PRECISION, LOW NOISE, RAIL-TO-RAIL OUTPUT, EXCELLENT EMI IMMUNITY, CMOS OPERATIONAL AMPLIFIERS

FEATURES

- High Precision
  - Low Input Offset Voltage 500µV max.
  - Low Offset Voltage Drift 0.5µV/°C typ.
- Low Noise 10nV/√Hz typ.
- Low Input Bias Current 1pA typ.
- Rail-to-Rail Output
  - R_L=10kΩ 0.02V to 4.98V typ. (V^+=5V)
  - R_L=600Ω 0.08V to 4.92V typ. (V^+=5V)
- Ground Sensing
- Integrated EMI Filter EMIRR=59dB typ. @f=900 MHz
- Operating Voltage 2.2V to 5.5V
- Unity-Gain Stable
- Package
  - NJU7066 MSOP8 (VSP8)*

*meet JEDEC MO-187-DA

DESCRIPTION

The NJU7066 is a dual channel, precision, low-noise, rail-to-rail output CMOS operational amplifiers.
The combination of these specifications makes the devices well-suited for sensor applications such as temperature sensors, weight sensors, high-precision current sensing amplifiers, and current-voltage converters.

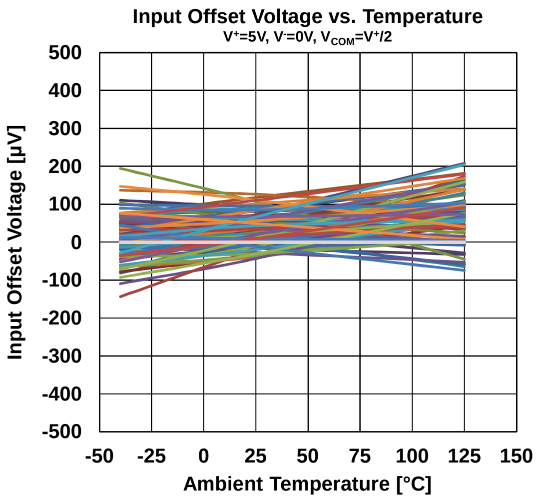
The output swing can reach 20 mV from the rails while driving a 10kΩ load (at 5V operation). Input voltage includes ground, enabling direct sensing near ground.

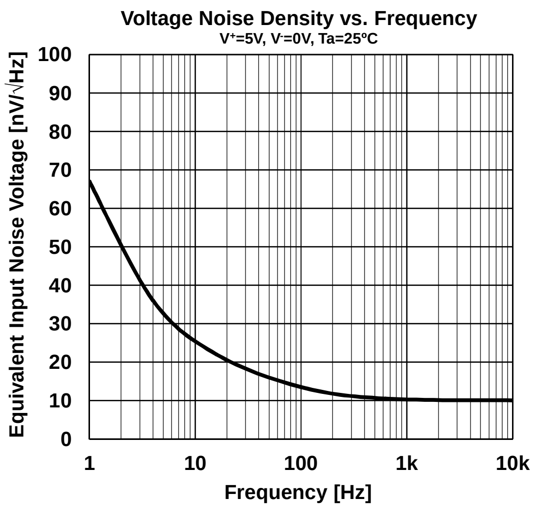
The NJU7066 have high EMI immunity to reduce malfunctions, making them ideal for EMI-sensitive applications.

APPLICATIONS

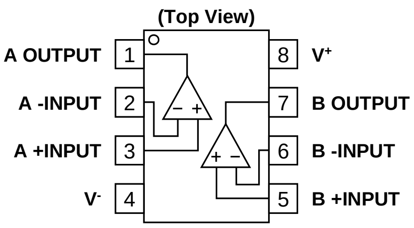
- Thermocouple / Thermopile Amplifiers
- Strain Gauge / Pressure Sensor Amplifiers
- Load Cell and Bridge Transducer Amplifiers
- High-Resolution Data Acquisition
- Precision Current Sensing
- Battery Monitoring
- Photodiode Amplifiers

■ TYPICAL CHARACTERISTICS





■ PIN CONFIGURATIONS

PRODUCT NAME	NJU7077R
Package	MSOP8 (VSP8)
Pin Functions	

■ PRODUCT NAME INFORMATION

NJU7066 R (TE1)

Part Number Package Taping Form

■ ORDER INFORMATION

PRODUCT NAME	PACKAGE	RoHS	HALOGEN-FREE	TERMINAL FINISH	MARKING	WEIGHT (mg)	MOQ (pcs)
NJU7066R	VSP8	**Yes**	**Yes**	Sn2Bi	7066	21	2000

■ ABSOLUTE MAXIMUM RATINGS

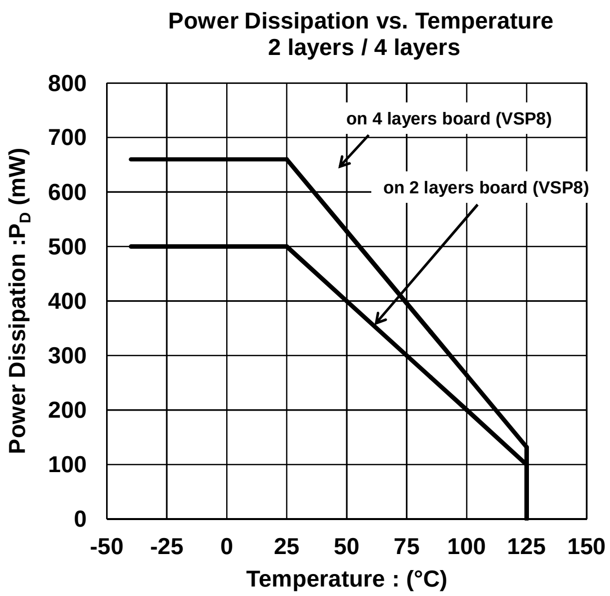
PARAMETER	SYMBOL	RATING	UNIT
Supply Voltage	$V^+ - V^-$	7	V
Differential Input Voltage(1)	V_{ID}	±7(2)	V
Input Voltage	V_{IN}	V^--0.3 to V^++0.3(3)	V
Power Dissipation (Ta=25°C) MSOP8 (VSP8)	P_D	2-Layer / 4-Layer(4) 500 / 660	mW
Storage Temperature Range	T_{stg}	-55 to 150	°C
Maximum Junction Temperature	T_{jmax}	150	°C

■ THERMAL CHARACTERISTICS

PACKAGE	SYMBOL	値	UNIT
Junction-to-Ambient Thermal Resistance VSP8	Θja	2-Layer / 4-Layer(4) 250 / 189	ºC/W
Junction-to-Top of Package Characterization Parameter VSP8	Ψjt	2-Layer / 4-Layer(4) 62 / 53	ºC/W

(1) Differential voltage is the voltage difference between +INPUT and -INPUT.
(2) For supply voltage less than 7V, the absolute maximum rating is equal to the supply voltage.
(3) The absolute maximum input voltage is limited at 7V.
(4) 2-Layer: Mounted on glass epoxy board. (76.2×114.3×1.6 mm: based on EIA/JDEC standard, 2-layer FR-4)
4-Layer: Mounted on glass epoxy board. (76.2×114.3×1.6 mm: based on EIA/JDEC standard, 4-layer FR-4), internal Cu area: 74.2 x 74.2 mm

■POWER DISSIPATION vs. AMBIENT TEMPERATURE



■ RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	CONDITIONS	VALUE	UNIT
Supply Voltage	$V^+ - V^-$	Ta=25˚C	2.2 to 5.5	V
Operating Temperature Range	T_{opr}		-40 to 125	°C

