Nisshinbo Micro Devices Inc.

NJU77552-T1

1.7MHz, 50µA/ch, High EMC Performance, Rail-to-Rail Input/Output, Operational Amplifier

FEATURES

(V^+ = 5V, Typical value)

- AEC-Q100 grade 1 Compliant
- High Efficiency:
- GBW 1.7MHz
- Supply Current 50µA/ch
- Rail-to-Rail Input and Output
- Integrated EMI filter EMIRR = 75dB @f = 900MHz
- Input Tolerant
- Unity-Gain stable
- Supply Voltage 2.2V to 5.5V
- Input Offset Voltage 6mV max.
- Slew Rate 0.8V/µs
- Operating Temperature -40°C to 125°C
- Package MSOP8 (VSP8)

APPLICATIONS

- Automotive
- Battery-Powered Equipment
- Sensor Interface
- Active Filter
- Photodiode Amplifier

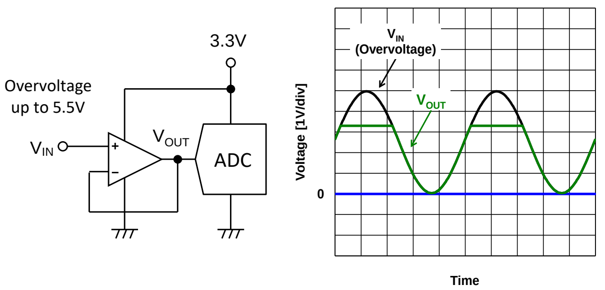
GENERAL DESCRIPTION

The NJU77552 is a dual rail-to-rail input and output single supply CMOS OpAmp, featuring low supply current of 50µA typical per amplifier, wide gain bandwidth product of 1.7MHz and a slew rate of 0.8V/µs. Furthermore, operating voltage from 2.2V single supply can contribute to energy saving design, it is most suitable for battery equipment required low power.

Low input bias current makes NJU77552 suitable for photodiode amplifiers, piezoelectric sensors, and other applications with high-impedance applications. A rail-to-rail input and output allows the device to be used in wide variety of applications, such as high-side current sensing, active filter, buffering and others.

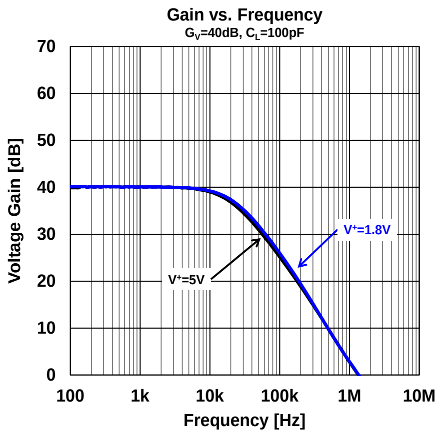
And also, High EMI immunity that can reduced malfunctions caused by RF-noises from mobile phones and other electronic devices, and input tolerant that allows the input voltage (Recommended: V^-+5.5V) that exceed positive supply voltage is ideal for robust applications.

■ TYPICAL APPLICATIONS



ADC buffer with input tolerant

GBW=1.7MHz (I_{SUPPLY} = 50µA/ch)



■ PRODUCT NAME INFORMATION

NJU77552 R - T1 (TE1)

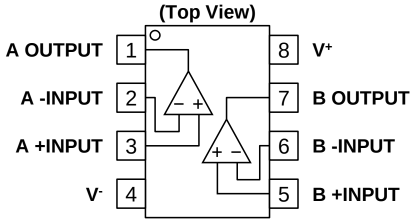
Description of configuration

Composition	Item	Description
R	Package code	Indicates the package. R: MSOP8 (VSP8)
T1	Quality grade	Automotive.
TE1	Packing	Insert Direction. Refer to the packing specifications.

■ ORDER INFORMATION

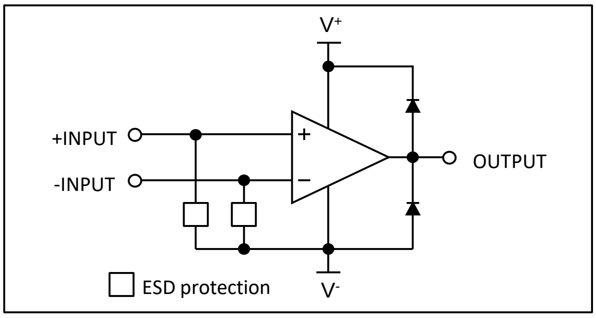
Product Name	Package	RoHS	Halogen-Free	Terminal Finish	Weight (mg)	Quantity per Reel (pcs/reel)
NJU77552R-T1 (TE1)	MSOP8 (VSP8)	✓	✓	Sn2Bi	21	2000

■ PIN DESCRIPTION (MSOP8 (VSP8))



Pin No.	Symbol	I/O	Description
1	A OUTPUT	O	Output channel A
2	A −INPUT	I	Inverting input channel A
3	A +INPUT	I	Non-inverting input channel A
7	B OUTPUT	O	Output channel B
6	B −INPUT	I	Inverting input channel B
5	B +INPUT	I	Non-inverting input channel B
8	V^+	-	Positive supply
4	V^-	-	Negative supply or GND (single supply)

■ BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RATINGS

	Symbol	Rating	Unit
Supply Voltage	$V^+ - V^-$	7	V
Input Voltage [*1]	V_{IN}	V^- - 0.3 to V^- + 7	V
Input Current [*2]	I_{IN}	-10	mA
Output Terminal Input Voltage [*3]	V_O	V^- - 0.3 to V^+ + 0.3	V
Differential Input Voltage [*4]	V_{ID}	±7	V
Output Short-Circuit Duration [*5]		Continuous	
Storage Temperature	T_{stg}	−65 to 150	°C
Junction Temperature [*6]	T_j	150	°C

[*1] Input voltage is the voltage should be allowed to apply to the input terminal independent of the magnitude of V^+.
The normal operation will establish when any input is within the "Common-Mode Input Voltage Range" of electrical characteristics.

[*2] Input voltages below the V^- will be clamped by ESD protection diodes. If the input voltage lower than V^- - 0.3V, the current must be limited 10 mA or less by using a restriction resistance. Input current outflow is negative.

[*3] The absolute maximum input voltage is limited at 7V.

[*4] Differential voltage is the voltage difference between +INPUT and −INPUT.

[*5] Power loss increases when output is short-circuited; do not exceed T_j.

[*6] Calculate the power consumption of the IC from the operating conditions, and calculate the junction temperature with the thermal resistance.
Please refer to "Thermal characteristics" for the thermal resistance under our measurement board conditions.

ABSOLUTE MAXIMUM RATINGS
Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause permanent damage and may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured.

■ THERMAL CHARACTERISTICS

Package	Measurement Result		Unit
	Thermal Resistance (θja)	Thermal Characterization Parameter (ψjt)	
MSOP8 (VSP8)	189	53	°C/W

θja:Junction-to-Ambient Thermal Resistance
ψjt:Junction-to-Top Thermal Characterization Parameter
Mounted on glass epoxy board (76.2 mm × 114.3 mm × 1.6 mm: based on EIA/JEDEC standard, 4-layer FR-4), internal Cu area: 74.2 mm × 74.2 mm.

■ ELECTROSTATIC DISCHARGE (ESD) PROTECTION VOLTAGE

	Conditions	Protection Voltage
HBM	C = 100 pF, R = 1.5 kΩ	±1000 V
CDM		±1000 V

ELECTROSTATIC DISCHARGE RATINGS
The electrostatic discharge test is done based on JEITA ED-4701.

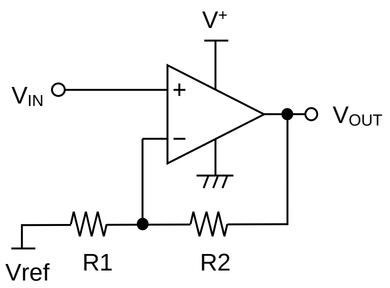
■ RECOMMENDED OPERATING CONDITIONS

	Symbol	Conditions	Rating	Unit
Supply Voltage	$V^+ - V^-$		2.2 to 5.5	V
Input Voltage	V_{IN}	Closed-loop	V^- - 0.3 to V^- + 5.5	V
Operating Temperature	T_a		−40 to 125	°C

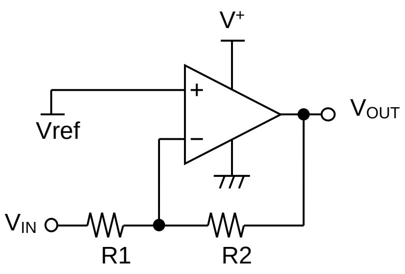
RECOMMENDED OPERATING CONDITIONS

All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

■ TYPICAL APPLICATION CIRCUIT



Non-inverting amplifier



Inverting amplifier

■ ELECTRICAL CHARACTERISTICS

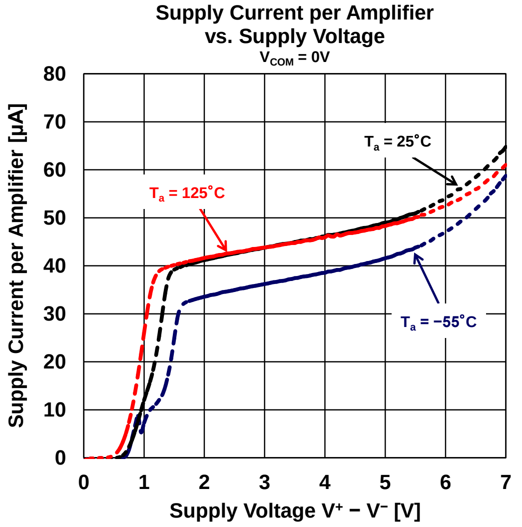
$V^+ = 5V$, $V^- = 0V$, $V_{COM} = V^+/2$, $R_L = 10kΩ$ to V_{COM}, $T_a = 25°C$, unless otherwise noted.
For parameter that do not describe the temperature condition, the value under the condition of T_a=25°C is described.

