

## High Output Current, Single Supply, Rail-to-Rail Output Dual CMOS Operational Amplifier

### ■ GENERAL DESCRIPTION

The NJU7036 is a Rail-to-Rail Output operational amplifier of single power supply operation. It has the characteristic of high power output current and is suitable for driving heavy loads such as a small motor, LED, and speakers. It has up to 0.15 V saturation voltages at an output current of 250mA. Therefore it can reduce the electric power loss in IC and contribute to the design of low power consumption. Moreover, micro leadless package (PCSP20-E3) is available for it, so that it can also contribute to the miniaturization of the equipment.

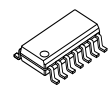
### ■ FEATURES

- Rail-to-Rail Output  $V_o=4.7V_{pp}$  min. at  $V_{DD}=5V, I_o=250mA$
- Single Supply
- Operating Voltage  $V_{opr}=2.7V$  to  $5.5V$
- Package Outline PCSP20-E3, EMP14
- CMOS Process
- Thermal Shutdown Circuit
- Current Limit Circuit

### ■ PACKAGE OUTLINE



**NJU7036SE3**  
(PCSP20-E3)

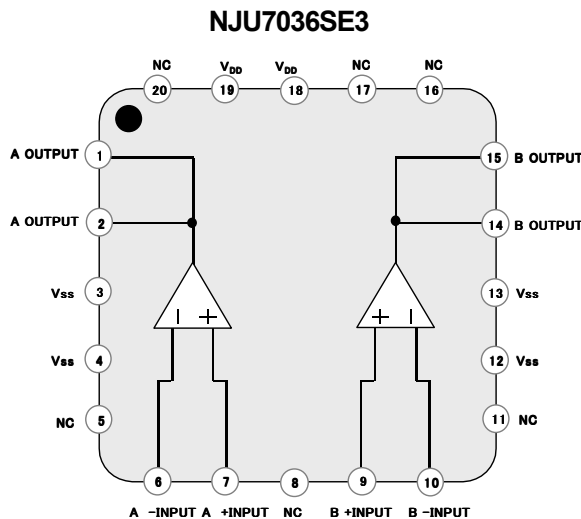


**NJU7036E**  
(EMP14)

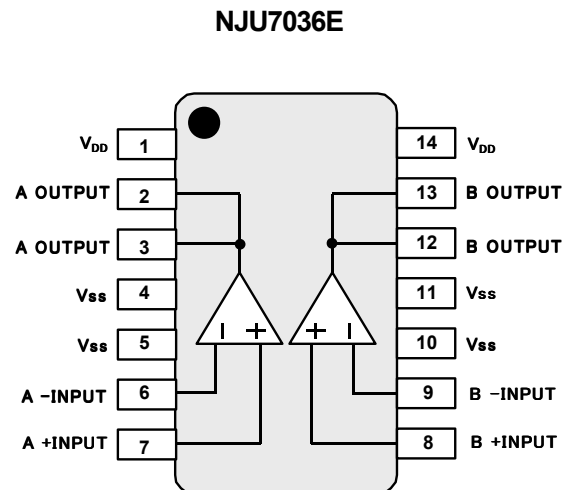
### ■ APPLICATION

- Motor Drivers, Audio Amplifiers, LED Drivers, etc.

### ■ PIN CONFIGURATION (Top View)



1,2	A OUTPUT	10	B -INPUT
3,4	V <sub>SS</sub>	11	NC
5	NC	12,13	V <sub>SS</sub>
6	A -INPUT	14,15	B OUTPUT
7	A +INPUT	16,17	NC
8	NC	18,19	V <sub>DD</sub>
9	B +INPUT	20	NC



1	V <sub>DD</sub>	8	B +INPUT
2,3	A OUTPUT	9	B -INPUT
4,5	V <sub>SS</sub>	10,11	V <sub>SS</sub>
6	A -INPUT	12,13	B OUTPUT
7	A +INPUT	14	V <sub>DD</sub>

V<sub>DD</sub> terminal, V<sub>SS</sub> terminal and OUTPUT terminal use two or more pins respectively and are lowering terminal resistance. You shall connect each two pins (V<sub>DD</sub>, V<sub>SS</sub> and OUTPUT) with the same electric potential.

When only one pin is used, the internal terminal resistance becomes high and the maximum output voltage declines.

