9V/µs High-Speed, Rail-to-rail I/O CMOS Operational Amplifier

FEATURES (V^+=5V, V^-=0V, Ta=25°C)

- ●High Slew Rate 9V/µs
- ●Wide Bandwidth 5MHz
- ●Low Input Bias Current 1pA
- ●Rail-to-Rail Input and Output
- ●Output Voltage
  - R_L=10kΩ 10mV from rail
  - R_L=600Ω 70mV from rail
- ●Short Circuit Output Current 110mA
- ●Equivalent Input Noise Voltage 20nV/√Hz
- ●Input Offset Voltage 5mV max.
- ●Low Input Offset Voltage Drift 2µV/°C typ.
- ●Supply Voltage 2.7V to 5.5V
- ●Operating Temperature Range -40 to 125°C
- ●RF-Noise Immunity
- ●Unity-Gain Stable
- ●Package
  - NJU7046 SOT-23-5, SC-88A
  - NJU7047 SOP8 JEDEC 150 mil
    MSOP8(TVSP8)*
    DFN8-U1(ESON8-U1)
  - NJU7048 SOP14, SSOP14

*meet JEDEC MO-187-DA / thin type

APPLICATIONS

- ●High speed sensor Amplifiers
- ●Current sensor amplifiers
- ●Photodiode amplifiers
- ●ADC front ends
- ●Battery-powered instruments

DESCRIPTION

The NJU7046/NJU7047/NJU7048 are rail to rail input and output single supply operational amplifier featuring high speed and low input bias current.

9V/us slew rate, 5MHz gain bandwidth, 1pA input bias current and -40 to 125°C operating temperature range, make these amplifiers useful in wide variety of applications such as filters, integrators, current sensing, photodiode amplifiers and industrial applications.

The rail-to-rail input and output enables designers to buffers of input and output for ADC, DAC, ASIC and other wide output swing devices.

The NJU7046/NJU7047/NJU7048 operates in single supply 2.7V to 5.5V, and input common-mode voltage range includes the supply rails. Output voltage typically swings to within 70mV of the supply rails with 600Ω load, and 110mA short-circuit current drive capability.

The NJU7046/NJU7047/NJU7048 are high RF-immunity to reduce malfunctions caused by RF noises from mobile phones and others.

The NJU7046 is available in 5-pin SC-88A and SOT-23 package. NJU7047 is available in 8-pin SOP: JEDEC 150 mil, MSOP(TVSP): meet JEDEC MO-187-DA / thin and DFN that is thin and 2mm square small package. NJU7048 is available in 14-pin SOP and SSOP package.

RELATED PRODUCTS

Features	Single	Dual	Quad
0.8V/µs, 2.1MHz, 260µA/ch Rail-to-rail Output	NJU7056	NJU7057	NJU7058
35V/µs, 34MHz, Rail-to-rail I/O (High slew rate type)	NJU77701		

PIN CONFIGURATION

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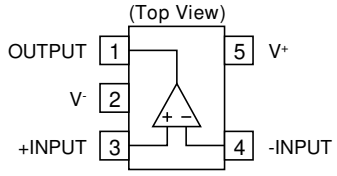
<tr><td>Pin Function</td><td colspan="2"> 
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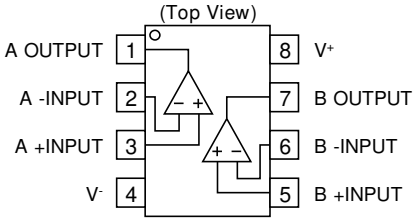
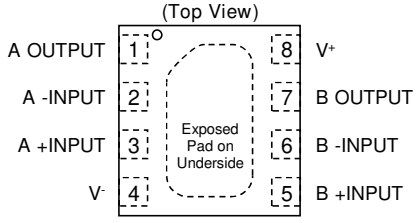
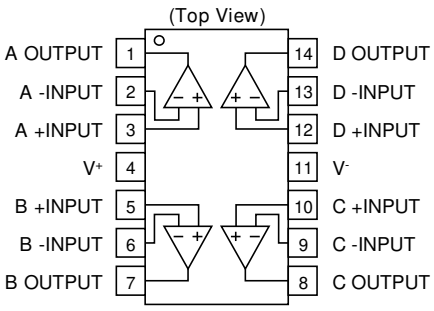
<tr><td>Package</td><td>SC-88A</td><td>SOT-23-5</td></tr>
<tr><td>Product Name</td><td>NJU7046F3</td><td>NJU7046F</td></tr>
<tr><td>Pin Function</td><td colspan="2"> 
</td><td> 

Connect to exposed pad to V-</td></tr>
<tr><td>Package</td><td>SOP8 JEDEC 150 mil.</td><td>MSOP8(TVSP8)</td><td>DFN8-U1(ESON8-U1)</td></tr>
<tr><td>Product Name</td><td>NJU7047E</td><td>NJU7047RB1</td><td>NJU7047KU1</td></tr>
<tr><td>Pin Function</td><td colspan="2"> 
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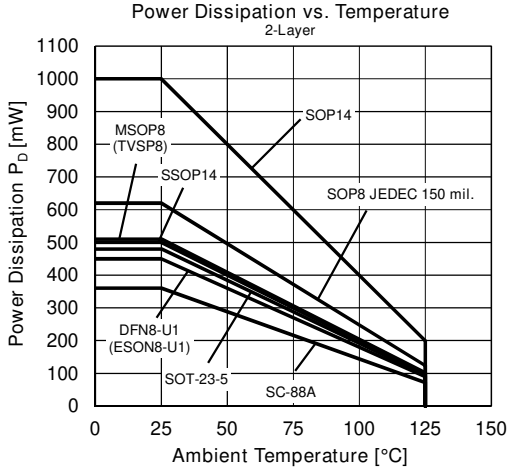
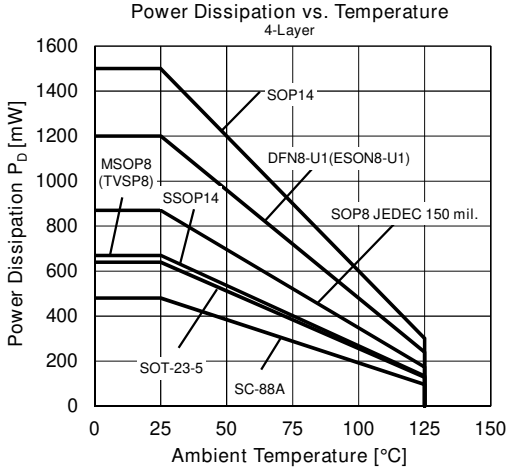
<tr><td>Package</td><td>SOP14</td><td>SSOP14</td></tr>
<tr><td>Product Name</td><td>NJU7048G</td><td>NJU7048V</td></tr>
</table>

■ ABSOLUTE MAXIMUM RATINGS (Ta=25°C, unless otherwise noted.)