■ **ELECTRICAL CHARACTERISTICS** (V^+=5V, V^-=0V, V_{COM}=V^+/2, Ta=25˚C, unless otherwise noted.)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC CHARACTERISTICS						
Input Offset Voltage	V_{IO}		-	20	500	µV
		Ta=-40°C to 125°C	-	-	800	
Input Offset Voltage Drift	$\Delta V_{IO}/\Delta T$	Ta=-40°C to 125°C (5)	-	0.5	10	µV/°C
Input Bias Current	I_B		-	1	-	pA
Input Offset Current	I_{IO}		-	1	-	pA
Open-Loop Voltage Gain	A_V	Vo=0.5V to 4.5V, R_L=10kΩ to 2.5V	100	130	-	dB
		Vo=0.5V to 4.5V, R_L=10kΩ to 2.5V, Ta= -40°C to 125°C	100	-	-	
Common-Mode Rejection Ratio	CMR	V_{ICM}=0V to 4V	70	90	-	dB
		V_{ICM}=0V to 4V, Ta= -40°C to 125°C	70	-	-	
Supply Voltage Rejection Ratio	SVR	V^+=2.2V to 5.5V	70	90	-	dB
		V^+=2.2V to 5.5V, Ta= -40°C to 125°C	70	-	-	
High-level Output Voltage	V_{OH}	R_L=10kΩ to 2.5V	4.95	4.98	-	V
		R_L=10kΩ to 2.5V, Ta= -40°C to 125°C	4.95	-	-	
		R_L=600Ω to 2.5V	4.85	4.92	-	
		R_L=600Ω to 2.5V, Ta= -40°C to 125°C	4.85	-	-	
		I_{SOURCE}=2mA	4.9	4.96	-	
		I_{SOURCE} =2mA, Ta= -40°C to 125°C	4.85	-	-	
Low-level Output Voltage	V_{OL}	R_L=10kΩ to 2.5V	-	0.02	0.05	V
		R_L=10kΩ to 2.5V, Ta= -40°C to 125°C	-	-	0.05	
		R_L=600Ω to 2.5V	-	0.08	0.15	
		R_L=600Ω to 2.5V, Ta= -40°C to 125°C	-	-	0.2	
		I_{SINK}=2mA	-	0.04	0.1	
		I_{SINK}=2mA, Ta= -40°C to 125°C	-	-	0.15	
Common-Mode Input Voltage Range	V_{ICM}	CMR≥70dB	0	-	4	V
		CMR≥70dB, Ta= -40°C to 125°C	0	-	4	
Supply Current (All Amplifiers)	I_{SUPPLY}	No Signal	-	1.2	1.8	mA
		No Signal, Ta = -40°C to 125°C	-	-	1.8	
AC CHARACTERISTICS						
Gain Bandwidth Product	GBW	G_V=40dB, R_F=100kΩ, R_L=10kΩ to 2.5V, C_L=20pF, f=100kHz	-	1.3	-	MHz
Phase Margin	Φ_m	G_V=40dB, R_F=100kΩ, R_L=10kΩ to 2.5V, C_L=20pF	-	60	-	deg
Gain Margin	G_m	G_V=40dB, R_F=100kΩ, R_L=10kΩ to 2.5V, C_L=20pF	-	12	-	dB
Equivalent Input Noise Voltage	e_n	f=1kHz	-	10	-	nV/√Hz
Slew Rate	SR	G_V=0dB, R_L=10kΩ to 2.5V, C_L=20pF, V_{IN}=3V_{PP}	-	0.5	-	V/µs
Total Harmonic Distortion + Noise	THD+N	G_V=20dB, R_L=10kΩ to 2.5V, f=1kHz, V_O=3V_{PP}	-	0.01	-	%
Channel Separation	CS	f=1kHz	-	140	-	dB

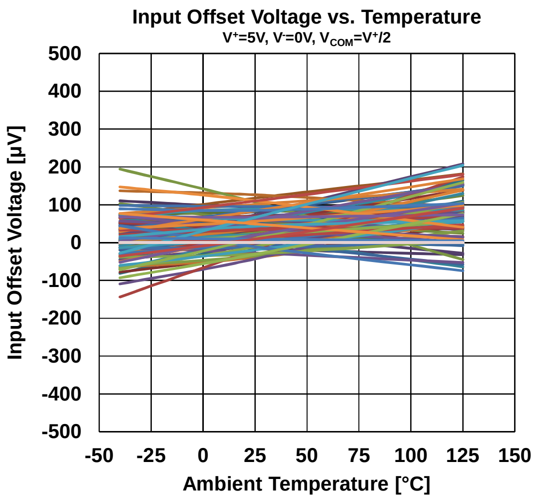
(5) Guaranteed by two points of Temperature -40˚C and 125˚C

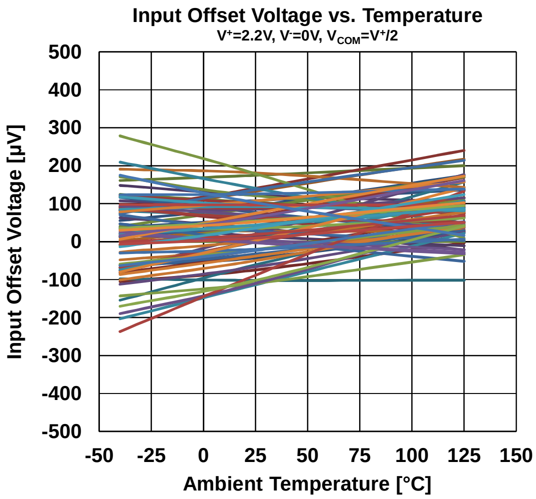
■ **ELECTRICAL CHARACTERISTICS** (V^+=2.2V, V^-=0V, V_{COM}=V^+/2, Ta=25˚C, unless otherwise noted.)

