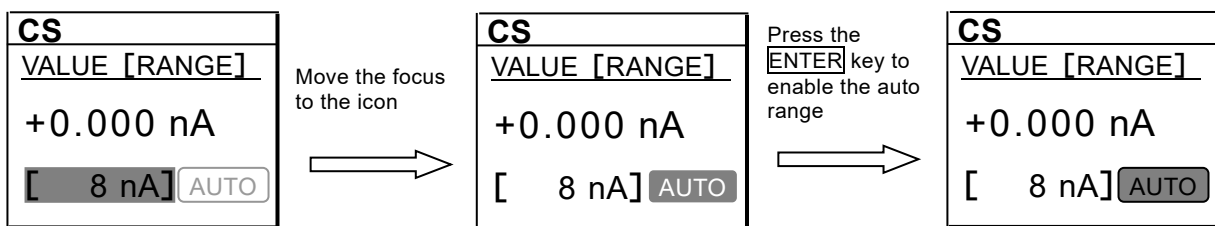
CS range	Settable range of CS value		Resolution
8 nA	-8.000 nA to	+8.000 nA	0.001 nA (1 pA)
80 nA	-80.00 nA to	+80.00 nA	0.01 nA (10 pA)
800 nA	-800.0 nA to	+800.0 nA	0.1 nA (100 pA)
8 μA	-8.000 μA to	+8.000 μA	0.001 μA (1 nA)
80 μA	-80.00 μA to	+80.00 μA	0.01 μA (10 nA)
800 μA	-800.0 μA to	+800.0 μA	0.1 μA (100 nA)
8 mA	-8.000 mA to	+8.000 mA	0.001 mA (1 μA)

4) Setting to auto range

Because the current suppression range is fixed the range set to, the current value can only be set within that range. If the current value exceeds that range, the range can be automatically changed to the adjacent range while the auto range is enabled.

To enable the auto range function, press and hold the **RANGE** key in the “**CURRENT SUPPRESS**” frame of the panel or move the focus to the inactive icon **AUTO** on the right of the range value, and then press the **ENTER** key.

To disable the auto range function, press the **RANGE** key and change the range value manually, press and hold the **RANGE** key, or move the focus to the active icon “**AUTO**” on the right of the range value, and then press the **ENTER** key.



5) Auto current suppression

This function automatically sets the range and current value required for eliminating dark current from a sensor. To enable it, press the **AUTO** key in the “**CURRENT SUPPRESS**” frame of the panel after connecting the signal source such as sensor to the input connector.

The range and current value will be adjusted so that the output voltage is almost 0 V against to the input current at the time of enabling the auto current suppression.

The message is displayed during the auto current suppression, and it will be automatically enabled after the adjustment.

If settling time is long, the setting of the auto current suppression may take a lot of time.

■ Restriction

The auto current suppression will not be executed in the following cases.

- When the Zero check is enabled
- When the OV I/O icon is displayed
- An input current fluctuates during the automatic settings and current suppression value goes out of the range

In this case, the range and current value will return to the settings before the execution.

- When the **CANCEL** key is pressed or the auto current suppression is interrupted

■ Reference material

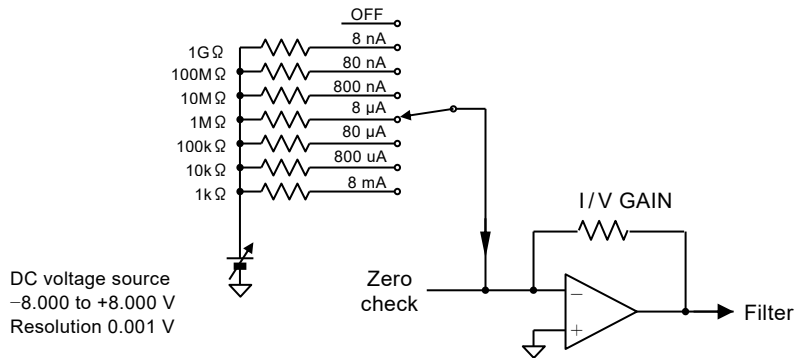


Figure 3-15 Block diagram of the current suppression

Note that the current suppression function will increase noise in the output signal of the **CA5351**. The bigger the “I/V GAIN” is or current suppression value is, the greater the degree of noise will increase.

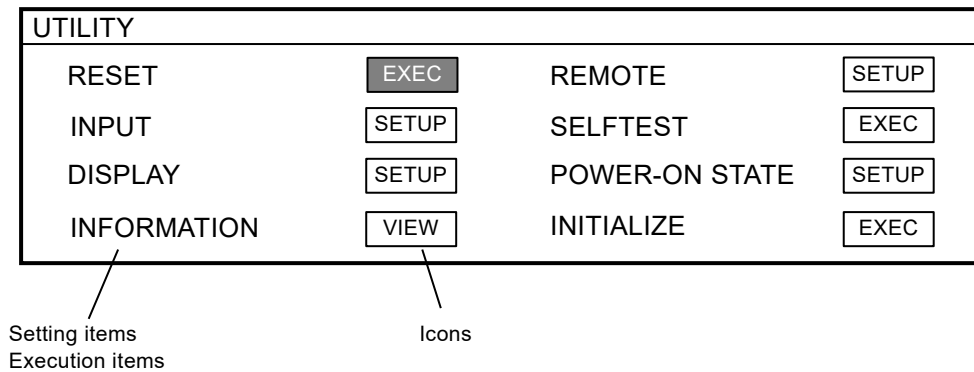
4. Advanced operation

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4.1 Utilities

The utility screen will be displayed by pressing the **UTILITY** key on the panel.

In the utility screen, you can reset the instrument, select the input connector, perform display settings, check product information, perform remote control settings, execute a self-diagnostic test, perform power on state settings, and reset the instrument to the factory default setting.

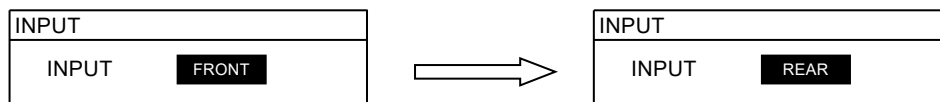


Move the focus on the icon on the right of the setting item or execution item by using the knob or (up and down keys) and (left and right keys).

The detail window of the item will be displayed by pressing the **ENTER** key. To close the window and return to the utility screen, press the **CANCEL** key.

Furthermore, you can back to the main screen from the utility screen by pressing the **CANCEL** key.

You can select parameters by moving the focus on the icon and pressing the **ENTER** key.



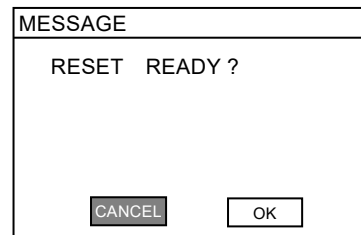
■ Restriction

The **ZERO CHECK** key, **ON/OFF** key in the “**FILTER**” frame, and **ON/OFF** and **AUTO** keys in the “**CURRENT SUPPRESS**” frame are invalid while the utility screen is being displayed.

4.1.1 RESET (reset execution screen)

In the reset execution screen, you can reset the instrument. The initial settings are that the Zero check is ON, the input connector is front, the I/V gain is 1E04, the filter settings are the auto filter and ON, the current suppression range is 8 nA, the current suppression value is 0 nA, and the current suppression is OFF.

To reset the instrument, move the focus on the “OK” icon and press the **ENTER** key.

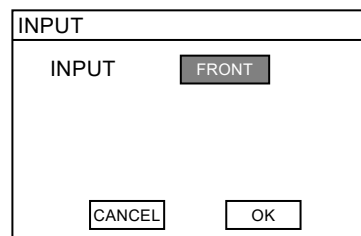


4.1.2 INPUT (input select screen)

In the input select screen, you can choose the input connector (INPUT) from located on the front panel (FRONT) or rear panel (REAR).

■ Restriction

If input selection is executed when the Zero check is OFF, the Zero check will be ON.



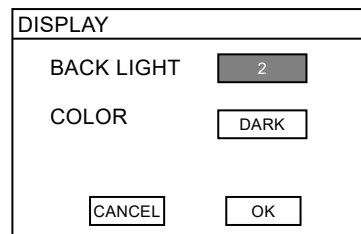
4.1.3 DISPLAY (display settings screen)

In the display settings screen, you can change the backlight brightness and color of the screen.

The backlight brightness can be selected from 3 levels from 1 to 3 (3 is the brightest) and OFF. In addition to the backlight, the pilot lamp etc. are turned off when the backlight brightness is OFF.

As for the display color, you can select the “DARK” with white characters on the navy background, “GRAY” with black characters on the gray background, and “LIGHT” with black characters on the yellow green background.

To change the color, select the color, focus on the “OK” icon and press the **ENTER** key. After that, the main screen will be displayed.



■ Screen restoration

It is difficult to change settings when the backlight is OFF. The screen is restored by pressing the **UTILITY** key.

4.1.4 INFORMATION (product information screen)

In the product information screen, the model of the instrument, version of the firmware, last adjustment date, and total working time are displayed.

INFORMATION	
MODEL	CA5351
FW Ver.	1.00
ADJ. DATA	2020/09/01
WORK TIME	999,999 hr
<input type="button" value="OK"/>	

4.1.5 REMOTE (remote control settings screen)

You can choose a remote interface from USB, GPIB, or LAN. After setting the interface you want to use and detail parameters, move the focus on the “OK” icon and press the **ENTER** key.

Besides, you can choose the SCPI (Standard Commands for Programmable Instruments) commands or the commands compatible with our product the **CA5350**.

1) USB

For the USB interface, no settings are required. The vendor ID, product ID, and serial number are displayed in the setting screen.

REMOTE			
INTERFACE	<input type="button" value="USB"/>	COMMAND	<input type="button" value="SCPI"/>
VENDER	0D4A	SERIAL	9999999
PRODUCT	0068		
<input type="button" value="CANCEL"/>		<input type="button" value="OK"/>	

2) GPIB

For the GPIB interface, the GPIB address can be set from 0 to 30.

REMOTE			
INTERFACE	<input type="button" value="GPIB"/>	COMMAND	<input type="button" value="SCPI"/>
ADDRESS	<input type="text" value="2"/>		
<input type="button" value="CANCEL"/>		<input type="button" value="OK"/>	

3) LAN

For the LAN interface, you can set the IP address, subnet mask, and default gateway.

REMOTE						
INTERFACE	LAN				COMMAND	SCPI
IP	192	168	0	2	MAC	00:14:CE:00:00:00
MASK	255	255	255	0	PORT	5025
GATE	0	0	0	0		
	CANCEL				OK	

4) Command

The remote commands for the instrument are usually SCPI commands. The instrument can be controlled by the commands compatible with our product the **CA5350** by selecting the icon on the right of the “**Command**” and selecting the “**5350**”.

For more details → “5.8 Compatibility with commands of the CA5350”

4.1.6 SELFTEST (self-diagnostic test execution screen)

When the self-diagnostic test is executed, the instrument will inspect itself by changing the I/V gain and current suppression settings.

To execute the test, focus on the “**OK**” icon and press the **ENTER** key.

The “Pass” message will be displayed on the screen when the instrument works normally.

If “Fail” message is displayed on the screen, refer to “6.1.2 Errors that occur during panel operations”.

■ Notes

Voltages will be generated from the output connectors (OUTPUT).

It is not recommended to connect a cable to the output connectors.

MESSAGE
START SELFTEST ?
Cancel OK

MESSAGE
MESSAGE No.11
SELFTEST DONE
Pass
0x00010000
OK

4.1.7 POWER ON STATE (Power on state settings screen)

The starting and Zero check state when the instrument is turned on or resumed can be set.

This function is utilized for situations when the standby switch cannot be turned off, for instance, in the event the **CA5351** is mounted on a rack etc. and the power switch will be turned on and off together with other devices.

The instrument can start without via the standby state after the power supply is cut off during operation.

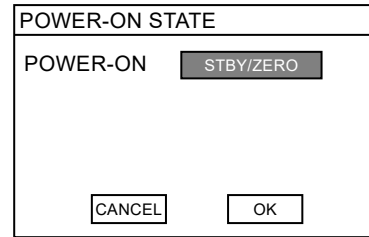
The instrument will always be standby state when it is turned off by the standby switch.

When STBY/ZERO or STBY is selected, it will definitely be standby state if the power supply is cut off during operation and it is turned on again or resumed.

When LAST/ZERO or LAST is selected, it will be operational state without via the standby state if the power supply is cut off during operation and it is turned on again or resumed.

The Zero check will definitely be ON when STBY/ZERO or LAST/ZERO is selected.

When STBY or LAST is selected, the Zero check state will be restored depending on the state at the end of the last operation.

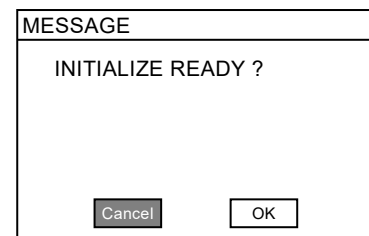


	Setting	Power on state	Zero check ON or OFF
1	STBY/ZERO	Always standby state	Always ON
2	STBY		Depending on contents stored in the resume memory
3	LAST/ZERO	It becomes standby state when turned off by the standby switch. Otherwise, it becomes operational state without via the standby state.	Always ON
4	LAST		Depending on contents stored in the resume memory

4.1.8 INITIALIZE (initialization execution screen)

In the initialization execution screen, you can return the **CA5351** to the factory default setting.

To initialize it, focus on the “OK” icon and press the **ENTER** key.



4.2 Memory operation



The memory settings screen will be displayed by pressing the **MEMORY** key on the panel.

There are 10 sets of the configuration memory. The No.1 to No.9 memories can be restored, saved, cleared, and the memory names can be changed.





MEMORY				
MENU	MEMORY			
RECALL	No.1	DEFAULT	No.6	DEFAULT
STORE	No.2	DEFAULT	No.7	DEFAULT
CLEAR	No.3	DEFAULT	No.8	DEFAULT
RENAME	No.4	DEFAULT	No.9	DEFAULT
	No.5	DEFAULT	No.0	PWR ON

Menu items

Memory lists

Move the focus on the menu item you want to execute by using the knob or the   (up and down keys) and press the **ENTER** key, and then the focus will be moved to the memory lists.

MEMORY				
MENU	MEMORY			
RECALL	No.1	DEFAULT	No.6	DEFAULT
STORE	No.2	DEFAULT	No.7	DEFAULT
CLEAR	No.3	DEFAULT	No.8	DEFAULT
RENAME	No.4	DEFAULT	No.9	DEFAULT
	No.5	DEFAULT	No.0	PWR ON

To execute the operation, move the focus on the number of the memory in which you want to execute in the memory lists by using the knob or the   (up and down keys) and the   (left and right keys), and then press the **ENTER** key. Press the **CANCEL** key to select a menu item.

Furthermore, you can back to the main screen from the memory settings screen by pressing the **CANCEL** key.