PARAMETER	SYMBOL	RATING	UNIT
Supply Voltage	V^+	7	V
Input Voltage (1)	V_{IN}	V^- - 0.3 to V^+ + 0.3	V
Differential Input Voltage (2)	V_{ID}	±7 (3)	V
Input Current (4)	I_{IN}	2	mA
Power Dissipation (5)	P_D	(2-layer / 4-layer)(6)	mW
SOT-23-5		480 / 640	
SC-88A		360 / 480	
SOP8 JEDEC 150 mil.		620 / 870	
MSOP8(TVSP8)		510 / 670	
DFN8-U1(ESON8-U1)		450(7) / 1200(7)	
SOP14		1000 / 1500	
SSOP14		500 / 690	
Operating Temperature Range	T_{opr}	-40 to +125	°C
Storage Temperature Range	T_{stg}	-55 to +150	°C

(1) The absolute maximum input voltage is limited at 7V.
(2) Differential voltage is the voltage difference between +INPUT and -INPUT.
(3) For supply voltage less than 7V, the absolute maximum rating is equal to the supply voltage.
(4) Input voltages outside the supply voltage will be clamped by ESD protection diodes. If the input voltage exceeds the supply voltage, the input current must be limited 2 mA or less by using a restriction resistance.
(5) Power dissipation is the power that can be consumed by the IC at Ta=25°C, and is the typical measured value based on JEDEC condition. When using the IC over Ta=25°C subtract the value [mW/°C]=P_D/(Tstg(MAX)-25) per temperature.
(6) 2-layer: EIA/JEDEC STANDARD Test board (76.2x114.3x1.6mm, 2layers, FR-4) mounting
4-layer: EIA/JEDEC STANDARD Test board (76.2x114.3x1.6mm, 4layers, FR-4) mounting
(7) 2-layer: Mounted on glass epoxy board. (101.5×114.5×1.6mm: based on EIA/JEDEC standard, 2Layers FR-4, with Exposed Pad)
4-layer: Mounted on glass epoxy board. (101.5×114.5×1.6mm: based on EIA/JEDEC standard, 4Layers FR-4, with Exposed Pad)
*For 4Layers: Applying 99.5×99.5mm inner Cu area and a thermal via hole to a board based on JEDEC standard JESD51-5)





■ RECOMMENDED OPERATING CONDITION (Ta=25°C)

PARAMETER	CONDITION	MIN.	TYP.	MAX.	UNIT
Supply Voltage		2.7	-	5.5	V

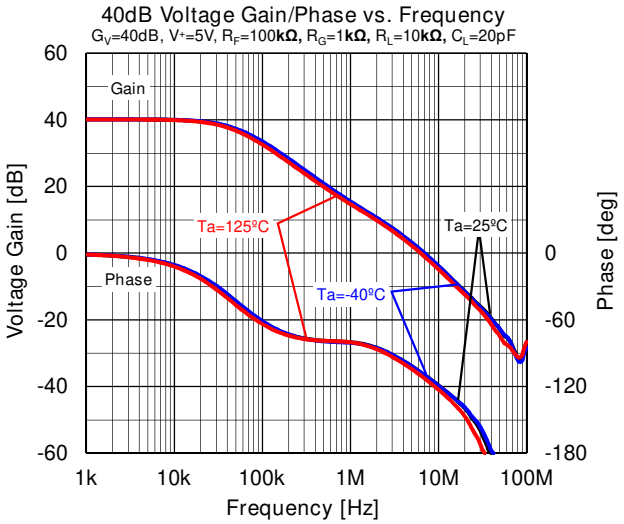
■ ELECTRICAL CHARACTERISTICS (V^+=5V, V^-=0V, Ta=25°C, unless otherwise noted.)

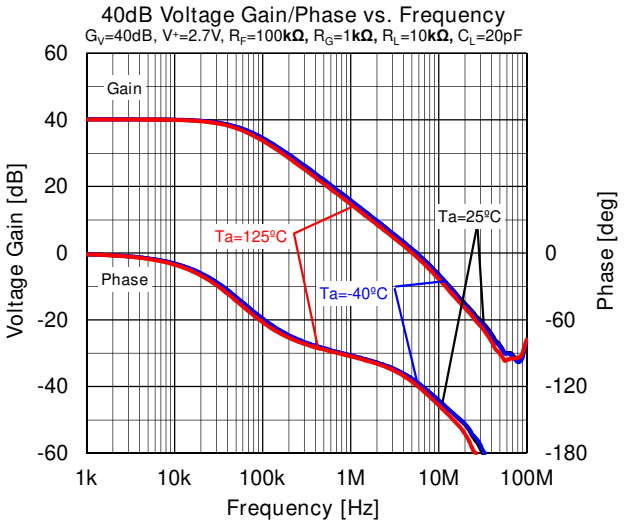
PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
DC CHARACTERISTICS						
Supply Current(All Amplifiers)	I_{SUPPLY}	No Signal				
NJU7046			-	1.4	2.2	mA
NJU7047			-	2.7	4.3	mA
NJU7048			-	5.3	8.4	mA
Input Offset Voltage	V_{IO}	V_{ICM}= 0V, 2.5V, 5V	-	0.9	5	mV
Input Offset Voltage Drift	$\Delta V_{IO}/\Delta T$		-	2	-	µV/°C
Input Bias Current	I_B		-	1	-	pA
Input Offset Current	I_{IO}		-	1	-	pA
Open-Loop Voltage Gain	A_V	Vout=1.5 to 3.5V, R_L=10kΩ to 2.5V	90	110	-	dB
Common-Mode Rejection Ratio	CMR	V_{ICM}=0V to 5V	60	80	-	dB
Supply Voltage Rejection Ratio	SVR	V^+=2.7V to 5.5V, V_{ICM}=0V	65	90	-	dB
Common-Mode Input Voltage Range	V_{ICM}	CMR≥60dB	0	-	5	V
High-level Output Voltage	V_{OH}	R_L=10kΩ to 2.5V	4.95	4.99	-	V
		R_L=600Ω to 2.5V	4.88	4.93	-	V
Low-level Output Voltage	V_{OL}	R_L=10kΩ to 2.5V	-	0.01	0.05	V
		R_L=600Ω to 2.5V	-	0.07	0.12	V
AC CHARACTERISTICS						
Slew Rate	SR	G_V=0dB, R_L=10kΩ, C_L=20pF, V_{IN}=2V_{PP}	5	9	-	V/µs
Gain Bandwidth Product	GBW	G_V=40dB, R_F=100kΩ, R_L=10kΩ, C_L=20pF	-	5	-	MHz
Phase Margin	Φ_M	G_V=40dB, R_F=100kΩ, R_L=10kΩ, C_L=20pF	-	70	-	deg
Gain Margin	G_M	G_V=40dB, R_F=100kΩ, R_L=10kΩ, C_L=20pF	-	16	-	dB
Equivalent Input Noise Voltage	V_{NI}	f=1kHz	-	20	-	nV/√Hz
Total Harmonic Distortion + Noise	THD+N	G_V=0dB, R_L=10kΩ, f=1kHz, Vout=1V_{PP}	-	0.01	-	%
Channel Separation	CS	f=1kHz, NJU7047/NJU7048	-	130	-	dB