# NJU7036

## ■ ABSOLUTE MAXIMUM RATINGS

Ta=25°C

PARAMETER	SYMBOL	RATINGS	UNIT
Supply Voltage	V <sub>DD</sub>	7.0	V
Power Dissipation	P <sub>D</sub>	EMP14:890 *1) , 1300 *2) PCSP20 *3):550 *1), 1080 *2)	mW
Output Peak Current	I <sub>OP</sub>	500	mA
Input Common Mode Voltage	V <sub>ICM</sub>	-0.3 to 7.0 *4)	V
Differential Input Voltage	V <sub>ID</sub>	±7 *4)	V
Operating Temperature Range	T <sub>opr</sub>	-40 to +85	°C
Storage Temperature Range	T <sub>stg</sub>	-55 to +150	°C

\*1) EIA/JEDEC STANDARD Test board (76.2 x 114.3 x 1.6mm, 4layers, FR-4) mounting

\*2) EIA/JEDEC STANDARD Test board (76.2 x 114.3 x 1.6mm, 2layers, FR-4) mounting

\*3) The back pad is mounted.

\*4) If the supply voltage V<sub>DD</sub> is less than 7V, the input voltage must not over the V<sub>DD</sub> level through 7V is limit specified.

## ■ RECOMMENDED OPERATING CONDITION

Ta=25°C

PARAMETER	SYMBOL	RATING	UNIT
Supply Voltage	V <sub>DD</sub>	2.7 to 5.5	V

## ■ ELECTRICAL CHARACTERISTICS

V<sub>DD</sub>=5V, V<sub>SS</sub>=0V, V<sub>IC</sub>=2.5V, R<sub>L</sub>=8Ω(connected V<sub>DD</sub>/2), Ta=25°C

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
<b>● DC CHARACTERISTICS</b>						
Maximum Output Voltage *RL=OPEN	V <sub>OH1</sub>	I <sub>source</sub> =250mA	4.85	4.90	-	V
	V <sub>OH2</sub>	I <sub>source</sub> =150mA	4.88	4.94	-	V
	V <sub>OH3</sub>	I <sub>source</sub> =50mA	4.92	4.98	-	V
	V <sub>OL1</sub>	I <sub>sink</sub> =250mA	-	0.10	0.15	V
	V <sub>OL2</sub>	I <sub>sink</sub> =150mA	-	0.06	0.12	V
	V <sub>OL3</sub>	I <sub>sink</sub> =50mA	-	0.02	0.08	V
Input Offset Voltage	V <sub>io</sub>		-	2	10	mV
Input Bias Current	I <sub>B</sub>		-	1	-	pA
Input Offset Current	I <sub>IO</sub>		-	1	-	pA
Large Signal Voltage Gain	A <sub>v</sub>	V <sub>o</sub> = V <sub>DD</sub> /2±2V	80	100	-	dB
Common Mode Rejection Ratio	CMR	V <sub>ICM</sub> =0V to 3.8V	60	80	-	dB
Supply Voltage Rejection Ratio	SVR	V <sub>DD</sub> =2.7V to 5.5V	60	80	-	dB
Input Common Mode Voltage Range	V <sub>ICM</sub>	CMR≥60dB	0	-	3.8	V
Operating Current	I <sub>DD</sub>	No Signal, R <sub>L</sub> =open	-	3.5	5.3	mA
<b>● AC CHARACTERISTICS</b>						
Unity Gain Bandwidth	f <sub>T</sub>	G <sub>v</sub> =6dB, C <sub>L</sub> =10pF	-	0.4	-	MHz
Equivalent Input Noise Voltage	V <sub>NI</sub>	f=1kHz, G <sub>v</sub> =6dB, R <sub>s</sub> =100Ω,	-	60	-	nV/√Hz
Total Harmonic Distortion (THD+N)	THD	G <sub>v</sub> =6dB, C <sub>L</sub> =10pF f <sub>in</sub> =1kHz, P <sub>o</sub> =250mW	-	0.03	-	%
Output Power	P <sub>o</sub>	G <sub>v</sub> =6dB, C <sub>L</sub> =10pF f <sub>in</sub> =1kHz, THD≤5%	-	400	-	mW
Channel Separation	CS	f=1kHz	-	90	-	dB

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
<b>● TRANSIENT CHARACTERISTICS</b> Slew Rate	SR	$G_V=0\text{dB}$ , $C_L=10\text{pF}$ $V_{in}=1.0\text{Vpp}$	-	0.7	-	V/ $\mu\text{s}$

$V_{DD}=3\text{V}$ ,  $V_{SS}=0\text{V}$ ,  $V_{IC}=1.5\text{V}$ ,  $R_L=8\Omega$  (connected  $V_{DD}/2$ ),  $T_a=25^\circ\text{C}$