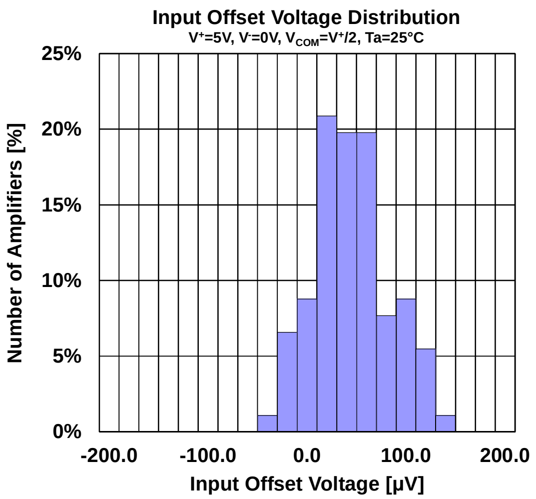
PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC CHARACTERISTICS						
Input Offset Voltage	V_{IO}		-	60	600	µV
		Ta= -40°C to 125°C	-	-	900	
Input Offset Voltage Drift	$\Delta V_{IO}/\Delta T$	Ta= -40°C to 125°C (5)	-	0.6	10	µV/°C
Input Bias Current	I_B		-	1	-	pA
Input Offset Current	I_{IO}		-	1	-	pA
Open-Loop Voltage Gain	A_V	Vo=0.6V to 1.6V, R_L=10kΩ to 1.1V	100	130	-	dB
		Vo=0.6V to 1.6V, R_L=10kΩ to 1.1V, Ta= -40°C to 125°C	100	-	-	
Common-Mode Rejection Ratio	CMR	V_{ICM}=0V to 1.2V	70	90	-	dB
		V_{ICM}=0V to 1.2V, Ta= -40°C to 125°C	70	-	-	
High-level Output Voltage	V_{OH}	R_L=10kΩ to 1.1V	2.15	2.18	-	V
		R_L=10kΩ to 1.1V, Ta= -40°C to 125°C	2.15	-	-	
		R_L=600Ω to 1.1V	2.1	2.14	-	
		R_L=600Ω to 1.1V, Ta= -40°C to 125°C	2.05	-	-	
		I_{SOURCE}=2mA	2.05	2.13	-	
		I_{SOURCE}=2mA, Ta= -40°C to 125°C	2	-	-	
Low-level Output Voltage	V_{OL}	R_L=10kΩ to 1.1V	-	0.02	0.05	V
		R_L=10kΩ to 1.1V, Ta= -40°C to 125°C	-	-	0.05	
		R_L=600Ω to 1.1V	-	0.06	0.1	
		R_L=600Ω to 1.1V, Ta= -40°C to 125°C	-	-	0.15	
		I_{SINK}=2mA	-	0.07	0.15	
		I_{SINK}=2mA, Ta= -40°C to 125°C	-	-	0.2	
Common-Mode Input Voltage Range	V_{ICM}	CMR≥70dB	0	-	1.2	V
		CMR≥70dB, Ta= -40°C to 125°C	0	-	1.2	
Supply Current (All Amplifiers)	I_{SUPPLY}	No Signal	-	1.0	1.5	mA
		No Signal, Ta = -40°C to 125°C	-	-	1.5	
AC CHARACTERISTICS						
Gain Bandwidth Product	GBW	G_V=40dB, R_F=100kΩ, R_L=10kΩ to 1.1V, C_L=20pF, f=100kHz	-	1.2	-	MHz
Phase Margin	Φ_m	G_V=40dB, R_F=100kΩ, R_L=10kΩ to 1.1V, C_L=20pF	-	60	-	deg
Gain Margin	G_m	G_V=40dB, R_F=100kΩ, R_L=10kΩ to 1.1V, C_L=20pF	-	12	-	dB
Equivalent Input Noise Voltage	e_n	f=1kHz	-	10	-	nV/√Hz
Slew Rate	SR	G_V=0dB, R_L=10kΩ to 1.1V, C_L=20pF, V_{IN}=1V_{PP}	-	0.5	-	V/µs
Total Harmonic Distortion + Noise	THD+N	G_V=20dB, R_L=10kΩ to 1.1V, f=1kHz, V_O=1V_{PP}	-	0.01	-	%
Channel Separation	CS	f=1kHz	-	140	-	dB

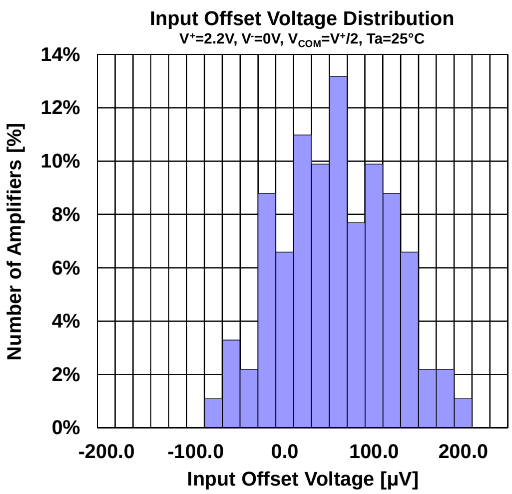
(5) Guaranteed by two points of Temperature -40˚C and 125˚C

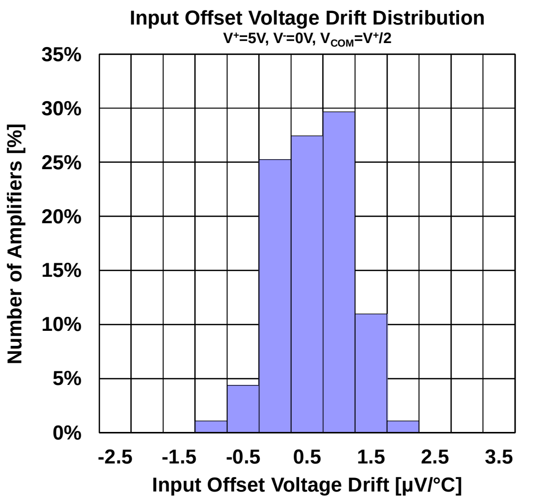
■ TYPICAL CHARACTERISTICS

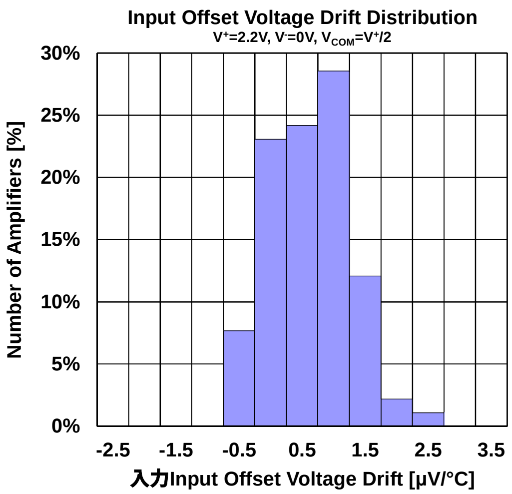






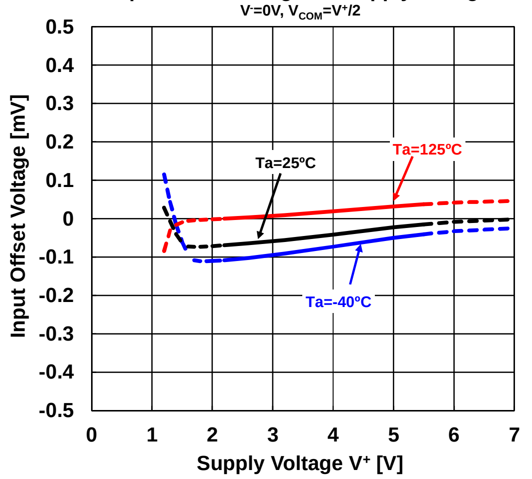




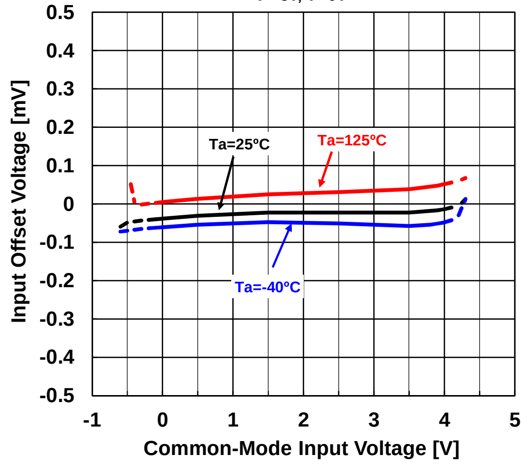


■ TYPICAL CHARACTERISTICS

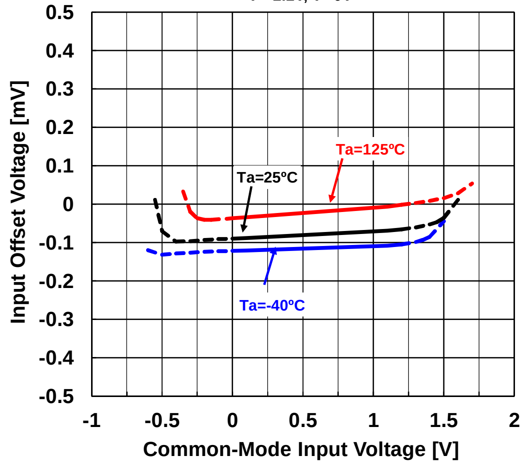
Input Offset Voltage vs. Supply Voltage
V⁻=0V, V_{COM}=V⁺/2



