



LOW NOISE FET DIFFERENTIAL AMPLIFIER

SA-421F5

INSTRUCTION MANUAL

NF Corporation

DA00062390-002

LOW NOISE FET DIFFERENTIAL AMPLIFIER

SA-421F5

INSTRUCTION MANUAL

———— Preface ————

Thank you for purchasing the SA-421F5 low noise FET differential amplifier.

Please read the "Safety Information" on the next page first to ensure the product is used in a correct and safe manner.

- Alert symbols in this manual

This manual uses the following alert symbols. The instructions next to these symbols must be carefully obeyed to ensure the equipment operator's safety and prevent damage to equipment

⚠ WARNING

This contains information for avoiding electric shock and other risks when handling the equipment that could result in death or bodily injury to the operator.

⚠ CAUTION

This contains information for avoiding risks when handling the equipment that could result in minor or moderate injury to the operator or damage to property.

- This manual consists of the following chapters.

1. Outline

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

2. Preparation before Use

This chapter describes important preparations to be made before installation and operation.

3. Panel Features and Basic Operations

This chapter explains the basic operations of the panels.

4. Maintenance

This chapter describes a method for simply inspecting operation.

5. Specifications

This chapter gives specifications (functions and performance).

6. Reference Data

This chapter shows the general electrical characteristics of a normal SA-421F5..

—————Safety Information—————

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 instruction 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.

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

To prevent electric shock, the enclosure must be connected to an electrical ground.

- **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 abnormal noise, 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.**

The product may contain high-voltage parts. Never remove the cover.

Even when the inside of this product 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.

- **Electromagnetic compatibility**

This product is a CISPR 11 Group 1 Class A compliant device. 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 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.



- **Protective earth ground terminal**

This indicates that the terminal needs to be grounded in order to prevent electric shock accidents.

Before operating the product, ensure to connect this terminal to an earth ground.



- **Warning**

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



- **CAUTION Caution**

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

- **Other symbols**



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



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



This indicates that the terminal or the outer conductor of the connector is isolated from the enclosure.

It indicates, however, that the difference of the potential from the ground potential is restricted to 42 Vpk or less for safety (this product is used grounded so the enclosure potential and ground potential are equal).

- **Waste disposal**

For environmental protection, do not discard this product in domestic household waste. This product shall be disposed of through an appropriate industrial waste disposer.

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1. Outline

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1.1 Overview

The SA-421F5 is an ultra-low-noise FET differential amplifier that achieves both an equivalent input noise voltage density of $0.5 \text{ nV}/\sqrt{\text{Hz}}$ and an equivalent input noise current density of $100 \text{ fA}/\sqrt{\text{Hz}}$. Furthermore, it has 200 times gain and a wide bandwidth (30 Hz to 30 MHz) with a high input impedance ($1 \text{ M}\Omega$).

By adopting a low noise FET and negative feedback technology, the SA-421F5 realizes both high input impedance and ultra-low-noise characteristics.

1.2 Features

a) Ultra low noise

Equivalent input noise voltage density: $0.5 \text{ nV}/\sqrt{\text{Hz}}$

Equivalent input noise current density: $100 \text{ fA}/\sqrt{\text{Hz}}$

b) Wide bandwidth

Bandwidth: 30 Hz to 30 MHz

c) High input impedance

Input impedance: $1 \text{ M}\Omega$

Input capacitance: 85 pF

d) High CMRR

Common-mode rejection ratio: 46 dB or higher 1 kHz to 10 MHz

e) High gain

Voltage gain: 46 dB (200 times) for 50Ω load.

f) High gain stability

Gain stability: $\pm 150 \text{ ppm}/^\circ\text{C}$ (at $20 \pm 10 \text{ }^\circ\text{C}$)

1.3 Operating Principle

A1 is a differential amplifier composed of discrete parts. Low-noise FETs are used for the first stage circuit. The negative feedback provided by each A2 and A3 stabilizes the operating point. The gain of A1 is 28 dB, and that of A4 is 24 dB, so the total gain is 52 dB (400 times). The output impedance of this product is 50 Ω, so the gain of this product is 46 dB (200 times) for a 50 Ω load.

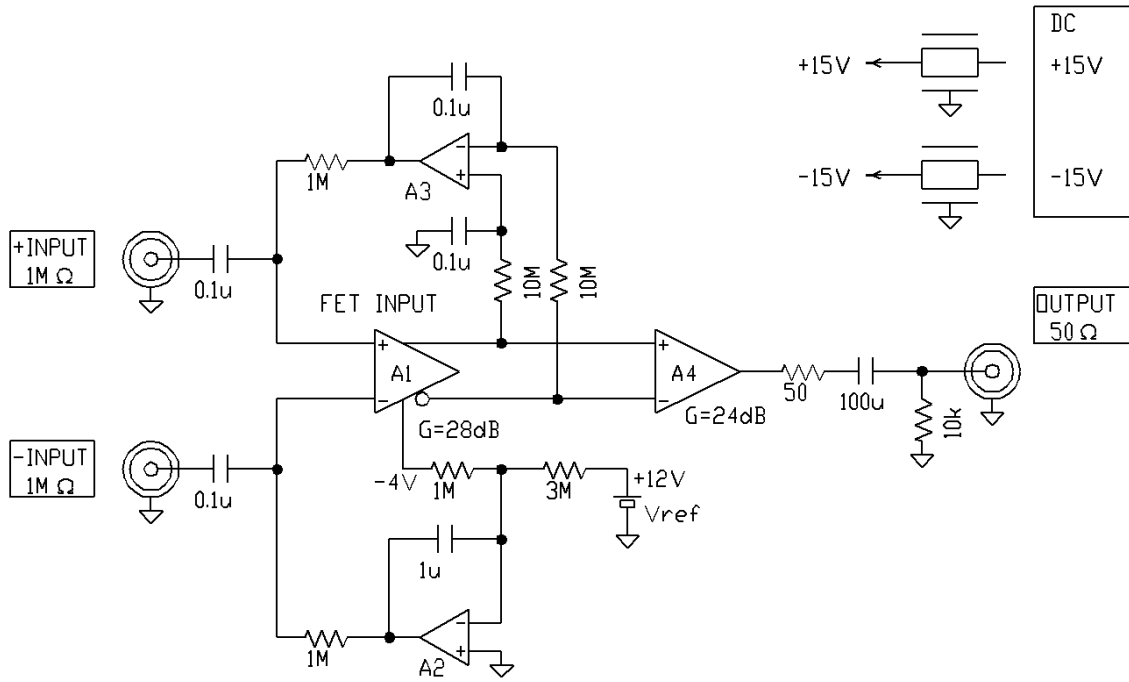


Figure 1-1 Block diagram

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2.1 Check Appearance and Accessories

If you notice that something is out of order on the outside of the packing box (such as a deep scratch or dent), closely check that the product is not affected when you remove it from the box.

When you take the contents out of the box, check them. If you find a deep scratch or dent on the product or an accessory is missing, report the problem to the NF Corporation or one of our representatives.

