



WIDEBAND CURRENT AMPLIFIER

SA-609F2

INSTRUCTION MANUAL

DA00094500-001

WIDEBAND CURRENT AMPLIFIER

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INSTRUCTION MANUAL

Preface

Thank you for purchasing “WIDEBAND CURRENT AMPLIFIER SA-609F2”.

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 use 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 or damage to the instrument in the use or handling of this instrument.

⚠ CAUTION

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

- This manual consists of the following chapters.

If using this product for the first time, start from "1. Outline."

1. Outline

This chapter describes an overview and describes the features and applications of this product and the simple operating principle.

2. Preparation Before Use

This chapter describes important preparations before installation and operation.

3. Panels future and Basic Operations

This chapter explains the basic operations of the panels.

4. Maintenance

This chapter explains the simple operation inspection method.

5. Specifications

This chapter describes the specifications (functions and performance).

6. Reference Data

This chapter shows the general electrical characteristics of the normal SA-609F2.

———— Safety Precautions ————

To ensure safe use, be sure to observe the following safety precautions.

NF Corporation shall not be held liable for damages that arise from a failure to observe these safety precautions or warnings or cautions in the instruction manual.

- Be sure to observe the information of the instructions manual.

The instruction manual contains information for the safe operation of the product.

Be sure to read the information first before using the product.

All the warnings in the instruction manual are intended for preventing risks that may lead to serious accidents. Ensure to obey them.

- Check the power supply voltage.

This product operates on the power supply voltage indicated in the instruction manual. Prior to connecting the power supply, check that the voltage of the power supply matches the rated power supply of the product.

- If you notice anything strange.

If this product emits smoke, an unusual smell or strange sound, immediately power it off and stop using it.

If such an anomaly occurs, prevent anyone from using this product until it has been repaired, and immediately report the problem to NF Corporation or one of our representatives.

- Do not operate in an explosive atmosphere.

An explosion or other such hazard may result.

- Do not remove the cover.

Never remove the cover.

Even when the inside of this production needs to be inspected, do not touch the inside. All such inspections are to be performed by service technicians designated by NF Corporation.

- Do not modify the product.

Never modify the product. Modification to the product may pose a new risk. We may refuse the repair of a modified product.

- Ensure that water does not get into this product.

Using the product in wet condition may cause electric shock and fire. When water etc. get into the product, immediately power it off, and contact NF Corporation or one of our representatives.

- If lightning occurs, power off and disconnect this product.

A lightning may cause an electric shock a fire and a failure.

Safety Precautions

- Electromagnetic compatibility

This product is CISPR 11 Group 1 Class A equipment. This product may cause interference if used in residential areas. Unless the user takes special measures to reduce electromagnetic emissions and prevent interference with radio and television broadcasts, such use should be avoided.

- Safety symbols



Caution, refer to instruction manual.

This notifies the user of potential hazards and indicates that he/she must refer to the instruction manual.



Caution, possibility of electric shock.

This indicates that an electric shock may occur under specific conditions.



Warning

This contains information to avoid risks in equipment handling that could result in loss life or bodily injury.



Caution

This contains information to avoid risks equipment handling that could result in minor or moderate injury to person or damage to property or the equipment.

- Other symbol



This indicates that the terminal or the outer conductor of the connector is connected to the signal ground.

- 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 include batteries.
- c) This product does not include mercury.

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WARRANTY

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1. Outline

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1.1 Overview

The SA-609F2 is a wideband current amplifier (current to voltage converter) with a high gain and wide frequency band.

1.2 Features

- (1) High gain (1 TV/A), Wideband (DC to 300 Hz)
- (2) Low noise (0.4 fA/Hz)
- (3) High stability (Low bias current 10 fA typ., Gain temperature drift 100 ppm/°C typ.)
- (4) Stable operation regardless of input capacitance (Cs)
- (5) Implements a low-pass filter (LPF) function in the first stage circuit
- (6) Implement strong input protection circuit
- (7) SMA connectors with excellent shielding characteristics are used for input/output connectors

1.3 Applications

This current amplifier with a high gain and wide frequency band is stable for input capacitance and can be widely used to amplify small currents.

- (1) Wideband current to voltage converter for a current output sensor (e.g. optical device).
- (2) Expansion of the frequency band and improvement of noise for a current amplifier with a built-in lock-in amplifier.
- (3) Measurement of leakage current for insulating materials, etc.

1.4 Operating Principle

The input circuit consists of an inverting amplifier with a large open loop gain and a feedback resistance of $1\text{ T}\Omega$, and the input current is converted into a voltage by the feedback resistance of $1\text{ T}\Omega$. Other circuits allow for offset adjustment and LPF switching.

This product operates stably regardless of additional input capacitance such as sensor capacitance.

Furthermore, it can be used safely because the input has a powerful current-limiting input protection circuit, and is more durable against overvoltage/current inputs than conventional current amplifiers.

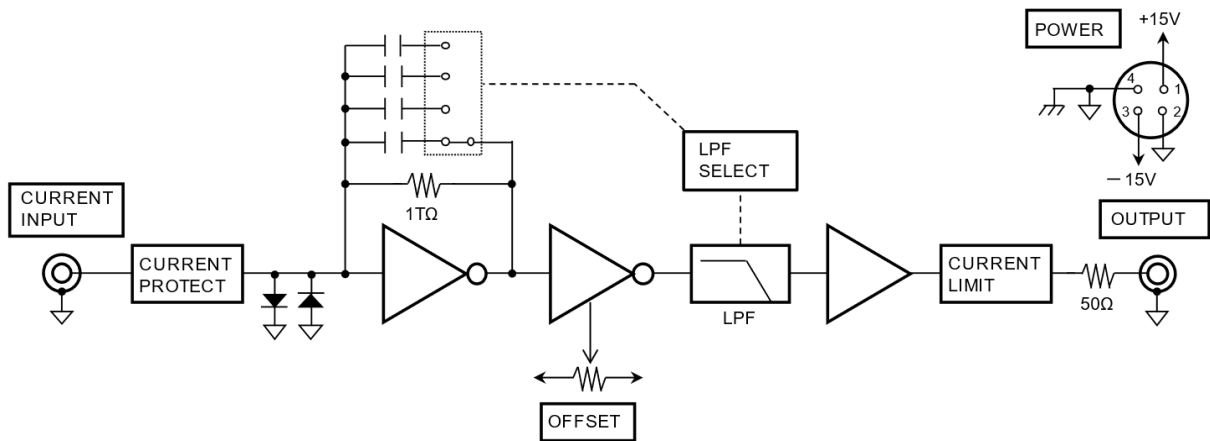


Figure 1-1 Block Diagram

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2.1 Checking Before Use

■ Safety check

Before using this product, read the following section of this manual.

