

This application manual describes basic characteristics such as operational amplifier general characteristics, terms, and precautions for use.

## 1 Absolute Maximum Ratings of Operational Amplifier

### 1-1 Supply Voltage

Defines the maximum voltage that can be applied between the positive and negative power supply voltage terminals of an operational amplifier. When operating with a single power supply specify the applied voltage, and with dual power supply operation the difference between the positive power supply and the negative power supply.

Representative Symbol :  $V^+ - V^-$ ,  $V^+ / V^-$ ,  $V_{DD}$ ,  $V_{SS}$

### 1-2 Differential Input Voltage

Specify absolute maximum voltage between the inverting and non-inverting input terminals.

The differential input voltage is specified with the plus minus ( $\pm$ ) description because the polarity of the input voltage stay on the opposite direction by assignment of the reference terminal. If an input voltage exceeding this voltage is applied, the transistor in the first stage may be damaged or the characteristics may deteriorate.

Representative Symbol :  $V_{ID}$

### 1-3 Common Mode Input Voltage

Specify absolute maximum input voltage to the inverting and non-inverting input terminals.

Operation limit is specified as the common mode voltage range ( $V_{ICM}$ ) in the each electrical characteristics.

Representative Symbol :  $V_{IC}$ ,  $V_{IN}$

### 1-4 Power Dissipation

Specify absolute maximum power dissipation. The  $P_D$  is limited by the power consumption of IC chip and the package heat resistance. The power consumption of IC chip is calculated based on the quiescent current and the load current. The allowable power consumptions is mentioned following formula.  $P_{D-I_{CC}} \cdot (V^+ - V^-)$

When using the NJM5532C with a large  $I_{CC}$  or the quad operational amplifier to obtain the output current at the same time, it is necessary to take precautions such as reducing the power supply voltage.

Representative Symbol :  $P_D$

## 2. Definition of operational amplifier characteristics

### 2-1 Input offset voltage

The voltage that must be applied between the two input terminals to obtain the output voltage to Zero. With reference to the +INPUT terminal, the voltage at the -INPUT terminal is expressed as an absolute value in the main products.

Representative Symbol :  $V_{IO}$

### 2-2 Input Bias Current

The average source or sink input current of the two input terminals.  $I_B = (I_B^- + I_B^+) / 2$

Representative Symbol :  $I_B$

### 2-3 Input offset current

When the output terminal voltage of the operational amplifier is 0V, it is expressed as an absolute value by the difference between the input currents flowing into or out of the two input terminals.  $I_{IO} = |I_B^- - I_B^+|$

Representative Symbol :  $I_{IO}$

### 2-4 Common Mode Input Voltage Range

The maximum/minimum range of input voltage at which the op amp function, with both positive and negative supply side values. To function means that the common-mode rejection ratio (CMR) is satisfied, and if the common-mode input voltage range is exceeded, the input offset voltage will fluctuate significantly and will not function.

Representative Symbol :  $V_{ICM}$

## 2-5 Common Mode Signal Rejection Ratio

The ratio of the input offset voltage to the input voltage that fluctuates when a common mode input voltage within the common mode input voltage range is applied. It expresses with the following formula.

Representative Symbol : CMR, CMRR

$$CMR = 20 \log \frac{\Delta V_{IN}}{\Delta V_{IO}}$$

## 2-6 Supply Voltage Rejection Ratio

The ratio of the input offset voltage that fluctuates when the power supply voltage is changed and the power supply voltage change amount, and is expressed by the following formula.

Representative Symbol : SVR, PSRR

$$SVR = 20 \log \frac{\Delta V^+}{\Delta V_{IO}}$$

## 2-7 Maximum Output Voltage

The output voltage that can change without the output saturating.  $V_{OM}$  defines positive and negative, and  $V_{OPP}$  defines maximum voltage swing peak-to-peak.

Representative Symbol :  $V_{OM}$ ,  $V_{OH}$ ,  $V_{OL}$ ,  $V_{OPP}$

## 2-8 Supply Current

The current flown on the power supply terminal in no load condition.

Representative Symbol :  $I_{CC}$ ,  $I_{DD}$ ,  $I_{SUPPLY}$

## 2-9 Open Loop Voltage Gain

Large voltage output differential voltage gain at DC.