- Appearance Check

Check that there are no deep scratches or dents on the panel surfaces, connectors, etc.

- Product Configuration Check

Table 2-1 shows the list of contents. Check that the quantities are correct and that there are no deep scratches or dents.

Table 2-1 List of contents

● SA-421F5	1
● Instruction manual	1
● Accessories		
Short plug	1
Bottom plate	1

2.2 Conditions for Installation Location

- The installation location shall meet the following temperature and humidity conditions.

Performance guarantee: $+23 \pm 5$ °C, 5 to 85 %RH

Operating conditions: $+5$ to $+35$ °C, 5 to 85 %RH

Storage conditions: -10 to $+50$ °C, 5 to 95 %RH

However, 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 risk of explosion. Never install or use the product in such locations.
 - Outdoors, locations exposed to direct sunlight, or near fire or heat sources
The expected performance of this product may not be exhibited, or a malfunction may result.
 - Location where corrosive gases, water vapor, or dust may be present or humid locations
This product may corrode or malfunction
 - Near an electromagnetic field source, high-voltage product, or power line
Noise may increase.
 - Location where there is a lot of vibration
Noise may increase or a malfunction may result.

2.3 Power Supply

This product operates under the following power supply conditions.

To obtain the best noise characteristics, we recommend Low Noise DC Power Supply LP series.

- Stabilized DC power supply with ± 15 V ± 5 %, $+15$ V: $+90$ mA or higher, -15 V: -80 mA or higher (a switching power supply is not recommended).

Attention

This product will be damaged by reversely connecting the power supply. Supplying a voltage greater than ± 16.5 V will damage the internal circuits of this product.

2.4 Connecting with Low Noise DC Power Supply LP Series

To connect this product to a dedicated LP series power supply, use the output cable B (PA-001-2373). Check that the output switch of the LP series is set to OFF. Connect the black line to the GND lug of this product, the pink line to the +15 V terminal, and the white line to the -15 V terminal.

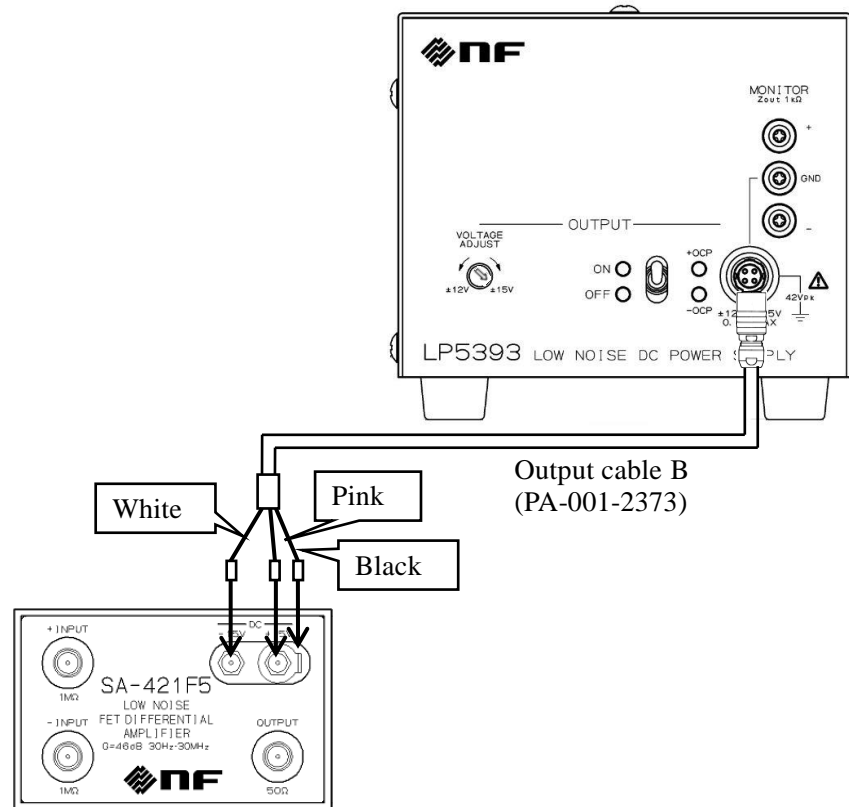


Figure 2-1 Connecting to LP Series power supply

Attention

- If the power supply is reversely connected, the internal circuits will be damaged.
 - Do not apply excessive force to the cable while the cable is connected to this product. The power supply pin of this product is easy to bend, and if strong force is applied, the pin may break (if it should be damaged, a repair fee will be charged)
-

2.5 Connecting to Power Supply other than LP Series

To connect this product to a DC power supply other than the dedicated LP series power supply, connect the cable (by soldering it) as shown in the figure below.

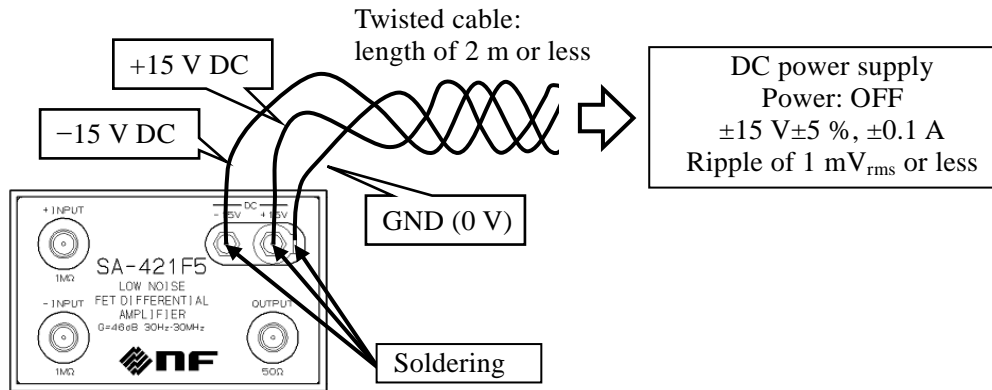


Figure 2-2 Connecting to a power supply other than the dedicated power supply

Attention

- Be sure to carefully reconfirm the polarity and voltage of the power supply.
 - If the power supply is reversely connected or a voltage of higher than $\pm 16.5\text{ V}$ is applied, the internal circuits will be damaged.
 - Use a DC power supply that restricts the current to 150 mA.
-

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 **+INPUT**

An SMA connector is used for the non-inverting input terminal of this product.

The input impedance is 1 M Ω , and the maximum input voltage is ± 10 V DC or 4 Vp-p AC.

Do not apply a voltage exceeding this value to avoid damage or deterioration of the internal circuit.

② **-INPUT**

An SMA connector is used for the inverting input terminal of this product.

The input impedance is 1 M Ω , and the maximum input voltage is ± 10 V DC or 4 Vp-p AC.

Do not apply a voltage exceeding this value to avoid damage or deterioration of the internal circuit.

③ **OUTPUT**

An SMA connector is used for the output terminal of this product.