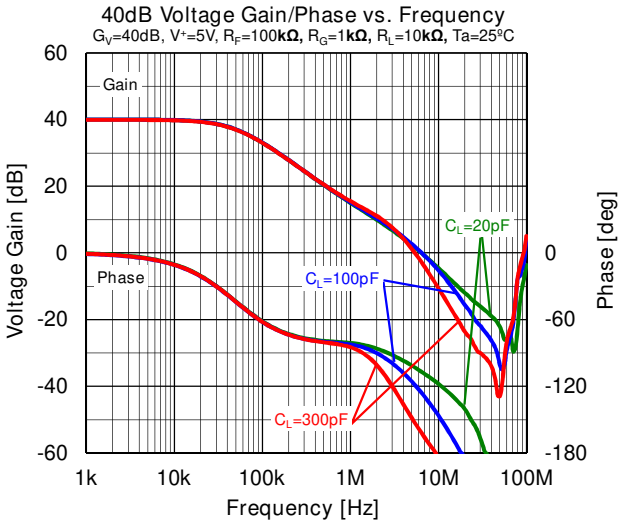
■ ELECTRICAL CHARACTERISTICS (V^+=2.7V, V^-=0V, Ta=25°C, unless otherwise noted.)

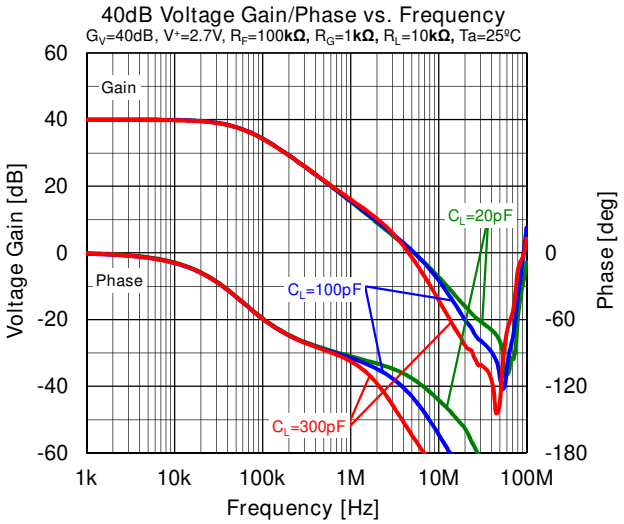
PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
DC CHARACTERISTICS						
Supply Current(All Amplifiers)	I_{SUPPLY}	No Signal				
NJU7046			-	1.2	2	mA
NJU7047			-	2.5	4	mA
NJU7048			-	4.5	7.2	mA
Input Offset Voltage	V_{IO}	V_{ICM}= 0V, 1.35V, 2.7V	-	0.9	5	mV
Input Offset Voltage Drift	$\Delta V_{IO}/\Delta T$		-	2	-	µV/°C
Input Bias Current	I_B		-	1	-	pA
Input Offset Current	I_{IO}		-	1	-	pA
Open-Loop Voltage Gain	A_V	Vout=0.35 to 2.35V, R_L=10kΩ to 1.35V	90	110	-	dB
Common-Mode Rejection Ratio	CMR	V_{ICM}=0V to 2.7V	55	75	-	dB
Supply Voltage Rejection Ratio	SVR	V^+=2.7V to 5.5V, V_{ICM}=0V	65	90	-	dB
Common-Mode Input Voltage Range	V_{ICM}	CMR≥55dB	0	-	2.7	V
High-level Output Voltage	V_{OH}	R_L=10kΩ to 1.35V	2.65	2.69	-	V
		R_L=600Ω to 1.35V	2.6	2.64	-	V
Low-level Output Voltage	V_{OL}	R_L=10kΩ to 1.35V	-	0.01	0.05	V
		R_L=600Ω to 1.35V	-	0.05	0.1	V
AC CHARACTERISTICS						
Slew Rate	SR	G_V=0dB, R_L=10kΩ, C_L=20pF, V_{IN}=2V_{PP}	3.5	7	-	V/µs
Gain Bandwidth Product	GBW	G_V=40dB, R_F=100kΩ, R_L=10kΩ, C_L=20pF	-	5	-	MHz
Phase Margin	Φ_M	G_V=40dB, R_F=100kΩ, R_L=10kΩ, C_L=20pF	-	65	-	deg
Gain Margin	G_M	G_V=40dB, R_F=100kΩ, R_L=10kΩ, C_L=20pF	-	18	-	dB
Equivalent Input Noise Voltage	V_{NI}	f=1kHz	-	20	-	nV/√Hz
Total Harmonic Distortion + Noise	THD+N	G_V=0dB, R_L=10kΩ, f=1kHz, Vout=1V_{PP}	-	0.02	-	%
Channel Separation	CS	f=1kHz, NJU7047/NJU7048	-	130	-	dB