- [Safety Precautions] at the beginning of this instruction manual.
- [2.3 Power Supply]

■ Check appearance and accessories

First check for any damage that may have occurred during transportation.

After unpacking the product, refer to “Table 2-2 List of contents” and confirm that all items are present in the quantities listed.

Table 2-1 List of Contents

● Wideband Current Amplifier	1
● Accessories	
Instruction manual	1
SMA open plug	1
SMA - BNC adapter	2
Bottom plate	1

* The bottom plate is attached to the main unit by four plastic screws (M3×6 mm).

* SMA open plug is attached to this product.

● Optional Item

Optional items below are separately available. If required, please contact NF or one of our agents.

PA-001-2986: SMA-BNC adapter

PA-001-2372: OUTPUT CABLE A (for low noise power supply LP series)

PA-001-3018: POWER SUPPLY CABLE (for DC power supply)

2.2 Conditions for Installation location

- The installation location shall meet the following temperature and humidity conditions.
 - Specifications guaranteed: 18 °C to 28 °C, 5 %RH to 75 %RH
 - Operating: 0 °C to 40 °C, 5 %RH to 75 %RH
 - Storage: -10 °C to 50 °C, 5 %RH to 75 %RHHowever, do not use the product if condensation is present.

- Use the product indoors at an altitude of up to 2000 m.

- Do not install the product in the following locations:
 - Locations where flammable gases may be present.

There is a risk of explosion. Never install or use the product in such locations.
 - Outdoors, locations exposed to direct sunlight, near fire or heat sources.

The performance may not be satisfied, or a failure may occur.
 - Locations where corrosive gases, water vapor dust, or too humid.

Malfunction or a failure may occur.
 - Near an electromagnetic field source, high-voltage product, or power line.

Noise may increase.
 - Where is a lot of vibration.

Noise may increase, or a malfunction may result.

- For heat dissipation, make sure there is a distance of at least 1 cm between the front panel (the panel on which the model name appears) and surrounding objects.

2.3 Power Supply

This product operates under the following power supply conditions.

- Stabilized DC power supply with $\pm 15\text{ V} \pm 1\text{ V}$, $\pm 40\text{ mA}$ or higher, and ripple noise of 0.35 mVrms or less.

Fluctuations in the power supply voltage affect the output signal. That effect is indicated by the PSRR (Power Supply Rejection Ratio) parameter. For example, a PSRR of 40 dB indicates that a power supply fluctuation of 100 mV produces a 1 mV fluctuation in the output voltage. The PSRR of this product is 40 dB at 1 Hz, so use of this product with a switching regulator or DC/DC converter that has a large switching noise is not recommended.

For accurate measurement of small signals, use of a DC power supply that has superior stability and noise performance is recommended.

We provide the excellent stability and low noise performance DC power supply LP series. For information on those products, please contact the NF corporation or one of our agents.

WARNING

Do not connect this product to an AC outlet, because doing so is dangerous.

Attention

Supplying a voltage greater than $\pm 18\text{ V}$ will damage this product.

2.3.1 Connecting with Low Noise DC Power Supply LP Series

The OUTPUT CABLE A (PA-001-2372) is available to connect this product to LP series power supply. If you require the cable, please contact NF or one of our agents.

The following figure shows the connection using the OUTPUT CABLE A. The output of LP series power supply is set as ± 15 V.

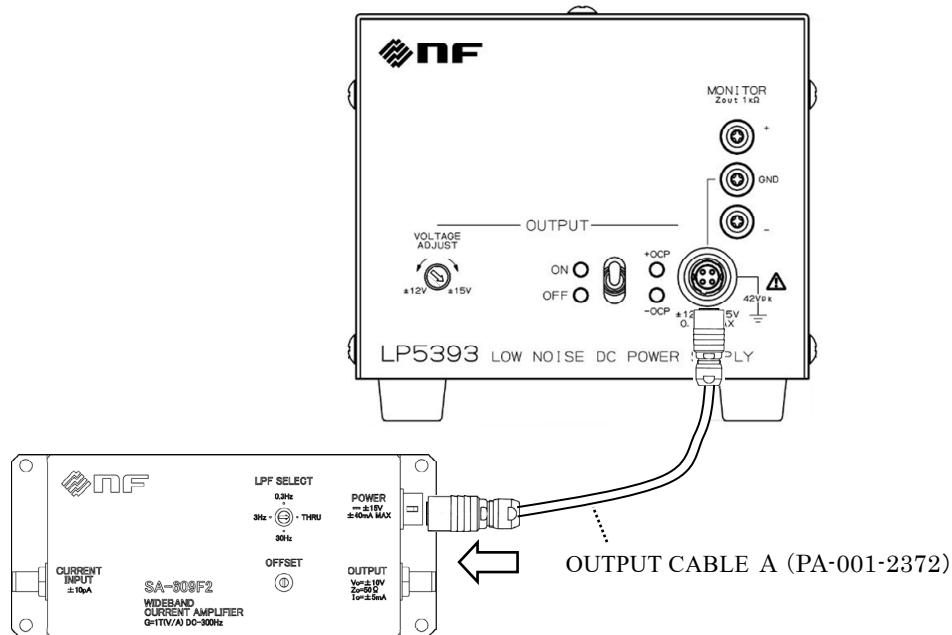


Figure 2-1 Connecting with LP Series

Attention

- Turn off the output switch of the power supply unit before connecting this product to the power supply unit.
- Do not plug / unplug the output cable A while the power supply is turned on. This product may be damaged.