The output impedance is 50 Ω , and the maximum output voltage is 2 Vp-p (when a 50- Ω load is applied).

Use the 50- Ω coaxial cable and be sure to set the termination to 50 Ω on the load side for high-frequency measurement.

④ **DC -15V**

The negative power supply input terminal of this product; -15 V DC is supplied to this terminal.

⑤ **DC +15V**

The positive power supply input terminal of this product; +15 V DC is supplied to this terminal.

⑥ **GND lug**

The power supply ground terminal of this product; 0 V is supplied to this terminal.

⑦ **Screw hole for attaching the bottom plate**

Used for attaching the supplied bottom plate to this product.

Four plastic screws are attached to protect the case while the product is shipped from the factory. Remove them when attaching the bottom plate.

The screw hole diameter for attaching the bottom plate is M3. Use metal screws (M3 pan head screw with a 4 mm length) when attaching it.

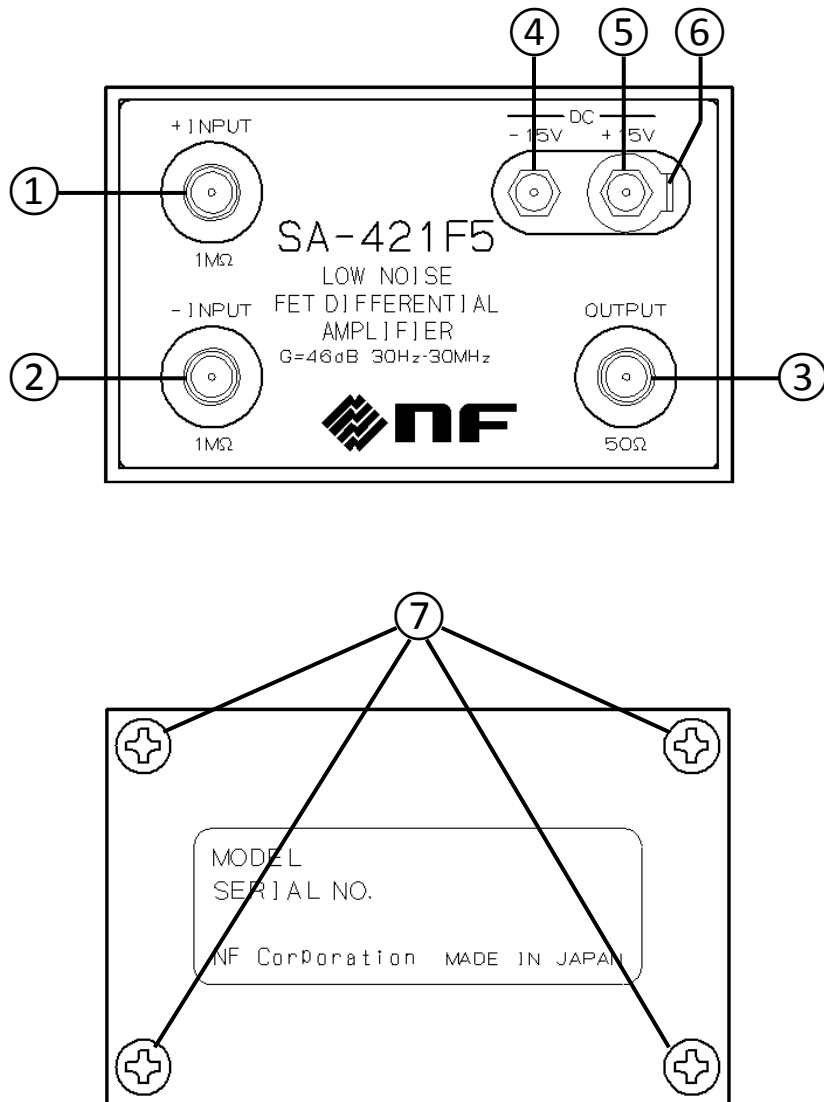


Figure 3-1 Front and rear panel views

3.2 Input Connection and Installation

The shielding of the input 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 close as possible to the sensor or signal source and make the input cable as short as possible.
- 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 (input and output coupling may cause oscillation and instability).
- Installing this product with the bottom plate connected to it on conductors, such as metals, insulates the product from the object to which it is connected, so GND loop noise can be reduced.
- If there is a product that includes a transformer, such as a DC power supply, install the sensor and this product as far away 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.
- An SMA connector and semi-rigid cable are useful for reducing disturbance and noise from the outside.
- Secure this product in a stable location.

Attention

- 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.
-

3.3 Output Connection

Be sure to terminate the output with 50 Ω . Use a coaxial cable with the characteristic impedance of 50 Ω as the connection cable.

The output impedance of this device is 50 Ω , and the gain is 46 dB (200 times) when the termination load resistance is 50 Ω .

Attention

If this device is used while its output is not terminated with 50 Ω , the prescribed performance cannot be achieved. Be sure to set the termination with 50 Ω .

3.4 Warm-up Time

It will take approximately 20 seconds before stable amplification is achieved. When a highly accurate measurement is required, our recommendation is 30 minutes warm up before measurement.

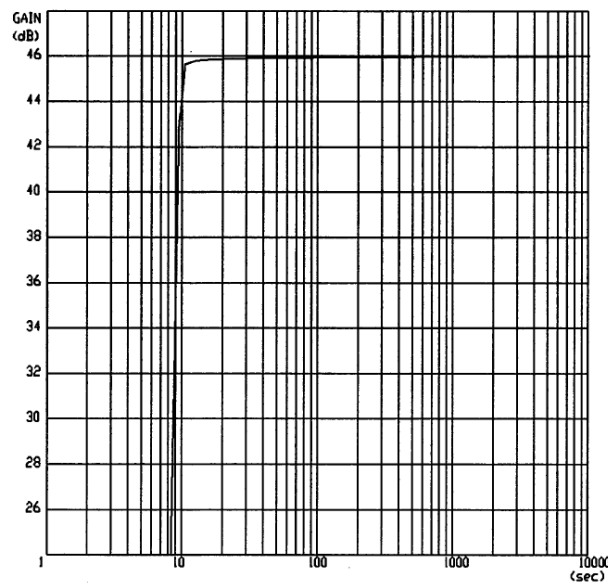


Figure 3-2 Time until gain is stabilized after power is activated

Attention

No signal is output immediately after power is activated (for 10 seconds approximately). This is not a malfunction. Wait for about 10 seconds.

3.5 Used for Single-Ended Input

This product is an amplifier by the differential input. However, it is possible to be used as a single-ended input amplifier by short-circuiting either of the input terminals by using the supplied SMA short plug. When +INPUT is short-circuited, it will become an inverting amplifier, and when -INPUT is short-circuited, it will become a non-inverting amplifier. If you use a short plug other than supplied one, this product might affect the performance.

4. Maintenance

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4.1 Before Maintenance

Maintenance is required to keep the product in the best condition.

This manual describes an operation check that can be easily performed to check if this product is normal. For advanced inspection, calibration, or maintenance, contact NF or our agent.