■ Restrictions

The **ZERO CHECK** key, **ON/OFF** key in the “**FILTER**” frame, **ON/OFF** key in the “**CURRENT SUPPRESS**” frame, and **AUTO** key will be disabled when the memory setting screen is displayed.

4.2.1 RECALL (recall)

The settings can be recalled from the designated configuration memory. The main screen will be displayed when the recall is executed.

When the instrument is shipped from a factory, the configuration memory name is “DEFAULT” and its contents are the factory default setting.

■ Restrictions

When the recall is executed, the Zero check will definitely be enabled.

4.2.2 STORE (save)

Contents of the current settings can be saved to the designated configuration memory. The name of the configuration memory will be changed to “MEM01” (numerical value represents the memory number) when they are saved.





4.2.3 CLEAR (clear)

Contents of the designated configuration memory can be cleared.

When cleared, the contents of the designated configuration memory will return to the factory default setting and its name will be changed to the “DEFAULT”.

4.2.4 RENAME (memory name change)

You can change the name of the designated configuration memory.

Select the number of the memory you want to change in the memory lists, and then press the **ENTER** key. The cursor will appear in the name of the memory, and then you can edit the name by using the   (left and right keys), knob, and   (up and down keys). Character strings can be set up to 8 characters from “space, A to Z, and 0 to 9”.

MEMORY	
No.1	CA5351
No.2	DEFAULT

You can back to the memory lists screen by pressing the **ENTER** or **CANCEL** key.

Because contents you edited are saved at any time, the contents will be reflected even if you move to another screen.

■ Resume

The **CA5351** has the resume function and stores the last operation state.

The **CA5351** will restore settings to the last them when it is restarted.

The resume memory cannot be operated by user.

Which setting items can be restored → Refer to “3.2.3 Initial settings”.

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5.1 Preparations before use

The **CA5351** can be controlled remotely via USB, GPIB, or LAN interfaces. Program messages can be sent from the controller to achieve the same control of operation as when you use the control panel of the instrument and receive configuration status from the instrument as response messages.

5.1.1 Selection of the remote control interface

Select one interface among USB, GPIB, or LAN as the remote control interface. The interface connectors are located on the rear panel of the **CA5351**. It is not possible to use more than one interface at the same time.

5.1.2 USB overview

5.1.2.1 Preparation of the controller

To use the USB interface, prepare a controller equipped with a USB interface (a personal computer for control).

Install the USBCDC (Universal Serial Bus Communication Device Class) driver on the controller.

■ USBCDC driver

The USBCDC driver is required before Windows10.

It can be downloaded from our web site (<http://www.nfcorp.co.jp>).

5.1.2.2 Preparation of the CA5351

Refer to “**4.1.5 REMOTE (remote control settings screen)**” for setup.

Vendor ID = 0D4A (hexadecimal notation): The number indicates the NF Corporation.

Product ID = 0068 (hexadecimal notation): The number indicates the product number for **CA5351**.

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 **CA5351** is always LF.

The program message terminator received by the **CA5351** is always LF.

Supplement: In the **CA5350** commands, these terminators are not fixed because having or not having EOI of the **CA5351** and the terminator sent by the **CA5351** can be changed.

5.1.2.3 Restrictions and cautions

- GPIB-specific functions such as SRQ cannot be used.
- The **CA5351** 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.

5.1.3 GPIB overview

The GPIB interface is not intended for use in an environment with electric noise. Avoid using in such place.

5.1.3.1 Preparation of the controller

To use the GPIB interface, install a commercial GPIB interface card on the controller (a personal computer for control) and connect the **CA5351** to the connector on the interface card with a GPIB cable. Refer to the manual for your GPIB interface card for information on driver software.

The operation of the **CA5351** is confirmed with NI-VISA (Ver.16.0) provided by National Instruments Corporation.

5.1.3.2 Preparation of the CA5351

The instruments in GPIB systems are identified by addresses that are specific to each instrument. Set a different GPIB address for each instrument.

Refer to “**4.1.5 REMOTE (remote control settings screen)**” for setup.

■ 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 **CA5351** is always LF^EOI.

Either of the following terminators can be used for the program message terminator received by the **CA5351**.

- LF Line Feed code
- LF^EOI LF accompanying an EOI (END message)
- (Last code)^EOI EOI (END message) added to the last code

Supplement: In the **CA5350** commands, these terminators are not fixed because having or not having EOI of the **CA5351** and the terminator sent by the **CA5351** can be changed.

5.1.3.3 Important points for using GPIB

- Turn off the power to all instruments that are connected to the bus before inserting or removing the GPIB connector cable.
- When using the GPIB interface, turn on the power to all instruments that are connected to the bus.
- Up to 15 instruments including the controller can be connected to a single GPIB bus. The following limitations apply to the length of cables.
 - The total cable length cannot exceed 2 m times the number of instruments or 20m, whichever is less.
 - The length of one cable cannot exceed 4 m
- Set a different value for the GPIB address of each instrument. If there are instruments that have the same address on a single bus, the instruments may be damaged by output collision.

5.1.3.4 Basic GPIB specifications

■ GPIB compliance standards

IEEE Std 488.1-1987, IEEE Std 488.2-1992

■ IEEE std 488.1-1987 interface functions

- SH1 All transmission flow control functions are supported.
- AH1 All receiving flow control functions are supported.
- T6 The basic talker, serial poll, and listener-specified talker release functions are supported; the talk-only function is not supported.
- L4 The basic listener function and the talker-specified listener release function are supported; the listen-only function is not supported.
- SR1 All service request functions are supported.
- RL1 All remote control functions are supported.
- PP0 The parallel poll function is not supported.
- DC1 ALL instrument clear functions are supported
- DT0 Instrument trigger function is not supported.
- C0 The controller function is not supported.
- E1 Open collector drive

5.1.4 LAN overview

5.1.4.1 Preparation of the controller

To use the LAN interface, prepare a controller equipped with a LAN interface (a personal computer for control). The **CA5351** can communicate by using the TCP/IP protocol.

5.1.4.2 Preparation of the CA5351

Refer to “**4.1.5 REMOTE (remote control settings screen)**” for setup.

■ 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 the IP addresses of lower-level network.

■ Default gateway

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

■ Port number

This is the port number that is used when the **CA5351** communicates using the TCP protocol. It cannot be changed. It is written in decimal notation.

■ MAC address

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

■ Message terminator

A set of commands and responses must end with a terminator that indicates the end of the message. The terminator for response messages sent by the **CA5351** and the terminator for the program messages received by the **CA5351** are fixed as LF.

Supplement: In the **CA5350** commands, these terminators are not fixed because having or not having EOI of the **CA5351** and the terminator sent by the **CA5351** can be changed.

5.1.4.3 Connection

The **CA5351** can distinguish between a straight cable and a crossover cable, so either type of cable can be used.

Use the type of cable that is compatible with the connector of the instrument to which the **CA5351** is being connected.

5.1.4.4 Restrictions and cautions

- GPIB-specific functions such as SRQ cannot be used.

5.1.5 Communication cautions

■ Input buffer

- The commands that have been sent are temporarily stored in the input buffer, from where 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 order.
- If an invalid command is encountered during interpretation and execution, an error will result 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 16 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. Alternatively, place an EOI (END message) byte at the end. If commands are sent without LF, CRLF, or EOI appended, the instrument may not operate properly.

Depending on the driver software used by the computer that is used for control, the program message terminator may not be outputted unless the terminator is specified separately from the command itself. The line feed (LF) is sometimes written as new line (NL), but these binary codes are the same in either case.

For the USB and LAN interface, there is no concept of the END message, so EOI is not appended.

■ Restrictions of the USB and LAN interface

GPIB-specific functions cannot be used. Examples are shown below.

- Receiving GTL (Go To Local) messages
- Receiving LLO (Local Lockout) messages
- Receiving GET (Group Execute Trigger) messages
- Receiving REN (Remote Enable) messages
- Sending a SRQ (Service Request) message
- Serial polling (receiving SPE or SPD and sending a status byte)
- Sending an END message (EOI signal as a message terminator)

5.2 Switching between remote and local modes

The **CA5351** has two operating modes relevant to remote control: remote and local.

In the local mode, all panel operations are enabled.

In the remote mode, all panel operations other than return to local mode and power-off are disabled.

■ Switching to the remote mode

Normally, operation from GPIB switches the instrument to the remote mode. That is a function of the driver on the controller side. According to the communication standard, asserting the REN line and specifying the instrument to a listener instrument sets the instrument to the remote mode. The operation is the same for USB (USBCDC) and LAN interfaces.

■ Switching to the local mode

Pressing the **LOCAL** key on the front panel returns the instrument to the local mode (except when the local lockout is enabled).

When the GTL command is sent from the controller or the REN line returns false, local mode operation will be possible. If the GPIB cable is removed, the REN line will become false, so the instrument will be returned to the local mode. Similarly, for USB and LAN interfaces, removing the cable returns the instrument to the local mode.

■ Disabling local panel operation

When the controller specifies the local lockout, unintentional local operations will be disabled. When the local lockout is in effect, the instrument cannot be returned to the local mode by pressing the **LOCAL** key.

Even when the local lockout is in effect, local operations can be enabled from the controller. This operation is not compatible with the USB and LAN interfaces.

■ Remote and local operation with the LAN interface

If a command is sent to the **CA5351**, the instrument will go into the remote mode.

Pressing the **LOCAL** key returns the instrument to the local mode and enables operations from the panel.

■ Displaying the remote control mode

It is possible to check the current state of the instrument by looking at the state display area in the upper part of the screen.

- (No display) Local mode
- RMT icon Remote mode
- LLO icon Local lockout mode

5.3 Responding to interface messages

Primary responses to IEEE-488.1 interface message are described in the following table.

Table 5-1 Responses to interface messages

Message	Function
IFC	< InterFace Clear > The GPIB interface is initialized. The specified listener and talker are released.
DCL, SDC	< Device Clear >, < Selected Device Clear > The input buffer is cleared and command interpretation and execution are stopped. The output buffer is cleared and stats byte register bit4 (MAV) is cleared.
LLO	< Local LockOut > Switching from the remote mode to the local mode by pressing the LOCAL key is disabled.
GTL	< Go To Local > Move to the local mode

The method that is used for sending interface messages from the controller varies with the instrument driver. For details, refer to the manual for each particular driver.

5.4 List of commands and command tree

5.4.1 List of commands

The remote control commands for the **CA5351** are listed in the following tables.

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

Supplement: Commands that perform a query end with a question mark (?). In these tables, queries are omitted for functions that can be both set and queried. The row of “R/W” in the tables indicates whether or not there are the query (R) and setting (W). The row of “*RST” indicates whether the function can be initialized by the *RST command.

[Amplifier setting commands]

Command	Function	R/W	*RST	Details
:INP:BIAS:CURR	Current suppression (CS) value	R/W	✓	P5-27
:INP:BIAS:CURR:AUTO	Auto settings of the current suppression (CS)	W	—	P5-28
:INP:BIAS:CURR:RANG	Current suppression (CS) range	R/W	✓	P5-28
:INP:BIAS:CURR:RANG:AUTO	Auto settings of the current suppression (CS) range	R/W	✓	P5-28
:INP:BIAS:CURR:STAT	Current suppression (CS) state	R/W	✓	P5-28
:INP:FILT	Filter state	R/W	✓	P5-29
:INP:FILT:TIME	Filter rise time	R/W	✓	P5-29
:INP:FILT:TIME:AUTO	Auto settings of the filter rise time	R/W	✓	P5-29
:INP:GAIN	I/V gain value	R/W	✓	P5-29

[Memory commands]

Command	Function	R/W	*RST	Details
*SAV	Save to the configuration memory	W	—	P5-26
*RCL	Read from the configuration memory	W	—	P5-26
:MEM:STAT:DEL	Initialize the configuration memory	W	—	P5-30
:MEM:STAT:DEF	Configuration memory name	R/W	—	P5-30

[Utility commands]

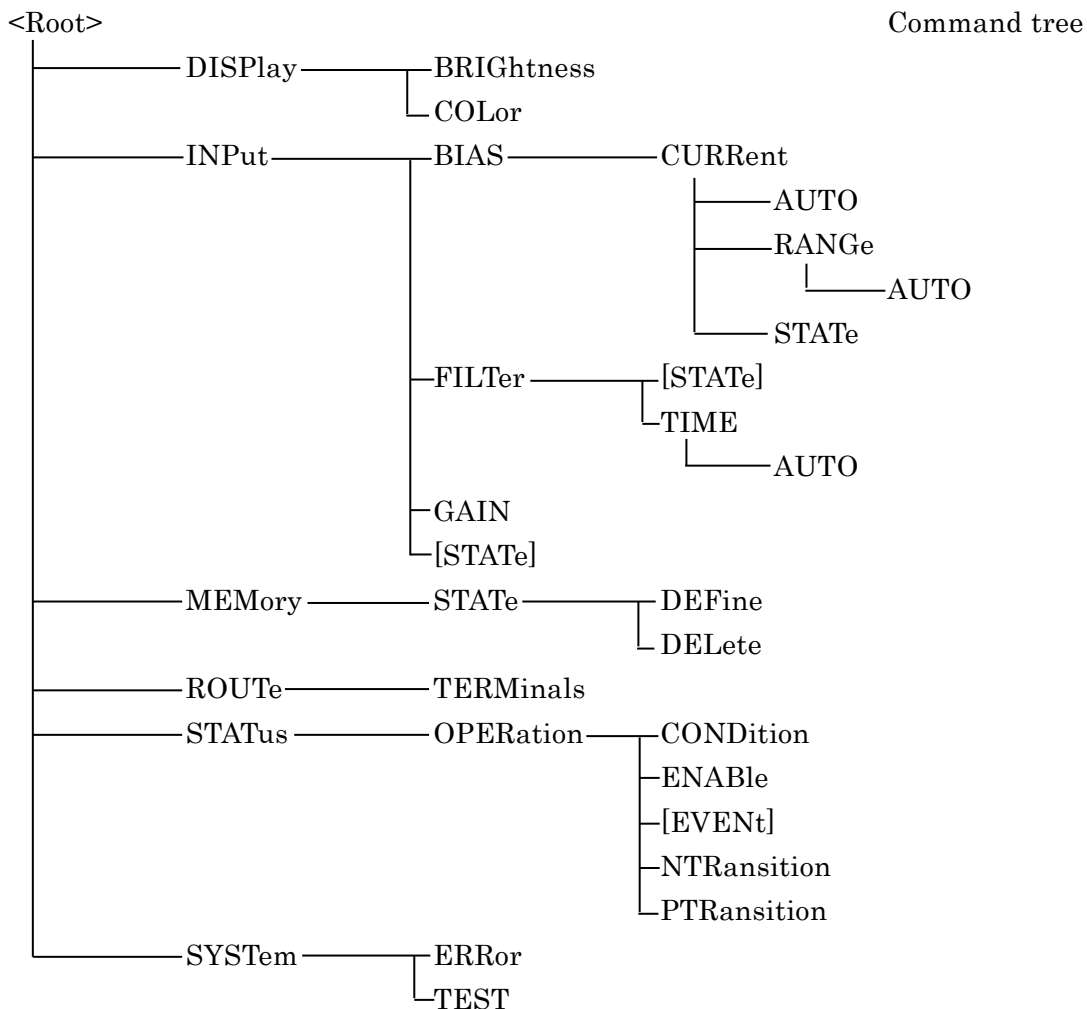
Command	Function	R/W	*RST	Details
:DISP:BRIG	LCD brightness	R/W	✓	P5-27
:DISP:COL	Color	R/W	—	P5-27
:INP	Zero check state	R/W	✓	P5-30
:ROUT:TERM	Input connector	R/W	✓	P5-30
*RST	Initialize configuration	W	—	P5-26
*IDN?	Query instrument-specific information	R	—	P5-25
:SYST:TEST	Execute the self-diagnostic test and query that results	R/W	—	P5-32
*TST?	Query results of the self-diagnostic test	R	—	P5-26
*OPC	Notification that all previous commands have ended	R/W	—	P5-25
*WAI	Wait for execution of commands and queries	W	—	P5-26

[Status system commands]

Command	Function	R/W	*RST	Details
*CLS	Clear status register and error queue	W	—	P5-25
*ESE	Standard event status enable register	R/W	—	P5-25
*ESR?	Query standard event status register	R	—	P5-25
*SRE	Service request enable register	R/W	—	P5-26
*STB?	Query status byte register	R	—	P5-26
:STAT:OPER:COND?	Query operation status condition register	R	—	P5-30
:STAT:OPER:ENAB	Operation status event enable register	R/W	—	P5-31
:STAT:OPER?	Query operation status event register	R	—	P5-31
:STAT:OPER:NTR	Operation status negative transition filter	R/W	—	P5-31
:STAT:OPER:PTR	Operation status positive transition filter	R/W	—	P5-31
:SYST:ERR?	Query error message	R	—	P5-31

5.4.2 Command tree

The subsystem command tree for the **CA5351** is shown below. The brackets ([]) in the tree indicate optional keywords.