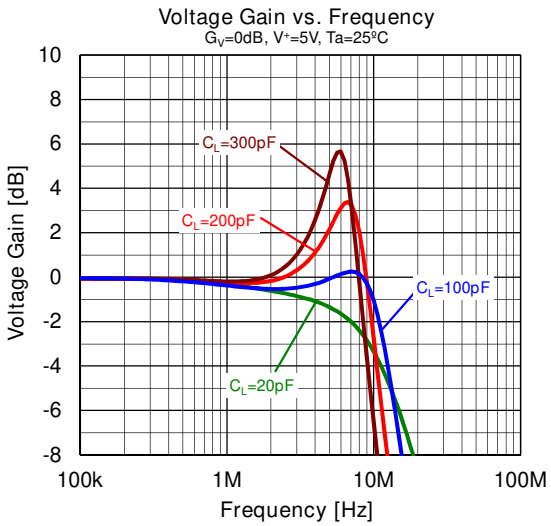
■ TYPICAL CHARACTERISTICS

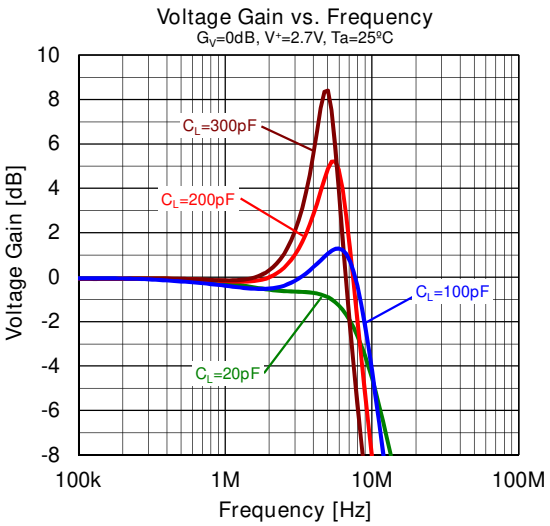






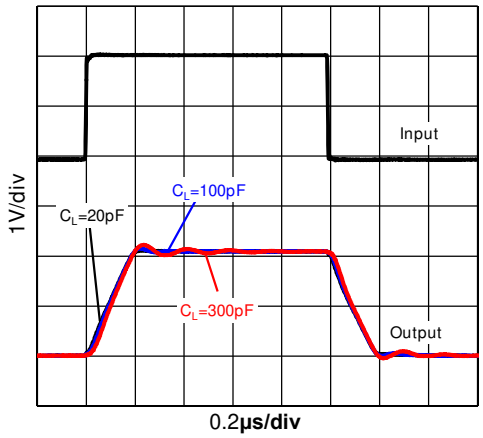




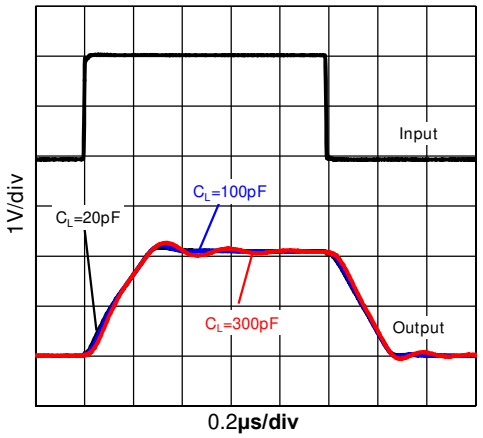


■ TYPICAL CHARACTERISTICS

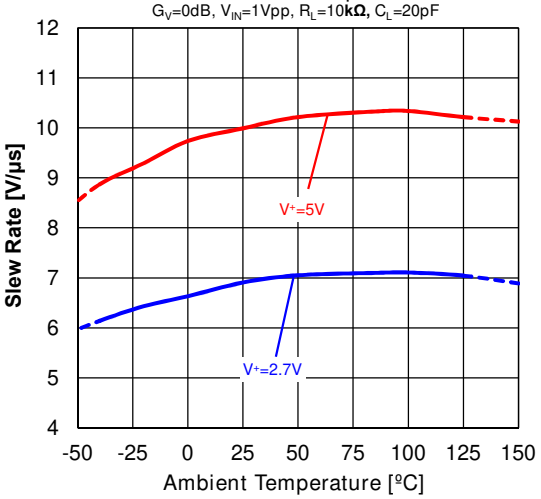
Pulse Response
V^+=5V, V_{IN}=2Vpp, R_L=10kΩ, Ta=25ºC



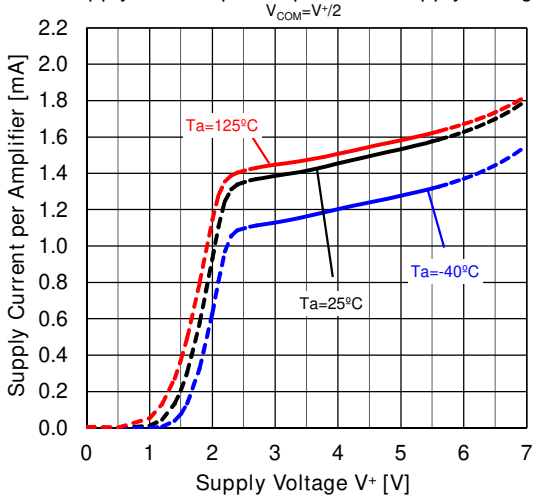
Pulse Response
V^+=2.7V, V_{IN}=2Vpp, R_L=10kΩ, Ta=25ºC



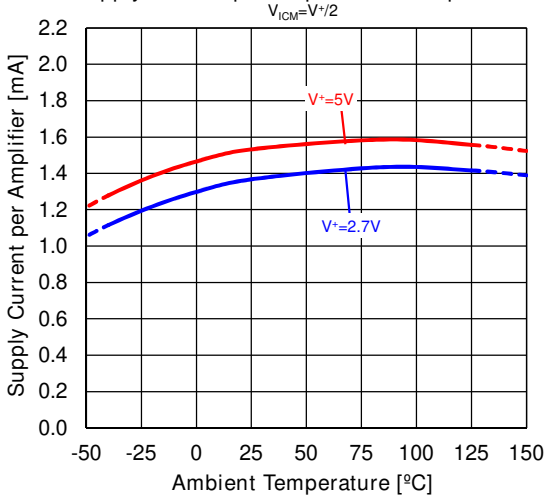
Slew Rate vs. Temperature
G_V=0dB, V_{IN}=1Vpp, R_L=10kΩ, C_L=20pF



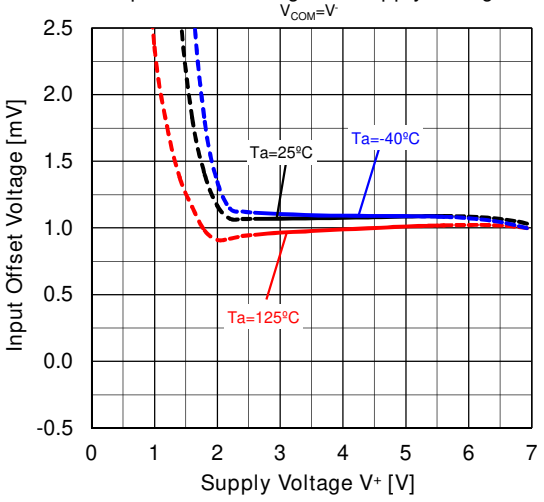
Supply Current per Amplifier vs. Supply Voltage
V_{COM}=V^+/2