For operation checks, the following measurement devices are required.

a) Signal generator

± 100 mV (70.7 mV_{rms}) at 10 kHz sine wave to be output

b) DC power supply

± 15 V, ± 0.1 A or higher, with current measurement function

c) Oscilloscope

Frequency band: 300 MHz or higher, Input impedance of 50 Ω

d) Jigs

50 Ω power divider $\times 1$

20dB attenuator (50 Ω) $\times 1$

50 Ω terminator (± 1 %) $\times 1$

Short plug $\times 2$

4.2 Consumption Current with No Signal

This product is normal if the consumption current of +15V is around +74 mA and the consumption current of -15V is around -64 mA when both inputs of this product are short-circuited by short plugs, etc.

4.3 Non-Inverting Input Operation

Make connections as shown in Figure 4-1.

The signal generator outputs a sine wave with an output voltage of ± 100 mV (70.7 mV_{rms}) and frequency of 10 kHz. If waveforms like those in Figure 4-2 are displayed on the oscilloscope, this is normal.

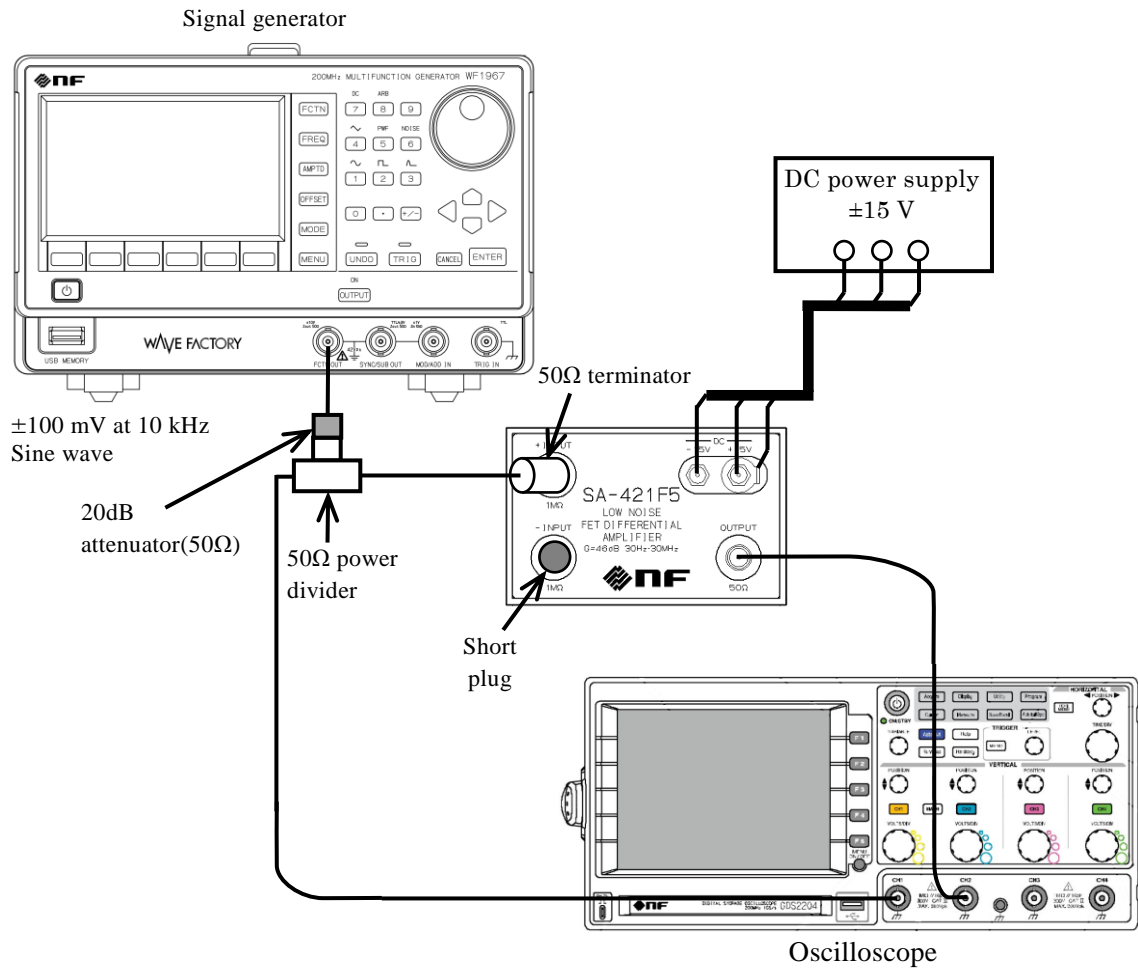


Figure 4-1 Connection diagram for non-inverting input operation

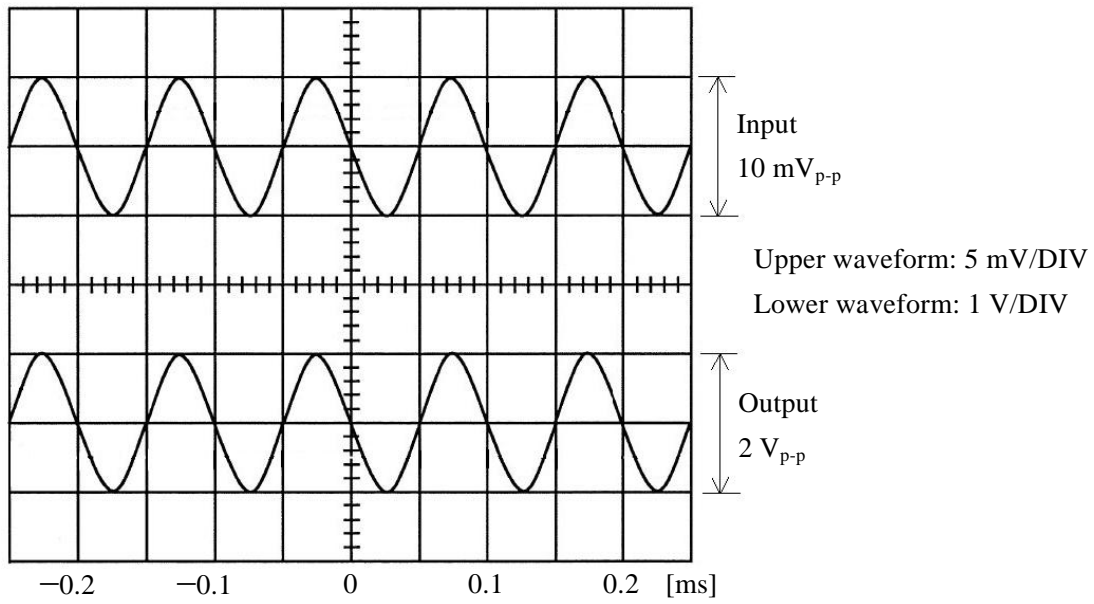


Figure 4-2 Non-inverting input voltage waveforms and output voltage waveforms

4.4 Inverting Input Operation

Make connections as shown in Figure 4-3.