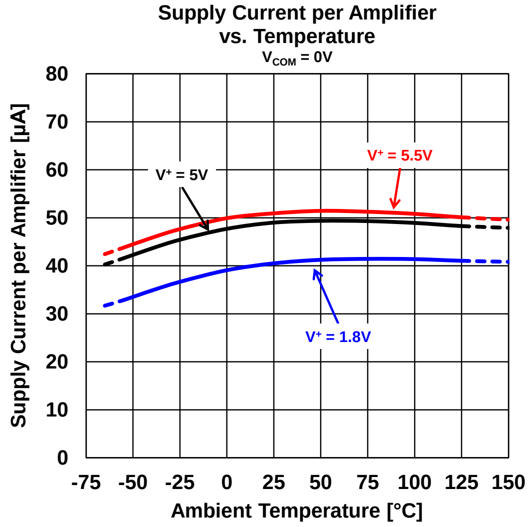
Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
INPUT CHARACTERISTICS [*1]						
Input Offset Voltage	V_{IO}	$V_{COM} = 0V$	-	1	6	mV
		$V_{COM} = 0V$, $T_a = -40°C$ to 125°C	-	-	6.5	mV
Input Bias Current	I_B		-	1	-	pA
Input Offset Current	I_{IO}		-	1	-	pA
Input Offset Voltage Drift	$ΔV_{IO}/ΔT$	$T_a = -40°C$ to 125°C	-	1	-	µV/°C
Open-Loop Voltage Gain	A_V	$R_L = 10kΩ$ to $V^+/2$	70	90	-	dB
		$R_L = 10kΩ$ to $V^+/2$, $T_a = -40°C$ to 125°C	70	-	-	dB
Common-Mode Rejection Ratio	CMR	$V_{COM} = V^- - 0.2V$ to $V^+ - 1.5V$	70	90	-	dB
		$V_{COM} = V^-$ to $V^+ - 1.5V$, $T_a = -40°C$ to 125°C	70	-	-	dB
		$V_{COM} = V^- - 0.2V$ to $V^+ + 0.2V$	55	70	-	dB
		$V_{COM} = V^-$ to V^+, $T_a = -40°C$ to 125°C	55	-	-	dB
Common-Mode Input Voltage Range	V_{ICM}	CMR ≥ 55dB	$V^- - 0.2$	-	$V^+ + 0.2$	V
		CMR ≥ 55dB, $T_a = -40°C$ to 125°C	V^-	-	V^+	V
OUTPUT CHARACTERISTICS						
High-level Output Voltage	V_{OH}	$R_L = 10kΩ$ to $V^+/2$	$V^+ - 0.025$	$V^+ - 0.01$	-	V
		$R_L = 10kΩ$ to $V^+/2$, $T_a = -40°C$ to 125°C	$V^+ - 0.025$	-	-	V
Low-level Output Voltage	V_{OL}	$R_L = 10kΩ$ to $V^+/2$	-	6	25	mV
		$R_L = 10kΩ$ to $V^+/2$, $T_a = -40°C$ to 125°C	-	-	25	mV
POWER SUPPLY						
Supply Current per Amplifier	I_{SUPPLY}	No Signal, $V_{COM} = 0V$	-	50	68	µA
		$T_a = -40°C$ to 125°C	-	-	65	µA
Supply Voltage Rejection Ratio	SVR	$V^+ = 2.2V$ to 5.5V, $V_{COM} = 0V$	70	90	-	dB
		$V^+ = 2.2V$ to 5.5V, $V_{COM} = 0V$, $T_a = -40°C$ to 125°C	70	-	-	dB
AC CHARACTERISTICS						
Slew Rate	SR	$C_L = 100pF$	-	0.8	-	V/µs
Gain Bandwidth Product	GBW	f=100kHz, $C_L = 100pF$	-	1.7	-	MHz
Total Harmonic Distortion + Noise	THD+N	Gain = +2, f = 1kHz, $V_O = 1.5Vrms$	-	0.005	-	%
Equivalent Input Noise Voltage	V_{NI}	f = 0.1Hz to 10Hz	-	1.6	-	$µV_{PP}$
	e_n	f = 1kHz	-	24	-	nV/√Hz
Channel Separation	CS	f = 1kHz	-	120	-	dB

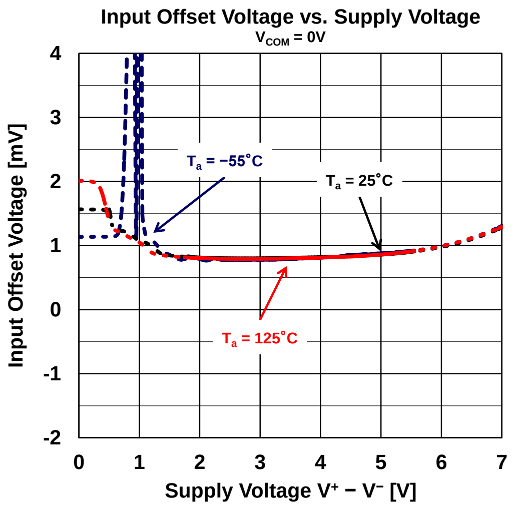
[*1] Input offset voltage and drift, Input bias and offset current are positive or negative, its absolute values are listed in electrical characteristics.

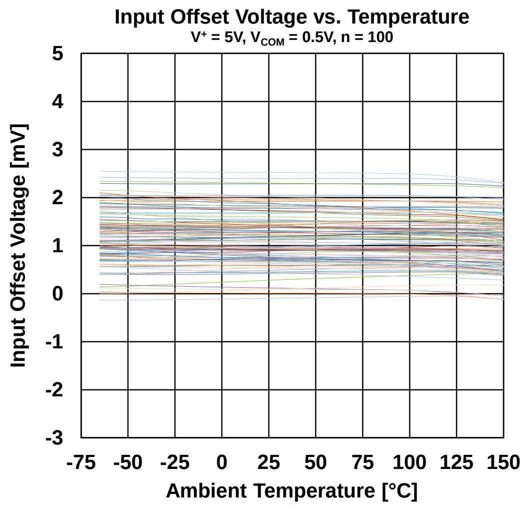
■ TYPICAL CHARACTERISTICS

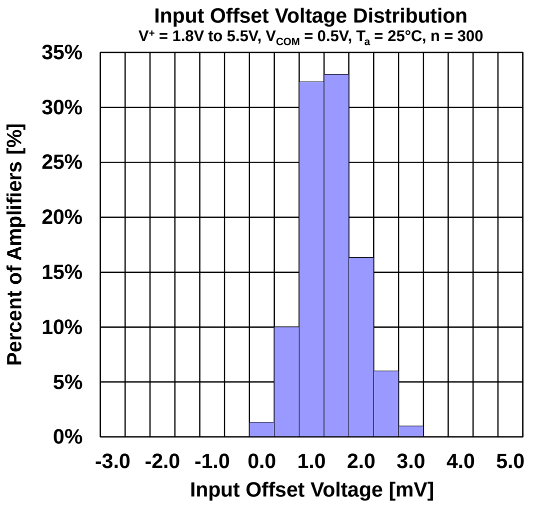
Note: Typical Characteristics are intended to be used as reference data; they are not guaranteed.

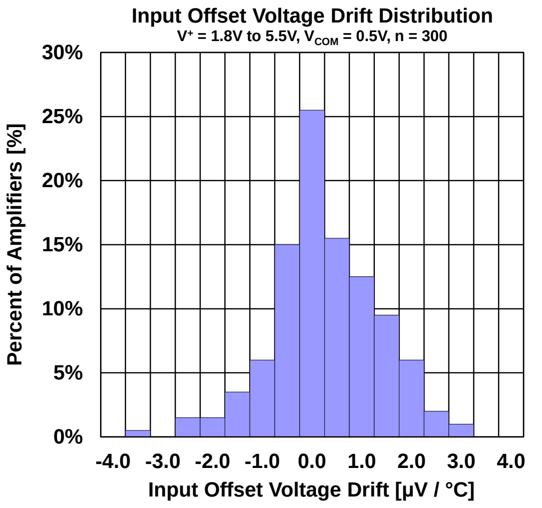












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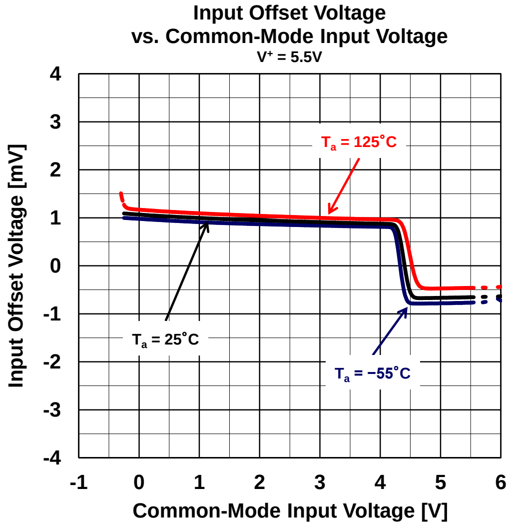