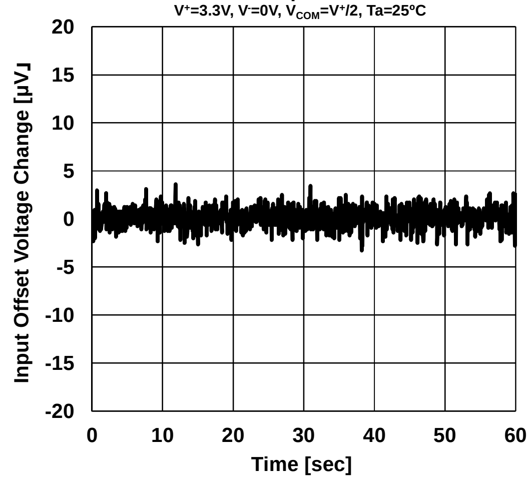
Input Offset Voltage
vs. Common-Mode Input Voltage
V⁺=5V, V⁻=0V



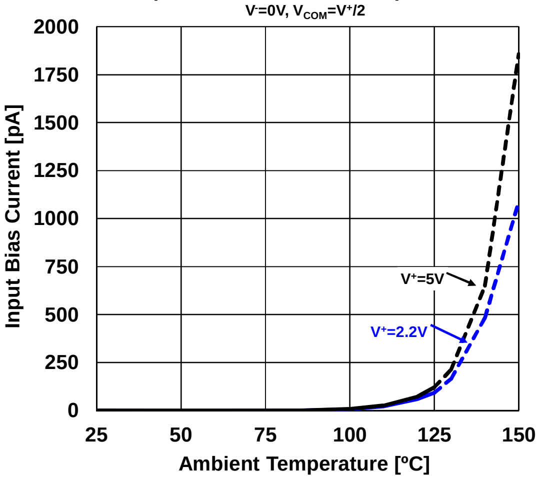
Input Offset Voltage
vs. Common-Mode Input Voltage
V⁺=2.2V, V⁻=0V



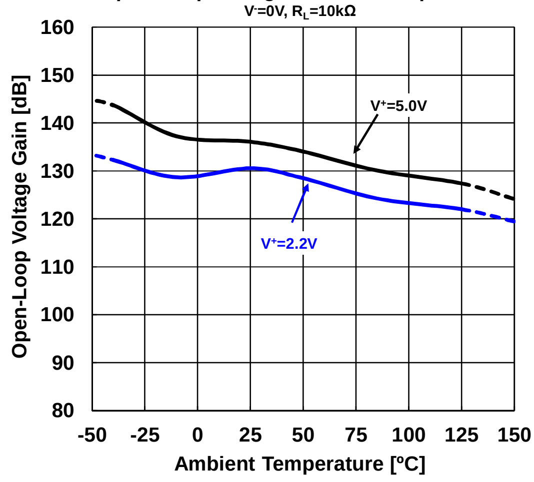
Warm-Up Vio Drift
V⁺=3.3V, V⁻=0V, V_{COM}=V⁺/2, Ta=25ºC



Input Bias Current vs. Temperature
V⁻=0V, V_{COM}=V⁺/2

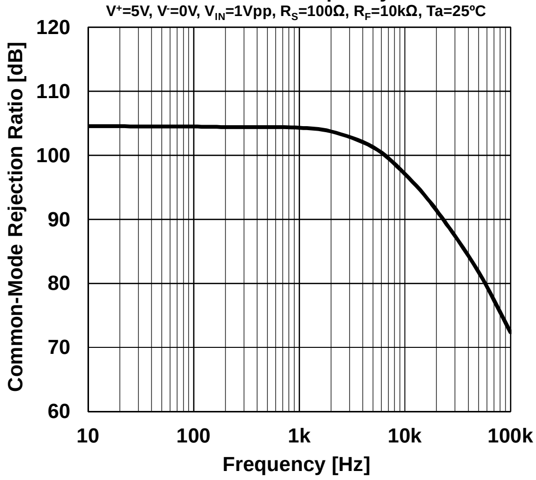


Open-Loop Voltage Gain vs. Temperature
V⁻=0V, R_L=10kΩ

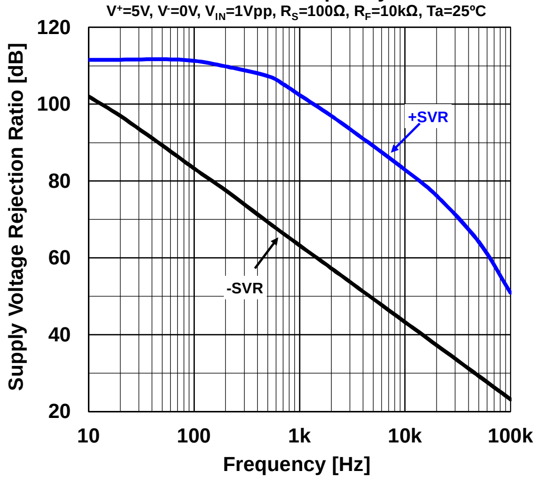


■ TYPICAL CHARACTERISTICS

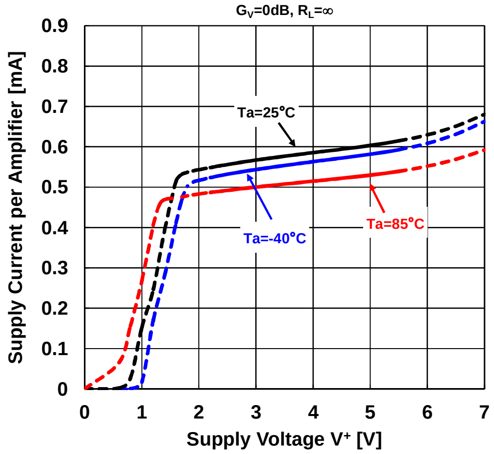
CMR vs. Frequency
V^+=5V, V^-=0V, V_{IN}=1Vpp, R_S=100Ω, R_F=10kΩ, Ta=25ºC



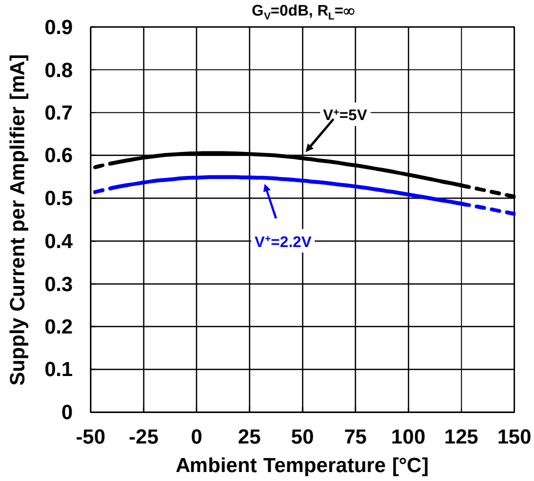
SVR vs. Frequency
V^+=5V, V^-=0V, V_{IN}=1Vpp, R_S=100Ω, R_F=10kΩ, Ta=25ºC



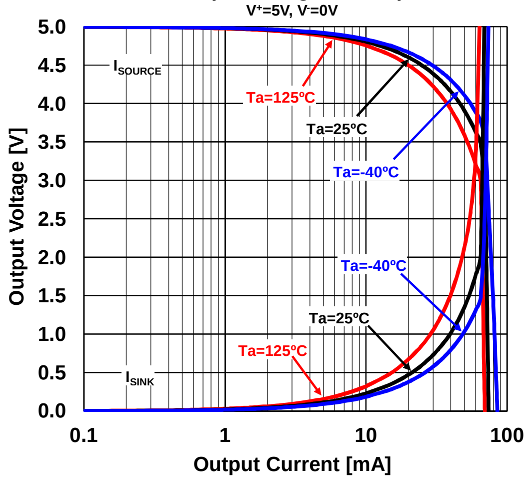
Supply Current per Amplifier vs. Supply Voltage
G_V=0dB, R_L=∞