The signal generator outputs a sine wave with an output voltage of ± 100 mV (70.7 mV_{rms}) and frequency of 10 kHz. If waveforms like those in Figure 4-4 are displayed on the oscilloscope, this is normal.

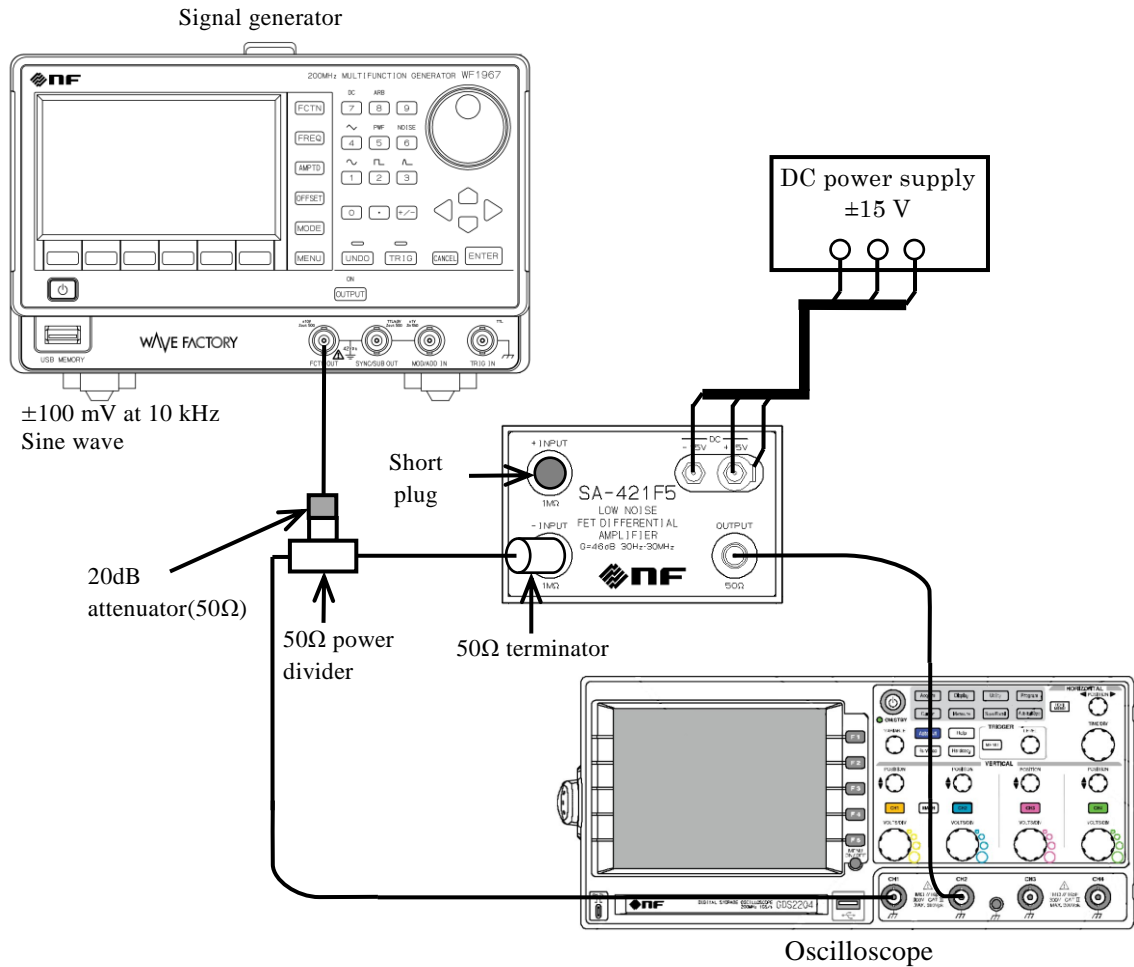


Figure 4-3 Connection diagram for inverting input operation

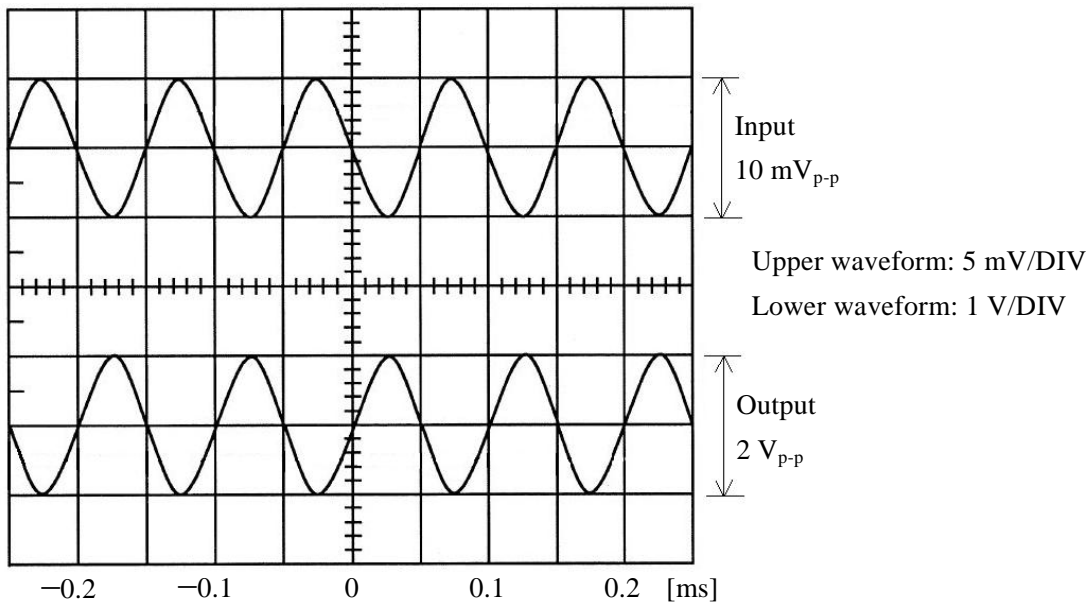


Figure 4-4 Inverting input voltage waveforms and output voltage waveforms

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5.1 Non-destructive Maximum Ratings

Input voltage

Differential input ± 10 V DC or 4 V_{p-p} AC

Common-mode input ± 10 V DC or 6 V_{p-p} AC

Supply voltage

± 16.5 V

5.2 Electrical Characteristics

Unless otherwise specified, 23 °C \pm 5 °C, V_s = ± 15 V (dedicated power supply), load resistance of 50 Ω , signal source resistance of 50 Ω , termination of 50 Ω (input).