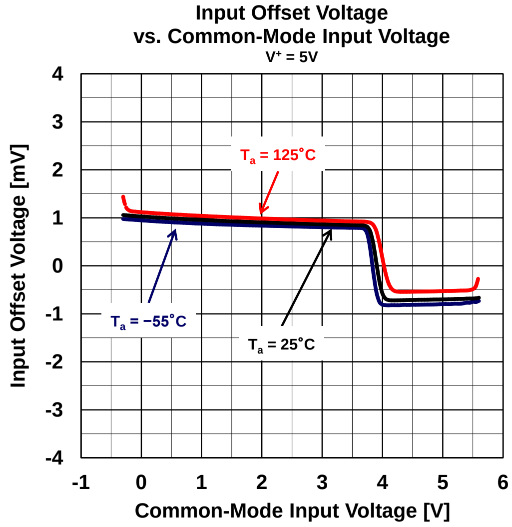

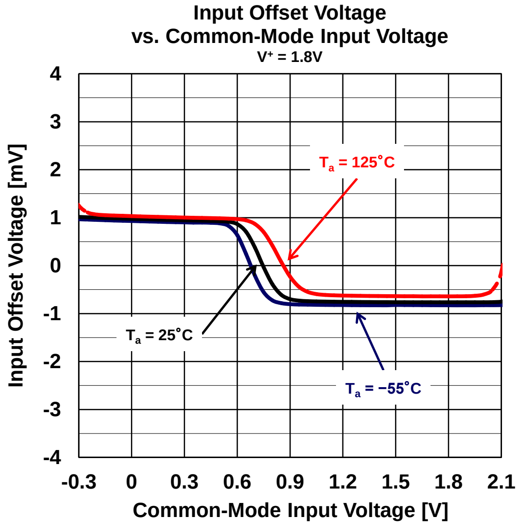

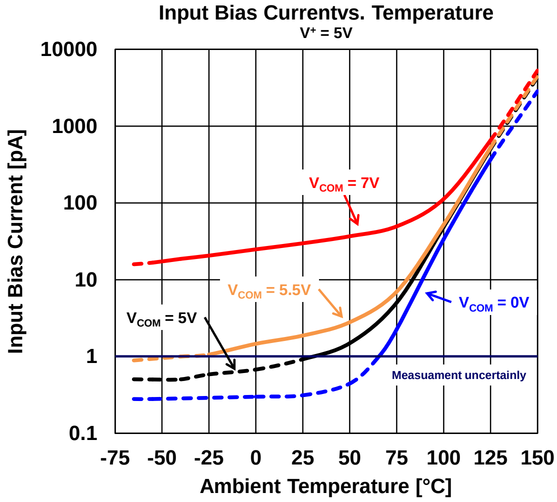

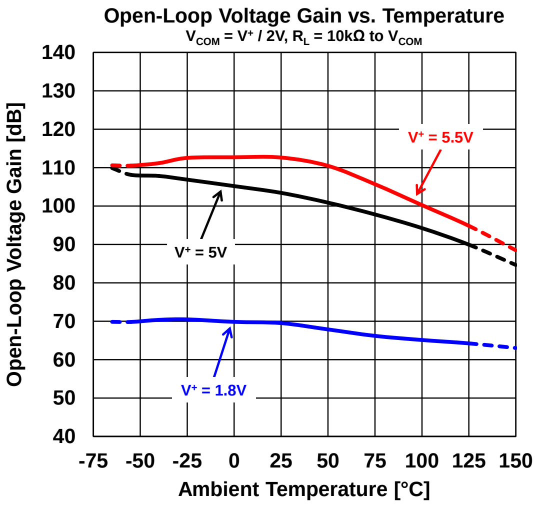

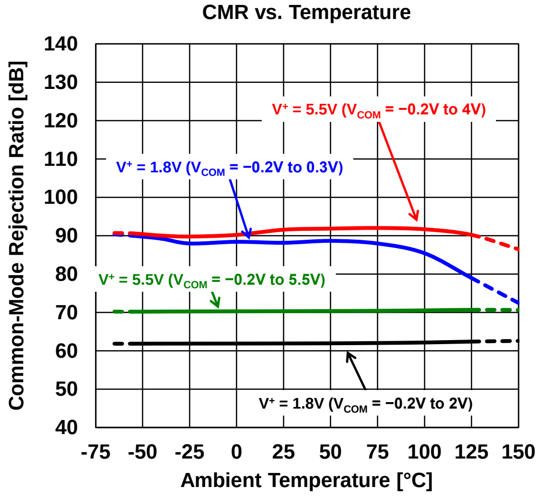

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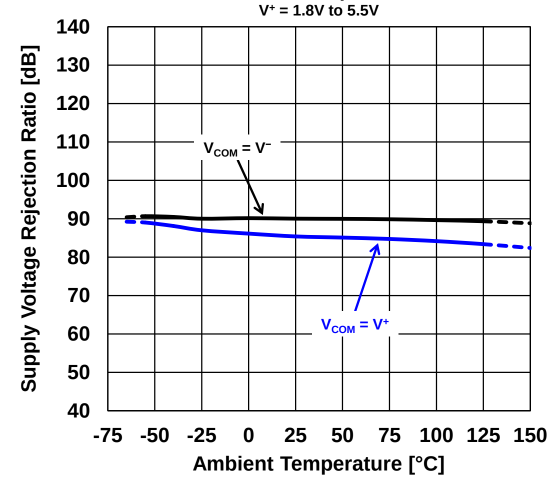
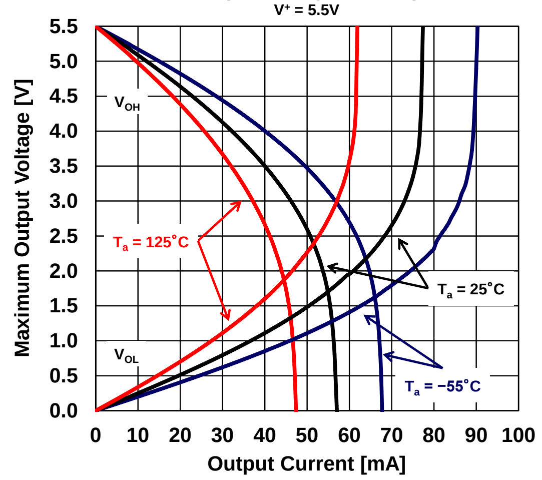
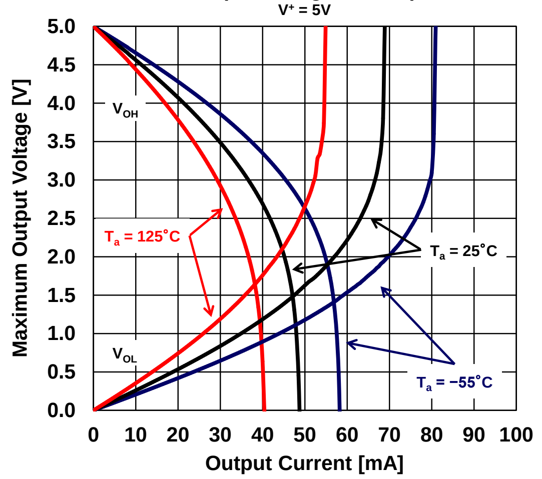
SVR vs. Temperature
V^+ = 1.8V to 5.5V



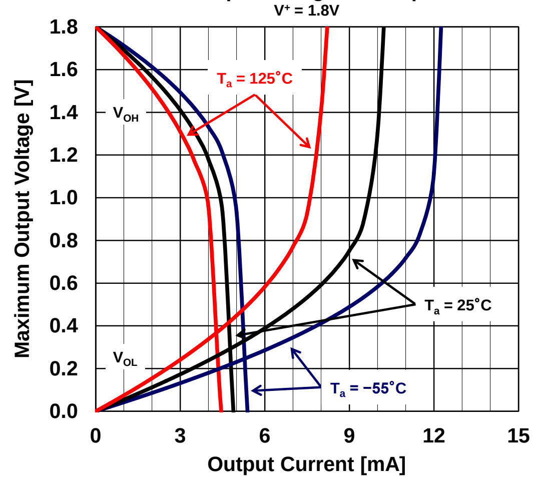
Maximum Output Voltage vs. Output Current
V^+ = 5.5V



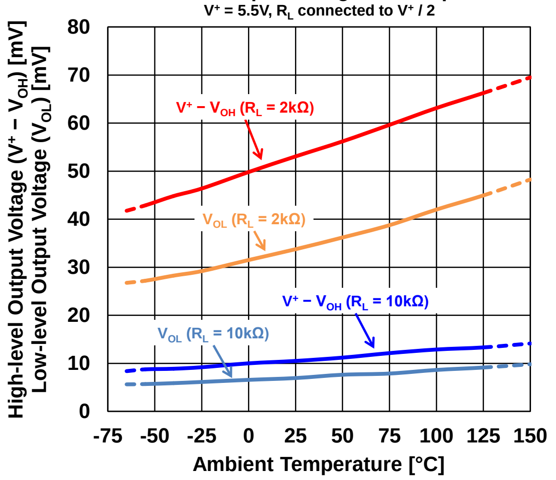
Maximum Output Voltage vs. Output Current
V^+ = 5V



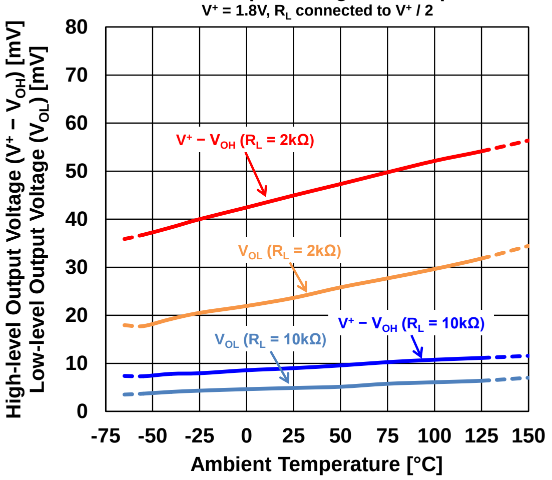
Maximum Output Voltage vs. Output Current
V^+ = 1.8V



