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4005

High Speed Power Amplifier

INSTRUCTION MANUAL

NF ELECTRONIC INSTRUMENTS

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TABLE OF CONTENTS

page

FIGURES

TABLES

1. GENERAL

1.1 Introduction

The 4005 high speed power amplifier is a wide-band power amplifier. Its frequency ranges from DC to 1MHz and maximum power output is 50VA. The maximum output voltage is 150Vp-p (DC to 100kHz, 100Ω load) and 130Vp-p (DC to 1MHz, 100Ω load). The maximum output 50VA can be output into a 50Ω load in the frequency range of 40Hz to 500kHz. Both the low impedance ($Z \doteqdot 0\Omega$) output connector and 50Ω impedance output connector are provided on both rear and front panels.

There are two input connectors (A and B) into which two different input signals can be applied. For input impedance, 50Ω or 600Ω can be selected.

Output input gain can be changed successively from 10 times to 300 times with 4-step switch and trimmer. Frequency characteristics are nearly flat in the range of DC to 1MHz. There is little overshoot and sag in the step response. Input output phases are the same.

A balanced output power amplifier can be easily configured using two 4005's. For the balanced output, the maximum output voltage is 300Vp-p and maximum output power 100VA.

The 4005 contains a protection circuit. This protection circuit uses the output current limit method and protects the output stage from overload. Limit current differs depending on the frequency range. When the frequency range is 40Hz or more, derating starts at 1.5A/40Hz and at 0.75A when the frequency range is 1Hz or less. The protection circuit is reset automatically.

The 4005 operates in the line frequency range of 48Hz to 62Hz and on the following voltages: 100V, 120V, 220V, or 240V. Unless specially requested by the user when an order is placed, the line voltage is set to 100V.

1.2 Features

(1)	Very wide band	DC to 1MHz Since direct current also passes, a waveform whose positive and negative forms are asymmetric and a waveform overlapped with DC can be transferred accurately.
(2)	Large output, high speed	130Vp-p (DC to 1MHz) 150Vp-p (DC to 100kHz) 750V/μs (slew rate)
(3)	Good waveform response	Overshoot, sag 5% or less
(4)	Variable gain	10 to 300 times

(5)	Input	Two inputs (A and B), 50Ω or 600Ω
(6)	Easy addition of two signals	A and B input can be added.
(7)	Output impedance	50Ω and 0Ω
(8)	Large balanced output	300Vp-p, 100VA (by using two systems.)
(9)	Protection circuit with overload display	
(10)	Input/output connectors	Front and rear panels

1.3 Rating

Note: Z_0: Output impedance R_L: Load resistance V_0: Output voltage

1.3.1 Input

(1)	Mode	A input, B input or addition of A and B inputs (Same output phase for A and B)
(2)	Impedance	50Ω or 600Ω ±5%
(3)	Maximum allowable voltage	±10V
(4)	Connector	One connector each for A and B inputs on both front and rear panels (BNC-R)

1.3.2 Output

(1) Maximum voltage

50Vrms	(40Hz to 500kHz)	$Z_0 \fallingdotseq 0\Omega$, $R_L \geqq 50\Omega$
45Vrms	(20Hz to 1MHz)	
±75V (150Vp-p)	(DC to 100kHz)	$Z_0 \fallingdotseq 0\Omega$, $R_L \geqq 100\Omega$
±70V (140Vp-p)	(DC to 500kHz)	
±65V (130Vp-p)	(DC to 1MHz)	
±37.5V (75Vp-p)	(DC to 100kHz)	$Z_0 = 50\Omega$, $R_L = 50\Omega$
±35V (70Vp-p)	(DC to 500kHz)	
±32.5V (65Vp-p)	(DC to 1MHz)	

(2) Maximum current

1Arms (2.82Ap-p)	(40Hz to 1MHz)
±0.75A	(DC to 40Hz)
	When $Z_0 = 50\Omega$, ±0.71A, 0.5Arms (DC to 1MHz).

(3) Impedance

$Z_0 \fallingdotseq 0\Omega$ output	0.5Ω + 1.5μH or less
	0.2Ω + 1μH (typ.)
$Z_0 = 50\Omega$ output	50Ω + 2%

(4) Connector — Each one on both front and rear panels (BNC–R)

(5) Pre-amplifier output

Output impedance	150Ω ±5%
Load impedance	600Ω or more
Gain	(Main output) $\times \frac{1}{15}$ ±10% ($R_L \geqq 10k\Omega$)
	(Phase is inverted with respect to input)
Connector	Rear panel (BNC–R)

1.3.3 Input/output characteristics

(1) Gain ($Z_0 \fallingdotseq 0\Omega$, $R_L = 50\Omega$)

×10, ×20, ×50, ×100 4 steps

× (1 to 3) continuously variable

Error ±2% (For CAL, FREQ: 400Hz)

(2) Frequency characteristics ($10 \leqq$ gain $\leqq 100$)

$Z_0 \fallingdotseq 0\Omega$ output	+0.5dB, –1dB	40Hz to 1MHz
	(0dB for $R_L = 50\Omega$, $V_0 = 40$Vrms, 400Hz)	
$Z_0 = 50\Omega$ output	+0.25dB, –0.5dB	40Hz to 1MHz
	(0dB for $R_L = 50\Omega$, $V_0 = 20$Vrms, 400Hz)	