5.5 Commands

5.5.1 Overview

The commands of the **CA5351** are classified into common commands compliant with IEEE488.2 and subsystem commands corresponding to device-specific functions.

5.5.1.1 Notation

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

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

[] Brackets are used to enclose options, which may be omitted.

{abc | xyz}

The vertical bar (|) indicates that either “abc” or “xyz” can be used.

[abc | xyz]

Here, the brackets indicate that either “abc” or “xyz” can be used, which may be omitted.

Uppercase and lowercase letters

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

5.5.1.2 SCPI commands

The program messages of the **CA5351** consist of 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**”.

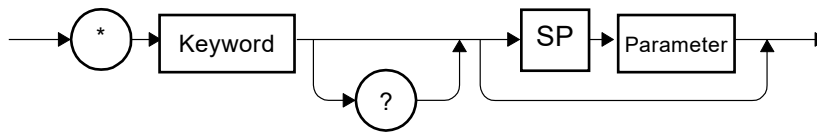


Figure 5-1 Common command syntax

The keywords 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, parameters, and a suffix. Examples of a command and a query are shown below.

```
:INPut:STATe ON
:INPut:STATe?
```

“INPut” is a root-level keyword that is concatenated with a second-level keyword. ON is a parameter.

■ Subsystem commands

The subsystem command syntax is illustrated in “Figure 5-2”.

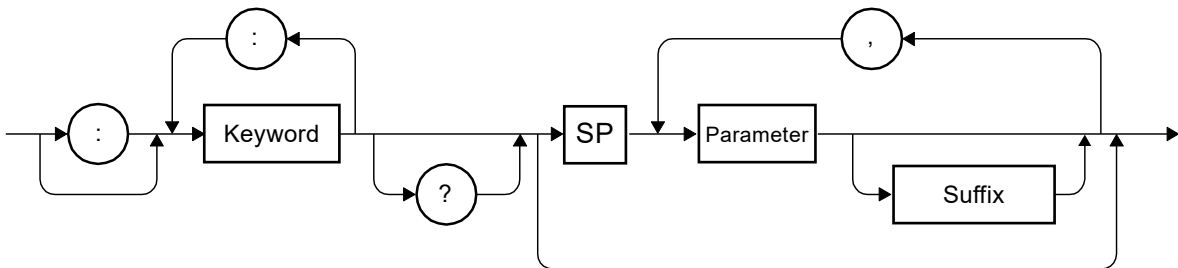


Figure 5-2 Subsystem command syntax

[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 “5.5.3 Command details” 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 in the actual commands, there is no distinction between uppercase and lowercase. The “Figure 5-2” shows an example for the keyword “INPut”.

**Table 5-2 Keywords that are accepted or not accepted by the instrument
(for the case of “INPut”)**

Keyword	Explanation
INPUT	Can be used as the long form
INP	Can be used as the short form
InpUt	Uppercase and lowercase characters are not distinguished. This can be used as the long form.
iNP	Uppercase and lowercase characters are not distinguished. This can be used as the short form.
INPU	This cannot be used, because it does not correspond to either the long form or short form.
IN	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 keywords and lower-level keywords 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 root.

[Keyword omission]

For the commands shown in “**5.5.3 Command details**”, the keywords enclosed in square brackets ([]) can be omitted. When a keyword is omitted, the instrument treats the keyword as an optional keyword and analyze it.

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

```
:INPut:STATe
```

```
:INPut
```

[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 number (exponent) (<NR3>). <NRf> is a generic expression that includes <NR1>, <NR2>, and <NR3>. The syntax for numerical parameters is illustrated below.

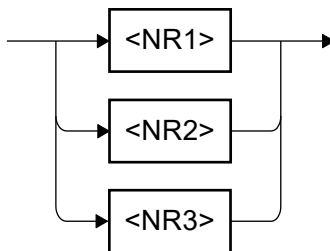


Figure 5-3 Numerical parameter syntax (<NRf>)

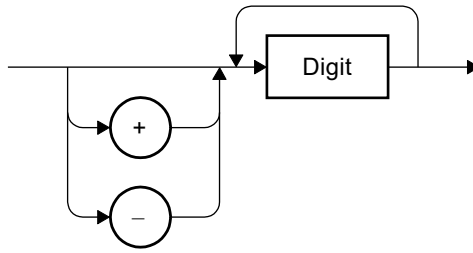


Figure 5-4 Numerical parameter syntax (<NR1>)

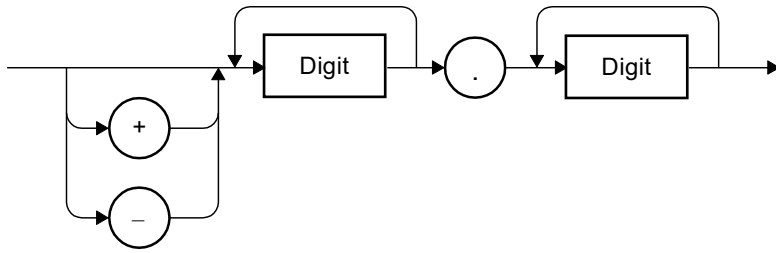


Figure 5-5 Numerical parameter syntax (<NR2>)

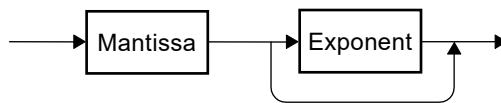


Figure 5-6 Numerical parameter syntax (<NR3>)

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

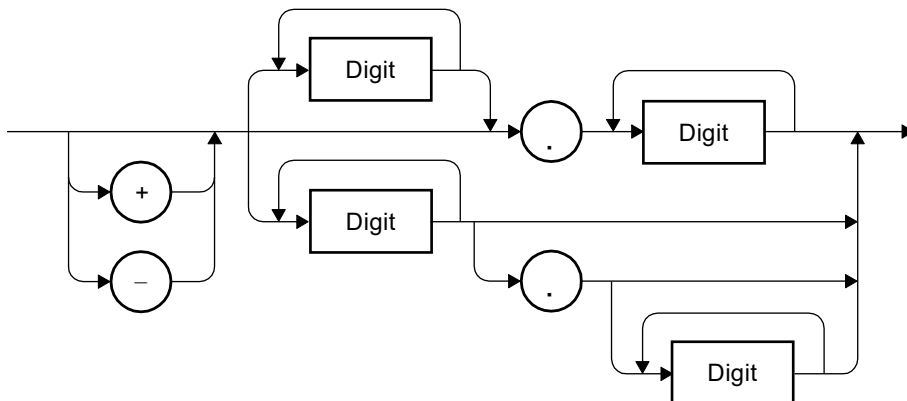


Figure 5-7 Mantissa syntax

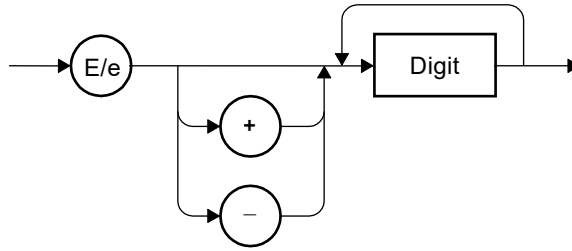


Figure 5-8 Exponent syntax

(2) Discrete parameters (<DISC>)

The syntax for discrete parameters is illustrated below.

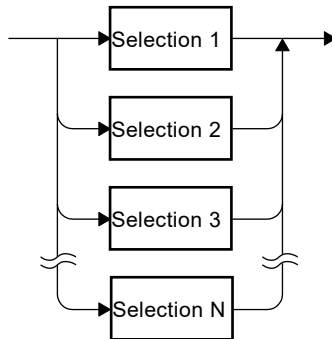


Figure 5-9 Discrete parameter syntax (<DISC>)

(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).

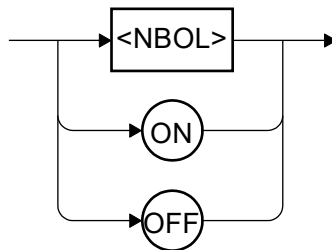


Figure 5-10 Boolean parameter syntax (<BOL>)

(4) Text string parameters (<STR>)

The syntax for text string parameters is illustrated below.

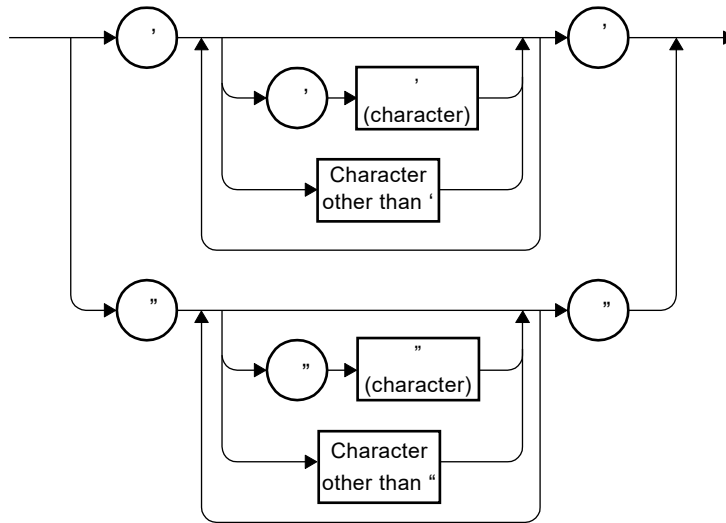


Figure 5-11 Text string parameters (<STR>)

(5) Block parameters (<BLK>)

The syntax for block parameters is illustrated below.

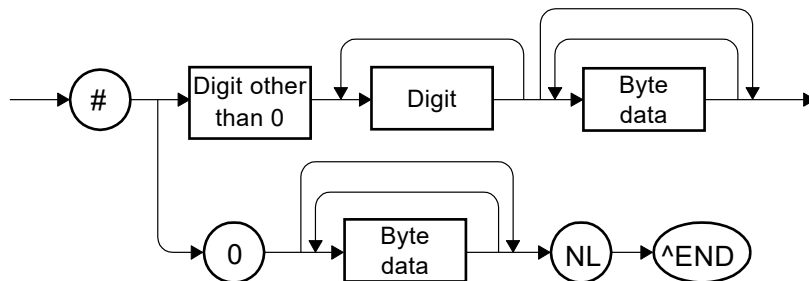


Figure 5-12 Block parameter syntax (<BLK>)

Here, NL is the new line character (ASCII code 10) and ^END is the last byte assertion (EOI).

[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.

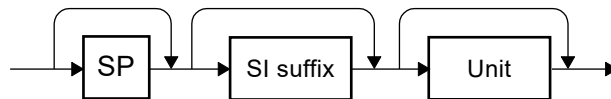


Figure 5-13 Suffix syntax

■ 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.

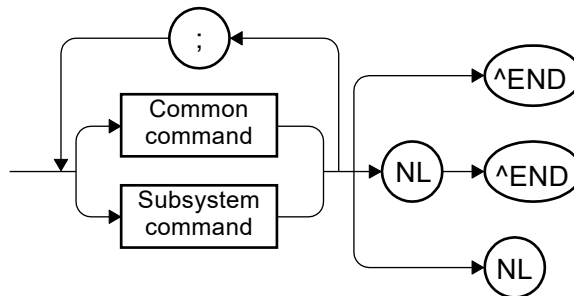


Figure 5-14 Program message syntax

Commands are separated by semicolons.

■ 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.

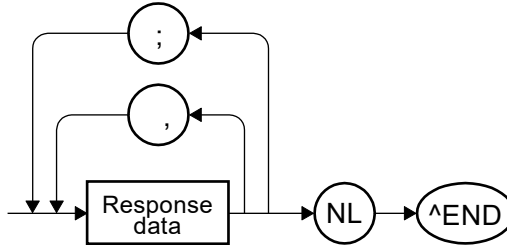


Figure 5-15 Response message syntax

In response messages, commas and semicolons are used as separators. When multiple values are returned for a single command, the data items will be delineated by commas. In a response message for a single program message that contains multiple queries, on the other hand, the data that is returned for those respective queries are 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.