Maximum Output Voltage vs. Temperature
V^+ = 5.5V, R_L connected to V^+ / 2



Maximum Output Voltage vs. Temperature
V^+ = 1.8V, R_L connected to V^+ / 2



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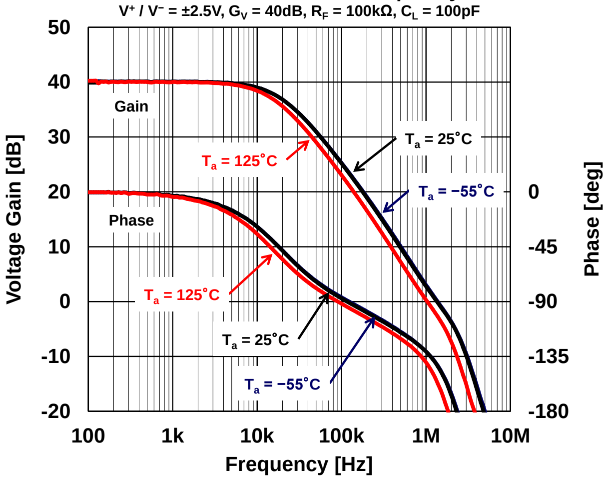
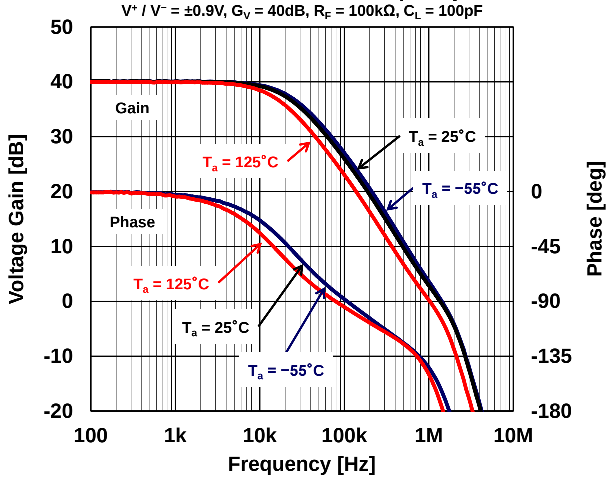
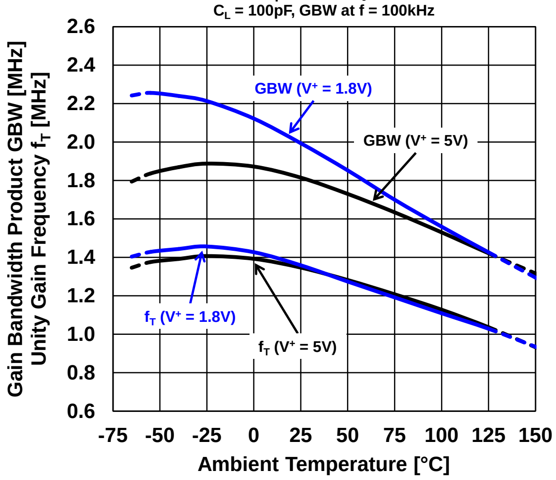
40dB Gain / Phase vs. Frequency
$V^+ / V^- = \pm 2.5V$, G_V = 40dB, R_F = 100kΩ, C_L = 100pF



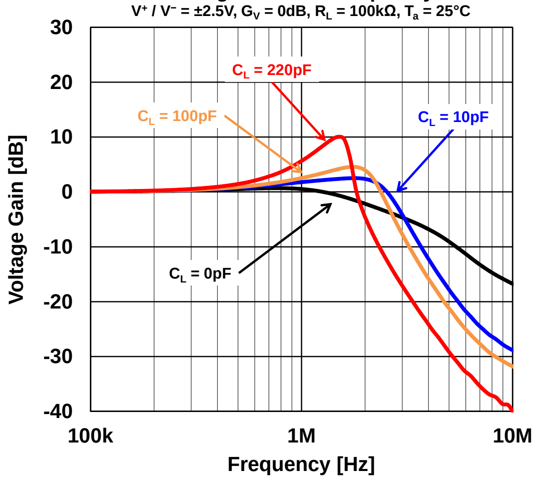
40dB Gain / Phase vs. Frequency
$V^+ / V^- = \pm 0.9V$, G_V = 40dB, R_F = 100kΩ, C_L = 100pF



GBW, f_T vs. Temperature
C_L = 100pF, GBW at f = 100kHz



Voltage Gain vs. Frequency
$V^+ / V^- = \pm 2.5V$, G_V = 0dB, R_L = 100kΩ, T_a = 25°C



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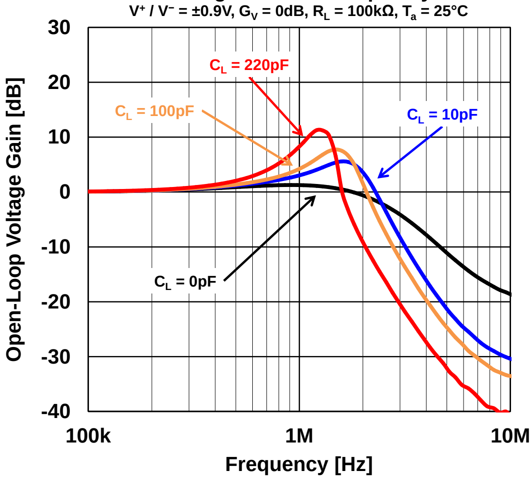
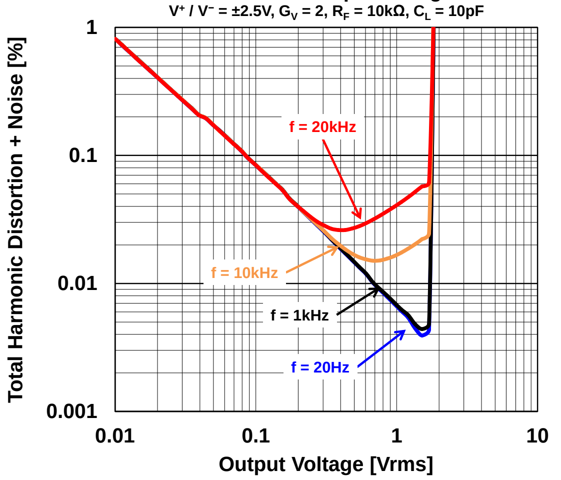


THD+N vs. Output Voltage
$V^+ / V^- = \pm 2.5V$, G_V = 2, R_F = 10kΩ, C_L = 10pF



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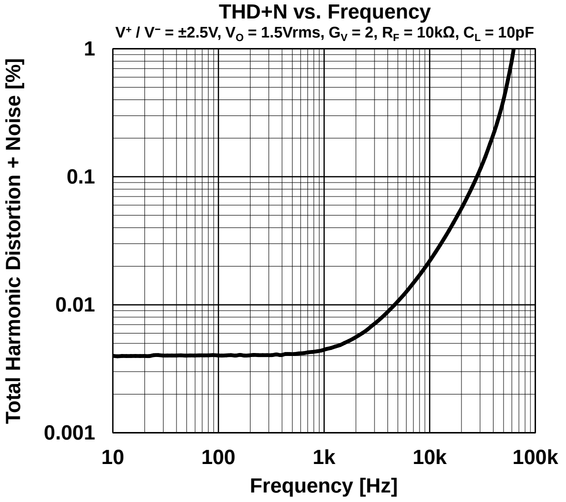