Supply Current per Amplifier vs. Temperature
V_{ICM}=V^+/2

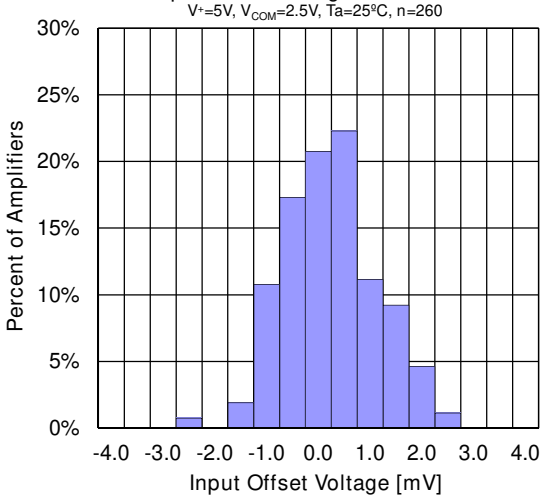


Input Offset Voltage vs. Supply Voltage
V_{COM}=V^-

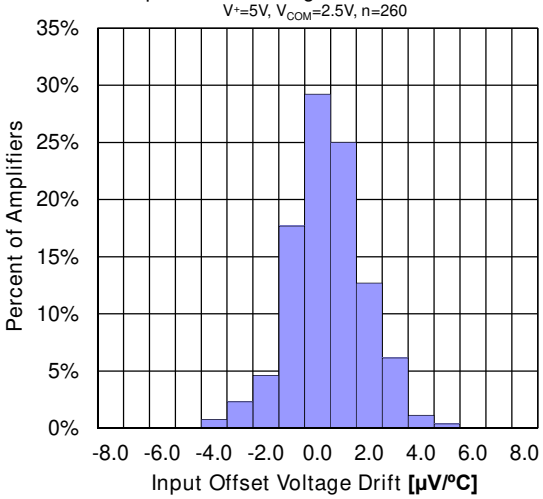


■ TYPICAL CHARACTERISTICS

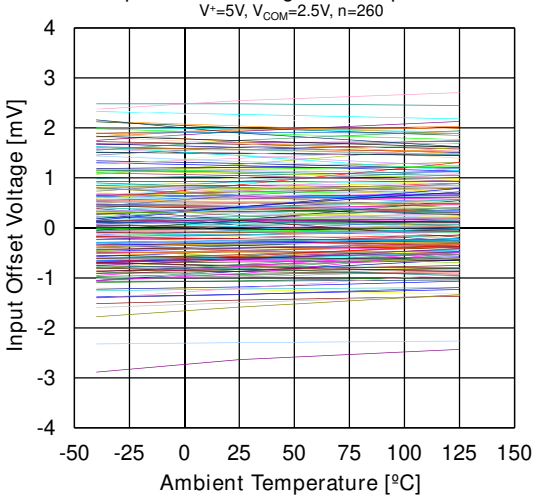
Input Offset Voltage Distribution
V+=5V, VCOM=2.5V, Ta=25ºC, n=260



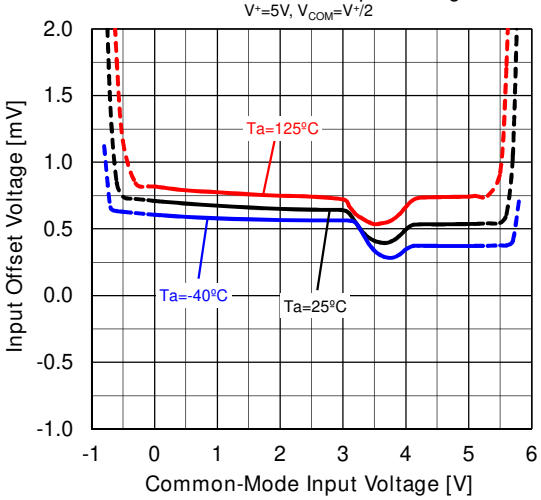
Input Offset Voltage Drift Distribution
V+=5V, VCOM=2.5V, n=260



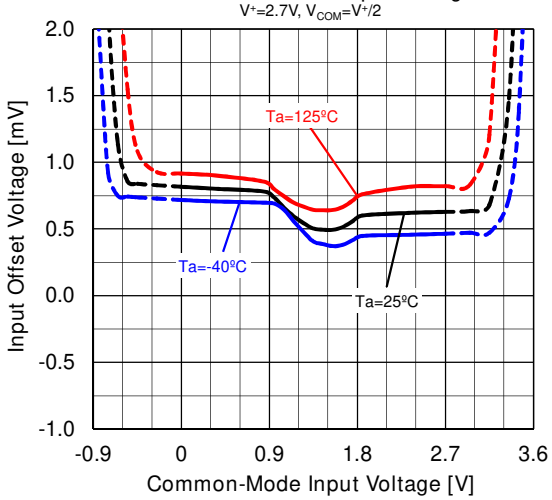
Input Offset Voltage vs. Temperature
V+=5V, VCOM=2.5V, n=260



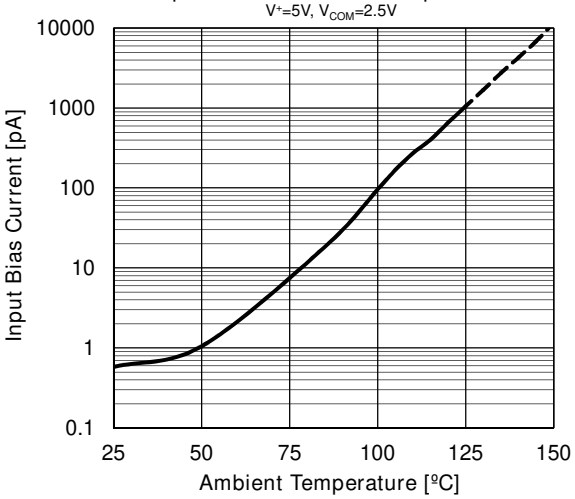
Input Offset Voltage
vs. Common-Mode Input Voltage
V+=5V, VCOM=V+/2