2.3.2 Connecting to DC Power Supply

When connecting this product to a stabilized DC power supply, it is convenient to use the PA-001-3018 POWER SUPPLY CABLE that is available for separate purchase. For information on this cable, please contact the NF corporation or one of our agents.

The connection diagram for when the PA-001-3018 POWER SUPPLY CABLE is used is illustrated in the following figure. Set the output voltage of the stabilized DC power supply to ± 15 V for use with this product. For the connection on the power supply side, the cable has three insulated wires. Strip the insulation from the ends of the wires for connection to the power supply. The power supply output terminals may require that banana plugs, crimped terminals or special connectors be attached to the ends of the wires.

Please refer to the instruction manual for the stabilized DC power supply.

Insulated wires

- pink : +15 V(AWG24)
- black : GND (AWG24)
- white : -15 V(AWG24)

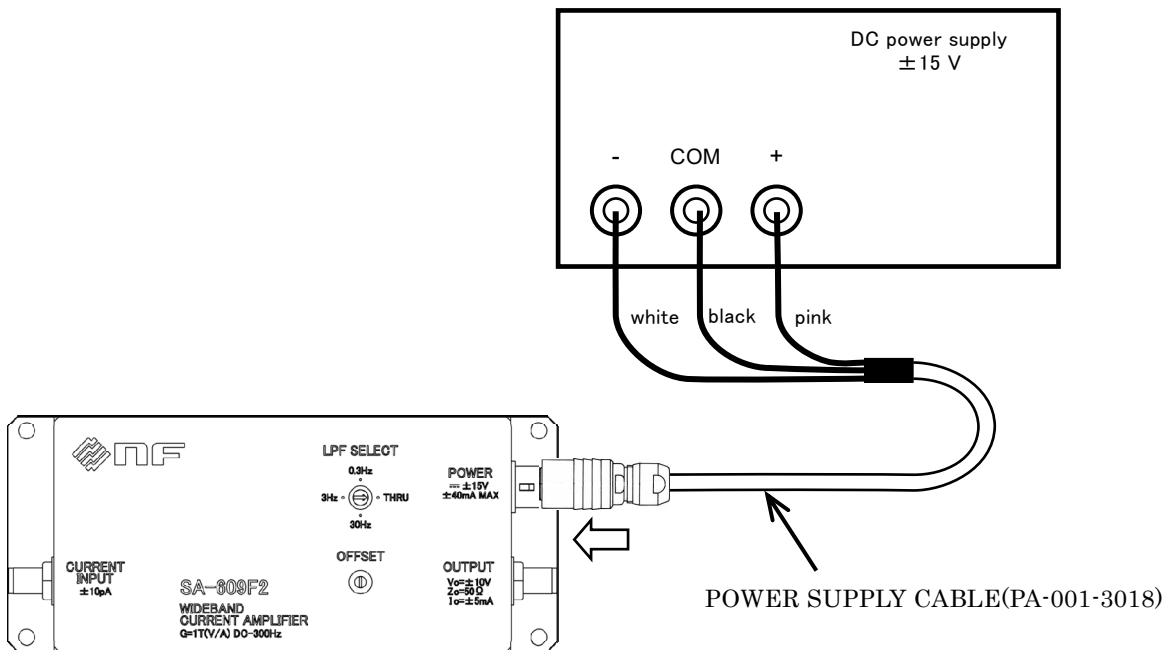


Figure 2-2 Connecting to DC Power Supply.

Attention

- Supplying a voltage greater than ± 18 V will damage this product.
- Before connecting this product to the power supply, re-check the polarity and voltage of the power supply.
- Do not plug / unplug the power cable while the power supply is turned on. That may result in damage to this product.

3. Panel Features and Basic Operations

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3.1 Panel Component Names and Functions

See Figure 3-1 Front and Rear Panel Views.

① CURRENT INPUT

This is the current input terminal of this product, which uses an SMA connector.

The maximum input current is ± 10 pA.

② OFFSET

This is a variable resistor for adjusting the output offset voltage of this product.

Use a screwdriver with a thin tip for adjustment. Using a screwdriver whose tip does not match or applying excessive force may cause damage.

③ LPF SELECT

This is a switch for selecting the upper cutoff frequency for the low pass filter of this product.

High cutoff frequency can be selected from four points: THRU (300 Hz), 30 Hz, 3 Hz, and 0.3 Hz.

Use a screwdriver with a thin tip for switching. Using a screwdriver whose tip does not match or applying excessive force may cause damage.

④ OUTPUT

This is the output connector of this product, which uses an SMA connector. The output impedance is $50\ \Omega$ and the maximum output current is ± 5 mA (± 10 V for a $2\ \text{k}\Omega$ load).

Note that the output of this product cannot drive the $50\ \Omega$ load directly.

⑤ POWER

This is the power input connector of this product, which uses a HR10-7R-4P (73). DC ± 15 V is supplied by connecting the DC cable with this connector.

⑥ Mounting holes

These holes (for M3 screw) are used to mount this product to the chassis, etc. with the bottom plate mounted to it. This product can be mounted to the chassis while they are electrically insulated.

⑦ Holes to mount this product

To remove the bottom plate and mount this product directly to the chassis, etc., use these screw holes (M3) (the length of the screws should be 4 mm or shorter).

Note that if the bottom plate is removed, this product and the object to which this product is mounted are electrically connected. The bottom plate is mounted to this product using 6 mm plastic screws (M3).