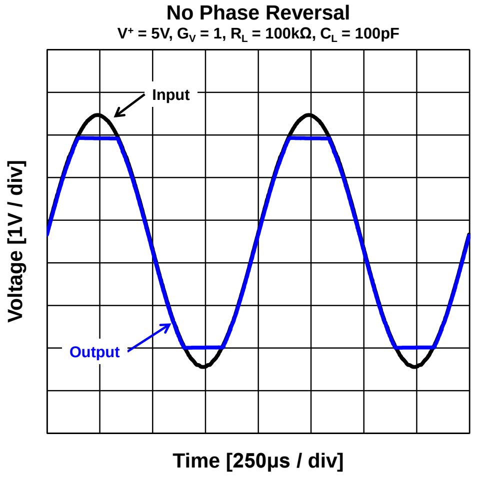

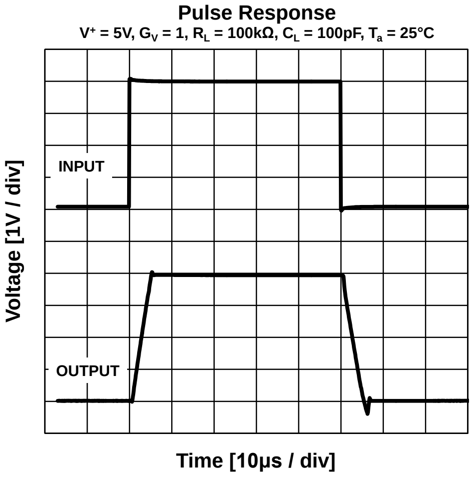

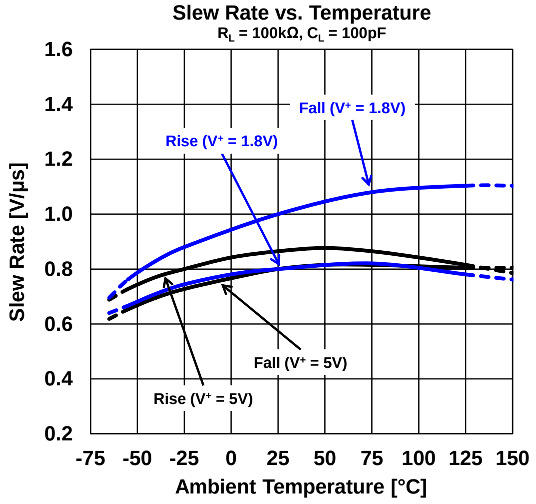

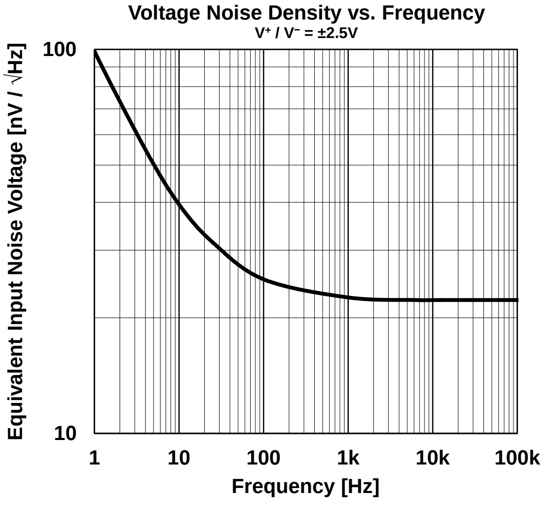

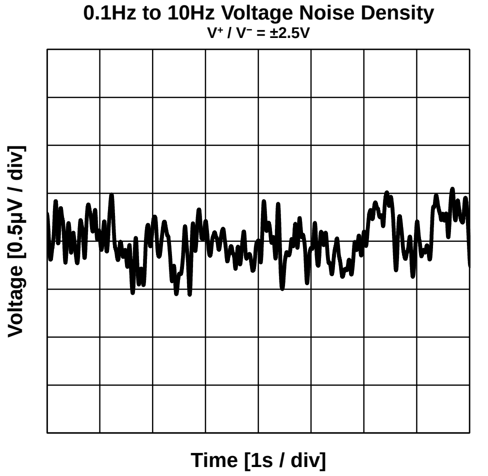

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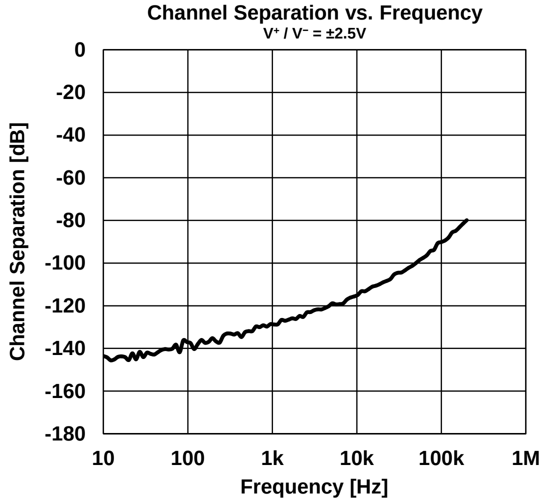
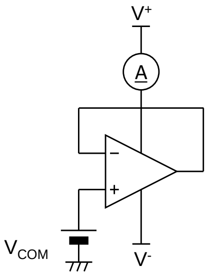


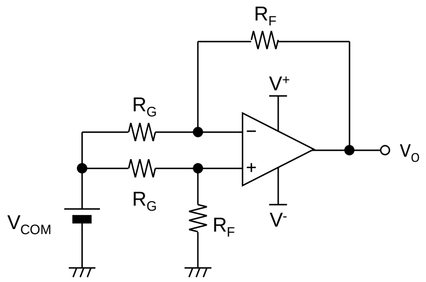
■ TEST CIRCUITS

- I_{SUPPLY}



- V_{IO}, CMR, SVR

$R_G = 50\Omega$, $R_F = 50k\Omega$



$$V_{IO} = \frac{R_G}{(R_G+R_F)} \times (V_O - V_{COM})$$

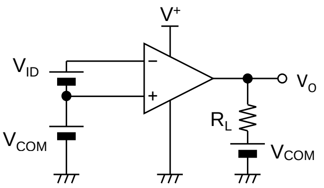
$$CMR = 20\log \frac{\Delta V_{COM}\left(1+\frac{R_F}{R_G}\right)}{\Delta V_O}$$

$$SVR = 20\log \frac{\Delta V_S\left(1+\frac{R_F}{R_G}\right)}{\Delta V_O}$$

$V_S = V^+ - V^-$

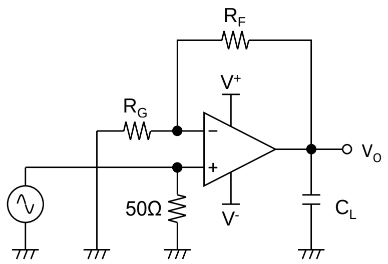
- V_{OH}, V_{OL}

$V^- = 0V$
V_{OH}; $V_{ID} = -1V$, $V_{COM} = V^+ / 2$
V_{OL}; $V_{ID} = 1V$, $V_{COM} = V^+ / 2$, V^-



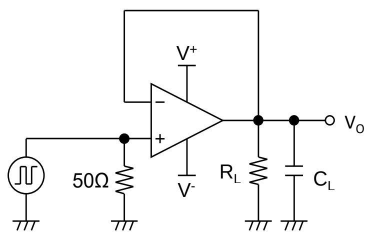
- GBW

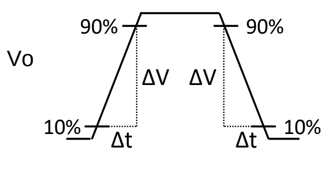
$R_G = 1k\Omega$, $R_F = 100k\Omega$



- SR

$R_L = 100k\Omega$





$$SR = \frac{\Delta V}{\Delta t}$$

■ APPLICATION NOTE

Single and Dual Supply Voltage Operation

The NJU7755x series works with both single supply and dual supply when the voltage supplied is between V^+ and V^-. These amplifiers operate from single 2.2V to 5.5V supply and dual 1.1V to ±2.75V supply. The power supply pin should have bypass capacitor (i.e. 0.1μF).

No Phase Reversal

The NJU7755x series are designed to prevent phase reversal at the input voltage above the supply voltage. Figure1 shows no phase reversal characteristics with the input voltage exceeding the supply voltage.

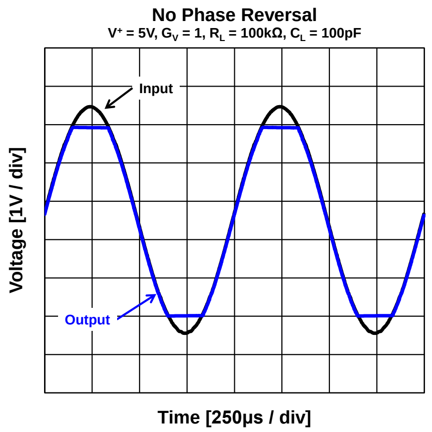


Figure1. No phase reversal

Power-on Time

The NJU7755x series typically require a power-on time of 20μs (Figure2). Power-on time depends on the supply voltage, bypass capacitor, impedance of supply source and impedance other devices. While settling time, IC is unstable, such as output voltage, input offset voltage and slew rate.

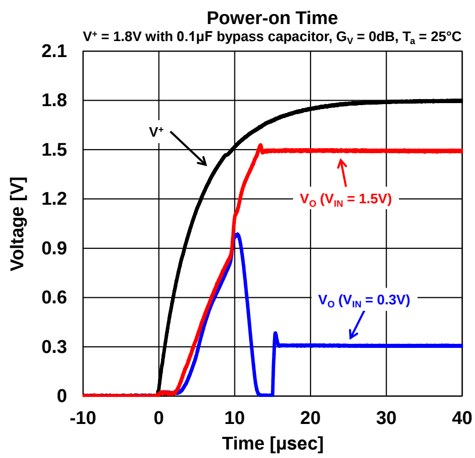


Figure2. Power on time

Rail-to-Rail Input

The input stage of NJU7755x series has two input differential pairs, PMOS and NMOS (Figure3). When the common- mode input voltage is from 200mV below the negative supply voltage to the typically (V^+) − 1.3V, the PMOS pair is active. When the common-mode input voltage close to the positive supply, typically (V^+) − 1.3V to 200mV above positive supply, the NMOS pair is active. In the transition region, the performance of offset voltage, as shown in figure4, offset voltage drift, CMR, SVR and THD is slightly degraded.

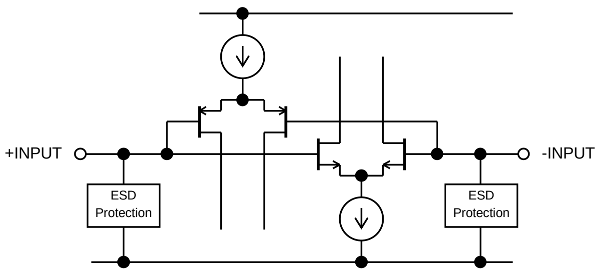


Figure3. Simplified Schematic of Input Stage

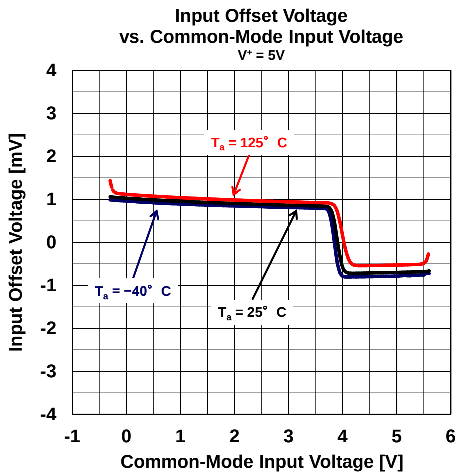


Figure4. Offset Voltage change with common-mode input voltage.

For the best performance design is inverting amplifier shown in Figure5. Inverting amplifier has a constant common-mode voltage equal to Vref. If Vref voltage is constant and is chosen to avoid transition region, output will be best linearity performance.

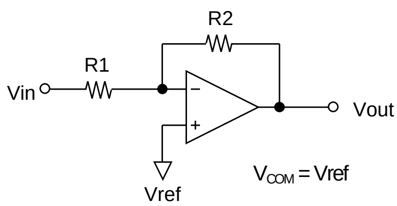


Figure5. Inverting Amplifier

■ APPLICATION NOTE

Input Tolerant

In general, common OpAmp is protected by internal ESD diode that is connected from input pin to both the positive and negative power supply. In a buffer configuration, when input exceeds either supply voltage, ESD diode will be forward biased and current. If the current is high enough, even when input current over long periods of time or even short periods of time, can shift the electrical characteristics beyond the data sheet's guaranteed limits, or cause a permanent failure of the op amp.
The input of the NJU7755x series has an ESD protection as shown in Figure 3. The input bias current is minimized in the input voltage even in operating voltage range and exceeding the V^+ supply, and the OpAmp is protected from overvoltage current (Figure6).
The maximum input voltage is absolute maximum rating of V^- + 7V, but usually recommend design so that the input voltage is up to V^- + 5.5V.