Input Offset Voltage
vs. Common-Mode Input Voltage
V+=2.7V, VCOM=V+/2

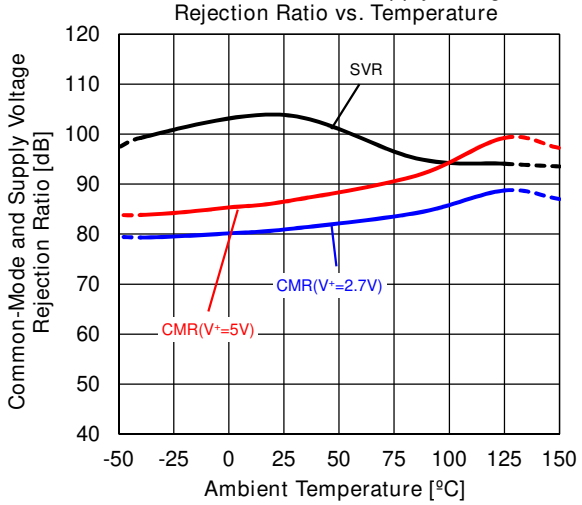


Input Bias Current vs. Temperature
V+=5V, VCOM=2.5V



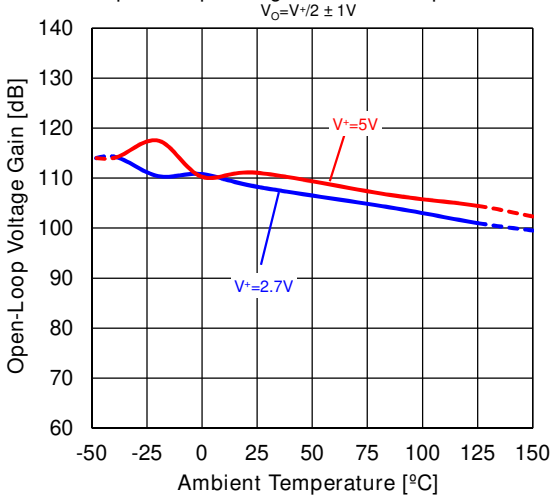
■ TYPICAL CHARACTERISTICS

Common-Mode and Supply Voltage Rejection Ratio vs. Temperature



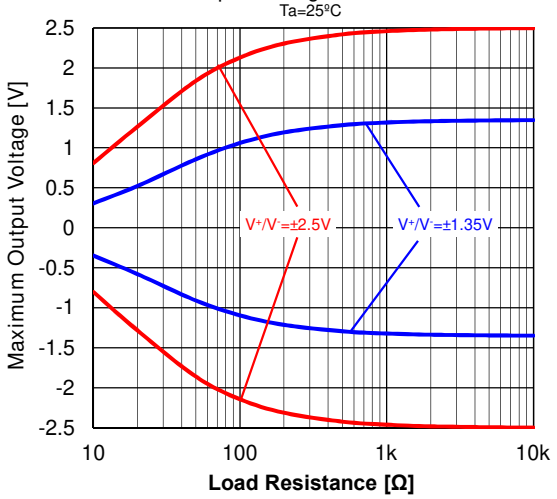
Open-Loop Voltage Gain vs. Temperature

$V_O=V^+/2 \pm 1V$



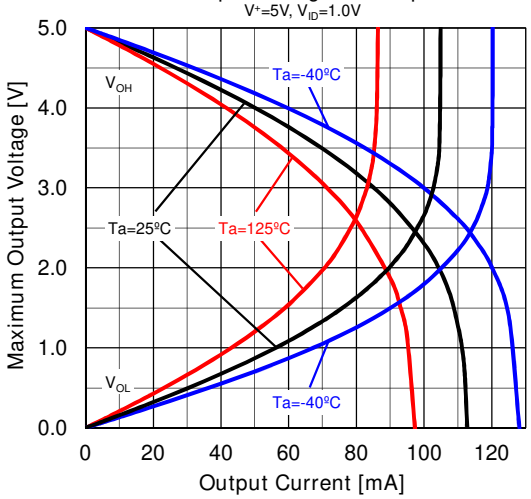
Maximum Output Voltage vs. Load Resistance

Ta=25ºC



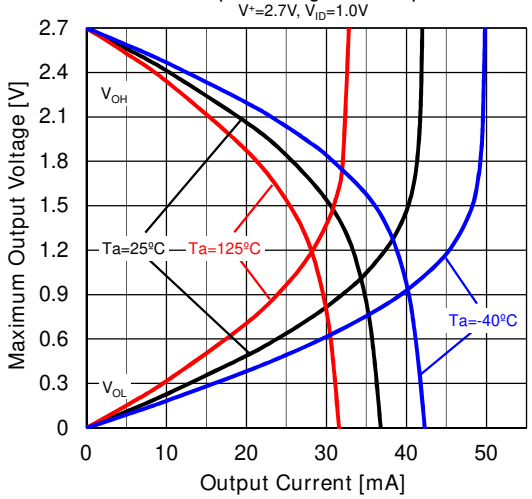
Maximum Output Voltage vs. Output Current

$V^+=5V$, $V_{ID}=1.0V$



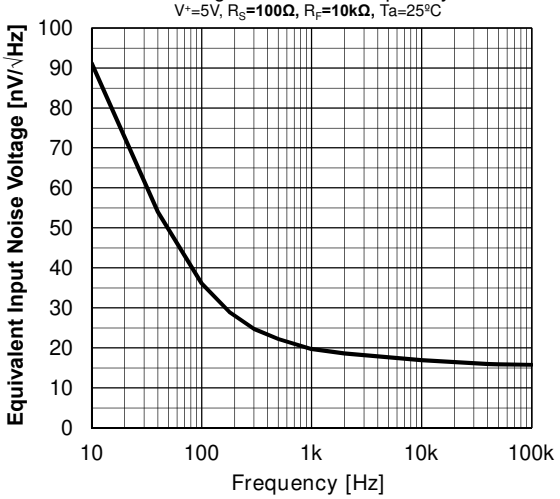
Maximum Output Voltage vs. Output Current

$V^+=2.7V$, $V_{ID}=1.0V$

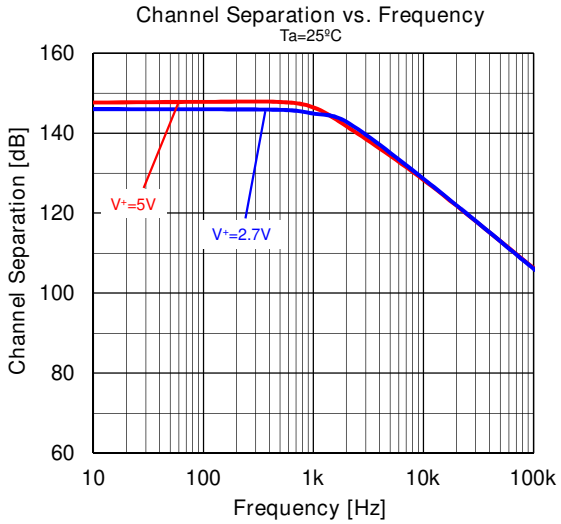


Voltage Noise vs. Frequency

$V^+=5V$, R_S**=100Ω**, R_F**=10kΩ**, Ta=25ºC



■ TYPICAL CHARACTERISTICS



■ APPLICATION NOTE

Single and Dual Supply Voltage Operation

The NJU7046/NJU7047/NJU7048 works with both single supply and dual supply when the voltage supplied is between V^+ and V^-. These amplifiers operate from single +2.7 to +5.5V supply and dual ±1.35V 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^+ (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^-+10mV to V^+-10mV (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.

Input Voltage Exceeding the Supply Voltage

Inputs of the NJU7046/NJU7047/NJU7048 are protected by ESD diodes (shown in Figure1) that will conduct if the input voltages exceed the power supplies by more than approximately 300mV. Momentary voltages greater than 300mV beyond the power supply, inputs can be tolerated if the current is limited to 2mA. Figure2 is easily accomplished with an input resistor. If the input voltage exceeds the supply voltage, the input current must be limited 2mA or less by using a restriction resistance (R_{LIMIT}) as shown in figure2.

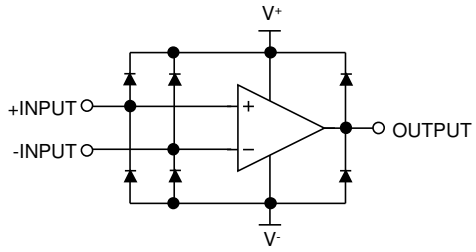


Figure1. Simplified Schematic

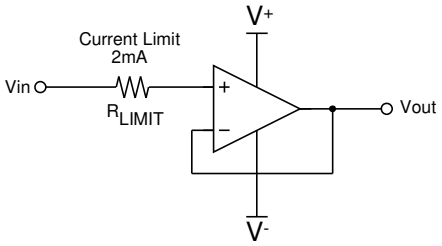


Figure2. Input Current Protection for Voltages exceeding the Supply Voltage.

Capacitive load

The NJU7046/NJU7047/NJU7048 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.
To drive heavy capacitive loads, an isolation resistor, R_{ISO} as shown Figure3, 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.