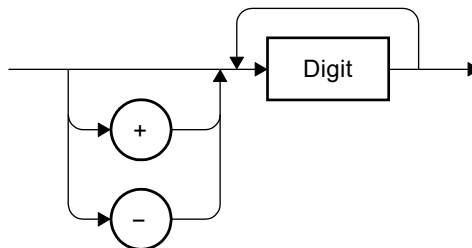


Figure 5-16 Integer response data syntax (<NR1>)

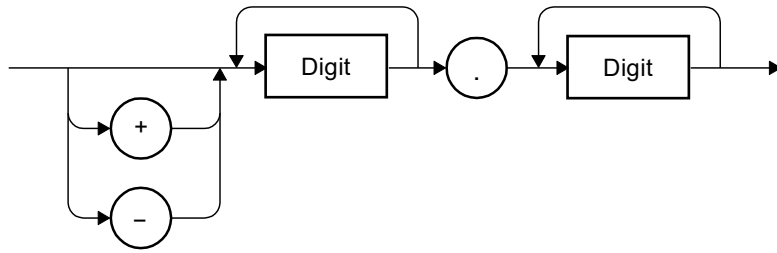


Figure 5-17 NR2 numerical response data syntax (<NR2>)

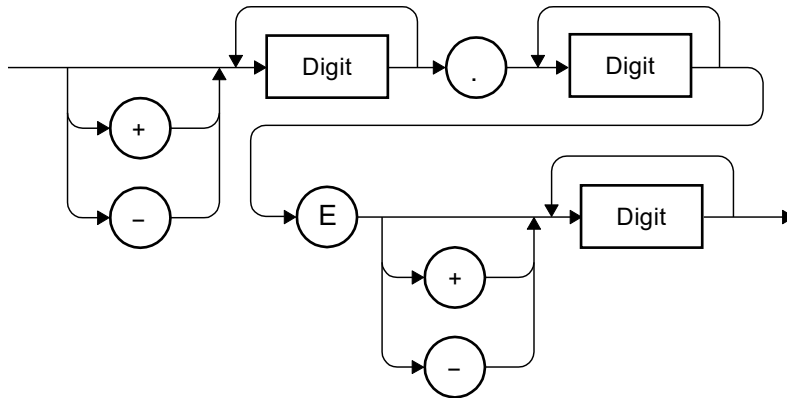


Figure 5-18 NR3 numerical response data syntax (<NR3>)

(2) Discrete response data (<DISC>)

The syntax for discrete response data is illustrated below.

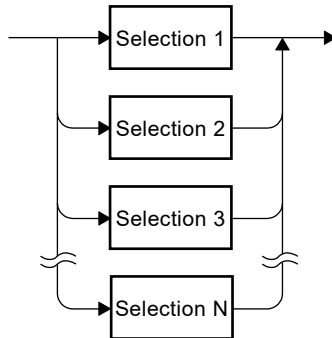


Figure 5-19 Discrete response data syntax (<DISC>)

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

The syntax for numerical Boolean response data is illustrated below.

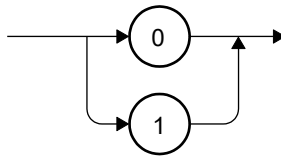


Figure 5-20 Numerical Boolean response data syntax (<NBOL>)

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

The syntax for text string response data is illustrated below.

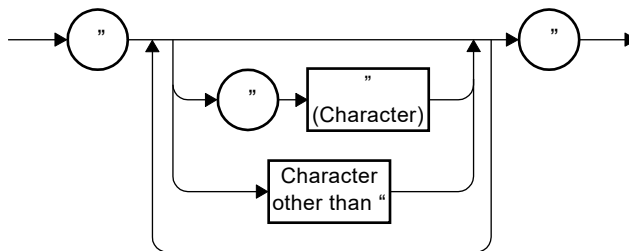


Figure 5-21 Text string response data syntax (<STR>)

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

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

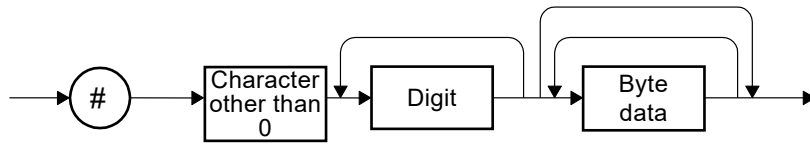


Figure 5-22 Defined-length arbitrary block response data syntax (<DBLK>)

5.5.2 Sequential commands

The commands of the **CA5351** are all sequential commands. When execution of the command is completed, the next command will be executed. There are no overlapping commands.

5.5.3 Command details

Each command is explained in detail below.

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}).

5.5.3.1 *CLS

Explanation	Clear the event register and error queue
Comments	Targets for the clear operation: <ul style="list-style-type: none"> • Status byte register • Standard event status register • Operation status event register • Error queue

5.5.3.2 *ESE <value>

*ESE?

Explanation	Set and query the standard event status enable register		
Parameters	<value>	<NRf>	Standard event status enable register Range: 0 to 255 Resolution: 1 Default: 0
Response format	<NR1>		
Comments	Initialized when the power is turned on. Not initialized by *RST		

5.5.3.3 *ESR?

Explanation	Query 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

5.5.3.4 *IDN?

Explanation	Query the instrument identification information		
Response format	<corporation>, <model>, <serial>, <ver>		
	<corporation>	<STR>	Company name (NF Corporation)
	<model>	<STR>	Model name (CA5351)
	<serial>	<STR>	Serial number
	<ver>	<STR>	Version
Comments	The response is returned without including double quotation marks. NF Corporation,CA5351,1234567,Ver1.00		

5.5.3.5 *OPC

*OPC?

Explanation	*OPC: Set the OPC bit to “1” when all of the previous commands have ended *OPC?: Set “1” to the output buffer when all the previous commands have ended
Response format	<NR1>
Comments	—

5.5.3.6 *RCL <value>

Explanation	Execute a read from the configuration memory (internal memory)		
Parameters	<value>	<NRf>	Configuration memory number
			Range: 0 to 9 Resolution: 1
Comments	No.0 memory stores the power-on settings.		

5.5.3.7 *RST

Explanation	Initialization settings
Comments	Refer to “ 3.2.3 Initial settings ” what contents to be initialized

5.5.3.8 *SAV <value>

Explanation	Execute a save to the configuration memory (internal memory)		
Parameters	<value>	<NRf>	Configuration memory number
			Range: 1 to 9 Resolution: 1
Comments	Refer to “ 3.2.3 Initial settings ” what contents to be saved		

5.5.3.9 *SRE <value>***SRE?**

Explanation	Set and query the service request enable register		
Parameters	<value>	<NRf>	Service request enable register
			Range: 0 to 255 Resolution: 1 Default: 0
Response format	<NR1>		
Comments	Initialized when the power is turned on. Not initialized by *RST.		

5.5.3.10 *STB?

Explanation	Query the status byte register
Response format	<NR1>
Comments	—

5.5.3.11 *TST?

Explanation	Execute the self-diagnostic test and query its results
Response format	<NR1>
Comments	<ul style="list-style-type: none"> • It is SCPI command. “0” is always returned. • Refer to “:SYSTEM:TEST” about executing the self-diagnostic test.

5.5.3.12 *WAI

Explanation	Standby for end of overlapping command execution
Comments	There are no overlapping commands for the CA5351 .

5.5.3.13 :DISPlay:BRIGhtness <value>**:DISPlay:BRIGhtness?**

Explanation	Set and query the LCD brightness		
Parameters	<value>	<NRf>	LCD brightness Range: 0 to 3 Resolution: 1
Response format	<NR1>		
Comments	<ul style="list-style-type: none"> • 0: Backlight OFF • 1 to 3: Brightness (3 is the brightest) 		

5.5.3.14 :DISPlay:COLor <value>**:DISPlay:COLor?**

Explanation	Set and query the display color		
Parameters	<value>	<NRf>	Color Range: 1 to 3 (DARK, GRAY, LIGHT) Resolution: 1
Response format	<NR1>		
Comments	The parameter corresponds to the color in the parentheses.		

5.5.3.15 :INPut:BIAS:CURRent <value>**:INPut:BIAS:CURRent?**

Explanation	Set and query the current suppression (CS) value		
Parameters	<value>	<NRf>	Current value [A] Range 【Auto range】 : -8 m to 8 m (10 ⁻³) 【Range: 8 nA】 : -8 n to 8 n (10 ⁻⁹) 【Range: 80 nA】 : -80 n to 80 n (10 ⁻⁹) 【Range: 800 nA】 : -800 n to 800 n (10 ⁻⁹) 【Range: 8 μA】 : -8 μ to 8 μ (10 ⁻⁶) 【Range: 80 μA】 : -80 μ to 80 μ (10 ⁻⁶) 【Range: 800 μA】 : -800 μ to 800 μ (10 ⁻⁶) 【Range: 8 mA】 : -8 m to 8 m (10 ⁻³) Resolution 【Auto range】 : 4 digits (1 p (10 ⁻¹²) when <10 n (10 ⁻⁹)) 【Range: 8 nA】 : 0.001 [nA] 【Range: 80 nA】 : 0.01 [nA] 【Range: 800 nA】 : 0.1 [nA] 【Range: 8 μA】 : 0.001 [μA] 【Range: 80 μA】 : 0.01 [μA] 【Range: 800 μA】 : 0.1 [μA] 【Range: 8 mA】 : 0.001 [mA] *RST value: 0.0
Response format	<NR3>		
Comments	<ul style="list-style-type: none"> • The setting range and resolution will change depending on the automatic CS range adjustment or the current suppression range. • When the current value is out of range as a result of changing to a lower range, the value will be set to the maximum or minimum value corresponding to the new range. 		

5.5.3.16 :INPut:BIAS:CURRent:AUTO <value>

Explanation	Auto settings of the current suppression (CS)			
Parameters	<value>	<DISC>	Operation	
			EXEC	Execute auto settings
			CANcEl	Interrupt auto settings
Comments	<ul style="list-style-type: none"> • After the execution of the auto settings, the CS will be enabled and the CS range and value will be automatically set. • After the execution of the auto settings, an error will result if it is failed to set. • If the Zero check is ON, an error will result. • If I/O over is detected, an error will result. • A received command will result an error, but the auto settings will continue if the auto settings are interrupted or a command other than a query is received when the auto settings are being executed. 			

**5.5.3.17 :INPut:BIAS:CURRent:RANGe <value>
:INPut:BIAS:CURRent:RANGe?**

Explanation	Set and query the current suppression (CS) range		
Parameters	<value>	<NRf>	Range
			Range: 1 to 7 (8 nA, 80 nA, 800 nA, 8 uA, 80 uA, 800 uA, 8 mA)
			Resolution: 1 *RST value: 1
Response format	<NR1>		
Comments	<ul style="list-style-type: none"> • The range parameter corresponds to the value in the parentheses. • When the auto settings state of the CS range are ON, an error will result. 		

**5.5.3.18 :INPut:BIAS:CURRent:RANGe:AUTO <value>
:INPut:BIAS:CURRent:RANGe:AUTO?**

Explanation	Set and query the auto settings of the current suppression (CS) range			
Parameters	<value>	<BOL>	Auto settings state of the CS range	
			ON 1	Enable the auto settings
			OFF 0	Disable the auto settings
			*RST value: 0	
Response format	<NBOL>			
Comments	The CS range will be automatically changed corresponding to the CS value if the auto settings are ON.			

**5.5.3.19 :INPut:BIAS:CURRent:STATe <value>
:INPut:BIAS:CURRent:STATe?**

Explanation	Set and query the current suppression (CS) state			
Parameters	<value>	<BOL>	Current suppression (CS) state	
			ON 1	Enable the current suppression (CS)
			OFF 0	Disable the current suppression (CS)
			*RST value: 0	
Response format	<NBOL>			
Comments	—			

5.5.3.20 :INPut:FILTer[:STATe] <value>**:INPut:FILTer[:STATe]?**

Explanation	Set and query the filter function state		
Parameters	<value>	<BOL>	Filter state
			ON 1 Enable the filter function
			OFF 0 Disable the filter function
			*RST value: 1
Response format	<NBOL>		
Comments	—		

5.5.3.21 :INPut:FILTer:TIME <value>**:INPut:FILTer:TIME?**

Explanation	Set and query the filter rise time		
Parameters	<value>	<NRf>	Filter rise time
			Range: 1 to 12 (1 μ s, 3 μ s, 10 μ s, 30 μ s, 100 μ s, 300 μ s, 1 ms, 3 ms, 10 ms, 30 ms, 100 ms, 300 ms)
			Resolution: 1
			*RST value: 1
Response format	<NR1>		
Comments	—		

5.5.3.22 :INPut:FILTer:TIME:AUTO <value>**:INPut:FILTer:TIME:AUTO?**

Explanation	Set and query the auto settings state of the filter rise time		
Parameters	<value>	<BOL>	Auto settings state of the filter rise time
			ON 1 Enable the auto settings
			OFF 0 Disable the auto settings
			*RST value: 1
Response format	<NBOL>		
Comments	The filter rise time will be automatically changed corresponding to the I/V gain value if the auto settings are ON.		

5.5.3.23 :INPut:GAIN <value>**:INPut:GAIN?**

Explanation	Set and query the I/V gain value		
Parameters	<value>	<NRf>	I/V gain value
			Range: 1 to 8 (1E03, 1E04, 1E05, 1E06, 1E07, 1E08, 1E09, 1E10)
			Resolution: 1
			*RST value: 2
Response format	<NR1>		
Comments	The value parameter corresponds to the value in the parentheses.		

5.5.3.24 :INPut[:STATe] <value>**:INPut[:STATe]?**

Explanation	Set and query the Zero check state		
Parameters	<value>	<BOL>	Zero check state
			ON 1 Enable the Zero check
			OFF 0 Disable the Zero check
			*RST value: 1
Response format	<NBOL>		
Comments	—		

5.5.3.25 :MEMory:STATe:DEFine “<name>”, <memory>**:MEMory:STATe:DEFine? <memory>**

Explanation	Set and query the configuration memory name		
Parameters	<name>	<STR>	Memory name
			Range: Up to 8 characters For memory names, refer to “4.2 Memory operation”.
	<memory>	<NRf>	Configuration memory number
			Range: 1 to 9 Resolution: 1
Query parameters	<memory>	<NRf>	Configuration memory number
			Range: 1 to 9 Resolution: 1
Response format	<STR>		
Comments	<ul style="list-style-type: none"> The response is returned with double quotation marks included. Characters below are available for the memory name. ABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789□ (“□” represents space.) 		

5.5.3.26 :MEMory:STATe:DeLete <memory>

Explanation	Initialize the configuration memory		
Parameters	<memory>	<NRf>	Configuration memory number to be initialized
			Range: 1 to 9
			Resolution: 1
Comments	—		

5.5.3.27 :ROUte:TERMinals <value>**:ROUte:TERMinals?**

Explanation	Set and query the input connector position		
Parameters	<value>	<DISC>	Input connector position
			FRONt Use the front input connector
			REAR Use the rear input connector
			*RST value: FRON
Response format	FRON REAR		
Comments	When the input connector is switched, the Zero check will be enabled.		

5.5.3.28 :STATus:OPERation:CONDition?

Explanation	Query the operation status condition register
Response format	<NR1>
Comments	—

5.5.3.29 :STATus:OPERation:ENABLE <value>**:STATus:OPERation:ENABLE?**

Explanation	Set and query the operation status event enable register		
Parameters	<value>	<NRf>	Operation status event enable register Range: 0 to 65535 Resolution: 1 Default: 0
Response format	<NR1>		
Comments	Initialized when the power is turned on. Not initialized by *RST.		

5.5.3.30 :STATus:OPERation[:EVENT]?

Explanation	Query the operation status event register		
Response format	<NR1>		
Comments	The operation status event register will be cleared if the event register is queried or the *CLS command is received.		

5.5.3.31 :STATus:OPERation:NTRansition <value>**:STATus:OPERation:NTRansition?**

Explanation	Set and query the negative operation status transition filter		
Parameters	<value>	<NRf>	Negative operation status transition filter Range: 0 to 65535 Resolution: 1 Default: 0
Response format	<NR1>		
Comments	Initialized when the power is turned on. Not initialized by *RST.		