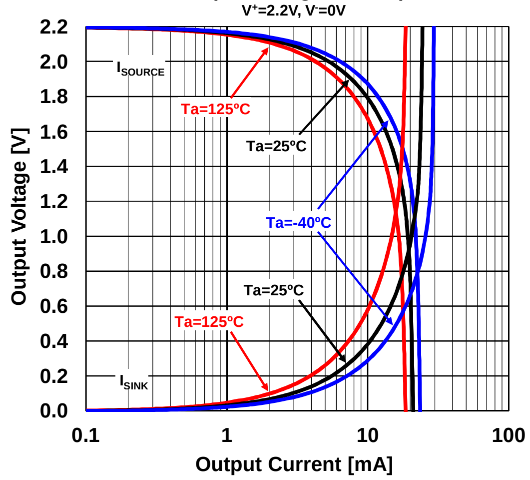
Supply Current per Amplifier vs. Temperature
G_V=0dB, R_L=∞



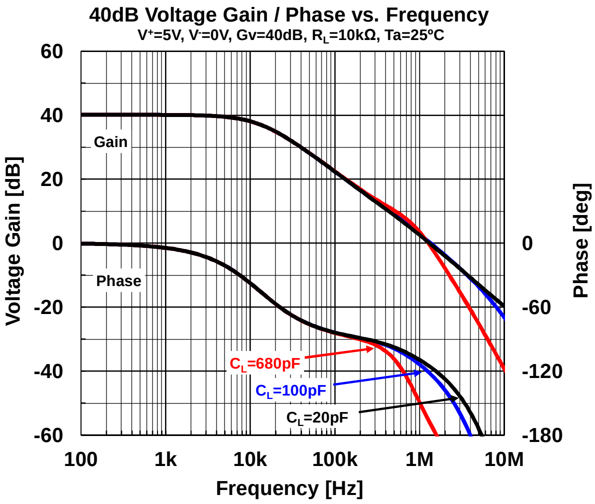
Maximum Output Voltage vs. Output Current
V^+=5V, V^-=0V

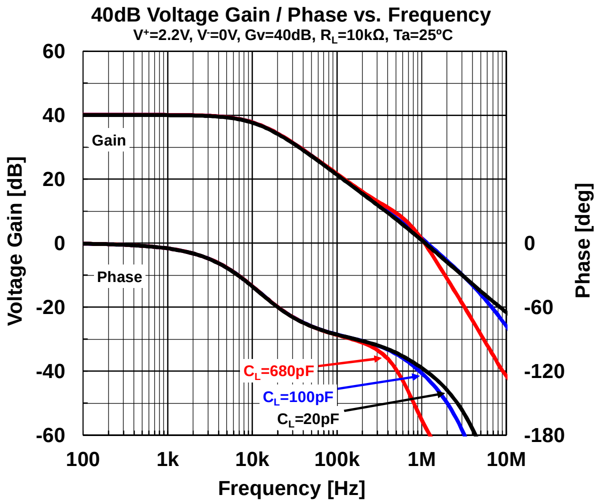


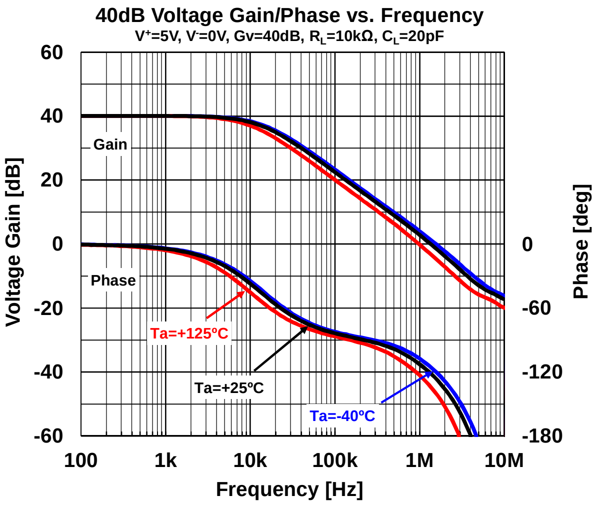
Maximum Output Voltage vs. Output Current
V^+=2.2V, V^-=0V