5.2.1 Input

Input form

AC coupling and balanced differential input

Two SMA connectors

Linear input voltage range

Differential input 10 mV_{p-p}

Common-mode input 1 V_{p-p}

Input impedance

1 M Ω ± 5 % (at 1 kHz)

Input capacitance (parallel capacitance)

100 pF or lower

85 pF typical

CMRR

46 dB or higher (1 kHz to 10 MHz)

Equivalent input noise voltage density (input terminal short circuit)

0.7 nV/ $\sqrt{\text{Hz}}$ or lower (at 100 kHz)

0.5 nV/ $\sqrt{\text{Hz}}$ typical (100 kHz to 10 MHz)

Equivalent input noise current density

100 fA/ $\sqrt{\text{Hz}}$ typical (at 100 Hz)

5.2.2 Output

Output form

AC coupling and unbalanced single-ended output

SMA connector

Maximum output voltage

$2 V_{p-p}$ (100 Hz to 20 MHz)

Output impedance

$50 \Omega \pm 5 \%$ (at 100 kHz)

Output VSWR

1.3 or lower (100 kHz to 100 MHz)

5.2.3 Amplifier

Voltage gain

46 ± 0.5 dB (at 1 MHz)

Voltage gain frequency characteristic

30 Hz to 30 MHz $+0.5 / -3$ dB ($V_{out} = 400$ mV_{p-p})

Voltage gain stability

± 150 ppm/°C typical (at 20 ± 10 °C)

5.2.4 Power supply

Operating supply voltage range

± 15 V $\pm 5 \%$

Recommended power supply and cable: LP5391, LP5393 or LP5394 and PA-001-2373

Consumption current (± 15 V, no signal)

+90 mA or lower, +74 mA typical

-80 mA or lower, -64 mA typical

5.3 General

External dimensions

68 (W) × 43 (D) × 28 (H) mm (without protrusions)

Weight (net)

Approx. 100 g

Operating temperature and humidity ranges

5 to 35 °C, 5 to 85 %RH (non-condensation)

Storage temperature and humidity ranges

-10 to 50 °C, 5 to 95 %RH (non-condensation)

5.4 External View

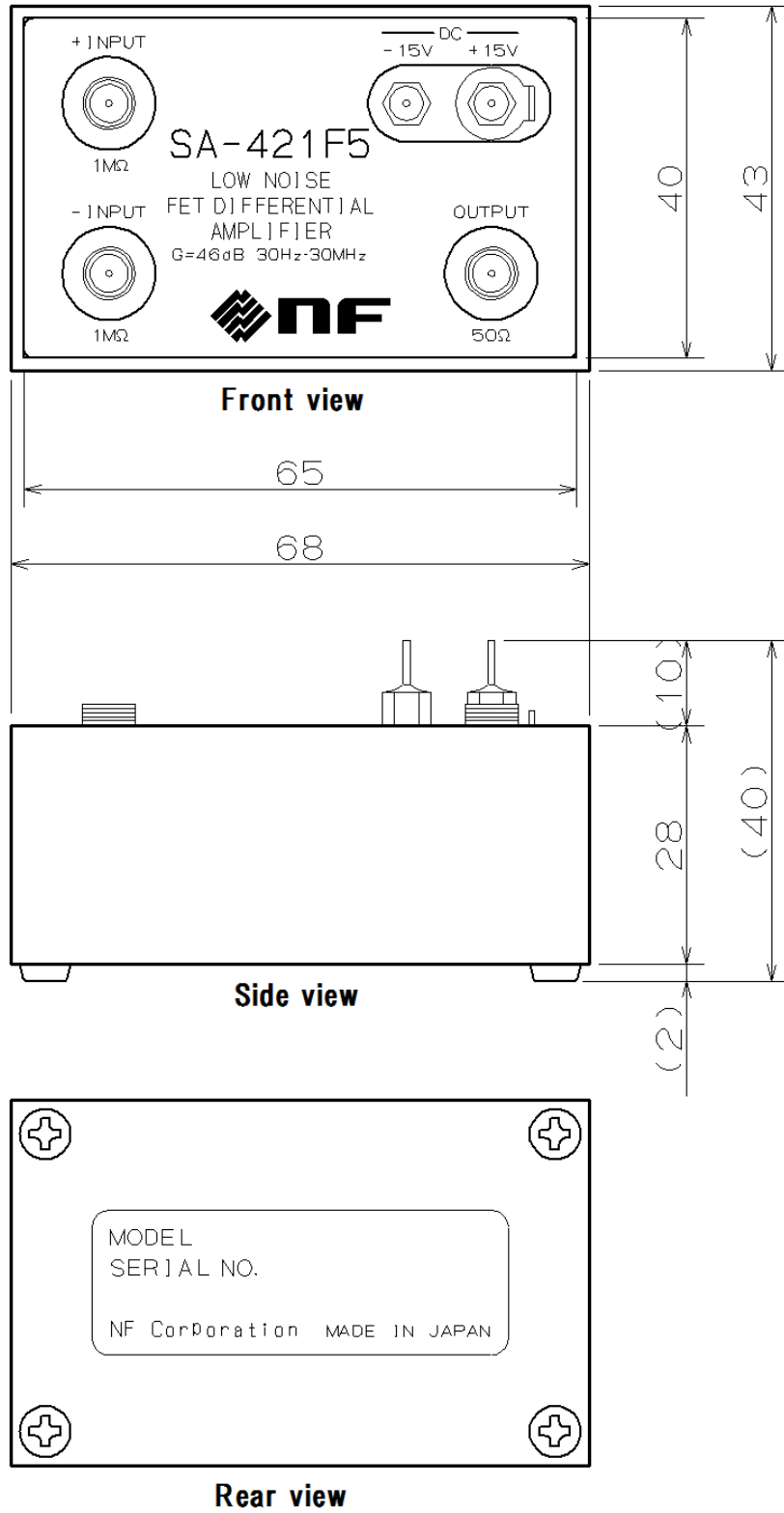


Figure 5-1 External view

5.5 External Dimensions of Bottom Plate

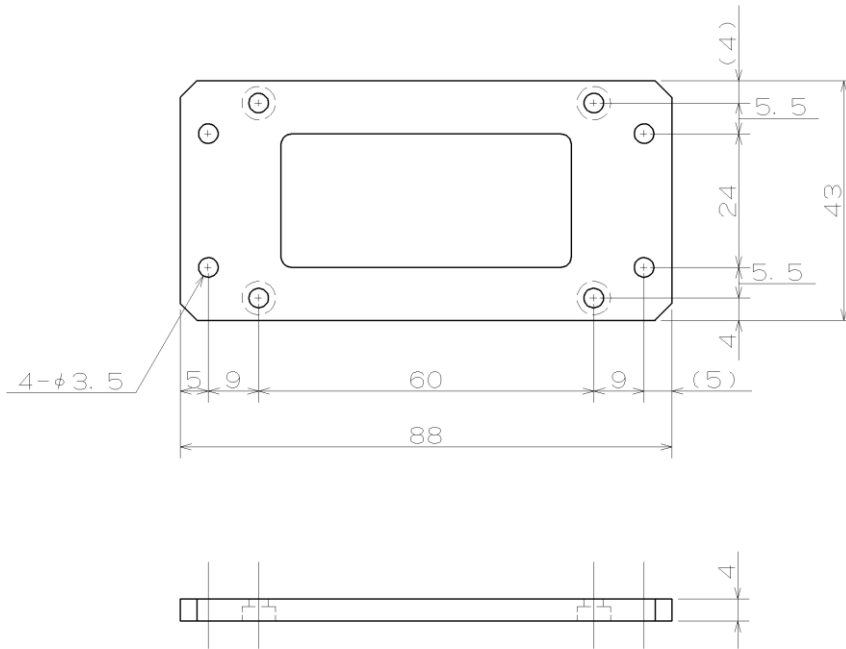


Figure 5-2 External dimensions of bottom plate

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6.1 Reference Data

This chapter shows the general electrical characteristics of a normal SA-421F5. These data show the average values obtained by measuring the performance of individual products. The performance of this product may not achieve the level of these data, but all products have been strictly tested before shipment to check that they meet the specifications.