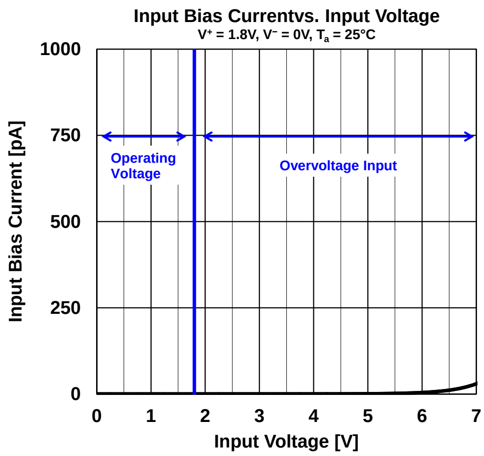
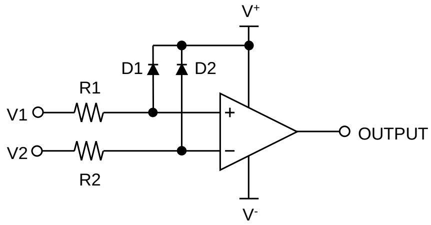


Figure6. Input bias current vs. input voltage

NJU7755x series protects the input pin from overvoltage by shunting the overvoltage current to the V^- supply rail.
When the input voltage for V^- − 0.3V to V^- + 7V, the ESD protection is not activate and minimize the input bias current (Figure6).
For the input voltage 300mV below the negative supply voltage, the ESD protection operates to protect the input terminal. At this moment, the current flowing in protection element is allowed up to 10 mA.
Momentary voltages above V^- + 7V, the ESD protection also activate, and clamp inputs, but cannot protect against overvoltage excepting ESD.

In some applications, it may be necessary to prevent excessive overvoltage. Figure6 is example to protect input transistors. The external resistors R1, R2 limit the current through external diodes D1, D2.



$$(R1, R2) > \frac{V^- - (V1, V2)}{10mA}$$

$$(R1, R2) > \frac{(V1,\ V2) - V^+}{I_F}$$

I_F: Forward current of external diode.

Figure7. Example of input protection

Power Supply Protection for Overvoltage Condition

In general, many power supplies cannot sink current. If nothing within the circuit can sink the overvoltage current, if the overvoltage occurs with the supplies powered on, in the ESD diode protection OpAmp, the supply voltage can exceed the intended operating voltage of the system. Even if the overvoltage occurs with the system powered off, the overvoltage current can unintentionally power up the OpAmp or system. NJU7755x series prevents the positive overvoltage current flowing from input pin to positive supply pin, prevents rising the supply voltage, and prevents malfunctioning with OpAmp or system. Figure8 shows the output voltage when applying 5V peak to peak overvoltage to the input pin when the power supply V^+ is 0V, 3V. Due to the input tolerant, the output voltage is clamped at V^+ (0V, 3V).

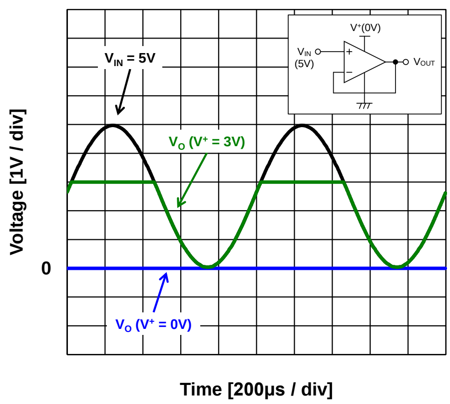


Figure8. Output voltage with overvoltage application

■ APPLICATION NOTE

Power Supply Protection for Overvoltage Condition (Continues)

Input tolerant can be applied to the input buffer of the ADC (Figure9).

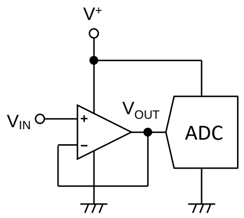


Figure9. ADC buffer with input tolerant

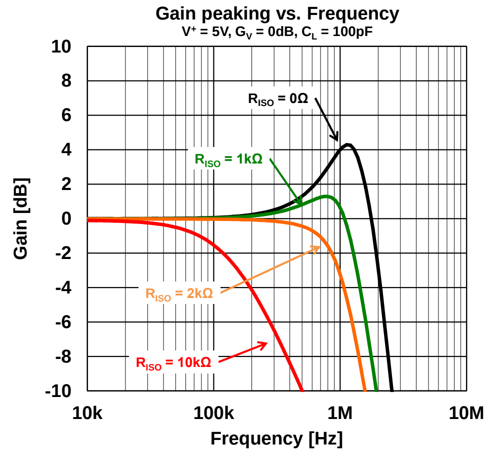


Figure11.Gain peaking with R_{ISO}

Capacitive Load

The NJU7755x series can use at unity gain follower, but the unity gain follower is the most sensitive configuration to capacitive loading. The combination of capacitive load placed directly on the output of an amplifier along with the output impedance of the amplifier creates a phase lag which in turn reduces the phase margin of the amplifier.
If phase margin is significantly reduced, the response will cause overshoot and ringing in the step response.
The NJU7755x series is unity gain stable for capacitive loads of 100pF. To drive heavier capacitive loads, an isolation resistor, R_{ISO} as shown Figure10, should be used. R_{ISO} improves the feedback loop's phase margin by making the output load resistive at higher frequencies. The larger the value of R_{ISO}, the more stable the output voltage will be. However, larger values of R_{ISO} result in reduced output swing, reduced output current drive and reduced frequency bandwidth (Figure11).

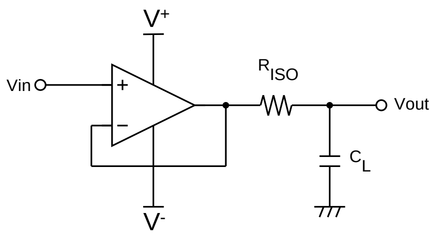
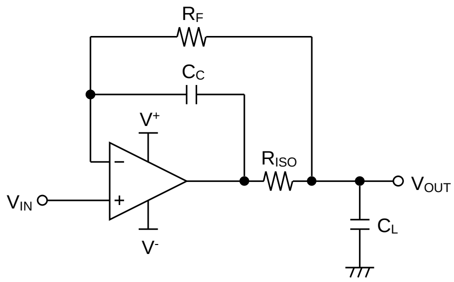


Figure10. Isolating capacitive load

Figure12 shows the isolation circuit with R_{ISO}, R_F and C_C. Minimize the effect of voltage drop due to R_{ISO} and output current.



$$10R_{ISO}C_L < R_FC_C$$

R_{ISO} is more than 300Ω

Figure12. Isolating capacitive load with R_{ISO}, R_F and C_C

Terminating unused OpAmps

Examples of common methods of terminating an uncommitted OpAmp are shown in Figure13. Improper termination can be result increase supply current, heating and noise in OpAmps.

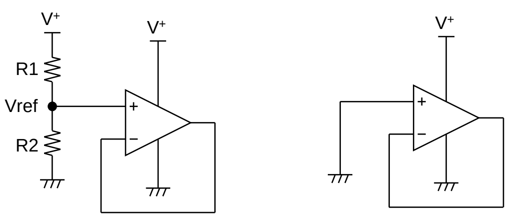
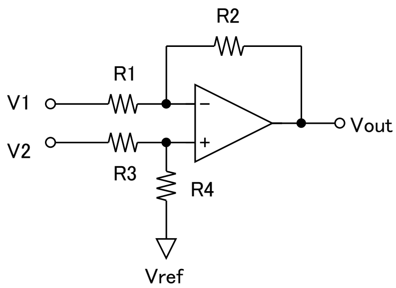


Figure13. Terminating unused OpAmps

■ APPLICATION NOTE

Differential Amplifier

Figure14 shows a one OpAmp differential amplifier that consists of the single OpAmp and four external resistors. Differential amplifier amplifies the difference between its two input pins, and rejects the common- mode input voltage at both input pins. This is used in variety of applications including current sensing, differential to single-end converter, isolation amplifier to remove common-mode noise.



$$Vout=\left(\frac{R1+R2}{R3+R4}\right)\frac{R4}{R1}V2-\frac{R2}{R1}V1+\left(\frac{R1+R2}{R3+R4}\right)\frac{R3}{R1}Vref$$

R1=R3, R2=R4

$$Vout=\frac{R2}{R1}(V2\text{-}V1)+Vref$$

Figure14. Differential Amplifier

The differential amplifier's common-mode rejection ratio (CMR) is primarily determined by resistor mismatches, not by the OpAmp's CMR. Ideally, the resistors are chosen such that R2/R1 = R4/R3. The CMR due to the resistors in differential amplifier can be calculated using the below formula:

$$CMR_{R\_error} \approx 20\log\left(\frac{1+\frac{R2}{R1}}{4R_{error}}\right)$$

CMR_{R_error} = CMR due only to the resistors

R_{error} = Resistor's tolerance

Example:

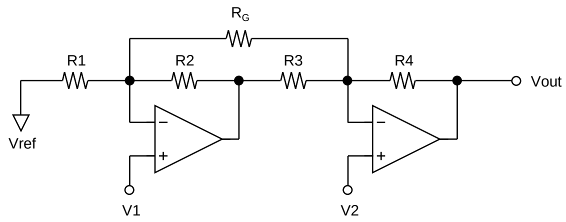
R2 / R1 = 1 and R_{error} = 0.1%, then CMR = 54dB

R2 / R1 = 1 and R_{error} = 1%, then CMR = 34dB

If using resistors with 1% tolerance and gain = 1, the CMR will only be 34dB.