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
<b>● DC CHARACTERISTICS</b>						
Maximum Output Voltage * $R_L=OPEN$	$V_{OH1}$	Is <sub>source</sub> =250mA	2.77	2.85	-	V
	$V_{OH2}$	Is <sub>source</sub> =150mA	2.83	2.91	-	V
	$V_{OH3}$	Is <sub>source</sub> =50mA	2.90	2.97	-	V
	$V_{OL1}$	Is <sub>sink</sub> =250mA	-	0.15	0.23	V
	$V_{OL2}$	Is <sub>sink</sub> =150mA	-	0.09	0.17	V
	$V_{OL3}$	Is <sub>sink</sub> =50mA	-	0.03	0.10	V
Input Offset Voltage	$V_{io}$		-	2	10	mV
Input Bias Current	$I_B$		-	1	-	pA
Input Offset Current	$I_{Io}$		-	1	-	pA
Large Signal Voltage Gain	$A_V$	$V_o = V_{DD}/2 \pm 1\text{V}$	70	90	-	dB
Common Mode Rejection Ratio	CMR	$V_{ICM}=0\text{V}$ to 1.8V	60	80	-	dB
Supply Voltage Rejection Ratio	SVR	$V_{DD} = 2.7\text{V}$ to 3.5V	58	70	-	dB
Input Common Mode Voltage Range	$V_{ICM}$	CMR $\geq 60\text{dB}$	0	-	1.8	V
Operating Current	$I_{DD}$	No Signal, $R_L=open$	-	2.4	3.5	mA
<b>● AC CHARACTERISTICS</b>						
Unity Gain Bandwidth	$f_T$	$G_V=6\text{dB}$ , $C_L=10\text{pF}$	-	0.4	-	MHz
Equivalent Input Noise Voltage	$V_{NI}$	$f=1\text{kHz}$ , $G_V=6\text{dB}$ , $R_s=100\Omega$ ,	-	60	-	nV/ $\sqrt{\text{Hz}}$
Total Harmonic Distortion (THD+N)	THD	$G_V=6\text{dB}$ , $C_L=10\text{pF}$ $f_{in}=1\text{kHz}$ , $P_o=60\text{mW}$	-	0.06	-	%
Output Power	$P_o$	$G_V=6\text{dB}$ , $C_L=10\text{pF}$ $f_{in}=1\text{kHz}$ , THD $\leq 5\%$	-	150	-	mW
Channel Separation	CS	$f=1\text{kHz}$	-	90	-	dB
<b>● TRANSIENT CHARACTERISTICS</b> Slew Rate	SR	$G_V=0\text{dB}$ , $C_L=10\text{pF}$ $V_{in}=0.5\text{Vpp}$	-	0.5	-	V/ $\mu\text{s}$

## Application Notes

### Package Power, Power Dissipation and Output Power

IC is heated by own operation and possibly gets damage when the junction power exceeds the acceptable value called Power Dissipation  $P_D$ . The dependence of the NJU7036  $P_D$  on ambient temperature is shown in Fig 1. The plots are depended on following two points. The first is  $P_D$  on ambient temperature  $25^\circ\text{C}$ , which is the maximum power dissipation. The second is  $0\text{W}$ , which means that the IC cannot radiate any more. Conforming the maximum junction temperature  $T_{j\text{max}}$  to the storage temperature  $T_{\text{stg}}$  derives this point. Fig.1 is drawn by connecting those points and conforming the  $P_D$  lower than  $25^\circ\text{C}$  to it on  $25^\circ\text{C}$ . The  $P_D$  is shown following formula as a function of the ambient temperature between those points.

$$\text{Dissipation Power } P_D = \frac{T_{j\text{max}} - T_a}{\theta_{ja}} \text{ [W]} \quad (T_a=25^\circ\text{C} \sim T_a=150^\circ\text{C})$$

Where,  $\theta_{ja}$  is heat thermal resistance which depends on parameters such as package material, frame material and so on. Therefore,  $P_D$  is different in each package.

While, the actual measurement of dissipation power on NJU7036 is obtained using following equation.

$$(\text{Actual Dissipation Power}) = (\text{Supply Voltage } V_{DD}) \times (\text{Supply Current } I_{DD}) - (\text{Output Power } P_o)$$

The NJU7036 should be operated in lower than  $P_D$  of the actual dissipation power.

To sustain the steady state operation, take account of the Dissipation Power and thermal design.