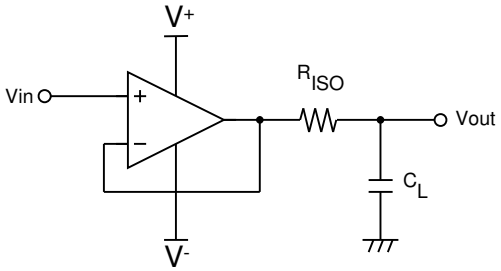
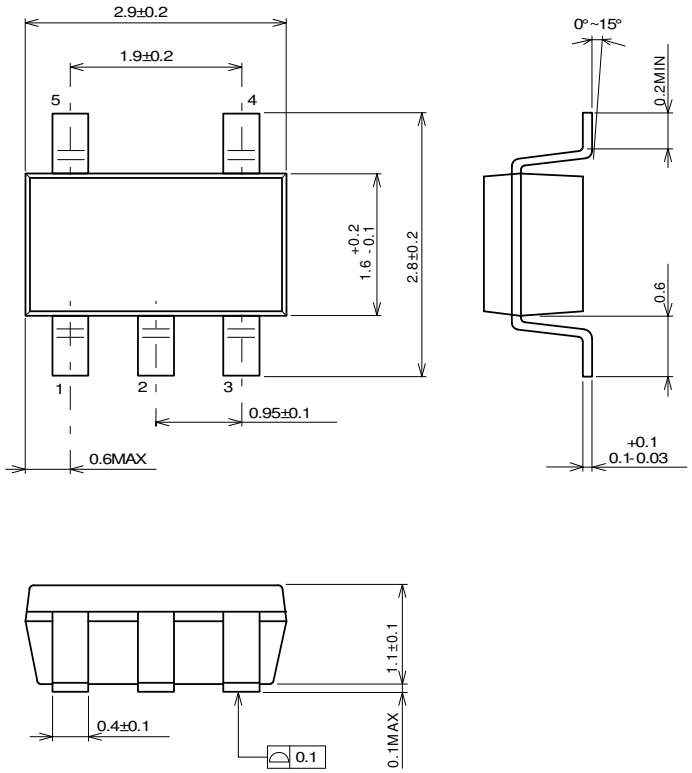