Instrumentation Amplifier

The instrumentation amplifier is suitable for requiring high input impedance and high common mode noise rejection at high gains. Figure15 and Figure16 is instrumentation amplifier using two or three OpAmp. Supply the reference voltage (Vref) with a low impedance source to keep accuracy.

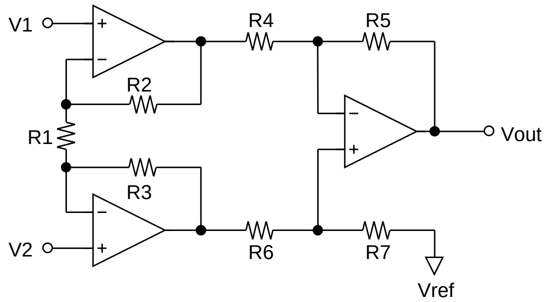


$$Vout=\left(1+\frac{R4}{R3}+\frac{2R4}{R_G}\right)(V2\text{-}V1)+Vref$$

R1=R4, R2=R3

$$CMR_{R\_error} \approx 20\log\left(\frac{1+\frac{R4}{R3}+\frac{2R4}{R_G}}{4R_{error}}\right)$$

Figure15. Instrumentation Amplifier with two OpAmp



$$Vout=\left(1+\frac{2R2}{R1}\right)\left(\frac{R5}{R4}\right)(V_2\text{-}V_1)+Vref$$

R2=R3, R4=R6, R5=R7

$$CMR_{R\_error} \approx 20\log\left(\frac{R1+2R2}{R1}\times\frac{1+\frac{R5}{R4}}{4R_{error}}\right)$$

Figure16. Instrumentation Amplifier with three OpAmp

■ APPLICATION NOTE

Current Sensing

Current sensing applications are one such application in a wide range of electronic applications and mostly used for feedback control systems, including power metering battery life indicators and chargers, over- current protection and supervising circuit, automotive, and medical equipment. In such applications, it is desirable to use a shunt with very low resistance to minimize the series voltage drop and minimizes wasted power, and allows the measurement of high current. The NJU7755x series is ideal for these current sensing applications.
Figure17 shows a high-side current sensing circuit, and Figure18 shows a low-side current sensing circuit. The NJU7755x series has rail-to-rail input and output characteristics, thus allows the both of high-side and low-side current sensing circuit. Futuremore, low supply current of 50µA/ch can save the power at battery applications.
The current detection circuit uses a differential amplifier consisting of an OpAmp and resistors R1/R2/R3/R4. The differential amplifier's common-mode rejection ratio (CMR) is primarily determined by resistor mismatches. For details, refer to differential amplifiers in the application note.

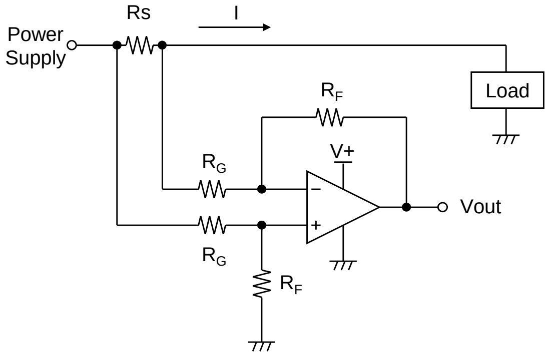


Figure17. High-Side Current Sensing

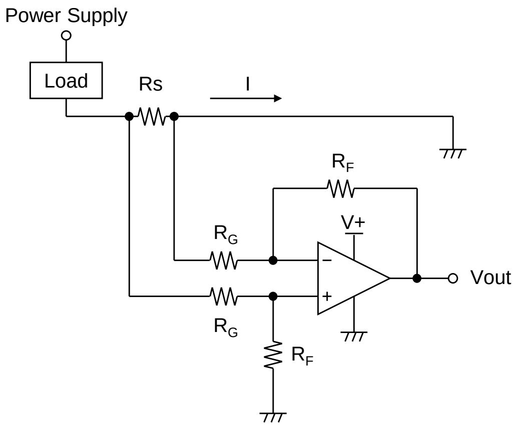
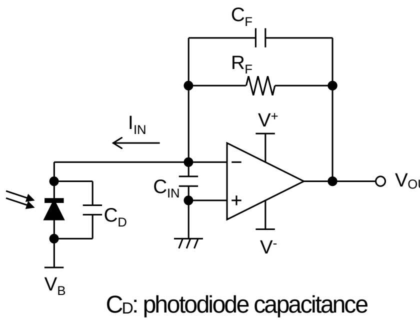


Figure18. Low-Side Current Sensing

Transimpedance Amplifier

The features high input impedance with CMOS input and low power can be used for transimpedance amplifier applications shown in Figure19. The output voltage of amplifier is given by the equation $V_{OUT} = I_{IN} \cdot R_F$. Since the output voltage swing of amplifier is limited, R_F should be selected such that all possible values of I_{IN} can be detected.



C_D: photodiode capacitance

C_{IN}: OpAmp input capacitance

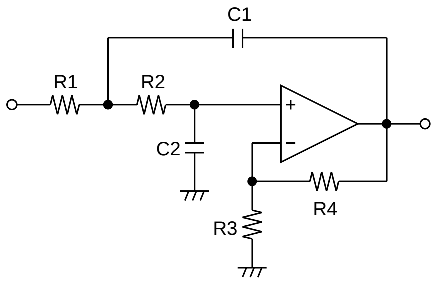
Figure19. Transimpedance amplifier

The C_D, C_{IN} and R_F generate a phase lag which causes gain-peaking and can destabilized circuit. The essential component for obtaining a maximally flat response is a feedback capacitor C_F. C_F is usually added in parallel with R_F to maintain circuit stability and to control the frequency response. To maximally flat, 2nd order response, R_F and C_F should be chosen by using below equation.

$$C_F=\sqrt{\frac{C_{IN}+C_D}{GBW\times 2\pi\times R_F}}$$

Sallen-Key 2nd-Order Active Low-Pass Filter

The Sallen-Key 2nd-order active low-pass filter is shown in Figure20. It can be used for a multiple pole filter required high attenuation.



$R=R1=R2$, $C=C1=C2$

Q: Quality factor , G_{DC}: DC Gain

$f_{-3dB}=\frac{1}{2\pi RC}$, $Q=\frac{1}{3-G_{DC}}$, $G_{DC}=1+\frac{R4}{R3}=3-\frac{1}{Q}$

Figure20. Sallen-Key 2nd-Order Low-Pass Filter

■ APPLICATION NOTE

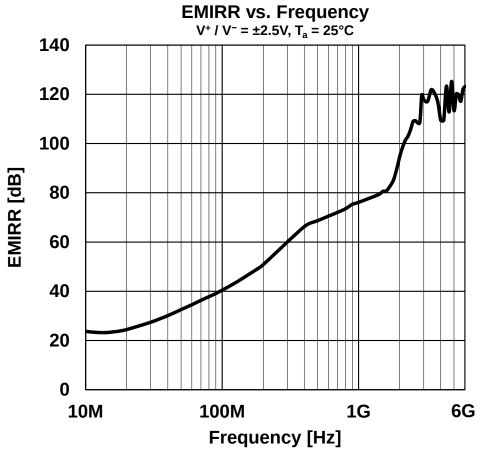
EMIRR (EMI Rejection Ratio) Definition

EMIRR is a parameter indicating the EMI robustness of an OpAmp. The definition of EMIRR is given by the following equation1.

$$EMIRR = 20 \cdot \log\left(\frac{V_{RF\_PEAK}}{|\Delta V_{IO}|}\right) \quad \text{--- eq.1}$$

V_{RF_PEAK}: RF Signal Amplitude [V_P]
ΔV_{IO}: Input offset voltage shift quantity [V]

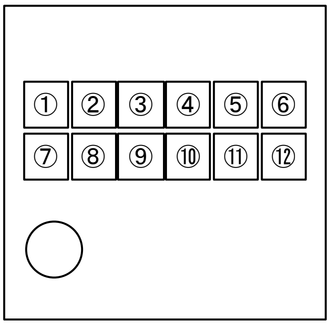
The tolerance of the RF signal can be grasped by measuring an RF signal and offset voltage shift quantity. Offset voltage shift is small so that a value of EMIRR is big. And it understands that the tolerance for the RF signal is high. In addition, about the input offset voltage shift with the RF signal, there is the thinking that influence applied to the input terminal is dominant. Therefore, generally the EMIRR becomes value that applied an RF signal to +INPUT terminal.



*For details, refer to “Application Note for EMI Immunity" in our HP.

■ MARKING SPECIFICATION (VSP-8-AF)

① to ⑨	Product Code	Refer to *Part Marking List*
⑩ to ⑫	Lot Number	Alphanumeric Serial Number



1Pin

NOTICE
There can be variation in the marking when different AOI (Automated Optical Inspection) equipment is used. In the case of recognizing the marking characteristic with AOI, please contact our sales or distributor before attempting to use AOI.