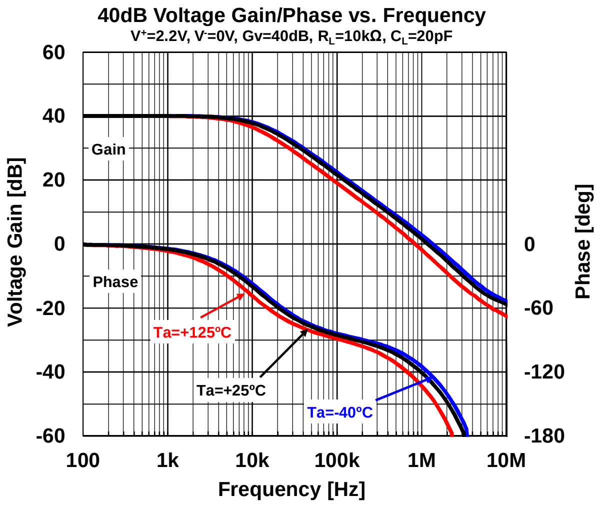


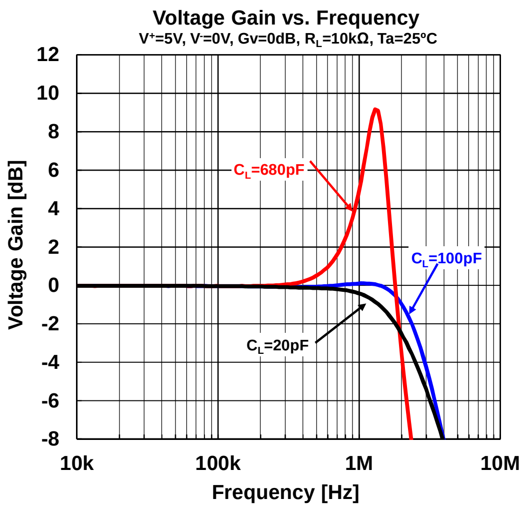
■ TYPICAL CHARACTERISTICS

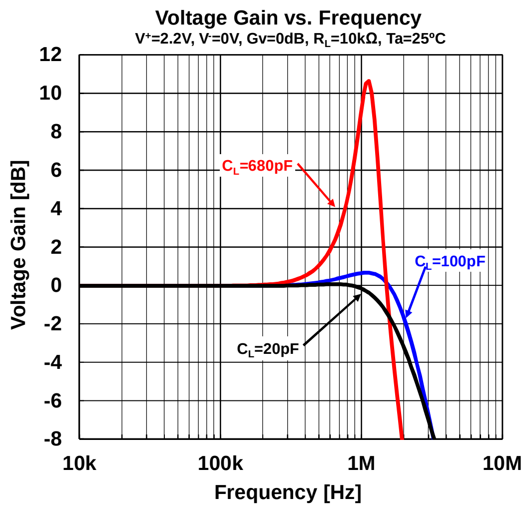






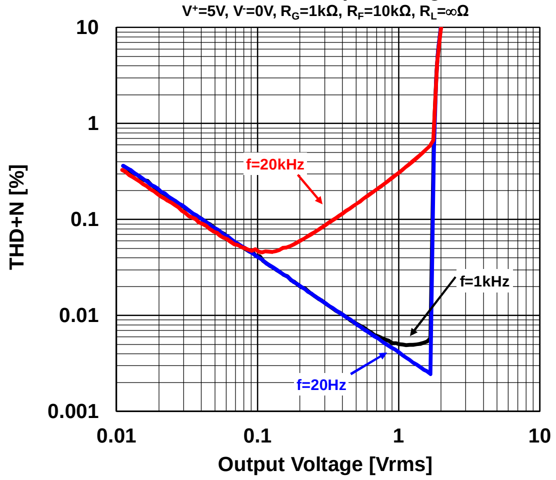




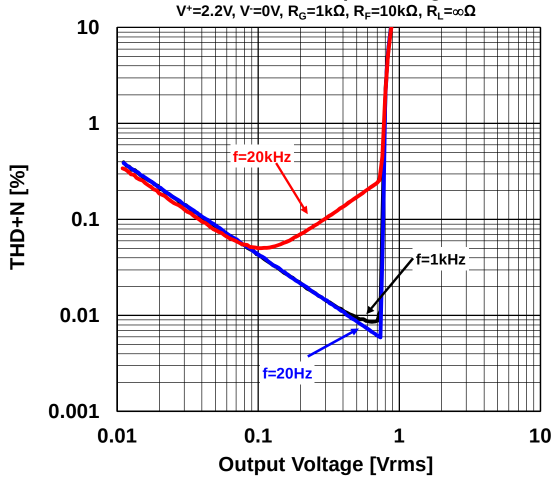


■ TYPICAL CHARACTERISTICS

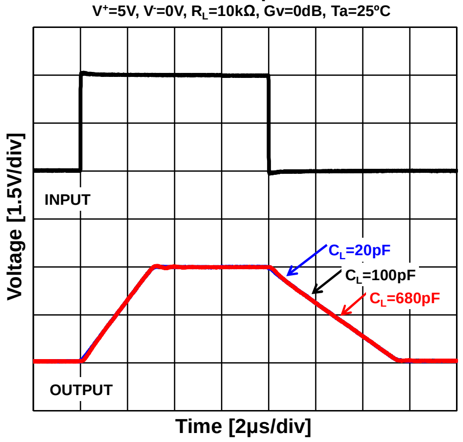
THD+N vs. Output Voltage
V^+=5V, V^-=0V, R_G=1kΩ, R_F=10kΩ, R_L=∞Ω



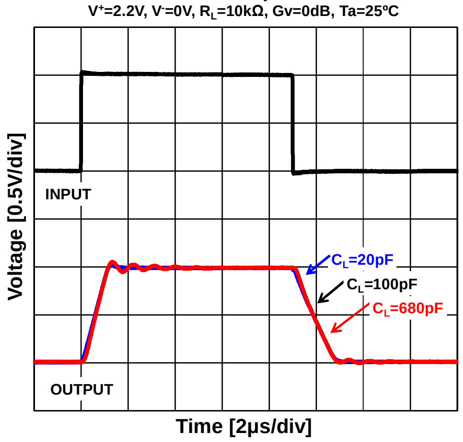
THD+N vs. Output Voltage
V^+=2.2V, V^-=0V, R_G=1kΩ, R_F=10kΩ, R_L=∞Ω



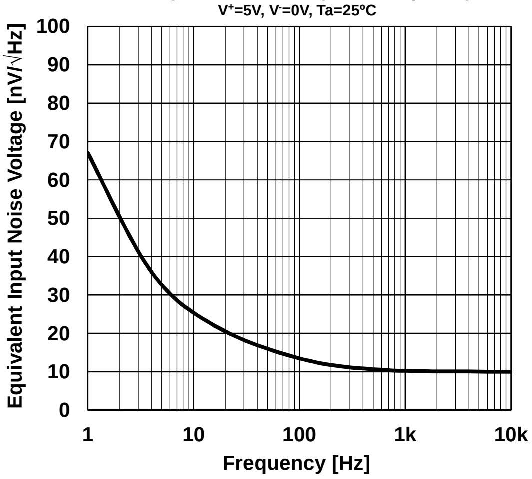
Pulse Response
V^+=5V, V^-=0V, R_L=10kΩ, Gv=0dB, Ta=25ºC



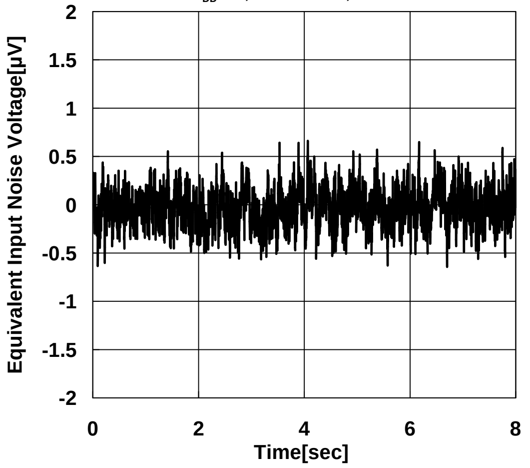
Pulse Response
V^+=2.2V, V^-=0V, R_L=10kΩ, Gv=0dB, Ta=25ºC



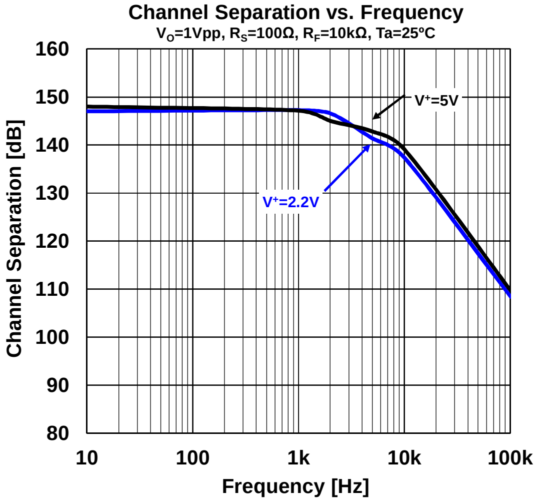
Voltage Noise Density vs. Frequency
V^+=5V, V^-=0V, Ta=25ºC



Equivalent Input Voltage Noise
V_{DD}=5V, BP=1~100Hz,Ta=25ºC

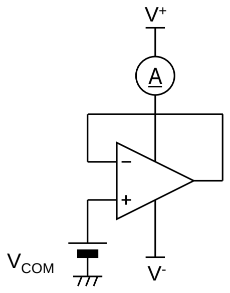


■ TYPICAL CHARACTERISTICS



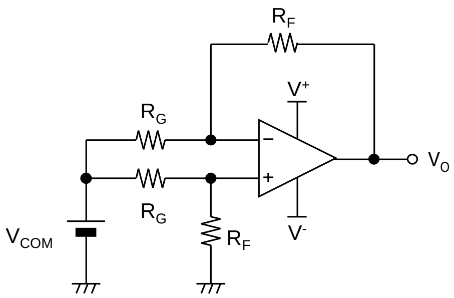
■ TEST CIRCUITS

● I_{SUPPLY}



● V_{IO}, CMR, SVR

R_G=50Ω, R_F=50kΩ



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

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

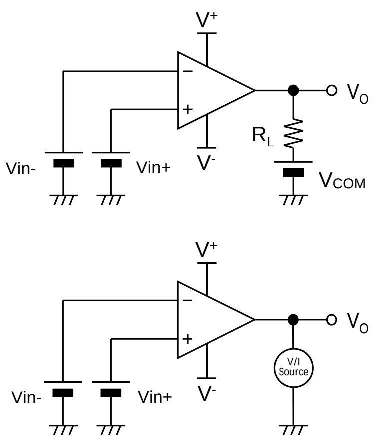
$$SVR=20\log\frac{\Delta V_S\left(1+\frac{R_F}{R_G}\right)}{\Delta V_O}$$