5.5.3.32 :STATus:OPERation:PTRansition <value>**:STATus:OPERation:PTRansition?**

Explanation	Set and query the positive operation status transition filter		
Parameters	<value>	<NRf>	Positive operation status transition filter Range: 0 to 65535 Resolution: 1 Default: 0
Response format	<NR1>		
Comments	Initialized when the power is turned on. Not initialized by *RST.		

5.5.3.33 :SYSTem:ERRor?

Explanation	Query the remote error		
Response format	<code>, <message>		
	<code>	<NR1>	Error code
	<message>	<STR>	Error message
Comments	<ul style="list-style-type: none"> • <message> includes double quotation marks. • The error queue can hold up to 16 error messages and the message can be read one by one in order of oldest first. • 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. • The error queue will be cleared when the *CLS command is received. 		

5.5.3.34 :SYSTEM:TEST**:SYSTEM:TEST?**

Explanation	Execute self-diagnostic test and query its results		
Response format	<result>, <code>		
	<result>	<NR1>	Results of the self-diagnostic test
	<code>	<NR1>	Self-diagnostic test code
Comments	<ul style="list-style-type: none"> • The self-diagnostic test results are described below. <ul style="list-style-type: none"> 0: Pass 1: Fail 2: Under testing • The execution status of the test can be confirmed in the operation status. • If a command other than a query receives while the execution of the test, the test will be continued but an error will result. • For the self-diagnostic test code, refer to “6.1.2 Errors that occur during panel operations”. 		

5.6 Status system

5.6.1 Status system overview

The status system of the CA5351 is illustrated in “Figure 5-23”.

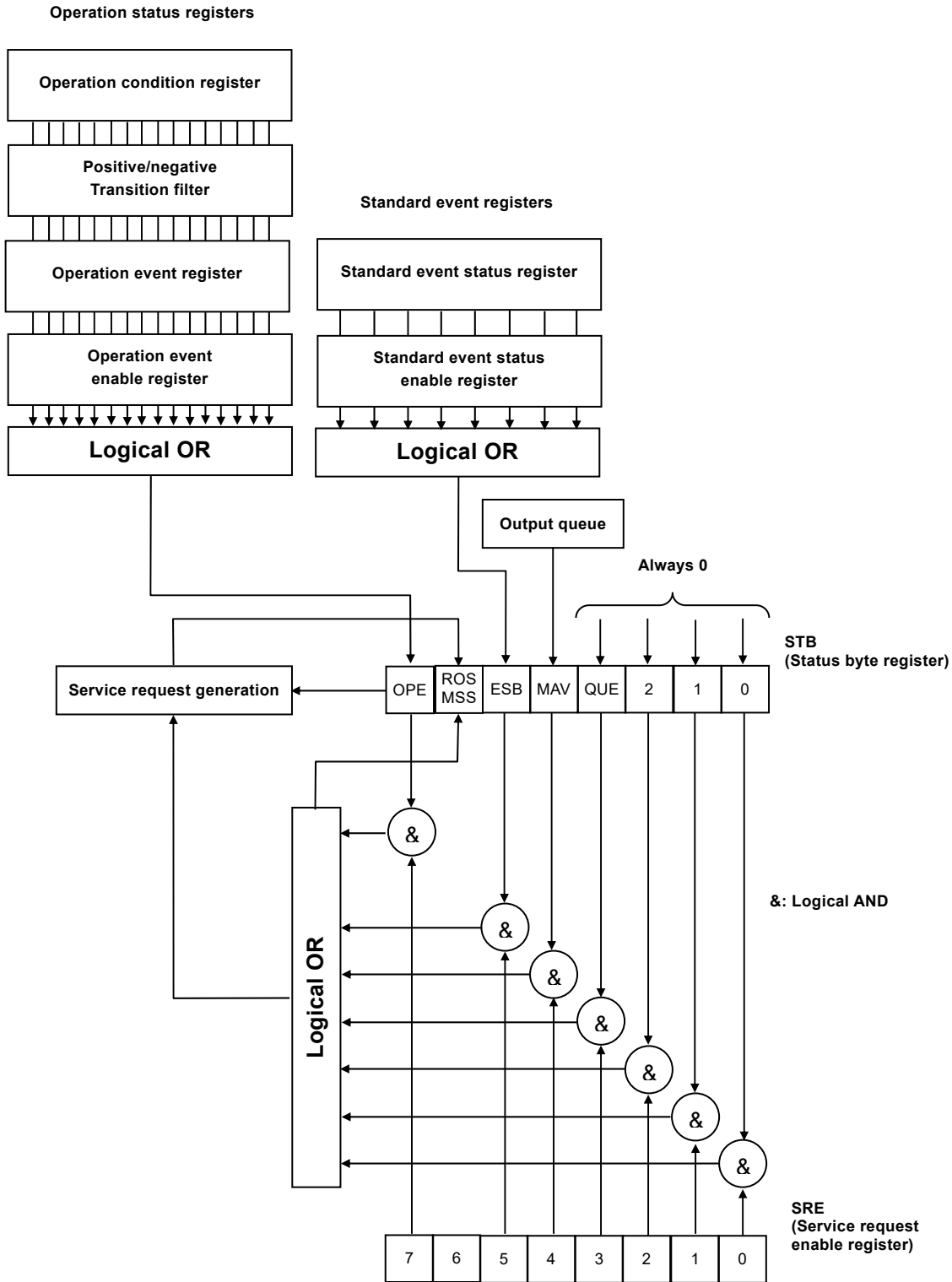


Figure 5-23 Status system

5.6.2 Status byte

The definitions of the status byte register are described in “Table 5-3”. The status byte can be read by serial polling. In that case, bit6 is RQS (Request service).

Table 5-3 Status byte and register definitions

Bit		Weight	Conditions for setting to “1”	Conditions 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 instrument clear command is received · 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 the response to the query has been prepared and can be outputted	When all of the responses have been outputted and there are no more responses to be outputted
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 the status byte register content.

Bit6 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”.

The message and response message parameters that are set in 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.

5.6.3 Standard event status

The structure of the standard event status is illustrated in “Figure 5-24”, and the details of status are described in “Table 5-4”. 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 take the value “1”, the ESP bit of the status byte register will be set to 1.

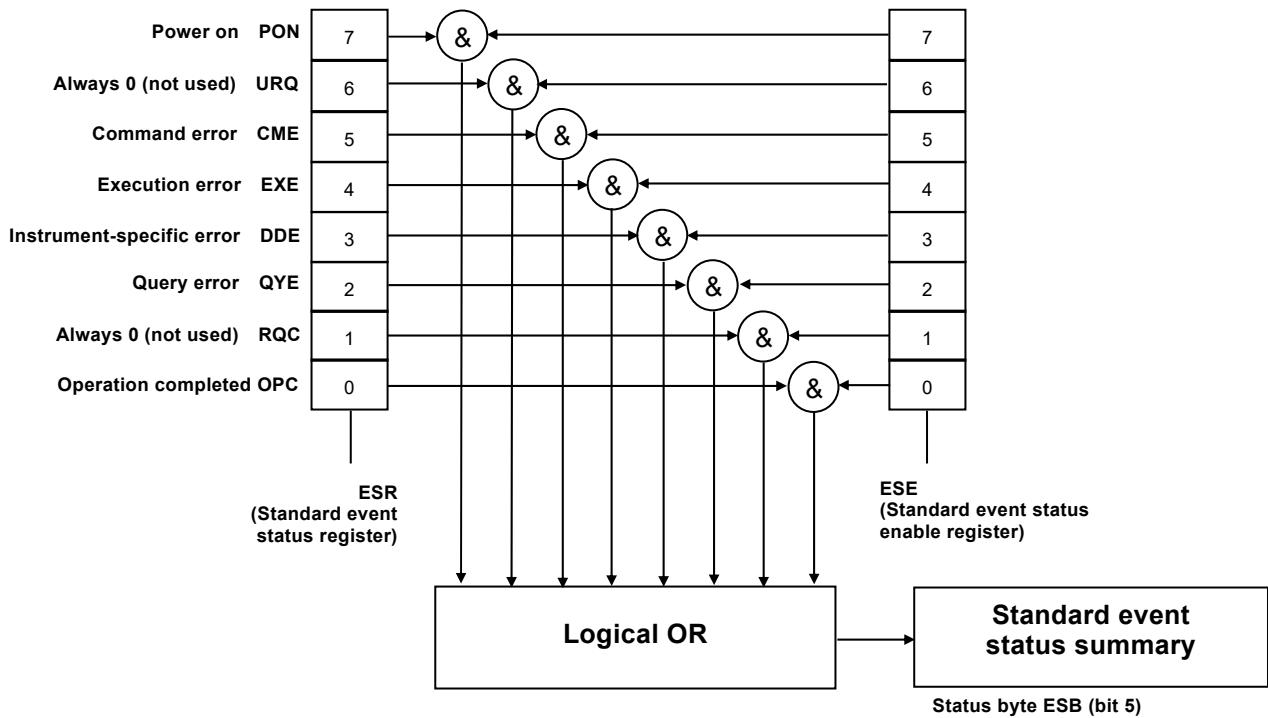


Figure 5-24 Standard event status structure

Table 5-4 Contents of the standard event status register

Bit	Weight	Content
PON	7	128 Power on This bit will be set to “1” when the power is turned on. It will be cleared to “0” when this register is read and the value remains 0 until the power is turned on again.
URQ	6	64 User request Always “0” (not used)
CME	5	32 Command error This bit will be set to “1” if there is a syntax error in a remote command.
EXE	4	16 Execution error This bit will be set to “1” if a parameter is out of range or there is a conflict in settings.
DDE	3	8 Instrument-specific error This bit will be set to “1” if the error queue is overflowed.
QYE	2	4 Query error 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 Always “0” (not used)
OPC	0	1 Operation completed This bit will be set to “1” when the processing for all of the commands up to the *OPC command has been completed.

■ Relevant commands and queries

*ESR?

This command can query 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.

The message and response message parameters that are set in each register are the sums of all the weights of the bits that have the value of “1”.

5.6.4 Operation status

The structure of the operation status is illustrated in “Figure 5-25”.

The operation conditions register (OPCR) indicates the status of the CA5351 as shown in “Table 5-5”. 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 the 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”.

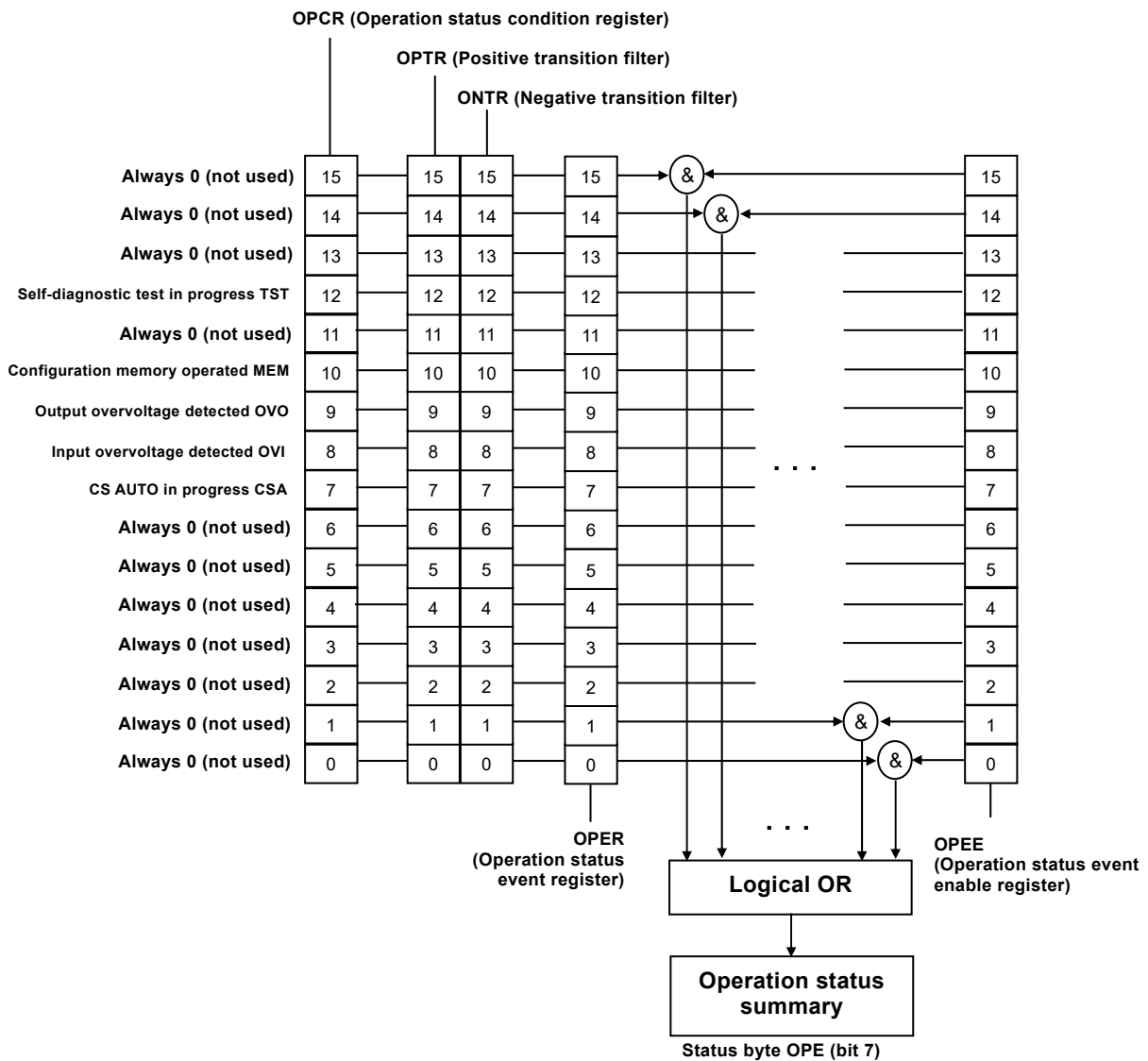


Figure 5-25 Operation status structure

Table 5-5 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)
TST	12	4096	Self-diagnostic test in progress “0”: not in progress “1”: in progress
–	11	2048	Always “0” (not used)
MEM	10	1024	Save to the configuration memory, clear it, or initialize it “0”: not in progress “1”: in progress
OVO	9	512	Output overvoltage detected “0”: not detected “1”: detected
OVI	8	256	Input overvoltage detected “0”: not detected “1”: detected
CSA	7	128	CS AUTO in progress “0”: not in progress “1”: in progress
–	6	64	Always “0” (not used)
–	5	32	Always “0” (not used)
–	4	16	Always “0” (not used)
–	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

:STATus:OPERation:CONDition?

This command can query the operation 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 the transition filter settings and event register transitions are shown in “Table 5-6”.