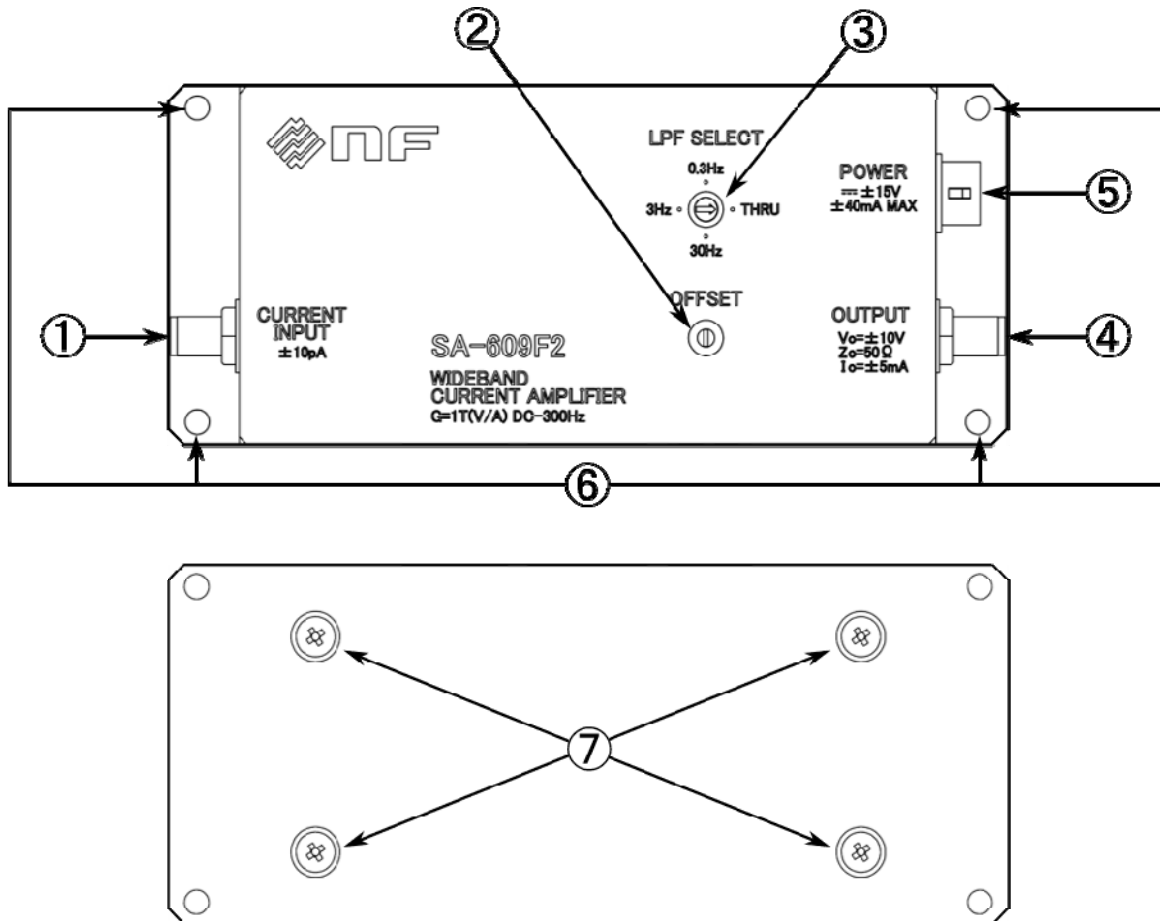


Figure 3-1 Front and Rear Panel Views

3.2 Input / Output Connection and Installation

The shielding of the input / output cable and the method for connecting and installing the product are important for using this product with the best noise characteristics. Follow the instructions below to connect and install this product.

- Install this product as near the sensor or signal source as possible, and make the input cable as short as possible. If it cannot be installed near the signal source, it is recommended to use an input cable with a length of 2 m or less. The longer the cable, the greater the circuit noise, making it more susceptible to external noise.
- Use of an SMA connector and semi-rigid cable is useful to reduce disturbance and noise from outside.
- The output impedance of this product is $50\ \Omega$, but the maximum output current is $\pm 5\ \text{mA}$. If $\pm 10\ \text{V}$ output is required, use a load of $2\ \text{k}\Omega$ or more.
- Installing this product with the bottom plate connected to it on conductors such as metals insulates the device from the object to which it is connected, so GND loop noise can be reduced.
- Longer output cables and power cables are more likely to be affected by external noise and other such factors. The shortest possible cables should be used, but if cable extension is necessary, the cable length should be limited to 2 m.
- If there is a device including a transformer such as a DC power supply nearby, install the sensor and this product as far as possible from it.
- Install this product in a location where there is as little vibration as possible. When a small signal is detected, it may be subject to the influence of microphonic noise generated by the vibration of the cable.
- Be sure to use shielded cables such as coaxial cables for input and output. Furthermore, install the input cable and output cable as far away from each other as possible (an input and output coupling may cause oscillation and instability).
- Use within the specified temperature and humidity range. Gain and frequency characteristics may be affected in a hot and humid environment.
- Secure this product in a stable location.
- Do not connect this product to an AC outlet, because doing so is dangerous.
- The signal GND and case have the same electric potential. Caution is required when giving a potential to the case or signal GND, because doing so may cause electric shock.

⚠ WARNING

Do not connect this product to an AC outlet, because doing so is dangerous.

Attention

- The signal GND and case have the same electric potential. Caution is required when giving a potential to the case or signal GND because doing so may cause electric shock.
-

3.3 Connecting Optical Sensor (Photo Diode), Etc.

- Be sure to install the sensor in a shielded box.