Part Marking List

Product Name	①	②	③	④	⑤	⑥	⑦	⑧	⑨
NJU77552RT1		7	7	5	5	2	T	1	

■ REVISION HISTORY

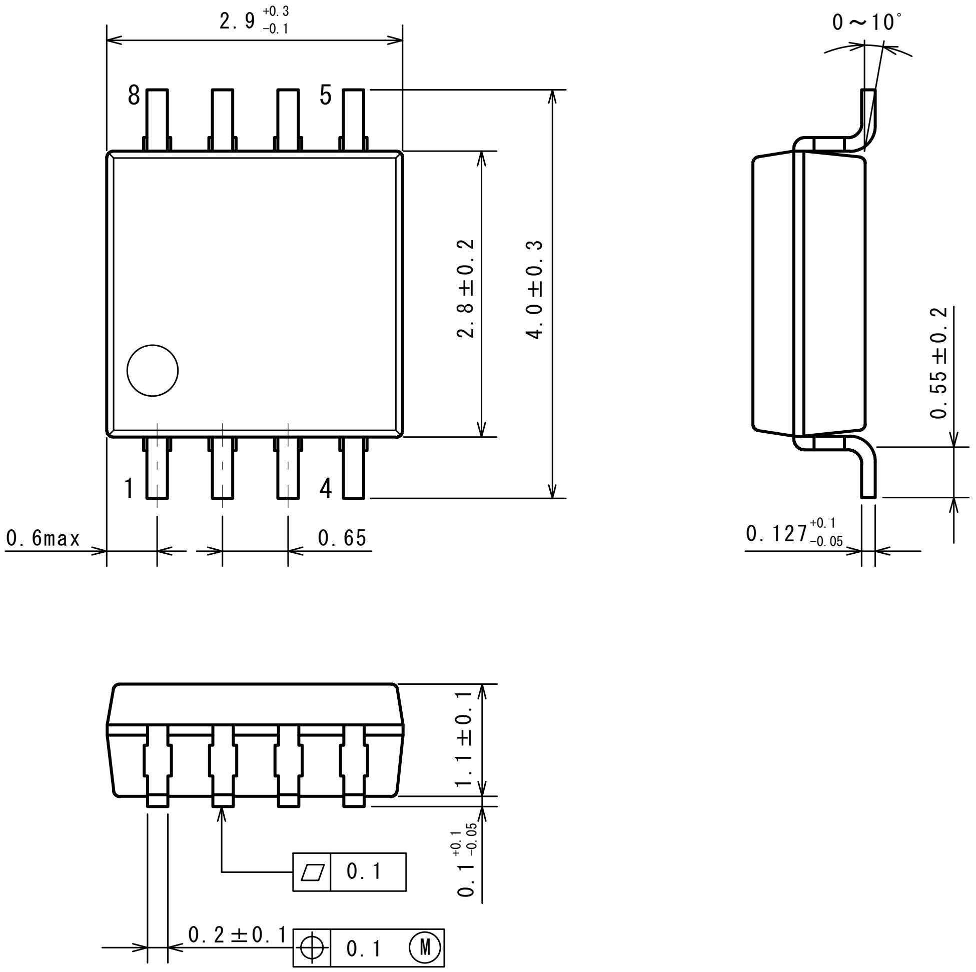
Date	Revision	Contents of Changes
November 8, 2022	Ver.1.0	Initial Release

Nisshinbo Micro Devices Inc.

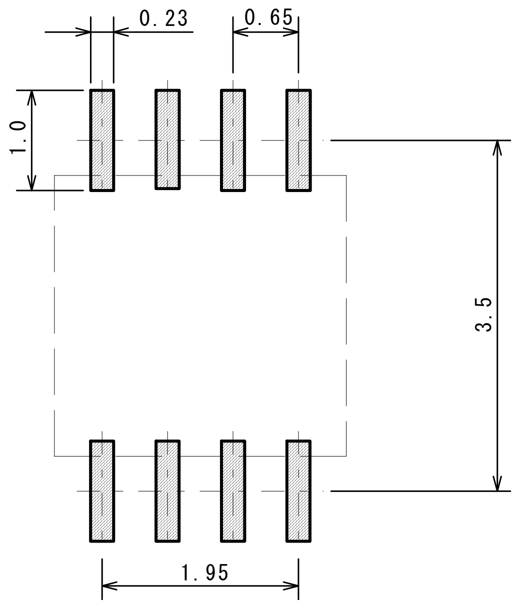
MSOP8 (VSP8)

■ PACKAGE DIMENSIONS

UNIT: mm



■ EXAMPLE OF SOLDER PADS DIMENSIONS



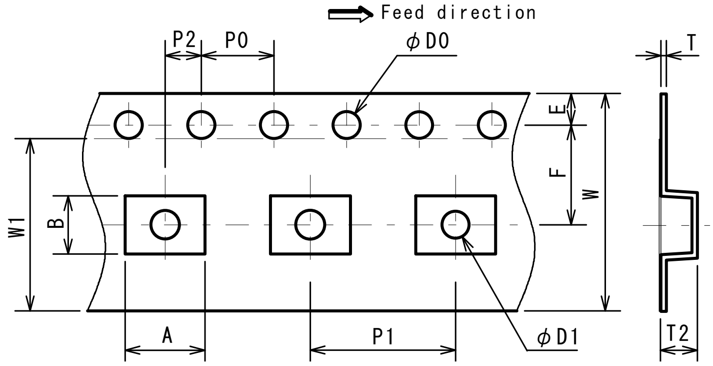
Nisshinbo Micro Devices Inc.

MSOP8 (VSP8)

■ PACKING SPEC

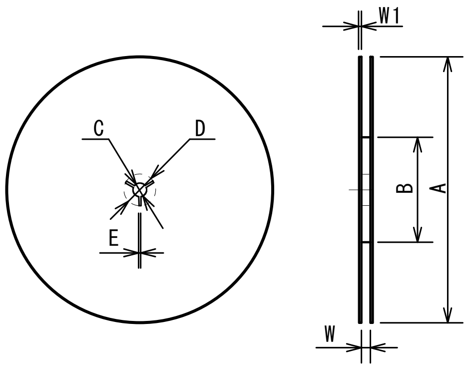
UNIT: mm

TAPING DIMENSIONS



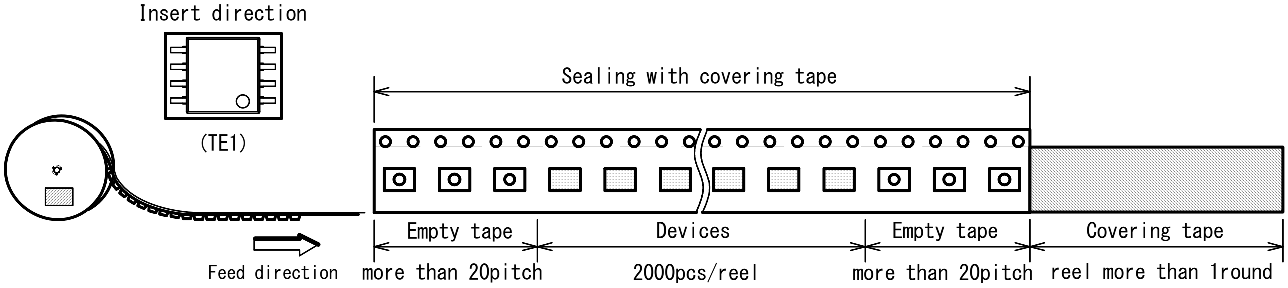
SYMBOL	DIMENSION	REMARKS
A	4.4	BOTTOM DIMENSION
B	3.2	BOTTOM DIMENSION
D0	$1.5^{+0.1}_{0}$	
D1	$1.5^{+0.1}_{0}$	
E	1.75±0.1	
F	5.5±0.05	
P0	4.0±0.1	
P1	8.0±0.1	
P2	2.0±0.05	
T	0.30±0.05	
T2	2.0 (MAX.)	
W	12.0±0.3	
W1	9.5	THICKNESS 0.1max

REEL DIMENSIONS

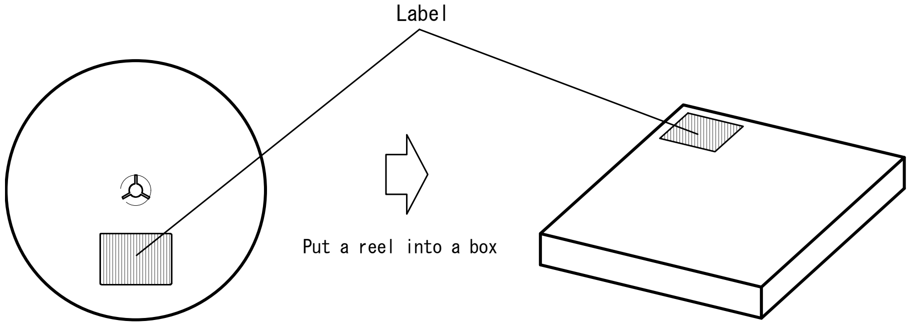


SYMBOL	DIMENSION
A	ϕ254±2
B	ϕ100±1
C	ϕ 13±0.2
D	ϕ 21±0.8
E	2±0.5
W	13.5±0.5
W1	2.0±0.2

TAPING STATE



PACKING STATE



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   - Equipment Used in the Deep Sea
   - Power Generator Control Equipment (nuclear, steam, hydraulic, etc.)
   - Life Maintenance Medical Equipment
   - Fire Alarms / Intruder Detectors
   - Vehicle Control Equipment (airplane, railroad, ship, etc.)
   - Various Safety Devices
   - Traffic control system
   - Combustion equipment

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   8-1. Quality Warranty Period

   In the case of a product purchased through an authorized distributor or directly from us, the warranty period for this product shall be one (1) year after delivery to your company. For defective products that occurred during this period, we will take the quality warranty measures described in section 8-2. However, if there is an agreement on the warranty period in the basic transaction agreement, quality assurance agreement, delivery specifications, etc., it shall be followed.

   8-2. Quality Warranty Remedies

   When it has been proved defective due to manufacturing factors as a result of defect analysis by us, we will either deliver a substitute for the defective product or refund the purchase price of the defective product.

   Note that such delivery or refund is sole and exclusive remedies to your company for the defective product.

   8-3. Remedies after Quality Warranty Period

   With respect to any defect of this product found after the quality warranty period, the defect will be analyzed by us. On the basis of the defect analysis results, the scope and amounts of damage shall be determined by mutual agreement of both parties. Then we will deal with upper limit in Section 8-2. This provision is not intended to limit any legal rights of your company.
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