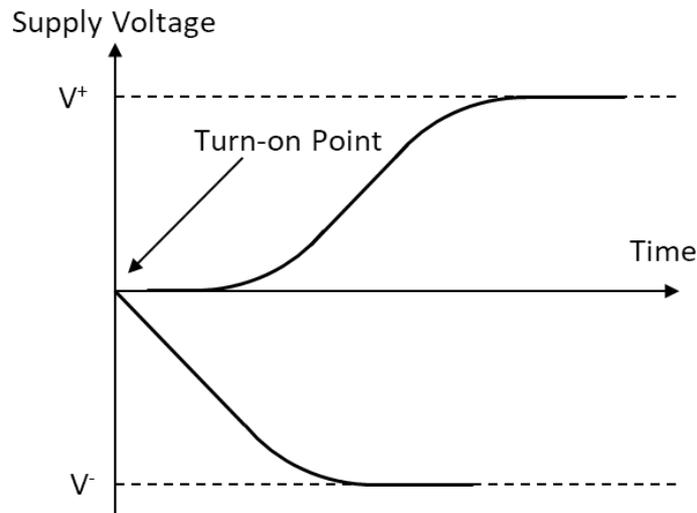
Representative Symbol:  $A_v$

## 3. Attentions point for use

### 3-1 Power On Sequence

It is necessary that the IC is used in the condition of no floating GND ( $V^-$ ) terminal. Therefore, it is necessary to be noted on using the dual power supply as follows;

- 1) When the power turns on,  $V^-$  power supply should be turned on before or just same with the  $V^+$  power supply.
- 2) When the  $V^-$  and  $V^+$  power supplies are turned on at the same time, it is ideal that the  $V^-$  power supply always rises earlier than the  $V^+$  power supply as shown in the figure above.
- 3) When the power turn off,  $V^+$  power supply should off before or just same with the  $V^-$  power supply.

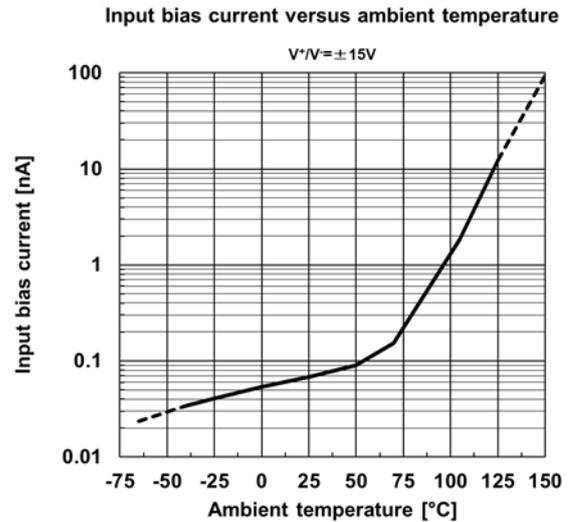


## 3-2 Precautions specific to J-FET input operational amplifiers

### 3-2-1 Temperature Characteristics of the Input Bias Current

The input bias current of J-FET operational amplifier is the PN junction leakage current of the gate, channel and gate, and substrate. Therefore, the temperature dependence is increased exponentially by the temperature just like as the general PN junction.

J-FET operational amplifier that has often been applied for the high input impedance circuit of which the special precaution must be taken for the  $I_B$  increase by the temperature rise. For instance, when it is about 60pA in the room temperature, it increase up to around 0.5nA at 80°C.



### 3-2-2 Comparison Between J-FET and Bipolar Operational Amplifier

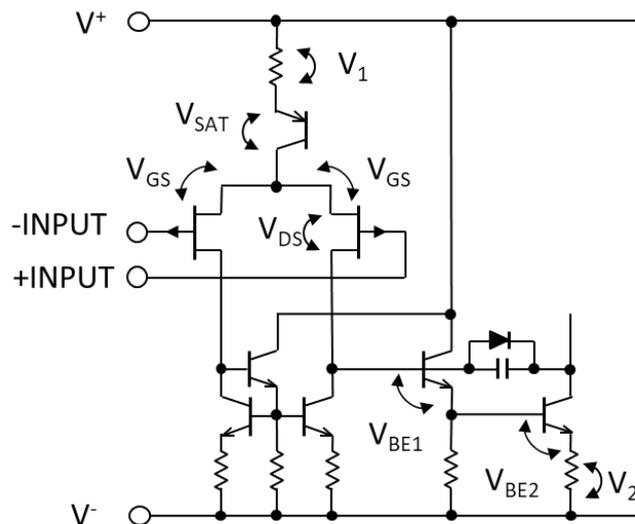
The table below shows the characteristics comparison of typical products. [\(Click here for JFET product lineup\)](#)

PRODUCT NAME	Input Bias Current Max. (pA)	Slew Rate Typical (V/μs)	Offset Voltage Max. (mV)	Bandwidth Typical (MHz)
NJM062C (JFET)	400	3.5	15	1
NJM072C (JFET)	200	13	10	3
NJM8512 (JFET)	80	20	0.8	7
NJM8065 (Bip)	200,000	4	3	10
NJM8068 (Bip)	1,000,000	6.8	3	19
NJM2904C (Bip)	150,000	0.6	7	1.1

### 3-2-3 Common Mode Input Voltage Range

In the case of a typical JFET input operational amplifier, the maximum positive-side voltage  $V_{IC}^+$  is " $V_{IC}^+ = V^+ - V_1 - V_{SAT} + V_{GS}$ " and  $V_{GS} > V_1 + V_{SAT}$ , so  $V_{IC}^+ \approx V^+ + 0.6V$ , which is wider than the positive power supply voltage.