(3) Step response ($Z_0 \fallingdotseq 0\Omega$, $R_L = 50\Omega$)

Overshoot and sag 5% or less

(4) Harmonic distortion ($Z_0 \fallingdotseq 0\Omega$, $R_L = 50\Omega$, $V_0 = 40$Vrms)

0.05% or less (40Hz to 1kHz)

0.5% or less (40Hz to 100kHz)

(5) Output noise level ($Z_0 \fallingdotseq 0\Omega$, $R_L = 50\Omega$)

(1+0.1G)mVrms G=gain

(6) Output DC offset voltage (adjustable to zero)

±(1+0.1G)mV/°C (typ.) G=gain

1.3.4 Power requirements

(1)	Frequency	48 to 62Hz 1ø	
(2)	Voltage range	100, 120, 220 or 240Vrms ±10%	
(3)	Power consumption	60W (100VA)	No load
		200W (300VA)	$Z_0 \fallingdotseq 0\Omega$, RL = 50Ω
			V_0 = 50Vrms, 400Hz Sine wave

1.3.5 Ambient temperature and moisture

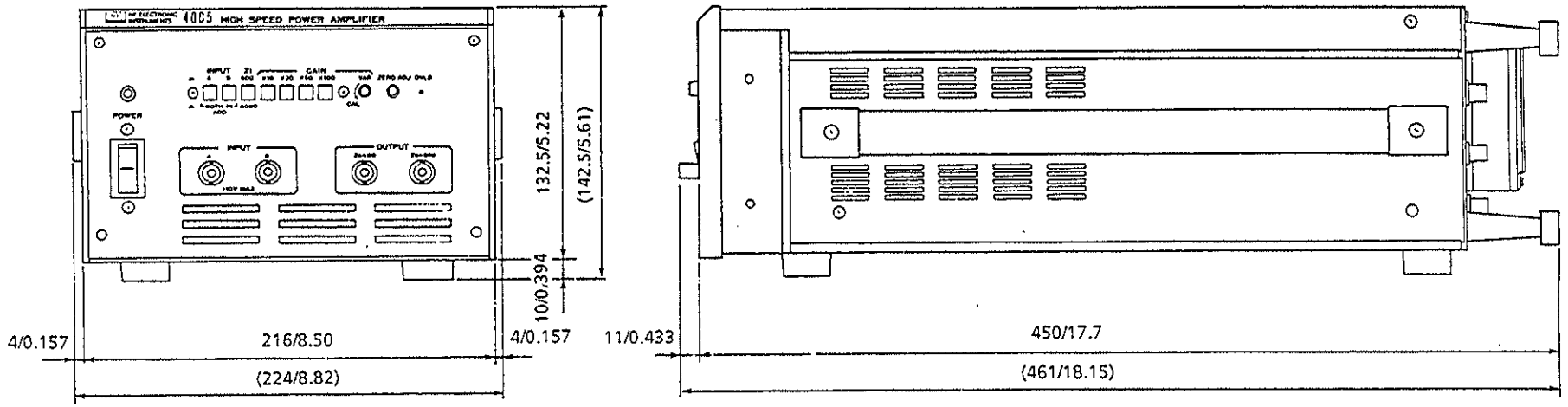
In operation	0 to 50°C, 10 to 90% RH
In storage	–20 to +60°C, 10 to 80% RH

1.3.6 Dimension and weight

216(W) × 132.5(H) × 450(D)mm, 10.5kg

1.3.7 Accessories

Power cable	1
Fuse	
Time lag 3.15A	1
Time lag 2A	2
Signal cable (BNC–BNC 1m)	3
Instruction manual	1



(unit : mm/inch)

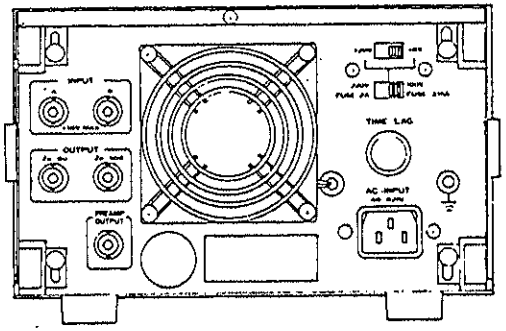


Fig.1-1 Dimensions

2. PREPARATION

Check the following items when unpacking and installing the 4005. Note that installation condition affects the life and reliability of the 4005 and the safety of personnel.

2.1 Unpacking and repacking

(1) Unpacking

After unpacking, check that no damage has been caused during transportation. Although loosness of knobs and the number of accessories have been carefully checked in factory, refer to Section 2.2 "Configuration" to check these items.

(2) Repacking

When repacking the 4005 for transportation, care should be taken regarding its weight. When using other than an original carton in which the 4005 was packed, wrap it with a polyethylene bag, etc., pack fillings into a carton which has sufficient room and strength to transport the 4005, and pack the system.

2.2 Configuration

The configuration of the 4005 is shown below. Confirm the number of accessories.