Table 5-6 Transition filter settings and event register transitions

Positive transition filter bit settings	Negative transition filter bit settings	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”

The message and response message parameters that are set in each register are the sums of all the weights of the bits that have the value of “1”.

5.7 Error messages

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

Table 5-7 Error messages 1/2

Error Number	Error Message	Description
0	No error	No abnormalities have occurred.
-100	Command error	There is an abnormality in a command (no detailed classification).
-101	Invalid character	There is an abnormality in text data.
-102	Syntax error	A command or data that cannot be recognized has been received.
-103	Invalid separator	There is an abnormality in a command separator.
-104	Data type error	The parameter format is inappropriate.
-108	Parameter not allowed	There are too many parameters or there is a parameter in a place that it cannot be used.
-109	Missing parameter	There are 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)
-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 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 string data (no detailed classification).
-200	Execution error	The command could not be executed (no detailed classification). (examples) · A setting operation was performed during the auto settings of the CS. · The auto settings of the CS were performed while the Zero check is ON.
-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"). (Example: DISPlay:BRIGhtness %1)

Table 5-7 Error messages 2/2

Error Number	Error Message	Description
-310	System error	An instrument-specific internal error has occurred. (memory contents were lost, etc.)
-330	Self-test failed	There is an abnormality in the self-diagnostic test.
-350	Queue overflow	The error queue has overflowed and cannot accommodate new errors.
-363	Input buffer overrun	The input buffer has been overflowed.
-410	Query INTERRUPTED	The next command was received before all of the requested responses are sent. The response was interrupted and the output buffer was cleared. (Occur only with the GPIB interface)
-420	Query UNTERMINATED	The received query was incomplete, so the requested response cannot be sent. The output buffer has been cleared. (Occur only with the GPIB interface)
-430	Query DEADLOCED	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?” within a text string (“*IDN?” must be the last query in received text string.).

Remote control errors are placed in the error queue and can be read one at a time in order of oldest first with the query “:SYSTem:ERRor?”. 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 a device clear interface message (DCL, SDC).

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

For operations that can also be performed from the panel, the displayed error messages are the same as those that result from panel operation. Refer to the explanation for the panel operations that are relevant to each command and query. Errors that occur during normal measurement are also displayed in the same way under remote control operation.

5.8 Compatibility with commands of the CA5350

This chapter describes the compatibility with the **CA5350** of our product.

The commands described in “**5.5 Commands**” and the commands described in this chapter cannot be used at the same time.

The commands of the **CA5350** can be available by selecting the “**5350**”. Refer to “**4.1.5 REMOTE (remote control settings screen)**” for more details.

5.8.1 Commands table compatible with the CA5350

The definitions of the status byte register compatible with **CA5350** are described in “Table 5-8”. The status byte can only be read by serial polling. It cannot be read by USB or LAN interface.

Table 5-8 Status byte register definitions compatible with the CA5350

Bit	Content	Conditions for setting to “1”	Conditions for setting to “0”
(MSB)7	0	Always “0” (not used)	
6	RQS	• When SRQ is sent ^{†1}	• When DCL or SDC is received • After the status byte is read
5	An error occurred.	• When error occurs	• After the error status is read ^{†2}
4	Ready to receive	• When ready to receive commands	• When the command for command execution is received ^{†3}
3	0	Always “0” (not used)	
2	0	Always “0” (not used)	
1	0	Always “0” (not used)	
(LSB)0	I/O over detected	• When I/O over is detected	• When from I/O over state to non-I/O over state

†1: It occurs only with the GPIB interface. For the USB interface, SRQ cannot be used.

†2: After the response message of the “U1” command is outputted

†3: When the “X” command is received

The commands of the **CA5350** consist of a 1 alphabetic character header and 0 to 2 parameters. If the parameters are omitted, it will be interpreted as the default parameters defined for that command.

■ Priority of the command execution

Commands are stored in the buffer in the sequence they are received. When the 'X' command is received, commands in the buffer will be executed starting from the command with higher priority which is defined in "Table 5-9".

Table 5-9 Priority of the command execution

Priority	Command	Content
1 (High)	M	SRQ mask settings
2	K	EOI, X command hold off settings
3	A	LCD brightness settings
4	I	Input select
5	R	I/V gain settings
6	T	Filter rise time settings
7	P	Filter, ON/OFF
8	Z	Auto filter, ON/OFF
9	S	Current suppression value settings
10	N0, N1	Current suppression, ON/OFF
11	C	Zero check, ON/OFF
12	N2	Execute auto current suppression
13	Y	Message terminator settings
14	U	Query information
15 (Low)	L	Operate configuration memory

If there is a command or parameter error in any command in the buffer, not only the command with an error, but all commands until the 'X' command will be discarded. To execute transferred commands in order, the 'X' command should be added to the end of each command.

Example: L0XZ0XM0X

5.8.2 Commands table compatible with the CA5350

The commands of the **CA5350** are described in the following table.

Each item in the command table shows the following contents.

- Command Command of the **CA5350**
- Function Function of the command
- Compatibility ✓: Available for the **CA5351**
 ▲: Available for the **CA5351** but specifications have changed
 ×: Not available for the **CA5351**
- Details Pages of detailed command description
- CA5351 command (for reference)
 Replaceable command
 Note that there are differences in the setting method and a response.

[CA5350 commands]

Command	Function	Compatibility	Details	CA5351 command (for reference)
A	LCD brightness	▲	P5-45	:DISP:BRIG
B	Voltage bias state	×	—	—
C	Zero check	✓	P5-45	:INP
D	Message display	×	—	—
H	Key input	×	—	—
I	Input connector	✓	P5-45	:ROUT:TERM
J	Self-check	×	—	—
K	EOI, X command hold OFF settings	✓	P5-45	—
L	Configuration memory operation	▲	P5-46	*SAV *RCL *RST
M	SRQ mask settings	✓	P5-46	*SRE
N	Current suppression state	✓	P5-46	:INP:BIAS:CURR:STAT :INP:BIAS:CURR:AUTO
P	Filter state	✓	P5-46	:INP:FILT
R	I/V gain value	▲	P5-47	:INP:GAIN
S	Current suppression range and value	✓	P5-47	:INP:BIAS:CURR :INP:BIAS:CURR:RANG :INP:BIAS:CURR:RANG:AUTO
T	Filter rise time	✓	P5-47	:INP:FILT:TIM
U	Query information	▲	P5-48	(each command query)
V	Voltage bias	×	—	—
W	Output amplifier gain	×	—	—
X	Command execution	✓	P5-49	—
Y	Message terminator	✓	P5-49	—
Z	Auto filter state	✓	P5-50	:INP:FILT:TIM:AUTO

5.8.3 Detailed description of the CA5350 commands

5.8.3.1 A Command

Explanation	LCD brightness settings	
Setting contents	A0	Brightness 3 (Maximum brightness)
	A1	Brightness 2
	A2	Brightness 1
	A3	Backlight OFF
	Default: A1	
Comments	—	

5.8.3.2 C Command

Explanation	Zero check state settings	
Setting contents	C0	Disable the Zero check
	C1	Enable the Zero check
	Default: C1	
Comments	—	

5.8.3.3 I Command

Explanation	Input connector select	
Setting contents	I0	Use the input connector on the front panel
	I1	Use the input connector on the rear panel
	Default: I0	
Comments	—	

5.8.3.4 K Command

Explanation	EOI, X command hold OFF settings	
Setting contents	K0	EOI enabled and X command hold off enabled
	K1	EOI disabled and X command hold off enabled
	K2	EOI enabled and X command hold off disabled
	K3	EOI disabled and X command hold off disabled
	Default: K0	
Comments	<ul style="list-style-type: none"> • It sets whether to append EOI in the last character of the message or not when the CA5351 responds a message to a controller. • When the CA5351 receives a command, EOI will be ignored irrespective of the settings of the K command. • If the X command hold off is enabled, the CA5351 will hold the bus at the time when the X command is received (without returning NRFD line to H), and the CA5351 will stop receiving the following command. • After executing a set of commands until the X command, the CA5351 will receive the following commands after returning NRFD line to H. • Available only for GPIB interface, not available for USB and LAN interfaces 	

5.8.3.5 L Command

Explanation	Initialization, configuration memory operation	
Setting contents	L0	Initializes current settings
	L10n	n is the number (1 to 9) of the specified configuration memory. Current settings are saved to the specified configuration memory. (If a command is L101, the settings will be saved to the memory No.1)
	L20n	n is the number (1 to 9) of the specified configuration memory. The contents stored in the specified configuration memory are read. (If a command is L201, the contents stored in the memory No.1 will be read)
Comments	Refer to “3.2.3 Initial settings” what contents to be initialized.	

5.8.3.6 M Command

Explanation	SRQ mask settings	
Setting contents	Mn	n is an 8bit numerical value (0 to 255) bit0 When bit0 is “1”, SRQ will be sent if I/O over is detected. bit1 Not used bit2 Not used bit3 Not used bit4 When bit4 is “1”, SRQ will be sent if the CA5351 is ready for receiving commands bit5 When bit5 is “1”, SRQ will be sent if an error occurs. bit6 Not used bit7 Not used
	Default: 0	
Comments	<ul style="list-style-type: none"> When one or more factors that mask bit is “1” occur, SRQ will be sent to a controller. bit5 will be “1” if “a” and “b” of the U1 command are “1”. Available only for GPIB interface, not available for USB and LAN interfaces 	

5.8.3.7 N Command

Explanation	Current suppression state settings Execution of the auto current suppression settings	
Setting contents	N0	Disable the current suppression
	N1	Enable the current suppression
	N2	Start the auto current suppression settings
Default: N0		
Comments	<ul style="list-style-type: none"> After the auto settings are executed, the CS will be enabled and the CS range and value will be automatically set. If the Zero check is ON, an error will result when to start the auto current suppression. If I/O over is detected, an error will result when to start the auto current suppression. 	

5.8.3.8 P Command

Explanation	Filter state settings	
Setting contents	P0	Disable the filter
	P1	Enable the filter
Default: P1		
Comments	—	

5.8.3.9 R Command

Explanation	I/V gain settings	
Setting contents	R3	1 k (= 10 ³) V/A
	R4	10 k (= 10 ⁴) V/A
	R5	100 k (= 10 ⁵) V/A
	R6	1 M (= 10 ⁶) V/A
	R7	10 M (= 10 ⁷) V/A
	R8	100 M (= 10 ⁸) V/A
	R9	1 G (= 10 ⁹) V/A
	R10	10 G (= 10 ¹⁰) V/A
	Default: R3	
	Comments	—

5.8.3.10 S Command

Explanation	Current suppression range and value settings	
Setting contents	Sv,0	Enable the auto range settings
	Sv,1	±8 nA range, 1 pA resolution
	Sv,2	±80 nA range, 10 pA resolution
	Sv,3	±800 nA range, 100 pA resolution
	Sv,4	±8 µA range, 1 nA resolution
	Sv,5	±80 µA range, 10 nA resolution
	Sv,6	±800 µA range, 100 nA resolution
	Sv,7	±8 mA range, 1 µA resolution
	S,10	Disable the auto range settings
	Default: S0,1	
Comments	<ul style="list-style-type: none"> • The parameter v indicates the current suppression value. • The setting range and resolution will be changed by the auto range settings and changing the CS range. • When the auto range settings are enabled, the manual range settings are ignored. • When the auto range settings are enabled, the CS range will automatically change depending on the CS value. 	

5.8.3.11 T Command

Explanation	Filter rise time settings	
Setting contents	T.	1 µs
	T/	3 µs
	T0	10 µs
	T1	30 µs
	T2	100 µs
	T3	300 µs
	T4	1 ms
	T5	3 ms
	T6	10 ms
	T7	30 ms
	T8	100 ms
T9	300 ms	
Default: T.		
Comments	—	

5.8.3.12 U Command

Explanation	Query information																								
Response contents	<p>U Query current suppression range and value</p> <p><u>N DCI + 0.000 E-03 <term></u></p> <p>The formats of the exponential part and mantissa part depend on the CS range as shown below.</p> <table border="1" data-bbox="502 645 1220 875"> <thead> <tr> <th>Range</th> <th>Mantissa part</th> <th>Exponential part</th> </tr> </thead> <tbody> <tr> <td>±8 nA</td> <td>0.000</td> <td>E-09</td> </tr> <tr> <td>±80 nA</td> <td>00.00</td> <td>E-09</td> </tr> <tr> <td>±800 nA</td> <td>000.0</td> <td>E-09</td> </tr> <tr> <td>±8 uA</td> <td>0.000</td> <td>E-06</td> </tr> <tr> <td>±80 uA</td> <td>00.00</td> <td>E-06</td> </tr> <tr> <td>±800 uA</td> <td>000.0</td> <td>E-06</td> </tr> <tr> <td>±8 mA</td> <td>0.000</td> <td>E-03</td> </tr> </tbody> </table>	Range	Mantissa part	Exponential part	±8 nA	0.000	E-09	±80 nA	00.00	E-09	±800 nA	000.0	E-09	±8 uA	0.000	E-06	±80 uA	00.00	E-06	±800 uA	000.0	E-06	±8 mA	0.000	E-03
	Range	Mantissa part	Exponential part																						
±8 nA	0.000	E-09																							
±80 nA	00.00	E-09																							
±800 nA	000.0	E-09																							
±8 uA	0.000	E-06																							
±80 uA	00.00	E-06																							
±800 uA	000.0	E-06																							
±8 mA	0.000	E-03																							
<p>U0 Query contents of settings</p> <p><u>CA5351 A0 C1 I0 K0 M000 N0 P0 R03 S0 7 T0 Y0 Z0 <term></u></p> <p>(1) (2) (3) (4) (5) (6) (7) (8) (9) (10) (11) (12) (13) (14) (15)</p> <ul style="list-style-type: none"> (1) Model name CA5351 fixed (2) LCD brightness (3) Zero check state (4) Input connector (5) EOI, X command hold OFF (6) SRQ mask (7) Current suppression ON, OFF, or AUTO (8) Filter state (9) I/V gain (10) Auto CS range state (11) Current suppression range settings (12) Filter rise time (13) Message terminator (14) Auto filter state (15) Message terminator, EOI 																									

Response contents	U1	<p>Query error state</p> <p>CA5351 a b c d e f g h i j k <term></p> <p>Message terminator, EOI Model name CA5351 fixed</p> <p>The response message is composed of the model name and 10 characters constituted by “1” or “0”. The characters of “a” to “k” in the above response message indicate the state (“0” or “1”) of the corresponding error.</p> <p>The conditions under which “a” to “k” becomes “1” are shown below.</p> <ul style="list-style-type: none"> a : Inappropriate command received b : Command containing inappropriate parameter received c : Not used (always “0”) d : Not used (always “0”) e : Inappropriate current suppression settings (Setting current value exceeds the range) f : Not used (always “0”) g : Auto current suppression settings enabled while the Zero check is enabled h : Not used (always “0”) i : Error in the configuration memory j : I/O over detected k : Not used (always “0”)
	U3	<p>Query the total gain</p> <p>1E03 V/A <term></p> <p>Message terminator, EOI Unit of gain, “V/A” fixed Total gain</p> <p>The total gain is the combined gain of the I/V gain and the output amplifier gain. The total gain is equal to the I/V gain because the output amplifier gain of the CA5351 is fixed at 1.</p>
	U4	<p>Query the model name and firmware version</p> <p>CA5351 1.00 <term></p> <p>Message terminator, EOI Space character (1 character) Firmware version Model name CA5351 fixed</p>
Comments	—	