$V_S=V^+\text{-}V^-$

● V_{OH}, V_{OL}

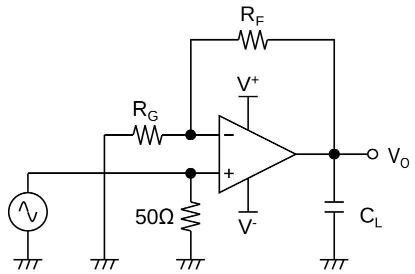
V_{OH}; Vin+ = V^+/2 + 1V, Vin- = V^+/2, V_{COM}=V^+/2

V_{OL}; Vin+ = V^+/2, Vin- = V^+/2 + 1V, V_{COM}=V^+/2



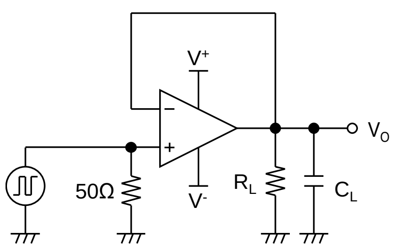
● GBW

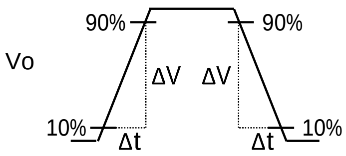
R_G=1kΩ, R_F=100kΩ



● SR

R_L=100kΩ





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

■ APPLICATION NOTE

Single and Dual Supply Voltage Operation

The NJU7066 work with both single supply and dual supply when the voltage supplied is between V^+ and V^-. These amplifiers operate from single 2.2 to 5.5V supply and dual ±1.1V to ±2.75V supply.

Common-Mode Input Voltage Range

When the supply voltage does not meet the condition of electrical characteristics, the range of common-mode input voltage is as follows:
V_{ICM} (typ.) = V^- to V^+-1 (Ta = 25°C)
Difference of V_{ICM} when Temperature change, refer to typical characteristic graph.
During designing, consider variations in characteristics for use with allowance.

Maximum Output Voltage Range

When the supply voltage does not meet the condition of electrical characteristics, the range of the typ. value of the maximum output voltage is as follows:
V_{OM} (typ.) = V^-+20mV to V^+-20mV (R_L=10kΩ to V^+/2, Ta=25°C)
During designing, consider variations in characteristics and temperature characteristics for use with allowance. In addition, also note that the output voltage range becomes narrow as shown in typical characteristics graph when an output current increases.

Capacitive Load

The NJU7066 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 NJU7066 is unity gain stable for capacitive loads of 470pF. To drive heavier capacitive loads, an isolation resistor, R_{ISO} as shown Figure1, 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.

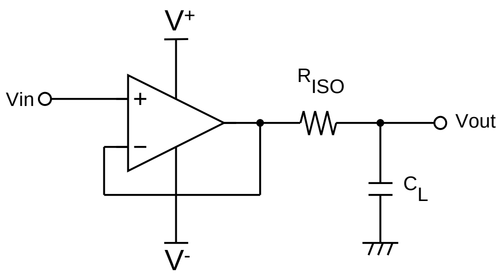


Figure1. Isolating capacitive load

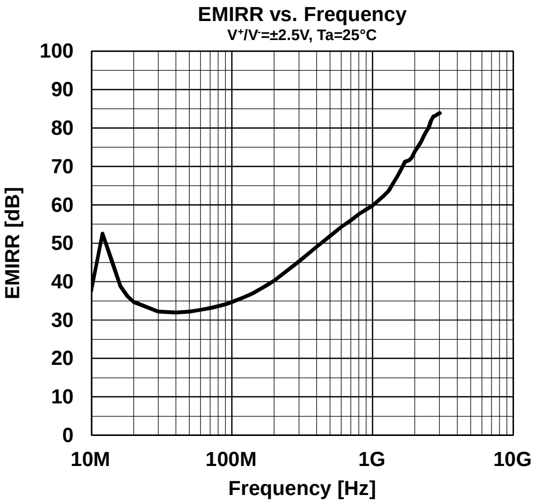
EMIRR (EMI Rejection Ratio) Definition

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

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

V_{RF_PEAK}: RF Signal Amplitude [VP]
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.

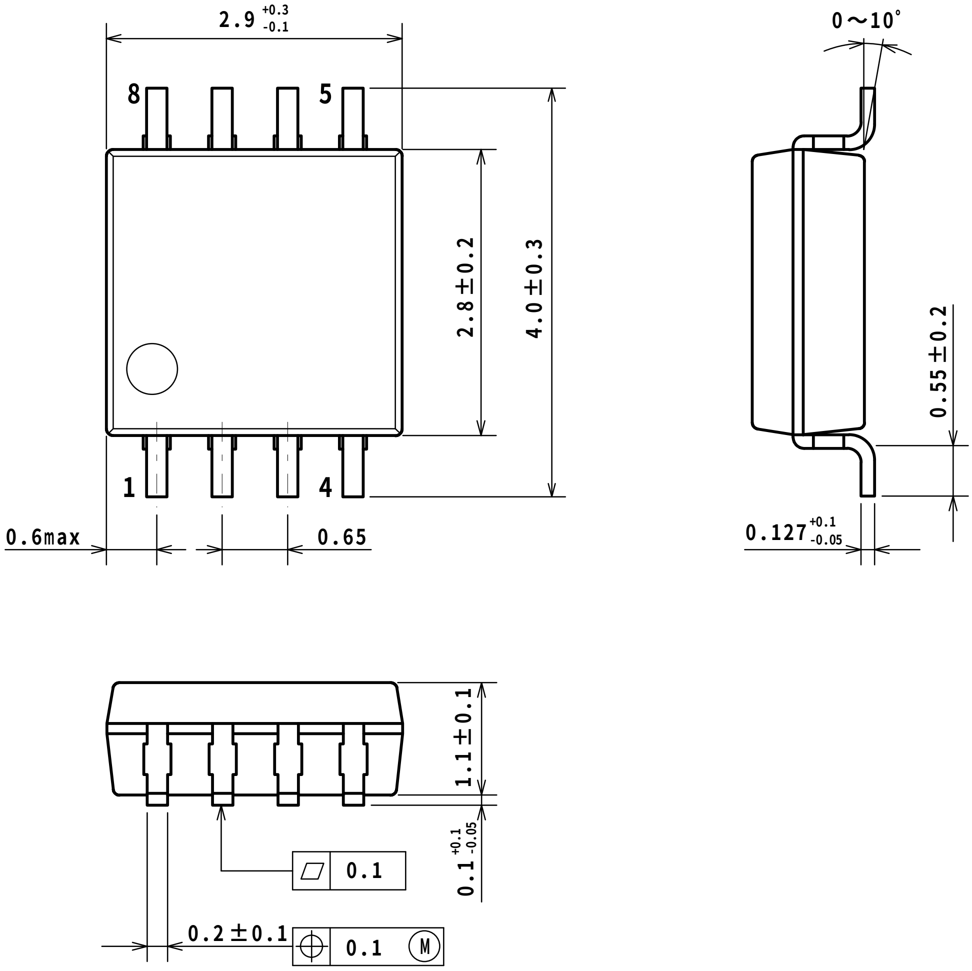


*For details, refer to "Application Note for EMI Immunity" in our HP: http://www.njr.com/