Table 2.1 Configuration

Main unit	1
Instruction manual	1
Accessories	
Power cable	1
Fuse (Ø5, 2 × 20mm)	
Time lag 3.15A	1
Time lag 2A	2
Signal cable (BNC-BNC 1m)	3

2.3 Installation site

The 4005 is forcibly cooled by air. On the sides of the front and rear panels, air inlets and outlets are provided. Be sure to have at least a 30cm space between other objects and these panels to assure smooth air circulation.

The allowable temperature and moisture ranges are shown below.

In operation	0°C to 50°C	10% to 90% RH
In storage	−20°C to 60°C	10% to 80% RH

Install the 4005 at the site where temperature and moisture are within these ranges and where it is subject to little dust and vibration and not subject to direct sun lighting.

If the 4005 is installed near a device which generates pulse noise or strong magnetic or electric field, its operation may be adversely affected. As much as possible avoid installing it near such a device.

2.4 Power requirements

Supply input ratings are shown below.

Frequency range	48Hz to 62Hz
Voltage	100, 12V, 220V or 240V ±10%

Unless otherwise specified, the voltage is set to 100V in factory. When using other than 100V, reset the two switches at the upper right of the rear panel. Switch positions and corresponding voltages are given below.

100V ----- 100V +0V, 120V ----- 100V +20V
220V ----- 220V +0V, 240V ----- 220V +20V

The fuse is rated at 3.15A for 100 and 120V and 2A for 220 and 240V. Both are time lag (slow blow) type. When a normal blow-type fuse is used, it may be blown by rush current when the power is turned on. Be sure to use the supplied fuse.

2.5 Rack mount adaptor (option)

With metal fixtures, the 4005 can be mounted on a standard rack (mm or inch). As the 4005 weighs 10.5kg, set up a shelf which can sustain its weight, then mount it on a rack. When ordering a rack mount adaptor, specify the size unit (mm or inch).

3. OPERATING PROCEDURE

This chapter explains the operation of front and rear panels. It also describes notes on handling.

3.1 Description and operation of each part

According to numbers specified in Fig.3.1, the description of each part is given below. The operating procedure is also explained below.

①		Power indicator Supplies power to the 4005. Goes on when switch ② is turned on.
②	POWER	Power switch Automatically turns off when the cooling fan stops.
③	INPUT A, B	Input signal selector Adds both signals when both A and B switches are pressed at the same time.
④	Zi	Input impedance selector 50Ω or 600Ω can be selected.
⑤	INPUT A, B	Input connector A signal whose signal source is connected to this BNC connector and for which switch ③ is pressed is used as an input signal.
⑥	GAIN	Switch to set input-output gain When ⑦ VAR trimmer is at CAL position, displayed gain can be obtained.
⑦	VAR	Fine control of input-output gain Changes input-output gain from 1 to 3 times. Gain is at the minimum level at CAL position.
⑧	OVLD	Overload indicator Goes on when the output of the 4005 is overloaded, limiting output current.
⑨	ZERO ADJ	Output offset voltage (output DC current when no input is applied.) Turns off both INPUT switches ③ and set Zi to 50Ω so that no input is applied. Observe the output level using a DC current meter or oscilloscope. Then, adjust the offset voltage to 0V. Offset voltage varies depending on gain. Adjust according to gain to be applied.

⑩ OUTPUT — Output connector

$Z_0 \fallingdotseq 0\Omega$ low output impedance (constant voltage) output

$Z_0 = 50\Omega$ output of 50Ω output impedance

⑪ INPUT — Input connector

Connected in parallel with the front panel input connector.

⑫ OUTPUT — Output connector

Connected in parallel with the front panel input connector.

⑬ PREAMP OUTPUT — Preamplifier output connector

The output impedance is 150Ω. Load resistance must be 600Ω or more. Gain from input is approximately 1/15 of that of the main output (⑩ · ⑫) when load is $10k\Omega$ or more. Phase is inverted with respect to main output.

⑭ — Line voltage selector

Make the following setting according to the line voltage to be used.

100V +0 for 100V, 100V +20 for 120V

220V +0V for 220V, 220 +20V for 240V

⑮ FUSE — Fuse holder for power input protection

For the line voltage of 100 and 120, use 3.15A time lag (slow blow) type fuse. For 220V and 240, use 2A time lag (slow blow) fuse. If a normal blow type fuse is used, it may be blown by rush current when the power is turned on.

NOTE

Before activating the line voltage selector or replacing a fuse, make sure that a power cable is not connected to the power input.

⑯ AC INPUT — Power input connector

Connect the supplied power cable to supply power.

⑰ — Cooling fan

The 4005 is forcibly cooled by air. If the fan stops, internal temperature rises, damaging the system. Therefore, when the fan speed drops or stops, the power switch turns off automatically.

3.2 Maximum output current and protection circuit

The maximum output current of the 4005 differs depending on frequency and output power. Also it is limited at the peak and mean values.

Fig.3.2 shows the relationship between the output voltage (V_0) of the $Z_0 \fallingdotseq 0\Omega$ output and the maximum output current (I_0 max). ▒ indicates the range of the mean values of DC current and AC output. □ indicates the peak value range of AC. In this case, AC refers to a repetitive waveform of 40Hz or more and the DC includes a repetitive waveform of 1Hz or less. Waveforms between 1Hz to 40Hz lie in the range between DC and AC.