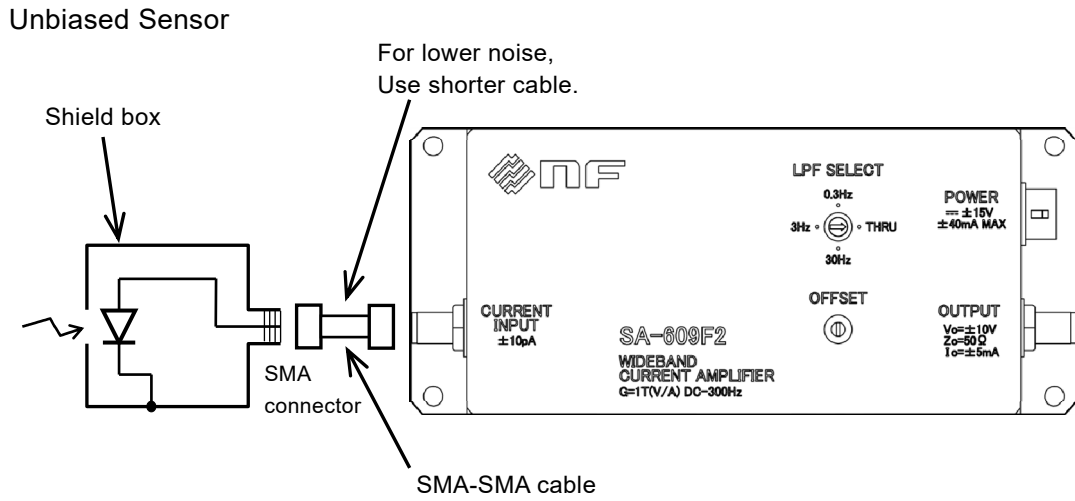


Figure 3-2 Connecting Unbiased Sensor

Reverse Biased Sensor

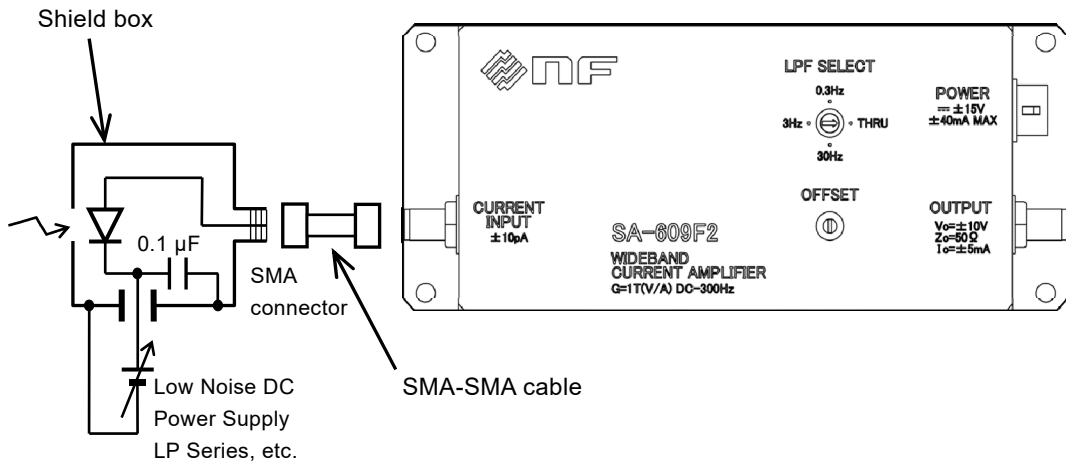


Figure 3-3 Connecting Reverse Biased Sensor

Note

If dark current is large when using a reverse biased sensor, this product cannot be used because the output of the device will be saturated. The maximum allowable dark current is approximately one-tenth of the full scale.

3.4 Turning On Power and Warm-up Time

This product exhibits the specified performance immediately after the power is turned on, but if you need highly accurate measurement, allows the device to warm up for at least 30 minutes before use.

3.5 Operating Temperature and Input Bias Current

This product uses a high-performance operational amplifier for the first stage, but the input bias current approximately doubles every time the temperature increases by 7 °C. It is recommended to use this product at 28 °C or less to obtain the best performance.

Attention

- Turn off the output switch of the power supply unit before connecting this product to the power supply unit.
 - Do not plug / unplug the output cable A while the power supply is turned on. This product may be damaged.
-

4. Maintenance

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4.1 Before Maintenance

- This chapter describes the following instructions.
 - Daily maintenance
 - Precautions and storage method when the product is not used for a long period of time
 - Precautions for repacking and transportation
 - Function test that is necessary for periodical inspection, incoming inspection, or function check after repair

If the results of function test are not satisfactory, please contact NF or one of our agents to request calibration or repair.

4.2 Daily Maintenance

- If the panels and cases are dirty
 - Wipe with a soft cloth to clean. To remove stubborn soiling, wipe with a cloth wrung out with neutral detergent.
 - Never use any volatile solvent like thinner, benzene, or a chemical cleaning cloth, as they may cause the surface finish to deteriorate or peel off.

4.3 Storage, Repacking and Transportation

- Storage when not used for a long period of time
 - Unplug the power supply from this product.
 - Store the product in a location free from falling objects and dust, such as a shelf or rack. If dust may be present, cover the product with a cloth or polyethylene cover.
 - The environmental conditions for storage are -10 to $+50$ °C and 5 to 75 %RH. However, avoid a location where the temperature fluctuates significantly or where the product will be exposed to direct sunlight, and store it in an environment as close to room temperature as possible. It is recommended to put this product in a highly moisture-proof aluminum bag with a desiccant and seal it with a heat seal or zipper so that air does not come in and out.
- Repacking and transportation

When repacking the product to transport or send it for repairs, pay attention to the following instructions.

 - Put this product with a desiccant in a highly moisture-proof aluminum bag, and seal it by heat-sealing or zipper so that air does not come in and out.
 - Prepare a cardboard box that can well withstand the weight of the product and is of a large enough size to accommodate it.
 - Fill the cardboard box with a cushioning material so that the six sides of the product can be protected.

- When making a request for transportation, inform the transport operator that the product is a precision instrument.

4.4 Operation Check

- Operation check is performed as a part of preventive maintenance as well as to prevent performance deterioration of this product.

- Test conditions

This product should be tested under the following conditions.

- Power supply $\pm 15\text{ V} \pm 1\text{ V}$
- Temperature $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$
- Humidity 5 to 75 %RH, no condensation

- Measurement instruments

The required measurement instruments are listed below.

a) Digital multimeter

At least 4 and half digits

b) DC power supply

$\pm 15\text{ V}$, $\pm 0.1\text{ A}$, with current measurement function

4.4.1 Checking Current Consumption with No Signal

Insert an open plug into the input terminal of this product. If the current consumption is within $\pm 40\text{ mA}$, the device is normal

4.4.2 Checking Output Offset Voltage

Connect as shown below and measure the output DC voltage of this product with a digital multimeter. If the value of the multimeter at this time is within ± 30 mV, this product is normal.