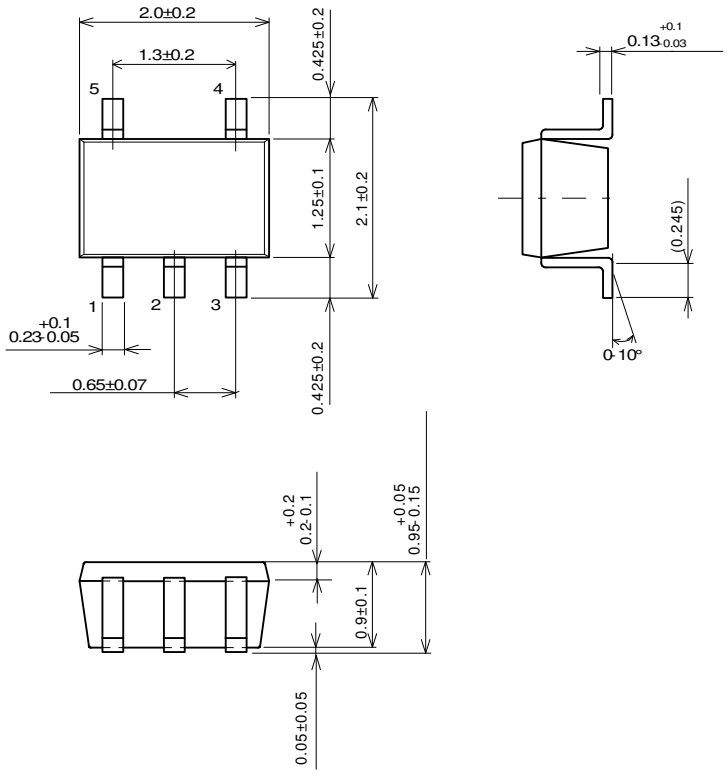
Figure3. Isolating capacitive load

■ PACKAGE DIMENSIONS



Unit: mm

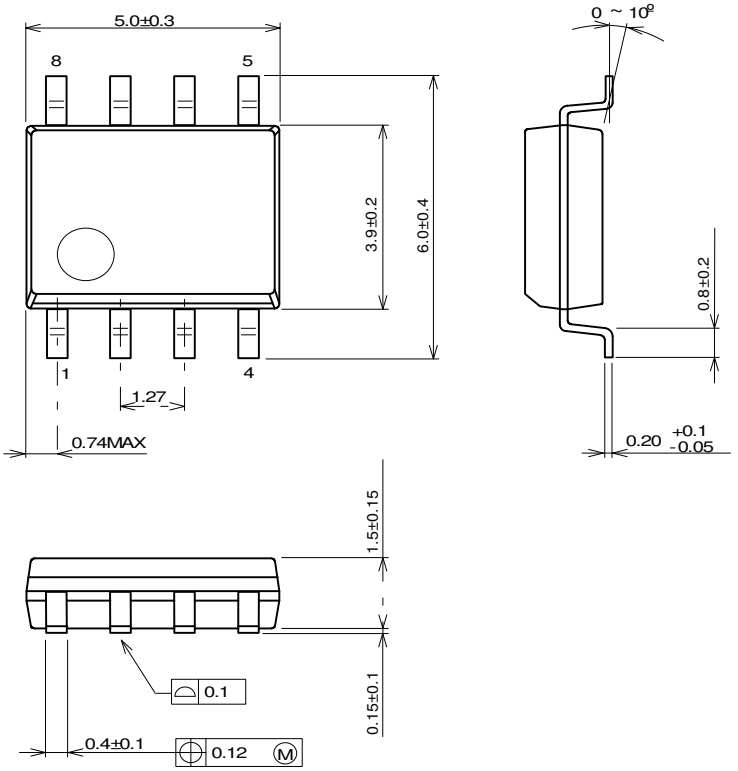
SOT-23-5 Package



Unit: mm

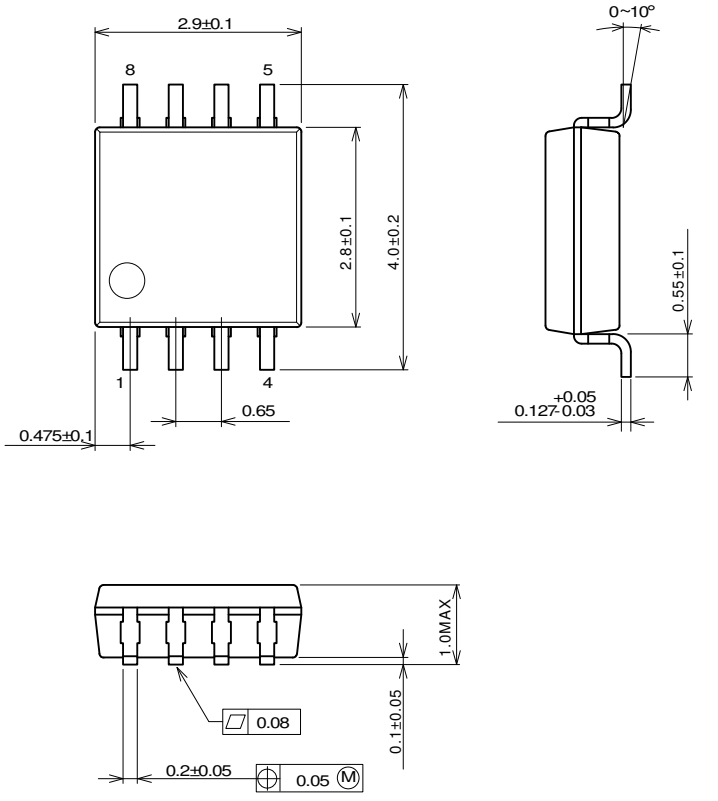
SC-88A Package

■ PACKAGE DIMENSIONS



Unit: mm

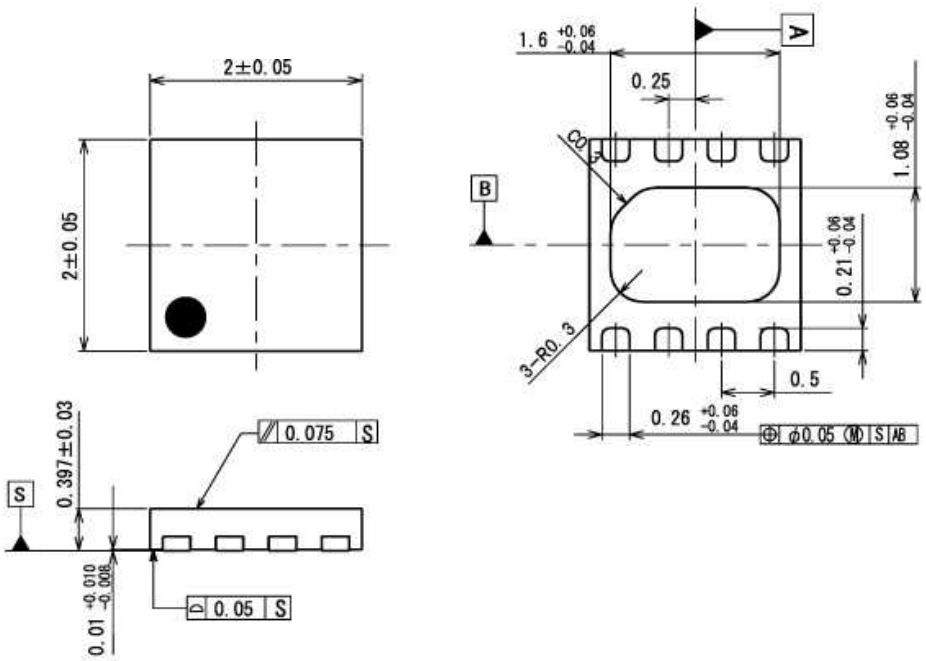
SOP8 JEDEC 150 mil Package



Unit: mm

MSOP8 (TVSP8) meet JEDEC MO-187-DA / thin Package

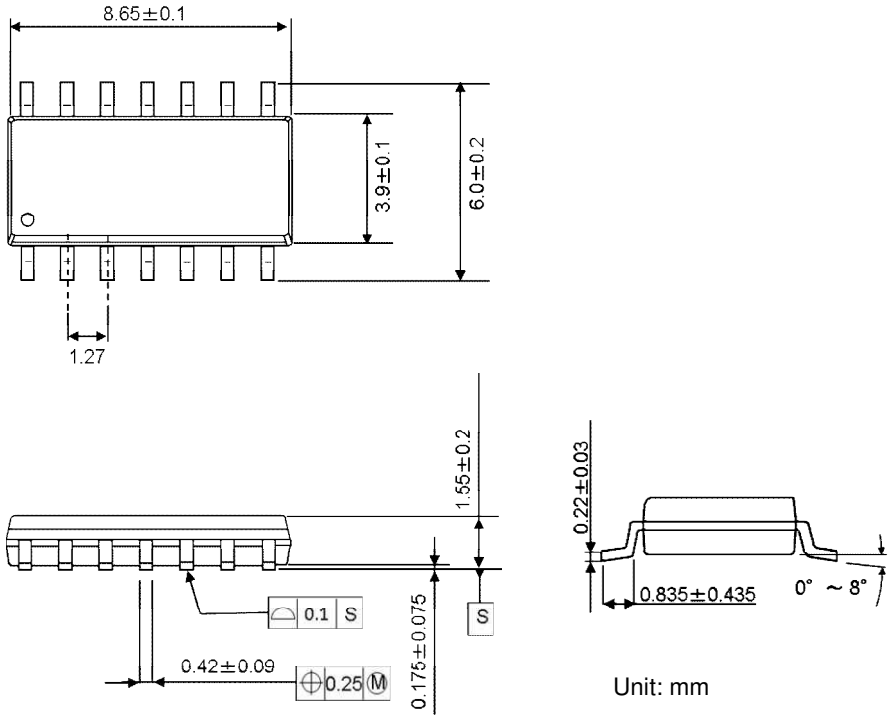
■ PACKAGE DIMENSIONS



Unit: mm

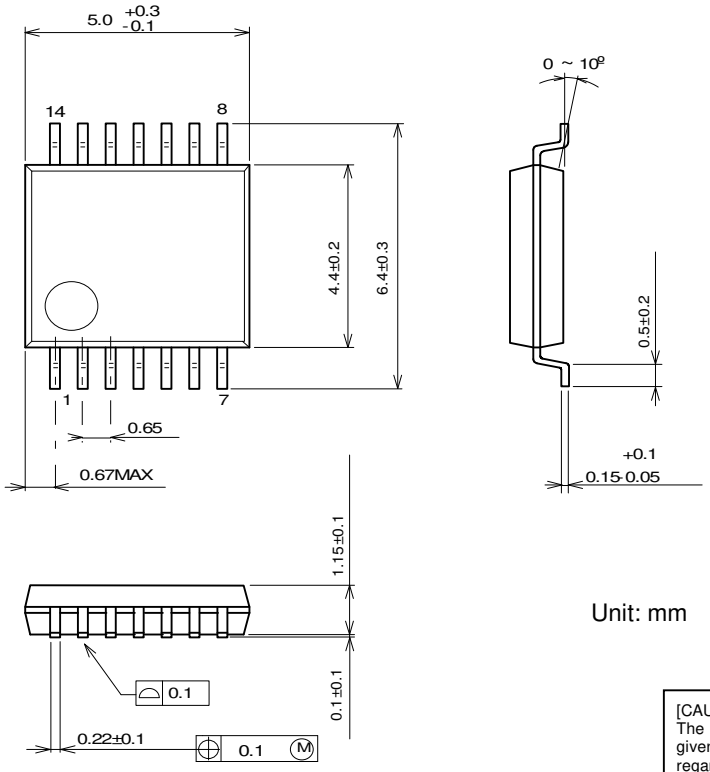
DFN8-U1(ESON8-U1) Package

■ PACKAGE DIMENSIONS



Unit: mm

SOP14 Package



Unit: mm

SSOP14 Package

[CAUTION]
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