In Fig.3.2, the possible quadrants for a passive load when AC is output are as follows. For a R load, I and III are the operation area. For single LC load or LCR complex load, all quadrants are the operation area.

When current is passed to or from a load with electromotive force, the 4005 operates in quadrant II and IV even when DC is output. The electronic load operation is just this case.

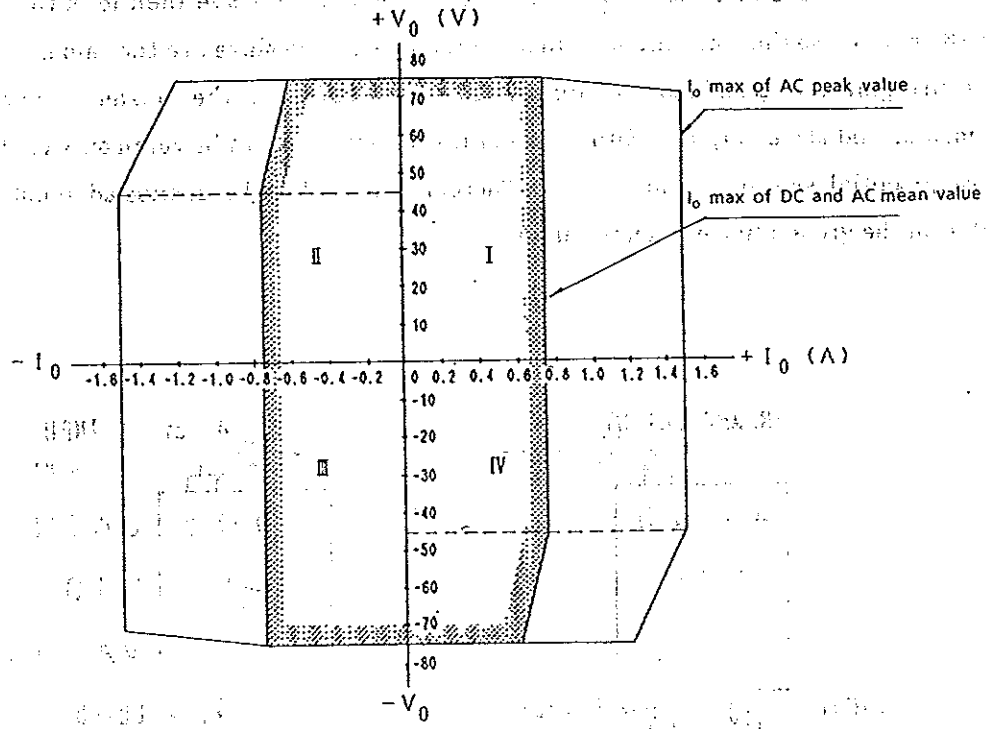


Fig.3.2 Operation area ($Z_0 \fallingdotseq 0\Omega$)

For instance, the AC output current (40Hz or more) shown in Fig.3.3 is limited to 1.5Apk or 0.75Aave as shown in the operation area. If the output current is increased, the peak value will reach the protection level at the positive side, the mean value will reach the protection level at the negative side, and the output current will be limited.

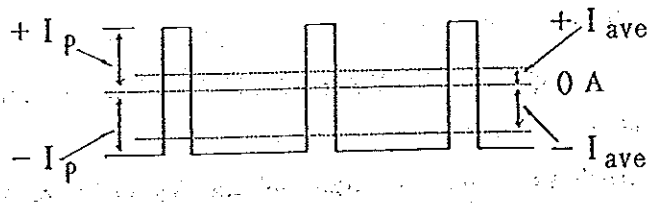


Fig.3.3 Peak value (Ip) and mean value (Iave) of output current

The maximum value of the output current of the $Z_0 = 50\Omega$ output is limited to ±0.71A or 0.5Arms in the frequency range of DC to 1MHz.

3.3 Power boost by balanced output

When two 4005s are used to balance output, both output voltage and output power can be doubled (300Vp-p and 100VA). As shown in Fig.3.4, connect the master pre-amplifier output to input A or B of the slave and set Zi to 600Ω. Set the gain of the slave then to ×10. Adjust the GAIN-VAR trimmer so that the output voltages of the master and slave are the same.

The entire gain is determined according to the gain setting on the master. Connect a load between master and slave outputs. Either side of the output must not be common with the chassis or the low potential side of signal source. Therefore, a load to be connected must be floated (isolated) from the ground line or signal source.