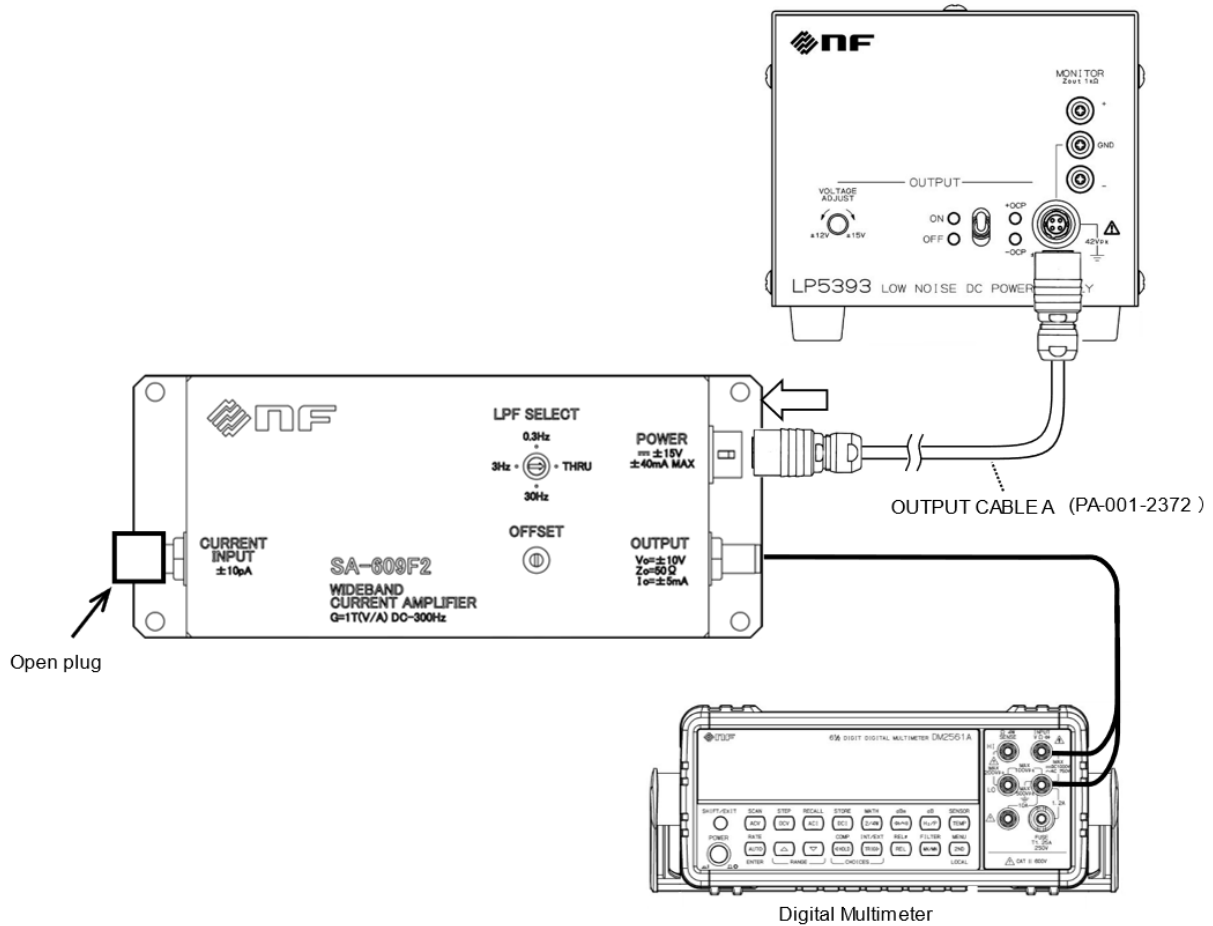


Figure 4-1 Connection Diagram for Checking Output Offset

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5.1 Non-destructive Maximum Rating

Supply voltage ($\pm V_S$) ± 18 V

* If a stress exceeding the above-mentioned absolute maximum rating is applied, permanent damage can be caused to the product.

5.2 Electrical Characteristics

Power supply ± 15 V, Temperature 23 ± 5 °C, Output load $R_L = 1$ M Ω , unless otherwise noted.

5.2.1 Input Section

No.	Items	Ratings	Notes
1.1	Input form	DC coupling, unbalanced single-ended input SMA connector	—
1.2	Maximum input current	± 10 pA	—
1.3	Input impedance	600 k Ω	—
1.4	Recommended signal source resistance	100 G Ω or more	—
1.5	Input bias current	10 fA typ.	23 °C, Increase by 2 times at about 7 °C rise
1.6	Equivalent input current noise density	0.4 fA/ $\sqrt{\text{Hz}}$ typ.	f = 10 Hz, input opened

5.2.2 Output Section

No.	Items	Ratings	Notes
2.1	Output form	DC coupling, unbalanced single-ended output	—
2.2	Maximum output voltage	± 10 V	f = 10 Hz, THD ≤ 0.3 %
2.3	Maximum output current	± 5 mA	f = 10 Hz, THD ≤ 0.3 %
2.4	Output impedance	50 Ω	—
2.5	Output offset voltage	Within ± 30 mV	Input opened
2.6	Output offset voltage adjust range	± 50 mV	Input opened

* THD sums up to 5th harmonic

5.2.3 Amplification Section

No.	Items	Ratings	Notes	
3.1	Gain	1×10^{12} V/A within ± 1 %	f = DC	
3.2	Gain flatness	DC to 30 Hz	Reference frequency of 10 Hz, Within ± 0.5 dB	
3.3	Frequency characteristics	C _s =10 pF	Reference frequency of 10 Hz, Within +0.5 dB / -3 dB	
		C _s =100 pF		DC to 210 Hz
3.4	Low-pass filter cutoff frequency	30 Hz setting	Reference frequency of 10 Hz (THRU setting), -3.0 dB frequency	
		3 Hz setting		3 Hz
		0.3 Hz setting		0.3 Hz
3.5	I/O polarity	Non-inverted	When current flows into the input, the output becomes a positive voltage	

5.2.4 Others

No.	Items	Ratings	Notes
4.1	Power supply connector	HR10-7R-4P(73), HIROSE Co., Ltd	The matching plug is HR10-7P-4S(73)
4.2	Operating supply voltage range	±15 V within ± 1 V	—
4.3	Current consumption	±40 mA or lower Approx. ±30 mA	—
4.4	Performance guarantee temperature range	23 °C within ± 5 °C	—
4.5	Temperature and humidity ranges	Operating	Non-condensation Absolute humidity 1 g/m ³ to 22 g/m ³
		Storage	
4.6	Pollution degree	2	Indoor use
4.7	Altitude	2000 m or lower	—
4.8	External dimensions	100(W)×50(D)×25(H) mm	Without protrusions and bottom plate
		120(W)×50(D)×29(H) mm	Without protrusions, with bottom plate
4.9	Weight	Approx. 140 g	Without bottom plate
		Approx. 170 g	With bottom plate
4.10	RoHS	Directive 2011/65/EU	—
4.11	EMC	EN61326-1 EN61326-2-1	—