5.8.3.13 X Command

Explanation	Command execution	
Setting contents	X	Execute the commands stored in the receiving buffer.
Comments	—	

5.8.3.14 Y Command

Explanation	Message terminator settings	
Setting contents	Y0	CR,LF
	Y1	LF,CR
	Y2	CR
	Y3	LF
	Default: Y0	
Comments	Set the message terminator when the response message is outputted by the U command	

5.8.3.15 Z Command

Explanation	Auto filter state settings	
Setting contents	Z0	Disable the auto filter
	Z1	Enable the auto filter
	Default: Z1	
Comments	—	

5.9 Command execution examples

5.9.1 CA5351 commands

A command execution example using SCPI are shown below.

```

*RST //Initialization
*CLS //Status register and error queue initialization

:INP:GAIN 4 //Gain = 1E06 'Change I/V gain
:INP:BIAS:CURR:RANG 4 //CS-Range = 8 uA 'Change CS range
:INP:BIAS:CURR 1.234e-6 //CS-Value = +1.234 uA 'Set CS value
:INP:BIAS:CURR:STAT ON //CS-on 'Enable CS
:INP:STAT OFF //Zero-off 'Disable Zero check

:INP:BIAS:CURR 0 //CS-Value = 0 uA 'Set CS value to 0 to change CS
range

:INP:BIAS:CURR:RANG 2 //CS-Range = 80 nA 'Change CS range
:INP:BIAS:CURR -12.34e-9 //CS-Value = -12.34 nA 'Set CS value
:INP:GAIN 6 //Gain = 1E08 'Change I/V gain

:INP:FILT:TIME:AUTO OFF //AutoFilter-off 'Disable auto filter
:INP:FILT:TIME 7 //Filter = 1 ms 'Set filter rise time to 1 ms

:INP:STAT ON //Zero-on 'Enable Zero check

```

5.9.2 CA5350 commands

A command execution example using the commands compatible with **CA5350** are shown below.

```

L0X //Initialization

R6X //Gain = 1E06 'Change I/V gain
S1.234e-6,4X //CS-Range = 8 uA 'Change CS range
(Include CS value and range) //CS-Value = +1.234 uA 'Set CS value
N1X //CS-on 'Enable CS
C0X //Zero-off 'Disable Zero check

(No need to set CS value to 0) //CS-Value = 0uA 'Set CS value to 0 to change CS
range

S12.34e-9,2X //CS-Range = 80nA 'Change CS range
(Include CS value and range) //CS-Value = -12.34 nA 'Set CS value
R8X //Gain = 1E08 'Change I/V gain

Z1X //AutoFilter-off 'Disable auto filter
T4X //Filter = 1ms 'Set filter rise time to 1 ms

C1X //Zero-on 'Enable Zero check

```



6. Troubleshooting

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6.1.4 Errors that occur during remote mode	6-5
6.2 Quick diagnosis	6-7

6.1 Error messages

The main errors that occur during the self-diagnostic process that is performed when the instrument is turned on, during panel operations, and 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 include a description of the error message that was displayed.

There are error messages that are not described in this manual, but which may occur in events, such as instrument malfunction due to strong external noise.

Error messages 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.

6.1.1 Errors that occur when the instrument power is turned on

When the power is turned on, a system check will be performed and settings will be read. If there is an abnormality during that time, the error messages that are described in “**Table 6-1 Power-up errors**” will appear on the LCD.

Table 6-1 Power-up errors

Error message	Description and cause	Handling
No.1024 Settings load error. Initialize and start up.	The settings have been initialized because the contents of the resume memory were lost.	If the error occurs repeatedly, the instrument will require repair.
No.1025 Settings load error. Calibration Data lost.	The calibration data was lost.	The instrument requires repair.
No.1026 Settings load error. Memory contents lost.	Contents of the configuration memory were lost.	If the error occurs repeatedly, the instrument will require repair.
No.7168, 7169 Hardware error.	Hardware error	The instrument requires repair.
No.7172 AC line voltage error.	An overvoltage was detected in the power supply voltage.	Review the power supply voltage and the voltage of the voltage selector switch.
No.7173 No Analog BD response.	Hardware error The analog unit was not detected.	The instrument requires repair.

6.1.2 Errors that occur during panel operations

The errors that may occur during panel operations are described in “**Table 6-2 Panel operation errors**”.

Table 6-2 Panel operation errors

Error message	Description and cause	Handling
No.2048 AUTO CS ERROR Cannot be executed with OVER.	The auto current suppression failed. I/O over had been detected.	Enable the auto current suppression after getting rid of I/O over.
No.2049 AUTO CS ERROR Cannot execute because ZERO CHECK on.	The auto current suppression failed. The Zero check had been ON.	Execute the auto current suppression after disable the Zero check.
No.2050 AUTO CS ERROR CS value out of range.	The auto current suppression failed. The setting current value was out of range while the range and value were being adjusted.	Input current fluctuated while the auto current suppression was working. Input current exceeded ± 8 mA.
No.11 SELFTEST DONE Fail 0XXXXXXXX†1	The self-diagnostic test failed.	Execute the self-diagnostic test again after disconnecting the cable from the output terminal. If the error occurs repeatedly, the instrument will require repair. Please contact the NF Corporation or its authorized agent.

†1: Error codes

If an error is detected during self-diagnostic test, it will stop and an error code will be displayed.

Descriptions of error codes are shown below.

Error code	Description
0x00010000	Pass
0x00020000	The analog unit was not detected.
0x0003XYXX	I/V gain or current suppression range error “X” does not matter and the range of “Y” is 0 to 7. When “Y” is 0, I/V gain 1E03 error or CS range 800 μ A or 8 mA error When “Y” is 1, I/V gain 1E04 error or CS range 80 μ A or 800 μ A error : When “Y” is 7, I/V gain 1E10 or CS Range 8 nA error
0x0004XZXX	Filter rise time error “X” does not matter and the range of “Z” is 0 to C. When “Z” is 0, rise time 1 μ s error When “Z” is 1, rise time 3 μ s error : When “Z” is B, rise time 300 ms error When “Z” is C, Filter function off error

6.1.3 Errors that occur during operation

The errors that may occur during operation are described in “**Table 6-3 Errors during operation**”.

Table 6-3 Errors during operation

Error message	Description and cause	Handling
No.7171 Over Temperature.	The inside of the housing is overheated. Ambient temperature is high. The cooling fan has failed.	Turn off the power switch and wait until the internal temperature falls within the normal range. If the error message appears after the power is turned on again, the instrument will require repair.
No.7172 AC line voltage error	An overvoltage was detected in the power supply voltage.	Review the power supply voltage and the voltage of the voltage selector switch.




6.1.4 Errors that occur during remote mode

Refer to “**5.7 Error messages**” when errors occur in the remote mode.

6.1.5 I/O over display

The I/O over icon will be displayed if excessive signal is detected in the internal circuit. The cause or handling in “Table 6-4” is one example.

Table 6-4 List of I/O over

Icon	Description	Handling
	The icon will be displayed if “OV I” and “OV O” occur simultaneously. The signal that generates “OV I” in the input side will be applied to the output side and will occur “OV O” unless the band of signal is limited with the filter.	See below.
	Excessive signal can be detected at the input terminal, I/V conversion amplifier, equalizer amplifier, and filter. <ul style="list-style-type: none"> • Excessive current • Much noise is mixed in the input signal • Vibration in the housing or input cable • A low-impedance signal source 	<ul style="list-style-type: none"> • Set the I/V gain value suitable for the magnitude of the input signal. • Fix on the input cable and take vibration-proof measures. • Use recommended signal source resistance. Note that equivalent signal source resistance for this instrument will decrease when the auto current suppression is ON.
	Excessive signal can be detected at the output amplifier and output terminals. <ul style="list-style-type: none"> • There is a possibility that voltage is applied to the output terminals. 	<ul style="list-style-type: none"> • Disconnect the cable from the output terminal. • Observe the voltage of the output terminal with an oscilloscope.

6.2 Quick diagnosis

If you suspect the instrument is malfunctioning, use “**Table 6-4 troubleshooting**” to identify the problem and understand how to deal with it. If you are still unable to solve the problem or if the method described below fails to restore the instrument to normal functioning, please contact the NF Corporation or its authorized agent.

Table 6-5 Troubleshooting

Problem	Possible cause	Handling
The instrument does not power up.	The power cord is not properly plugged in.	Make sure that the power cord is securely inserted into the inlet and outlet.
	The power source does not conform to the specifications.	Check the voltage of the power outlet with multimeter, etc. Check the voltage of the voltage selector switch. Unplug the power cord when changing the voltage of the switch.
	The fuse has blown.	Unplug the power cord and confirm that the power supply voltage matches the voltage of the voltage selector switch, and then replace the blown fuse. Despite that if the fuse blows, please contact the NF Corporation or its authorized agent.
Panel operations are not possible.	The instrument is operating in the remote mode.	When the remote icon is displayed, the instrument can be returned to the local mode by pressing the LOCAL key. If the instrument is in the local lockout mode, panel operations are not effective. In this case, use a remote controller to return the instrument to the local mode.
	The keys have been deteriorated.	Please contact the NF Corporation or its authorized agent and request repair.
Settings cannot be executed by external controller.	The address or port of the CA5351 is the same as that of device in the same system.	Set the address or port of the instrument different from that of the other devices.

Noise is large.	Noise is mixed.	Keep the input cable away from the power cord and a noise source.
	A source of vibration is nearby.	Vibration in the housing or input cable will result in noise. Keep away from the source of vibration or take vibration-proof measures.
Signal is small.	A connection error of the connection cable	Check whether the cable has not been disconnected. Moreover, clean the contact part.
Output signal is abnormally large.	A short circuit of the input connection cable	Check whether the inner and outer conductor of the input cable are not short-circuited.
	An output voltage is being saturated.	Set the I/V gain to 1E03 and disable the current suppression.

7. Maintenance

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7.1 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 perform according to 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 test performance.

For more advanced inspection, adjustment, calibration, and repair, contact the NF Corporation or its authorized agent.

WARNING

There are locations of high-voltage inside the instrument. Do not remove the cover of the instrument.

Inspection of the interior of the instrument should not be performed by anyone other than service technicians that have been trained to avoid hazards.

7.2 Daily Maintenance

Before use, install the instrument in a location that satisfies the installation conditions.

Installation conditions → Refer to “2.2.2 Installation environment”

Wipe the panel or case with a soft cloth to clean it as necessary. To remove stubborn soiling, wipe with 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.

7.3 Storage, repackaging, and transport

The instrument 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 material 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.

7.4 Checking the version number

The firmware version number of the instrument can be confirmed in the product information screen.

Confirmation method → Refer to “4.1.4 INFORMATION (product information screen) ”.

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 the description of the problem.

7.5 Self-diagnostic test

Before executing the performance test, execute the self-diagnostic test with reference to “2.4 Quick operation check”.

7.6 Performance test

7.6.1 Introduction

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

If the performance test indicates 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) The test environment

The performance test should be performed under the following conditions.

- Power supply voltage AC 100 V \pm 10 %, 120 V \pm 10 %, or 230 V + 10 % to -14 %, however 250 V or less
- Ambient temperature 23 \pm 5 °C
- Ambient humidity 5 to 85 %RH, no condensation
- Warm-up time 30 minutes or more

2) Preparation for testing

Before doing the test, initialize the settings.

Methods of initializing the settings → “3.2.3 3.2.3 Initial settings”

3) Testing equipment

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

Product	Required specifications	Example models
Digital multimeter	DC voltage (100 mV to 100 V) Accuracy: \pm 0.04 %	34401A (Keysight)
Other		
Coaxial cable	50 Ω , BNC, equivalent to RG58/U	

7.6.2 Current suppression and gain accuracy

How to easily measure the total accuracy of the accuracy of the current suppression and the gain accuracy of the amplifier is described below. For more advanced testing, please contact the NF Corporation.

- CA5351** settings: Zero check is ON.
 I/V gain is listed below.
 The filter function is ON and the rise time is 1 ms.
 The current suppression is ON and the range and value are listed below.
- Measuring instrument: Set the digital multimeter to DC voltage mode.
- Connections: Connect the output connector of the instrument to the digital multimeter with a coaxial cable.
- Judgment (passing range): Listed below

Current suppression		I/V GAIN (V/A)	Measured DC voltage	Passing range
RANGE	VALUE			
8 mA	+0.000 mA	1E03	___·___ V	-0.032 V ~ +0.032 V
8 mA	+8.000 mA	1E03	___·___ V	+7.900 V ~ +8.100 V
800 μ A	+0.0 μ A	1E04	___·___ V	-0.032 V ~ +0.032 V
800 μ A	+800.0 μ A	1E04	___·___ V	+7.900 V ~ +8.100 V
80 μ A	+0.00 μ A	1E05	___·___ V	-0.032 V ~ +0.032 V
80 μ A	+80.00 μ A	1E05	___·___ V	+7.900 V ~ +8.100 V
8 μ A	+0.000 μ A	1E06	___·___ V	-0.032 V ~ +0.032 V
8 μ A	+8.000 μ A	1E06	___·___ V	+7.900 V ~ +8.100 V
800 nA	+0.0 nA	1E07	___·___ V	-0.032 V ~ +0.032 V
800 nA	+800.0 nA	1E07	___·___ V	+7.880 V ~ +8.120 V
80 nA	+0.00 nA	1E08	___·___ V	-0.032 V ~ +0.032 V
80 nA	+80.00 nA	1E08	___·___ V	+7.808 V ~ +8.192 V
8 nA	+0.000 nA	1E09	___·___ V	-0.032 V ~ +0.032 V
8 nA	+8.000 nA	1E09	___·___ V	+7.648 V ~ +8.352 V
8 nA	+0.000 nA	1E10	___·___ V	-0.150 V ~ +0.150 V
8 nA	+0.900 nA	1E10	___·___ V	+8.490 V ~ +9.510 V

7.6.3 Output offset voltage

- CA5351 settings:** Zero check is ON.
 I/V gain is listed below.
 The filter function is ON and the rise time is listed below.
 The current suppression is OFF.
- Measuring instrument:** Set the digital multimeter to DC voltage mode.
- Connections:** Connect the output connector of the instrument to the digital multimeter with a coaxial cable.
- Judgment (passing range):** Listed below

I/V gain (V/A)	Rise time	Measured DC voltage	Passing range
1E03	1 μ s	----.--- mV	-20 mV to +20 mV
1E04	3 μ s	----.--- mV	
1E05	10 μ s	----.--- mV	
1E06	30 μ s	----.--- mV	
1E07	100 μ s	----.--- mV	
1E08	300 μ s	----.--- mV	
1E09	1 ms	----.--- mV	
1E09	3 ms	----.--- mV	
1E09	10 ms	----.--- mV	
1E09	30 ms	----.--- mV	
1E09	100 ms	----.--- mV	-30 mV to +30 mV
1E10	300 ms	----.--- mV	

7.7 Calibration

If the performance test reveals that the instrument is not performing according to 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.