The maximum negative input voltage  $V_{IC}^-$  is  $V_{IC}^- = V^- + V_2 + V_{BE1} + V_{BE2} + V_{DS} + V_{GS}$ , and  $V_{IC}^- \approx V^- + 2.3V$ .



### 3-2-4 Input Capacitance

With bipolar transistor input operational amplifiers, the input capacitance is 1 to 2 pF for NPN transistor inputs such as NJM5532C, and 3 to 4 pF for NJM4558 series lateral PNP transistor inputs, but the input capacitance of the NJM072C series is about 10 pF. Therefore, in the case of voltage follower by using NJM072C, the pole is made by the input capacitance ( $C_i$ ) and feed back resistor ( $R_f$ ). Figure1

$$f_p = \frac{1}{2\pi C_i R_f}$$

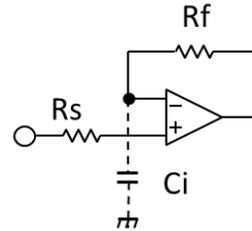


Figure1

For  $R_f = 10\text{ k}\Omega$  and  $C_i = 10\text{ pF}$ , a pole is created within  $f_T (\approx 3\text{ MHz})$  at  $f_p = 1.6\text{ MHz}$ , reducing phase margin.

As a countermeasure, stability can be increased by adding  $C_f$  such as  $C_f \gg C_i$ . Figure2

In case of inverting amplifier, influence by the input capacitance is eliminated by adding the  $C_f$  mentioned below. Figure3

$$C_f = \frac{R_1}{R_f} C_i$$

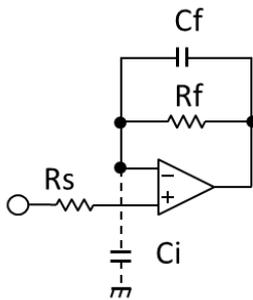


Figure2

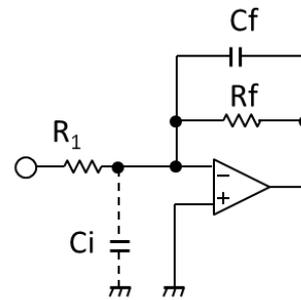


Figure3

### 3-3 About typical characteristics

The typical characteristics mentioned in each data sheet are representative for each device typical characteristics. But these are only technical data and it does not guarantee any characteristics and its application. Especially for the characteristics of the power, it should be designed within its maximum limit.

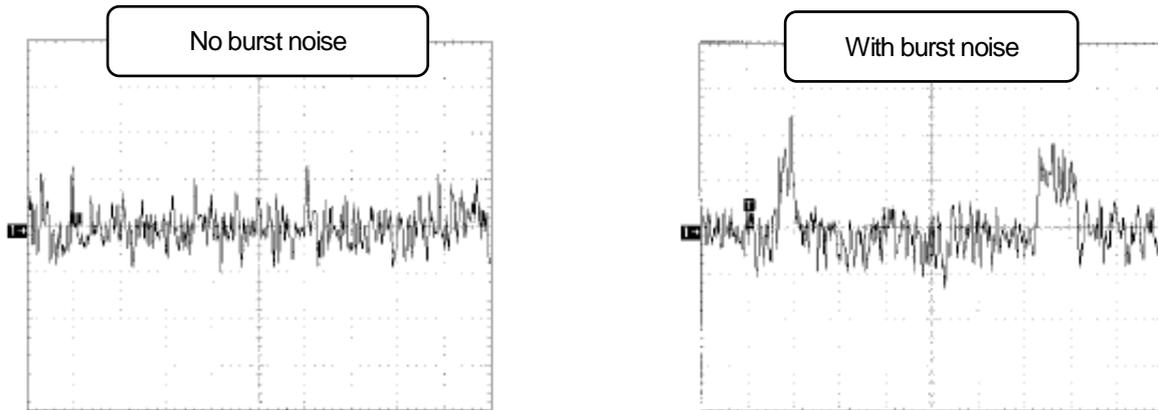
### 3-4 Type of noise

There are two types of noise, external noise and noise generated inside the operational amplifier. Representative noise generated inside the operational amplifier is (1) thermal noise, (2)  $1/f$  noise, (3) shot noise, and (4) burst noise. When high signal quality is required due to set specifications, it is necessary to design in consideration of noise inside the operational amplifier. In principle, this noise includes noise that is always generated and noise that is generated suddenly.

The noise that is constantly generated includes thermal noise, shot noise,  $1/f$  noise, etc. These noises are unique to semiconductor integrated circuits.

Moreover, the noise that occurs suddenly is the noise caused by the disorder of the crystal and is called "burst noise" or "popcorn noise", and it occurs as a sudden change in the bias current or bias voltage of the IC internal circuit.

For the noise characteristics of each product, please refer to the data sheet. If it is not listed in the data sheet, please contact us and we will submit a representative characteristic example. For applications that are significantly affected by popcorn noise, we will consider whether or not to offer a sorted product.



[CAUTION]

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