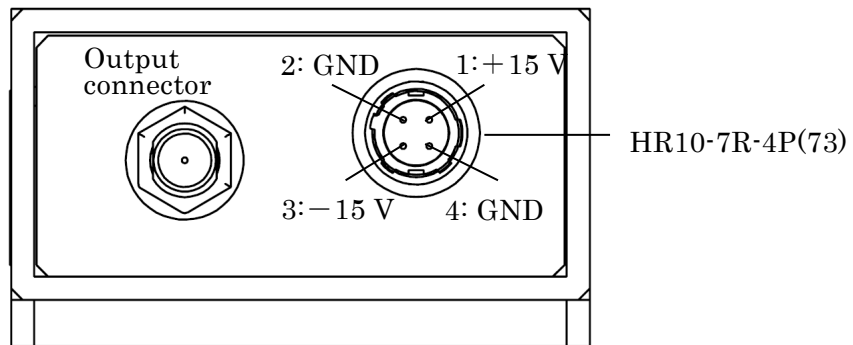


Figure 5-1 Power Connector

6. Reference Data

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6.1 Reference Data

This chapter shows the reference data of the SA-609F2.

The performance of this product may not achieve the level of these data. However, all products have been strictly tested before shipment to check that they meet the specifications.

Unless otherwise specified, power supply voltage is ± 15 V (low noise DC power supply LP5393 or equivalent is used), output load $R_L=1$ M Ω , LPF = THRU.

6.2 Equivalent Input Noise Current Density

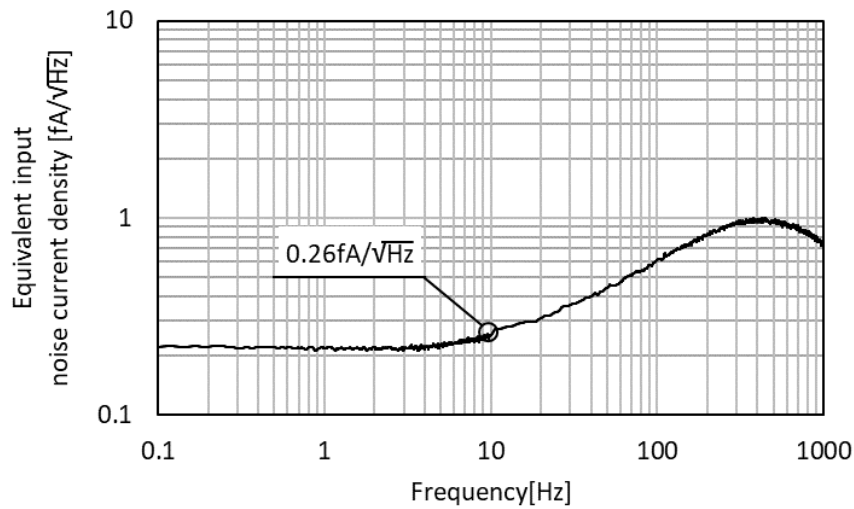


Figure 6-1 Equivalent Input Noise Current Density

6.3 Gain Frequency Characteristics by LPF settings

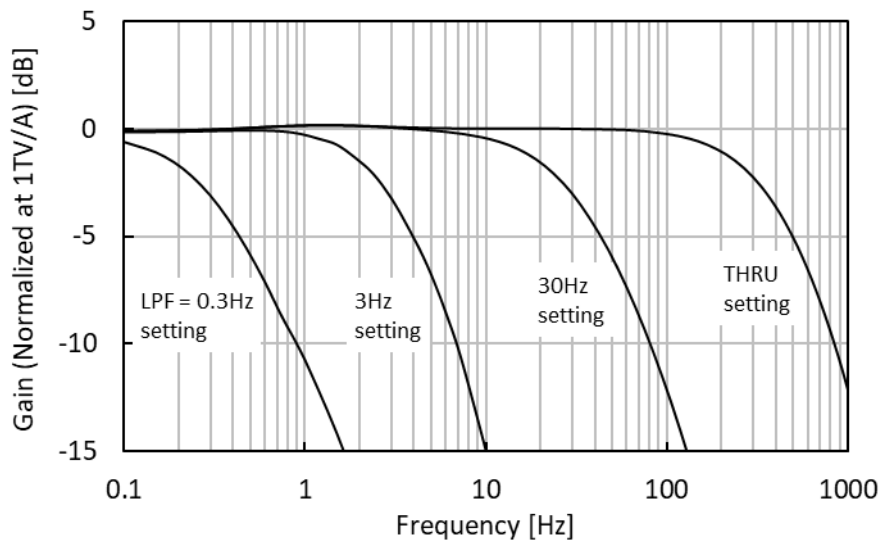


Figure 6-2 Gain Frequency Characteristics by LPF settings

6.4 Pulse Response

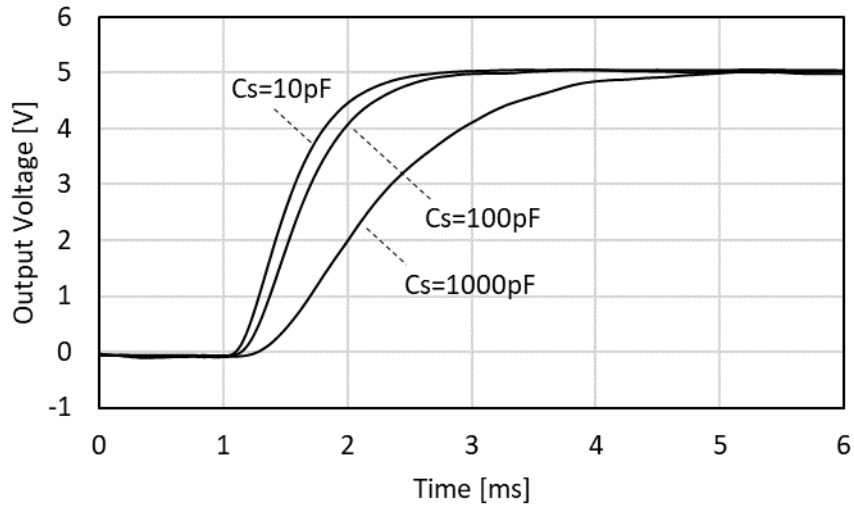


Figure 6-3 Pulse Response (LPF = THRU setting)