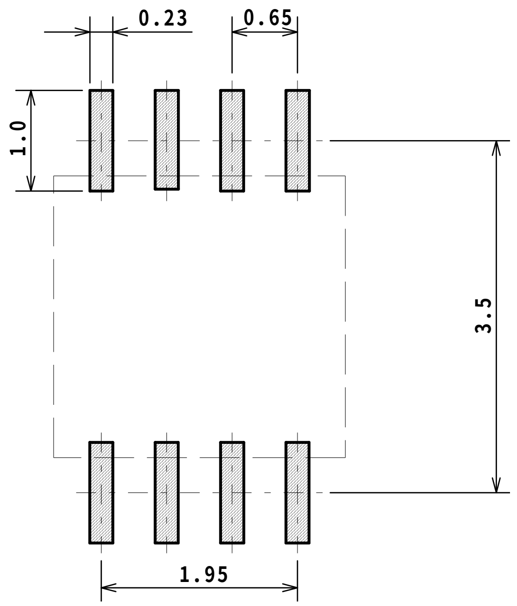
MSOP8 (VSP8) MEET JEDEC MO-187-DA

Unit: mm

■ PACKAGE DIMENSIONS



■ EXAMPLE OF SOLDER PADS DIMENSIONS

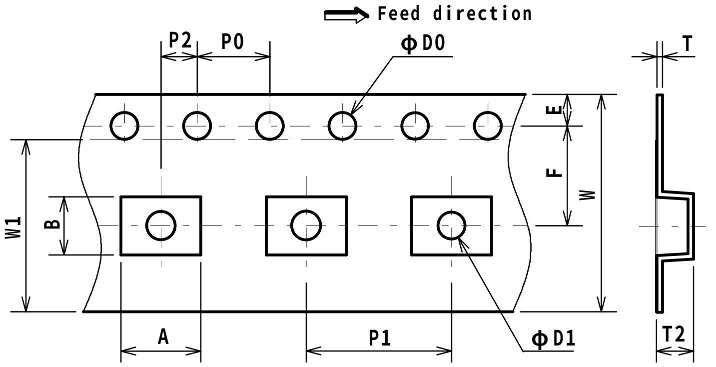


MSOP8 (VSP8) MEET JEDEC MO-187-DA

Unit: mm

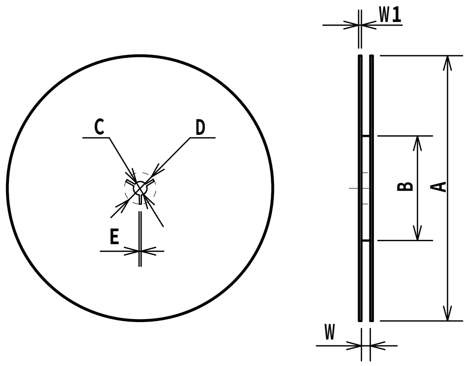
■ PACKING SPEC

TAPING DIMENSIONS



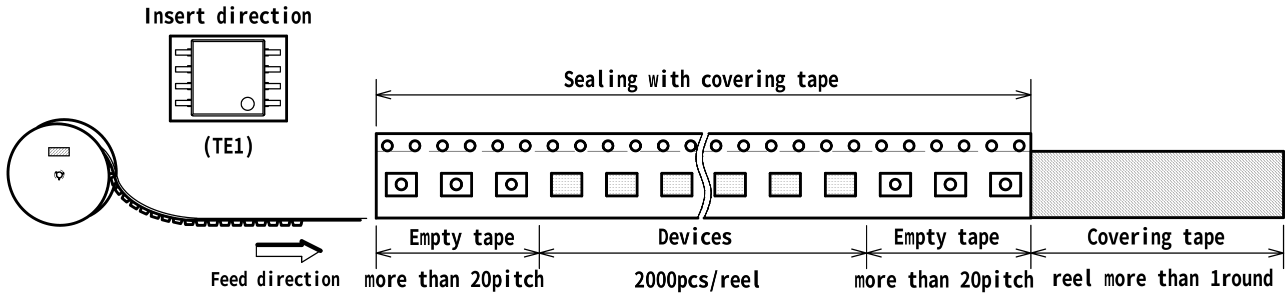
SYMBOL	DIMENSION	REMARKS
A	4.4	BOTTOM DIMENSION
B	3.2	BOTTOM DIMENSION
D0	1.5 $^{+0.1}_{0}$	
D1	1.5 $^{+0.1}_{0}$	
E	1.75±0.1	
F	5.5±0.05	
P0	4.0±0.1	
P1	8.0±0.1	
P2	2.0±0.05	
T	0.30±0.05	
T2	2.0 (MAX.)	
W	12.0±0.3	
W1	9.5	THICKNESS 0.1max

REEL DIMENSIONS

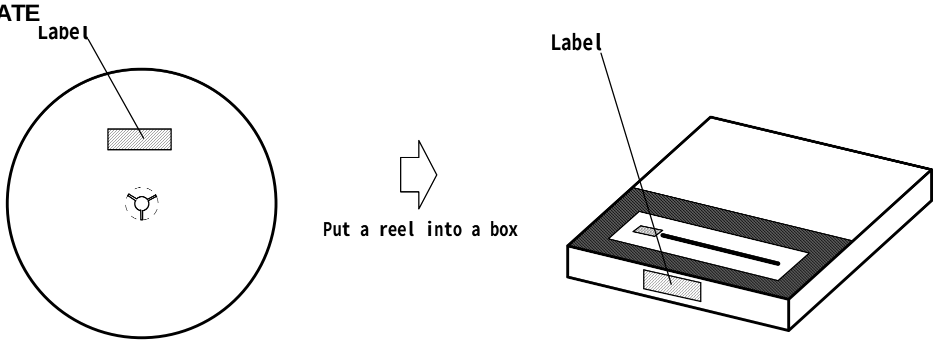


SYMBOL	DIMENSION
A	ϕ254±2
B	ϕ100±1
C	ϕ 13±0.2
D	ϕ 21±0.8
E	2±0.5
W	13.5±0.5
W1	2.0±0.2

TAPING STATE

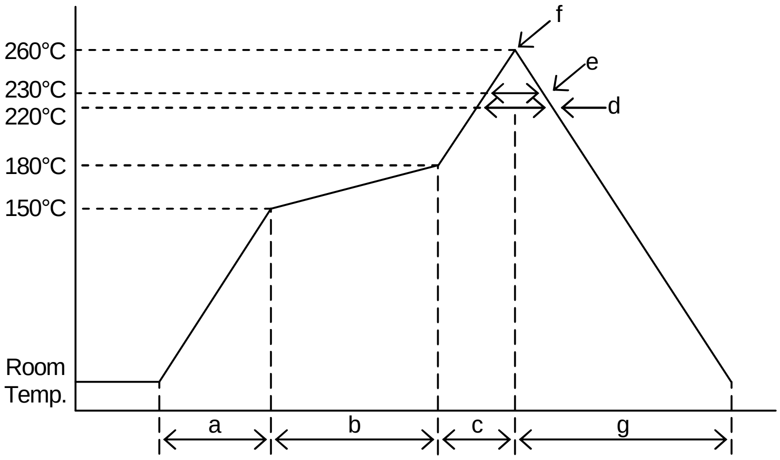


PACKING STATE



■ RECOMMENDED MOUNTING METHOD

INFRARED REFLOW SOLDERING PROFILE



a	Temperature ramping rate	1 to 4°C/s
b	Pre-heating temperature Pre-heating time	150 to 180°C 60 to 120s
c	Temperature ramp rate	1 to 4°C/s
d	220°C or higher time	shorter than 60s
e	230°C or higher time	shorter than 40s
f	Peak temperature	lower than 260°C
g	Temperature ramping rate	1 to 6°C/s

The temperature indicates at the surface of mold package.

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