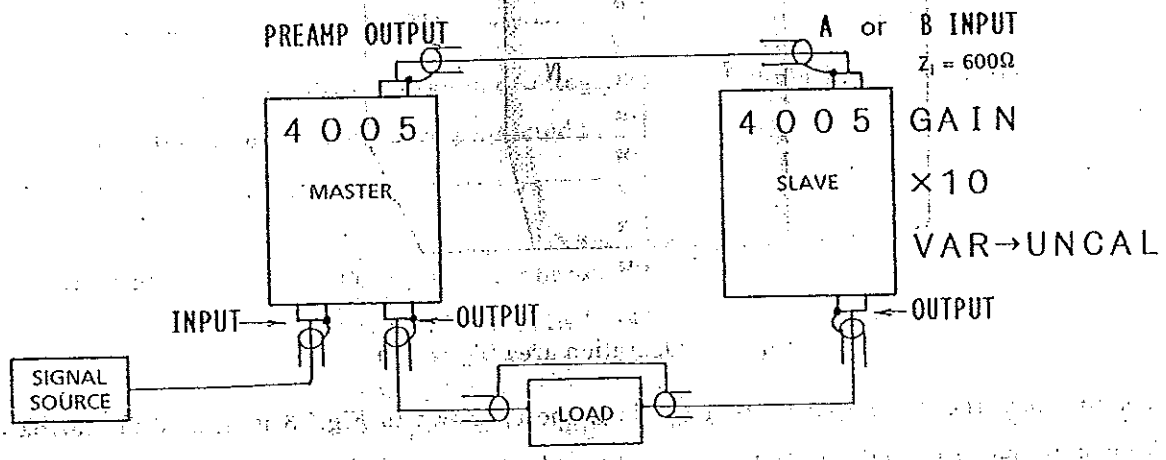
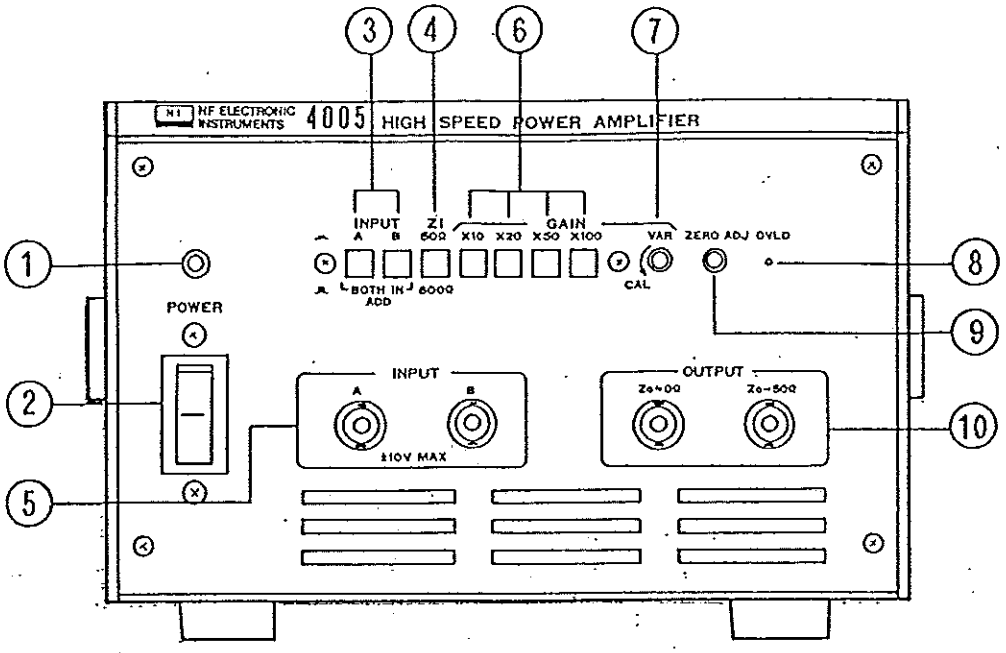
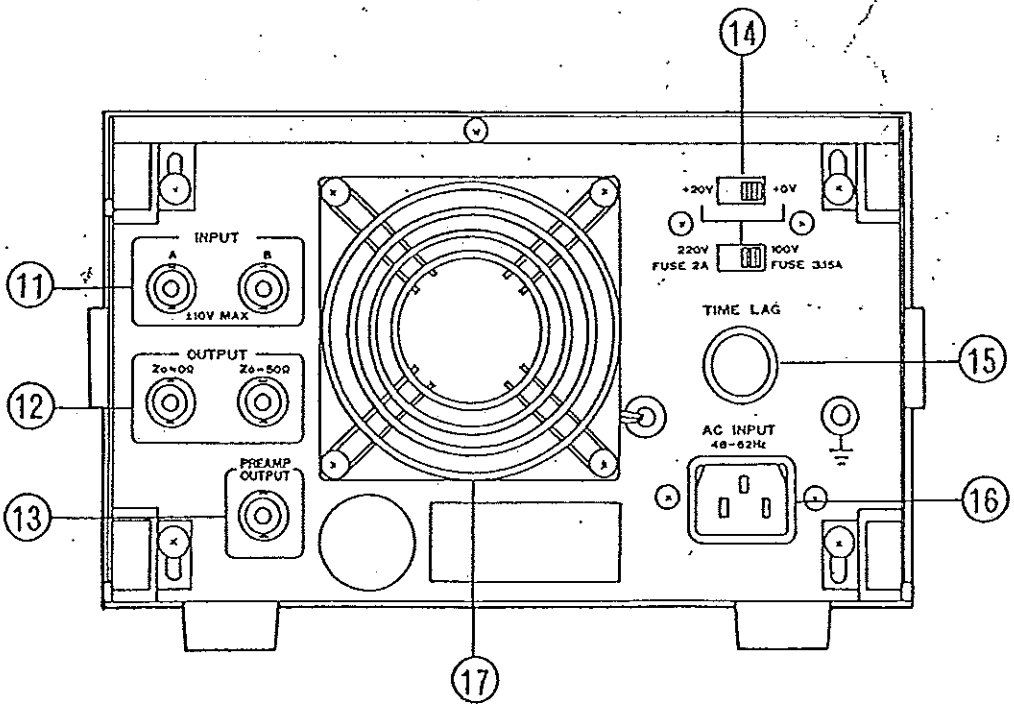