8. Specifications

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Supplementary value:

This value implies supplementary data of this product and it does not guarantee the product performance.

8.1 Input section

- Input type DC coupled unbalanced input
- Input connector BNC receptacle
Either the input connector of the front panel or rear panel can be used.
- Zero check ON/OFF
It is the function that disconnects an input signal from the internal circuit.
While the Zero check is ON, an input signal is disconnected from the internal circuit.
While the Zero check is OFF, an input signal is connected to the internal circuit and amplified.
- Non-destructive maximum input current ± 30 mA

- Maximum input current

I/V gain	Maximum input current
1E10 V/A	± 1 nA
1E09 V/A	± 10 nA
1E08 V/A	± 100 nA
1E07 V/A	± 1 μ A
1E06 V/A	± 10 μ A
1E05 V/A	± 100 μ A
1E04 V/A	± 1 mA
1E03 V/A	± 10 mA

- Input impedance (supplementary value)

I/V gain	Input impedance	Comments
1E10 V/A	30 k Ω	at 100 Hz
1E09 V/A	10 k Ω	at 1 kHz
1E08 V/A	3 k Ω	
1E07 V/A	1 k Ω	
1E06 V/A	400 Ω	
1E05 V/A	300 Ω	
1E04 V/A	10 Ω	
1E03 V/A	3 Ω	

- Recommended source resistance (supplementary value)

I/V gain	Recommended source resistance
1E10 V/A	1 G Ω or more
1E09 V/A	100 M Ω or more
1E08 V/A	10 M Ω or more
1E07 V/A	1 M Ω or more
1E06 V/A	100 k Ω or more
1E05 V/A	10 k Ω or more
1E04 V/A	1 k Ω or more
1E03 V/A	100 Ω or more

- Equivalent input current noise density (supplementary value)

I/V gain	Equivalent input current noise density	Comments
1E10 V/A	2.5 fA/√Hz	at 55 Hz
1E09 V/A	6 fA/√Hz	at 200 Hz
1E08 V/A	15 fA/√Hz	
1E07 V/A	45 fA/√Hz	at 1 kHz
1E06 V/A	150 fA/√Hz	
1E05 V/A	750 fA/√Hz	
1E04 V/A	6 pA/√Hz	
1E03 V/A	75 pA/√Hz	

Conditions: Input open, front input, auto filter ON, and no additional input capacitance

8.2 Current suppression section

The built-in current source is connected to the input connector for cancelling DC current of a signal source.

- Current suppression

ON/OFF

- Range

7 ranges (8 nA, 80 nA, 800 nA, 8 μA, 80 μA, 800 μA, and 8 mA)

- Range setting

Manual setting/Auto setting

- Setting range

8 nA range	-8.000 nA to +8.000 nA, resolution 1 pA
80 nA range	-80.00 nA to +80.00 nA, resolution 10 pA
800 nA range	-800.0 nA to +800.0 nA, resolution 100 pA
8 μA range	-8.000 μA to +8.000 μA, resolution 1 nA
80 μA range	-80.00 μA to +80.00 μA, resolution 10 nA
800 μA range	-800.0 μA to +800.0 μA, resolution 100 nA
8 mA range	-8.000 mA to +8.000 mA, resolution 1 μA

- Accuracy (supplementary value)

8 nA range	± (3.0 % of value + 0.15 % of range)
80 nA range	± (1.5 % of value + 0.15 % of range)
800 nA range	± (0.8 % of value + 0.15 % of range)
8 μA range to 8 mA range	± (0.6 % of value + 0.15 % of range)

- Auto current suppression

This function automatically sets the current suppression range and value to cancel the input current at the time of enabling the auto current suppression.

8.3 Amplifier section

- Accuracy

I/V gain	Accuracy
1E10 V/A	$1 \times 10^{10} \pm 1.0 \%$
1E09 V/A	$1 \times 10^9 \pm 1.0 \%$
1E08 V/A	$1 \times 10^8 \pm 0.5 \%$
1E07 V/A	$1 \times 10^7 \pm 0.3 \%$
1E06 V/A	$1 \times 10^6 \pm 0.25 \%$
1E05 V/A	$1 \times 10^5 \pm 0.25 \%$
1E04 V/A	$1 \times 10^4 \pm 0.25 \%$
1E03 V/A	$1 \times 10^3 \pm 0.25 \%$

Gain at DC

- Frequency characteristics

I/V gain	Frequency bandwidth (within +0.5 dB to -3.0 dB)	Response speed (supplementary value)	Comments
1E10 V/A	DC to 14kHz	25 μ s	Reference frequency: 1 Hz
1E09 V/A	DC to 70kHz	5.0 μ s	Reference frequency: 10 Hz
1E08 V/A	DC to 175kHz	2.0 μ s	
1E07 V/A	DC to 350kHz	1.0 μ s	
1E06 V/A	DC to 500kHz	0.7 μ s	
1E05 V/A			
1E04 V/A			
1E03 V/A			

Conditions: Filter OFF and no additional input capacitance

Response speed is the rise time (10 % to 90 %) of the output waveform when a square wave is inputted.

- Filter

Filter ON/OFF

Setting range Response speed (rise time) 1 μ s to 300 ms by 1-3 sequence, auto filter, or OFF

Setting method Manual setting/Auto filter

Accuracy Within $\pm 20 \%$ of the setting rise time (10 % to 90 % rise time, supplementary value)

Characteristics Low-pass filter (LPF), phase-linear type

Attenuation slope 12 dB/oct

- I/O polarity

Inverted (When current flows into the input connector, the output is negative potential.)

- Auto filter The filter rise time will be automatically set corresponding to the I/V gain

When the auto filter is enabled, the filter rise time will be automatically changed if the I/V gain is changed.

I/V gain	Filter rise time
1E10 V/A	100 μ s
1E09 V/A	100 μ s
1E08 V/A	30 μ s
1E07 V/A	10 μ s
1E06 V/A	10 μ s
1E05 V/A	3 μ s
1E04 V/A	1 μ s
1E03 V/A	1 μ s

8.4 Output section

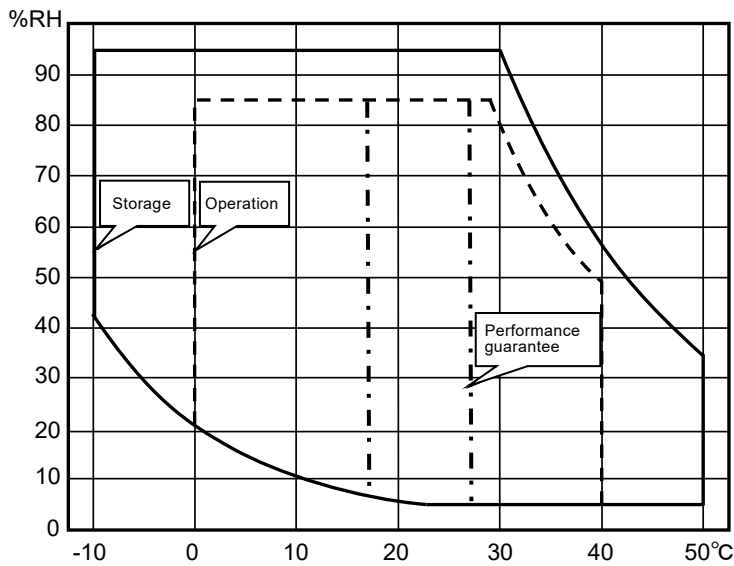
- Output type DC coupled unbalanced output
- Output connector BNC receptacle (front and rear)
The front and rear connectors are connected in parallel and the same signals are outputted.
- Maximum output voltage ± 10 V (when no load)
- Maximum output current ± 10 mA (total current of the front and rear connectors)
- Output impedance 50 Ω (supplementary value)
- Output offset voltage Within ± 30 mV (when I/V gain is 1E10)
Within ± 20 mV (when I/V gain is 1E04 to 1E09)
(Input open and the current suppression OFF)

8.5 Miscellaneous specifications

- Display unit
 - 3.9-inch, TFT color LCD
 - 3 levels of backlight brightness and OFF
- Configuration memory
 - 10 sets (one of them is the resume memory)
- Resume memory
 - Last operating settings will be restored when the instrument is restarted.
- I/O ground
 - Signal grounds of the input and output are isolated from the chassis.
 - These signal grounds are common.
 - The maximum withstanding voltage between signal grounds and the chassis is 42 Vpk (DC + ACpeak).
- Over-level detection
 - If an excessive signal is detected, the I/O over icons will be displayed on the LCD.
 - The over-level signal after current-voltage conversion (input over) and the over-level signal of the output connector (output over) can be detected respectively.
 - The I/O over icon can be displayed separately.
- Remote control
 - USB
 - USB1.1 full speed, device class CDC
 - GPIB
 - IEEE488.2
 - LAN
 - 10BASE-T/100BASE-TX, TCP/IP (socket communication)
- Power supply voltage
 - Voltage
 - AC 100 V \pm 10 %/AC 120 V \pm 10 %/AC 230 V +10 % to -14 %, however 250 V or less
 - Frequency
 - 50 Hz/60 Hz \pm 2 Hz
 - Power consumption
 - 40 VA or less
 - Overvoltage category
 - II
- Cooling
 - Forced air cooling, rear exhaust

● Environment

Operation	0 to +40 °C, 5 to 85 %RH (absolute humidity 1 to 25 g/m ³ , no condensation) Altitude of 2 000 m or less
Performance guarantee	23 ±5 °C, 5 to 85 %RH (absolute humidity 1 to 25 g/m ³ , no condensation) Altitude of 2 000 m or less
Storage	-10 to 50 °C, 5 to 95 %RH (absolute humidity 1 to 29 g/m ³ , no condensation)



Pollution degree 2 (indoor use)

- Warm-up time 30 minutes
- External dimensions Approximately 215 mm (W) × 88 mm (H) × 400 mm (D)
(excluding protruding parts)
- Weight Approximately 4.5 kg (main unit only, excluding accessories and optional equipment, etc.)
- RoHS directive Directive 2011/65/EU
- Safety standards and EMC EMC EN61010-1, EN61010-2-30
EN61326-1 (Group1, ClassA), EN61326-2-1
Note: Applies to products that have a CE marking displayed on the rear panel

8.6 External dimensions

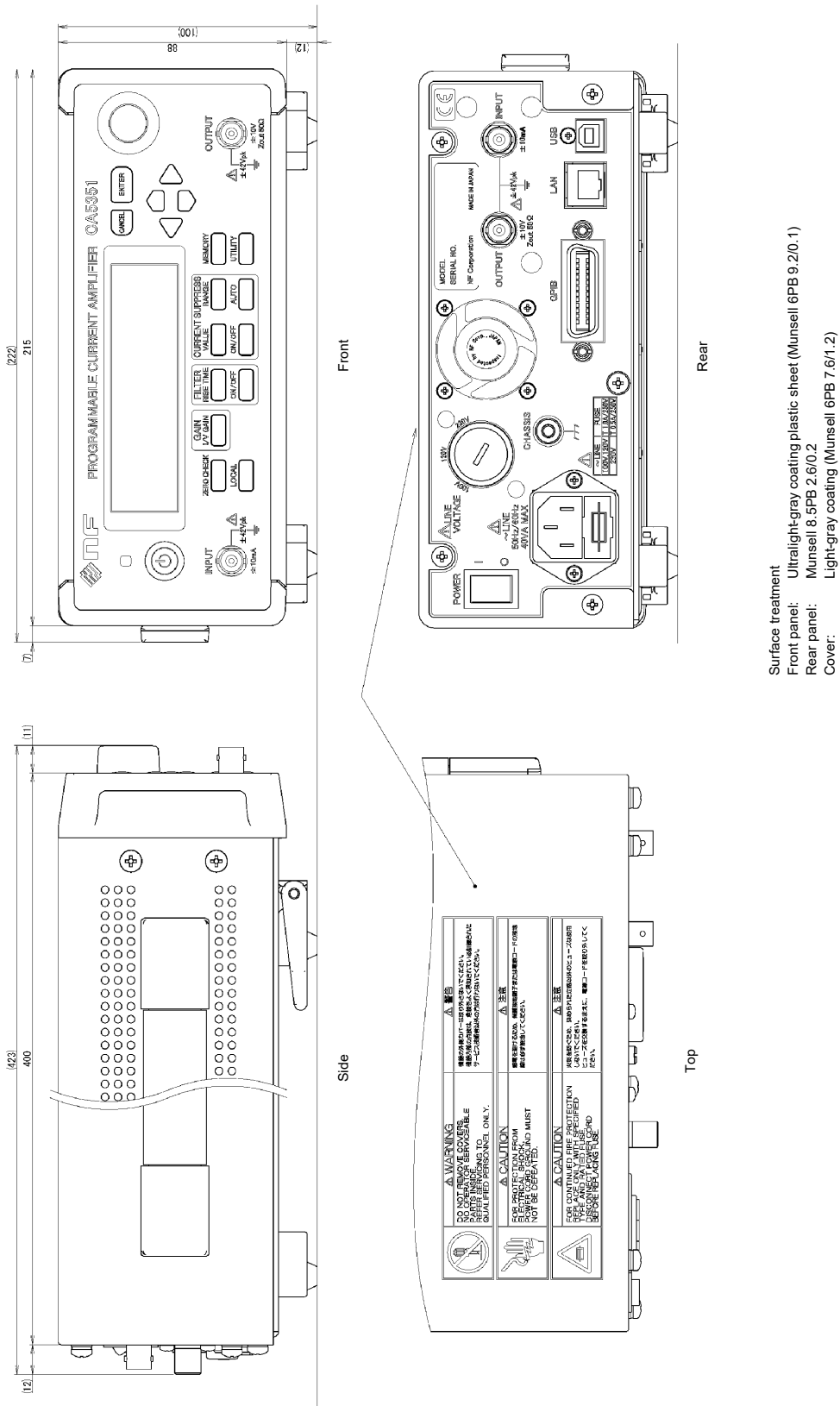


Figure 8-1 External dimensions of the CA5351

WARRANTY

NF Corporation certifies that this product 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 product.

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 product without any charge for the parts and labor.

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

This warranty shall not apply when corresponding to following particulars.

- A) Failure caused by improper handling or use of the product 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 product after purchase.
- C) Failure caused by repair, adjustment, or modification of the product by a company, organization, or individual not approved by NF.
- D) Failure caused by abnormal voltage or the influence of equipment connected to this product.
- 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: (DA00082421-002)

If there are any misplaced or missing pages, we will replace the manual. Contact the sales representative.

NOTES

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- The contents of this manual may be revised without notice.
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- We assume no responsibility for influences resulting from the operations in this manual.

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