6.2 Equivalent Input Noise Voltage Density

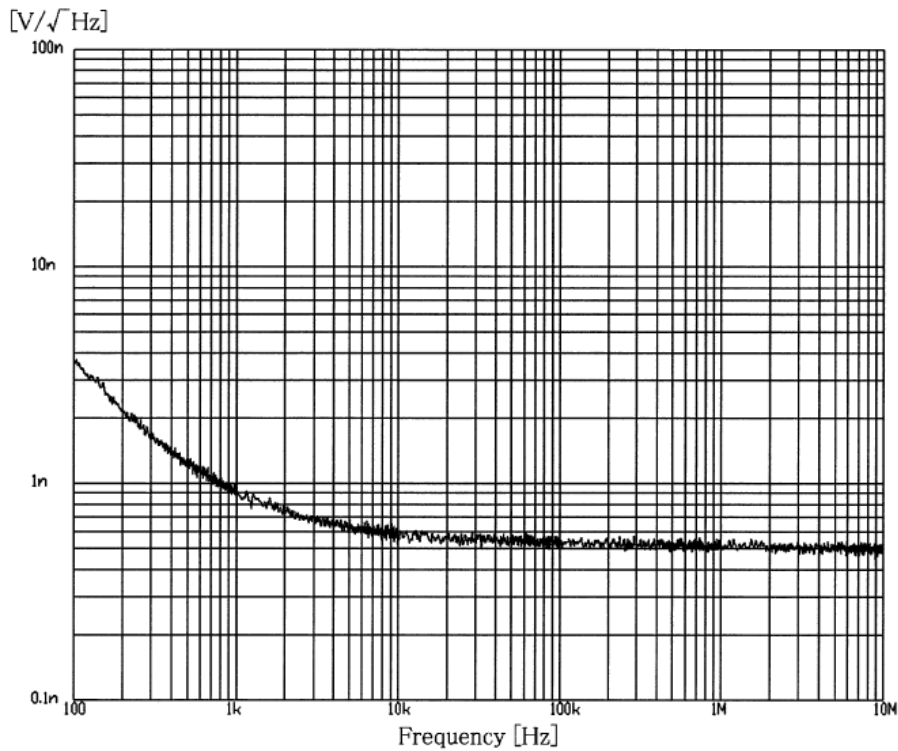


Figure 6-1 Equivalent input noise voltage density from 100 Hz to 10 MHz

6.3 Noise Figure Frequency Characteristic (for 50 Ω system)

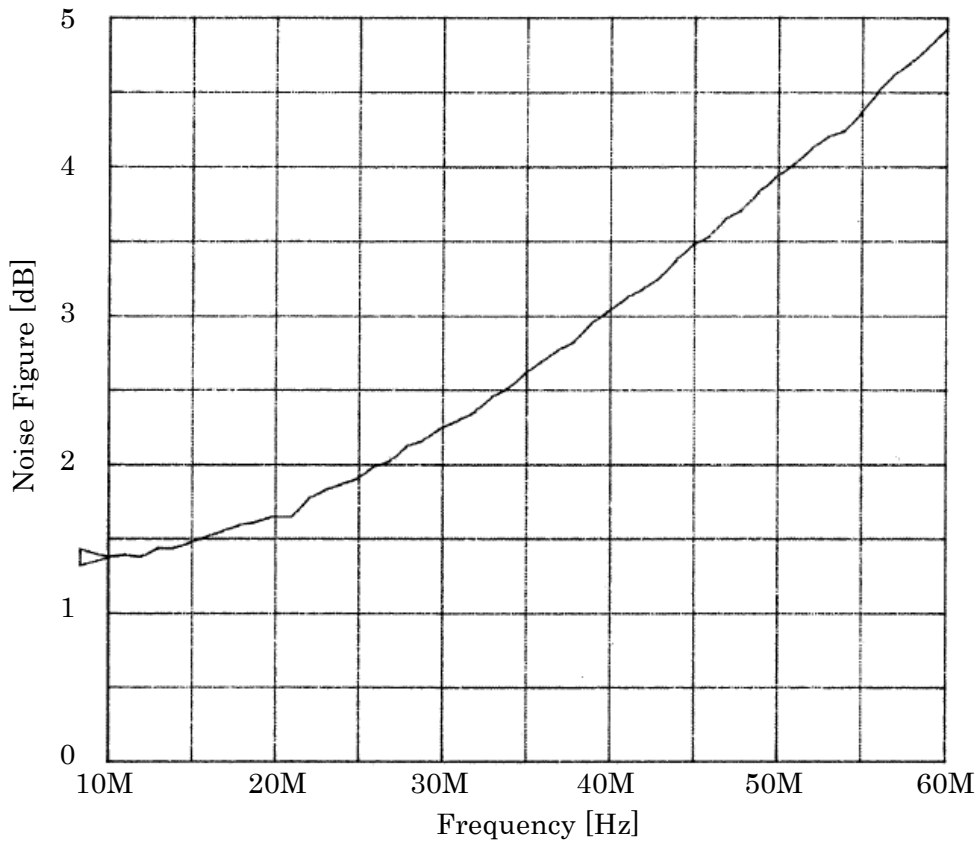


Figure 6-2 Noise figure frequency characteristic from 10 MHz to 60 MHz

6.4 Voltage Gain Frequency Characteristic

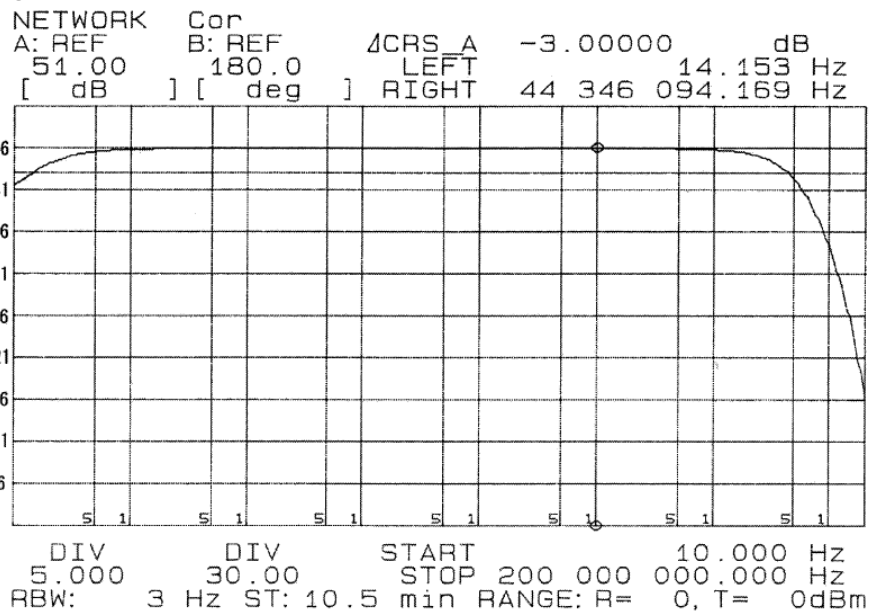


Figure 6-3 Voltage gain frequency characteristic from 10 Hz to 200 MHz

6.5 Output VSWR Frequency Characteristic

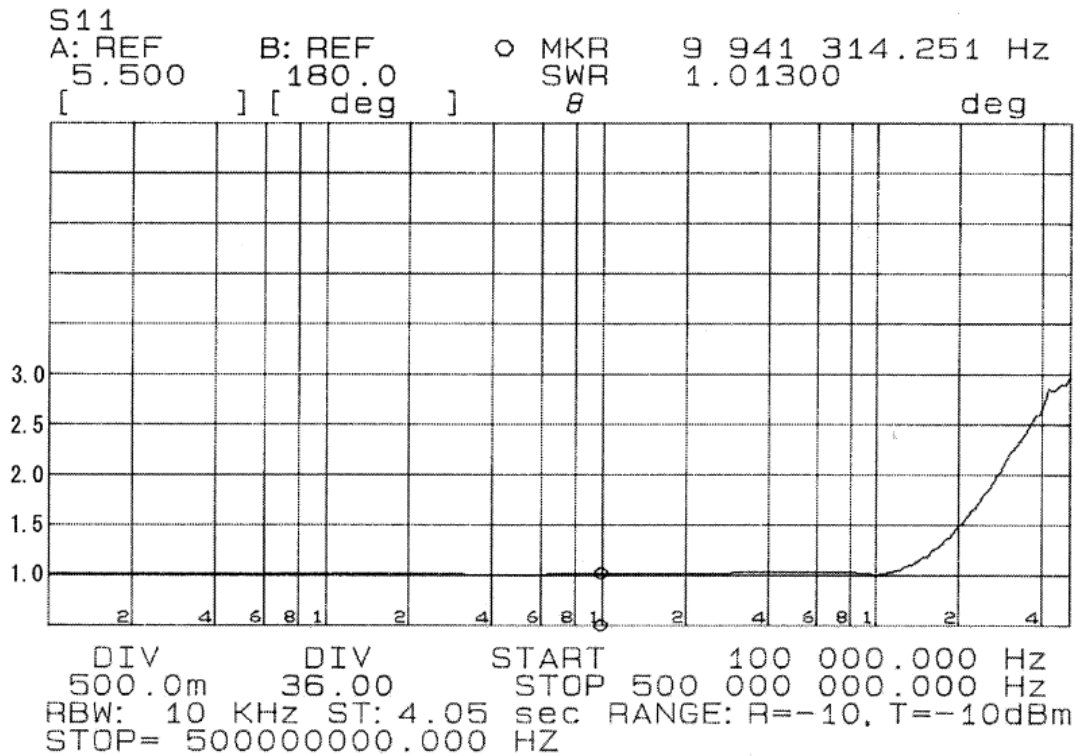


Figure 6-4 Output VSWR frequency characteristic from 100 kHz to 500 MHz

6.6 CMRR Frequency Characteristic

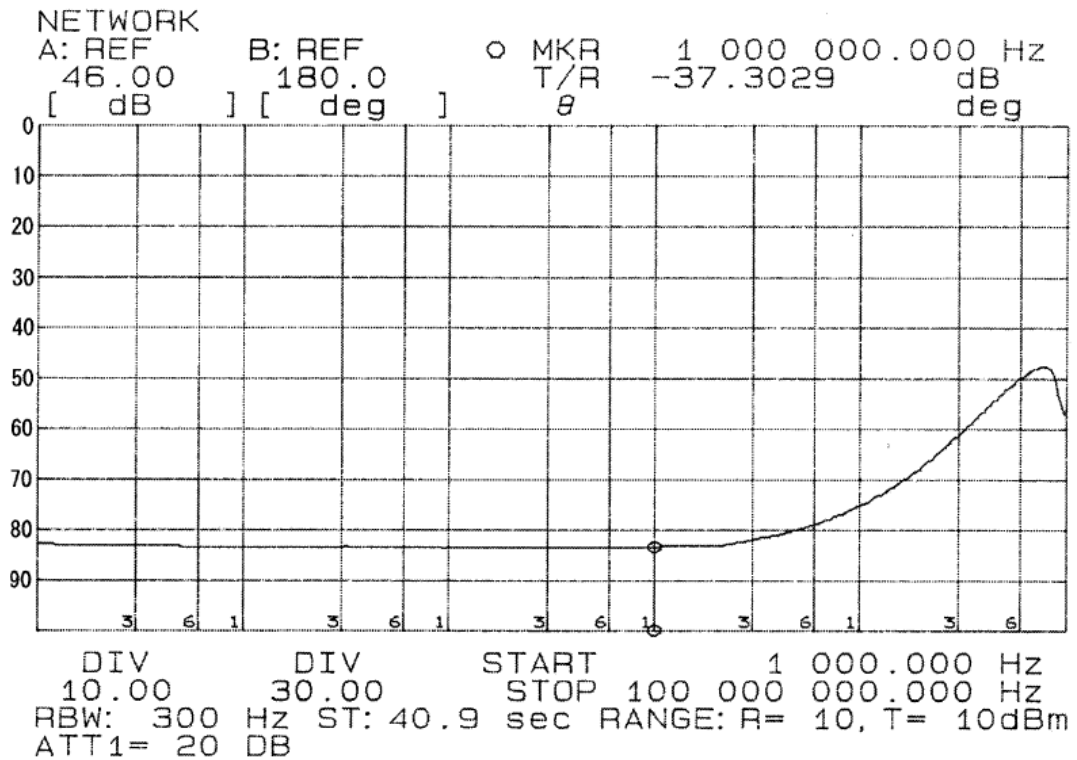


Figure 6-5 CMRR frequency characteristic from 1 kHz to 100 MHz

— WARRANTY —

The **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.

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 a 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 for all shipping charges, duties, and taxes for the product to either **NF** or an agent from another country, and the shipping charge for returning the product to the purchaser shall be paid by **NF**.

This warranty shall not apply to any defect, failure, or damage caused by a) improper use; b) improper or inadequate maintenance and care; or c) modifications made by the purchaser or personnel other than **NF** representatives.

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

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