Fig.3.4 Power boost by balancing output



Front Panel



Rear Panel

Fig.3.1 Nomenclature of panel parts

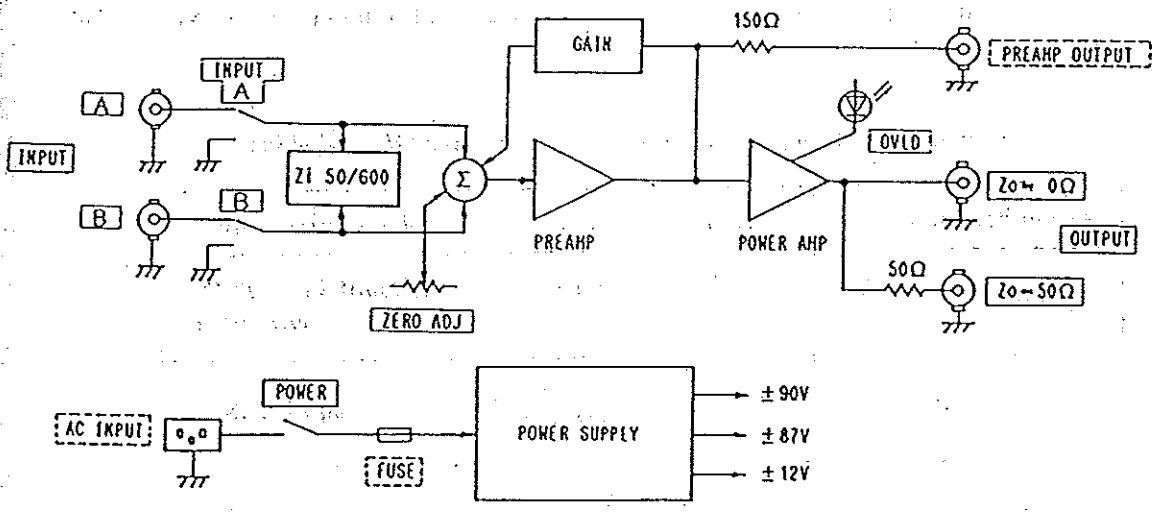
4. OPERATING PRINCIPLE

The 4005 consists of the pre-amplifier, power amplifier, and power supply section. Fig.4.1 shows a block diagram.

The pre-amplifier is a wide-band operation amplifier. It has gain and zero point adjustment functions. Gain from A and B inputs to the pre-amplifier output is 10/15 times when using GAIN ×10 and GAIN VAR CAL. The output level of the pre-amplifier is ±5V when the power amplifier output is at the maximum level (±75V).

The power amplifier is a wide-band power amplifier using power-MOSFET's at the output stage. The voltage gain is 15 times. The output stage is protected from overload by the current-limit-type (constant current dropping characteristics) protection circuit. The small fan forcibly cools the output stage by air. When the fan speed drops or the fan stops, the power switch turns off automatically.

In the power supply section, the AC line input is isolated and converted by a transformer to DC by the capacitator input rectifier. The converted current is then stabilized by the series regulator and supplied to power amplifier and pre-amplifier sections.



Note: Input and main output connectors are provided on both front and rear panels.

Fig.4.1 Block diagram

5. MAINTENANCE

5.1 General

The following maintenance operations are required to keep the 4005 in top condition.

a. Operation inspection

Check if the 4005 operates properly and measured values conform to the specifications.

b. Adjustment and calibration

When the deviation of a measured value exceeds the specification, adjust the specified part.

c. Faulty section check

If the above deviation cannot be corrcted, check the cause of failure.

d. Repair

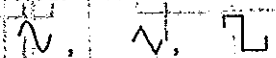
When a failure is suspected, contact NF or your NF sales agent.

This chapter explains only inspections which can be done easily. For calibration and repair, contact NF or your NF sales agent.

5.2 Measuring devices required for operation inspction

Measuring devices listed in Table 5.1 are required for operation inspection.

Table 5.1 Measuring devices required for operation inspection

Measuring device	Major performance	Recommended device
Wide-band function generator	0.01Hz to 10MHz 	NF FG-161/163
Oscilloscope	DC to 50MHz or more 10mV to 100V	TEK 465
AC voltmeter	10Hz to 1MHz 1V to 100V	NF M-170
Dummy load	1Ω to 10Ω ±5%, 30W 50Ω ±5%, 50W	

5.3 Operation inspection

This section explains how to check that the major performance of the 4005 conforms to the specifications and the major functions work properly. When results of the check described below are normal, performance and function operations closely conform to the specifications.