6.5 Gain Stability (Temperature)

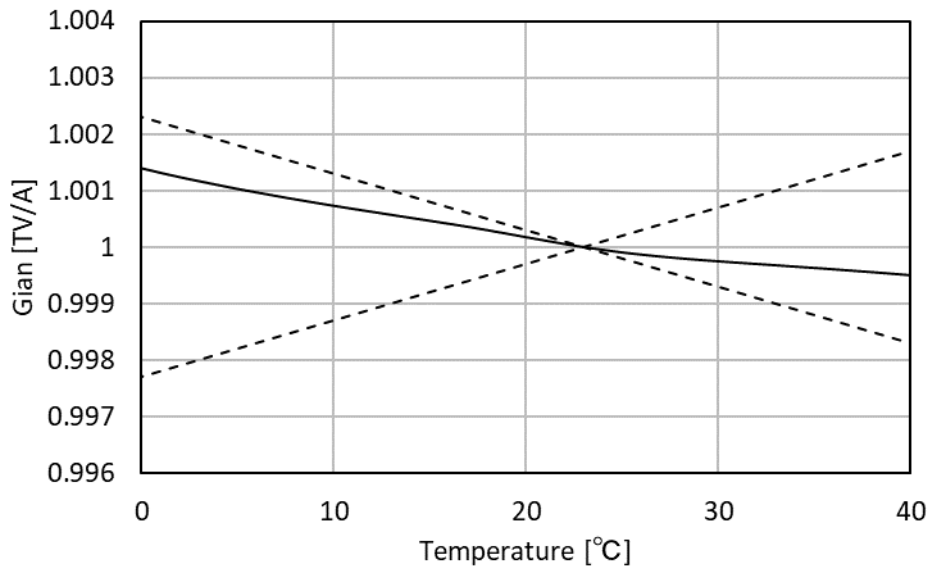


Figure 6-4 Gain Stability (Temperature)

6.6 Gain Stability (Humidity)

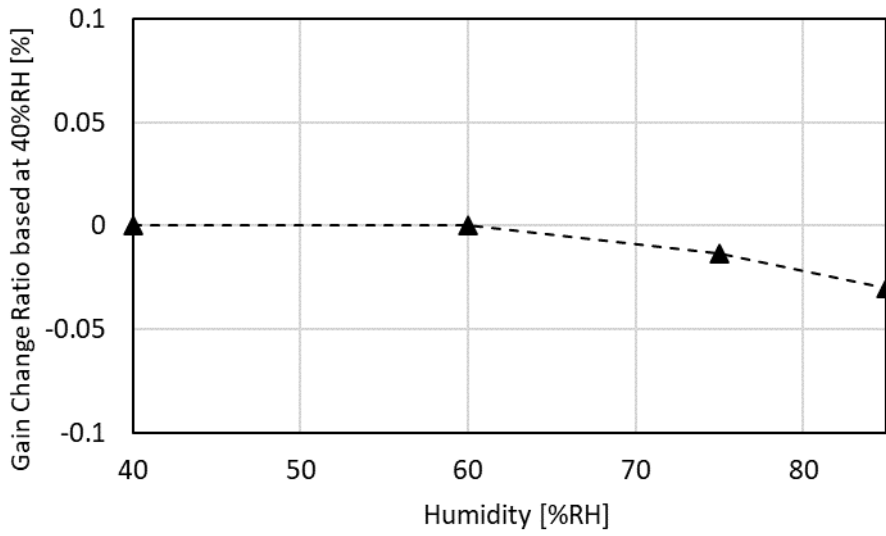


Figure 6-5 Gain Stability (Humidity, at 28°C)

6.7 PSRR

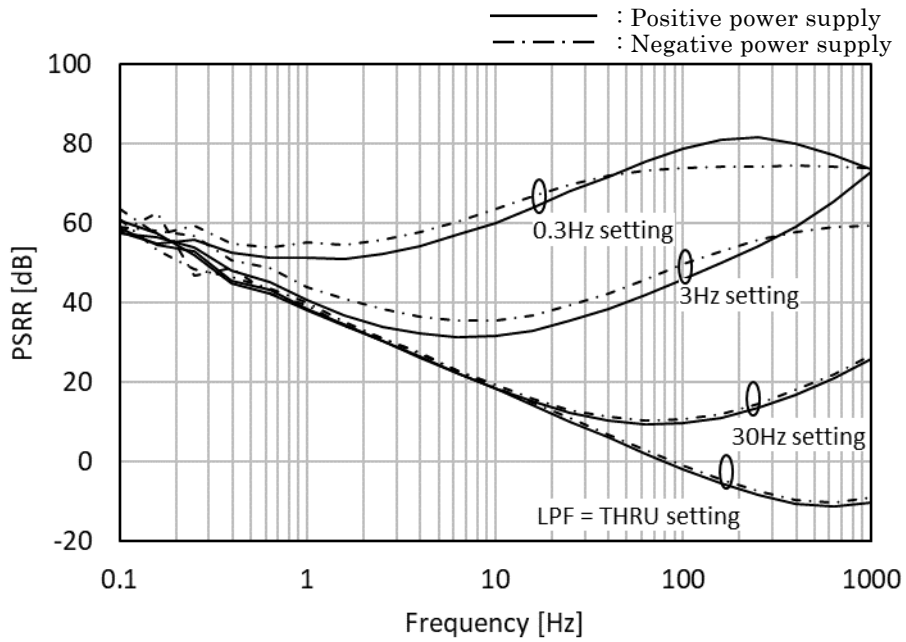


Figure 6-6 PSRR

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.
- K)

NF Corporation

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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