(1) Maximum output check

Test equipment connection	See Fig.5.1.
Supply input voltage	Rating (100V, 120V, 220V, or 240V)
Frequency	500kHz
Waveform	Sine wave
Gain of 4005	×20
Pass/fail	Set the function generator output so that the AC voltmeter reads 50Vrms. Monitor the 4005 waveform using an oscilloscope. The maximum output is proper if the waveform has no abnormality such as a clip and the overload lamp does not go on.

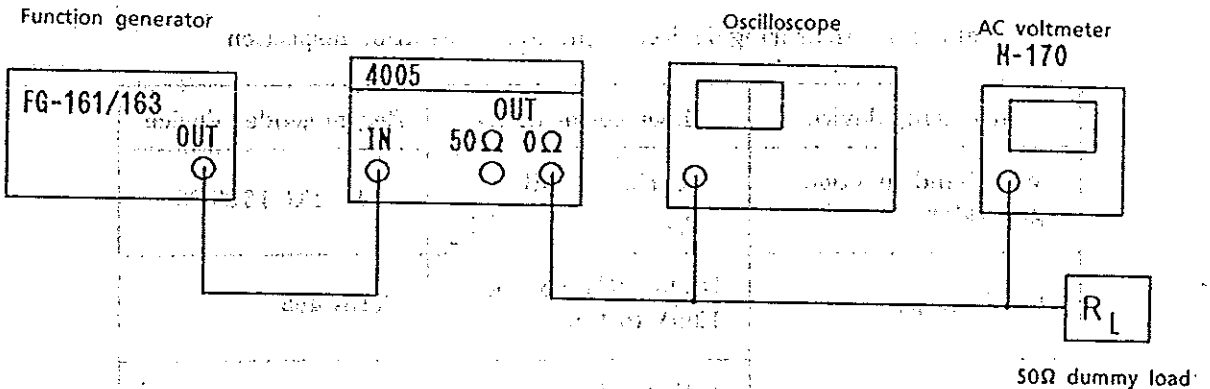


Fig.5.1 Maximum output check

(2) Frequncy characteristics check

Test equipment connection	See Fig.5.2.
Line input voltage	Rating (100V, 120V, 220V, or 240V)
Frequency	400Hz, 100kHz, and 1MHz
Waveform	Sine wave
Gain of 4005	×20
Pass/fail	Set the function generator (FG) output so that frequency is 400Hz and the AC voltmeter reads 0dB in the 30V range (22.34V). Then, keep the FG output level constant. If the reading of the AC voltmeter is +0.5/–1.0dB or less when frequency is set to 100kHz and 1MHz, frquency characteristics are proper.

Note:

Connect the oscilloscope and AC voltmeter to the $Z_0 \fallingdotseq 0\Omega$ output. Short the $Z_0 = 50\Omega$ output so that the connection is equivalent to that when a 50 load is connected to the $Z_0 \fallingdotseq 0\Omega$ output.

When a voltage exceeding 25Vrms is output in this state, an internal resistor may be damaged.

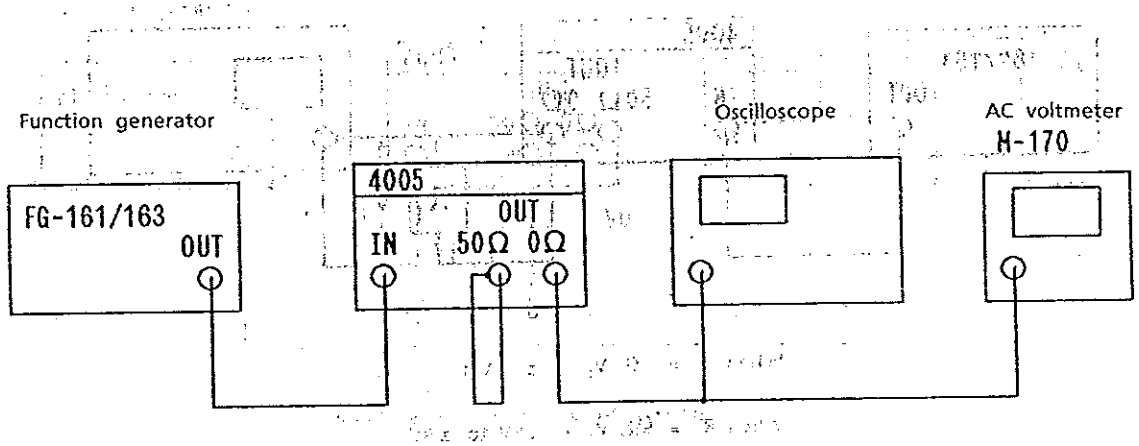


Fig.5.2 Frequency characteristics check

(3) Protection circuit check

Test equipment connection	See Fig.5.3.
Line input voltage	Rating (100V, 120V, 220V, or 240V)
Frequency	400Hz
Waveform	Square wave
Gain of 4005	×20
Pass/fail	When current passing to the dummy load (R_L) is limited to ±1.6A to ±1.8A, the protction circuit operation level is proper.

Note:

Set the FG output to zero and connect cables as shown in Fig.5.3. Then, increase the FG output gradually. Read the protection level (limit value) with $I_0 = V_0/R_L$ using an oscilloscope.

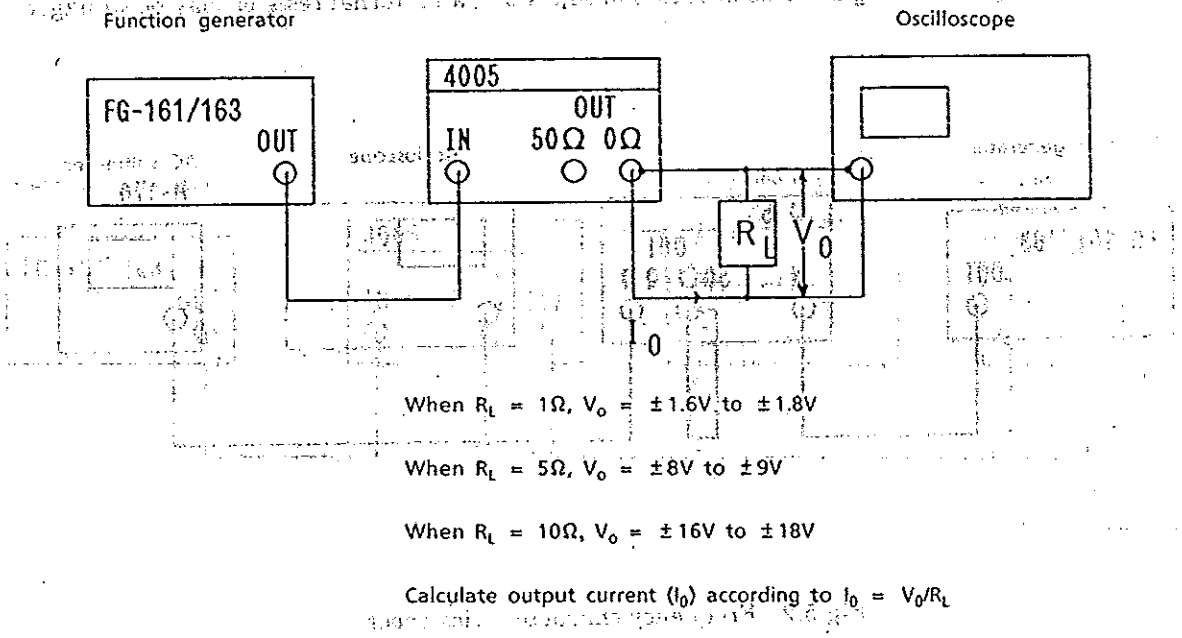


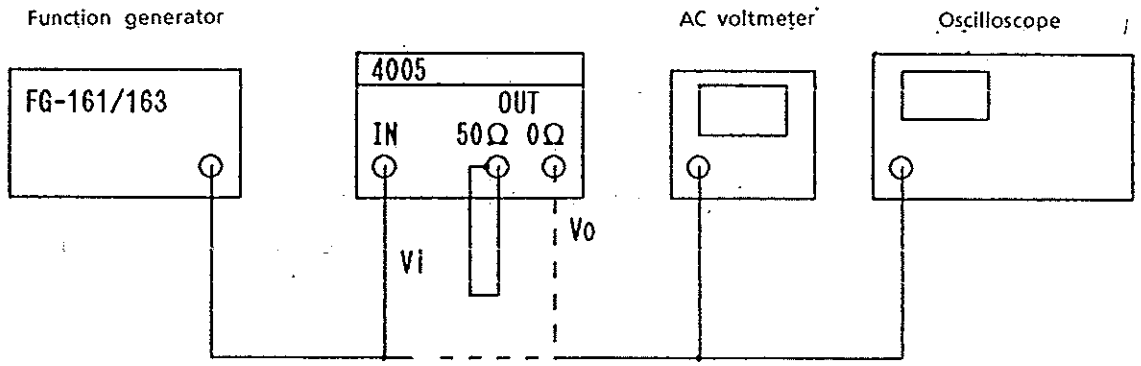
Fig.5.3 Protection circuit operation level check

(4) Gain error check

Test equipment connection	See Fig.5.4.
Line input voltage	Rating (100V, 120V, 220V, or 240V)
Frequency	400Hz
Waveform	Sine wave
Gain of 4005	× 10, 20, 50 or × 100
Pass/fail	As shown in Fig.5.4, measure V_i and V_0 by the AC voltmeter to obtain gain (G) = V_0/V_i. When that error is ±2% or less for each gain, the gain error is acceptable.

Note:

Short the Z_0 = 50Ω output connector. Set the output voltage (V_0) between 10V to 20Vrms. When a voltage exceeding 25Vrms is output, an internal resistor may be damaged.



* Measure V_i and V_0 by AC voltmter.
* Monitor V_o by oscilloscope
* Short the Z_0 = 50Ω output.
* V_o must be 10V ≦ V_0 ≦ 20Vrms.
* Calculate gain (G) according to G = V_o/V_i

Fig.5.4 Gain error check

WA:58273-2

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