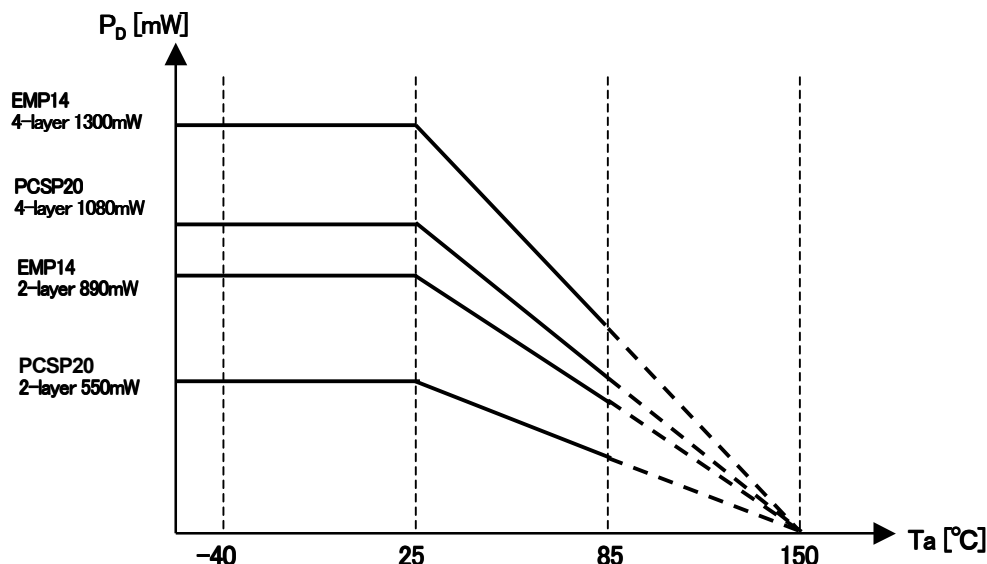


Fig.1 Power Dissipations vs. Ambient Temperature on the NJU7036.

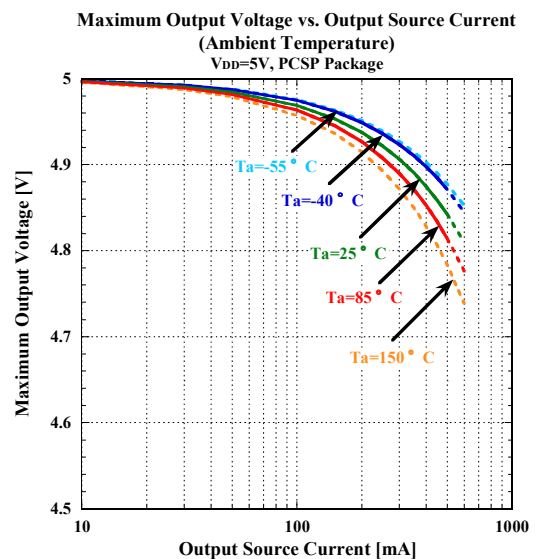
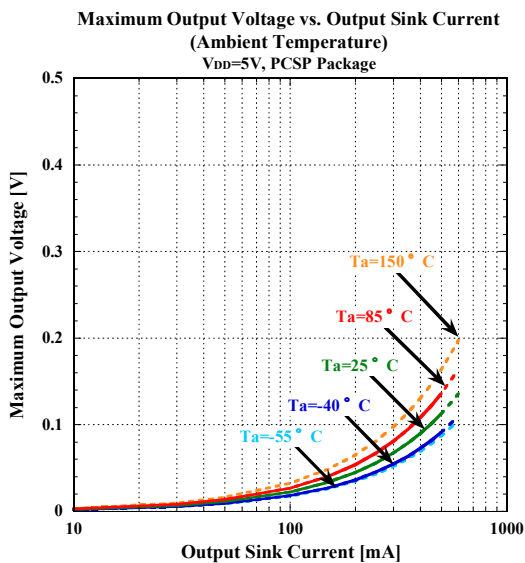
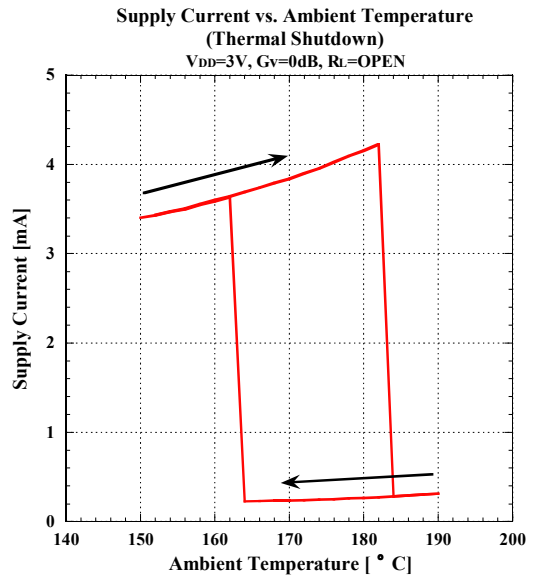
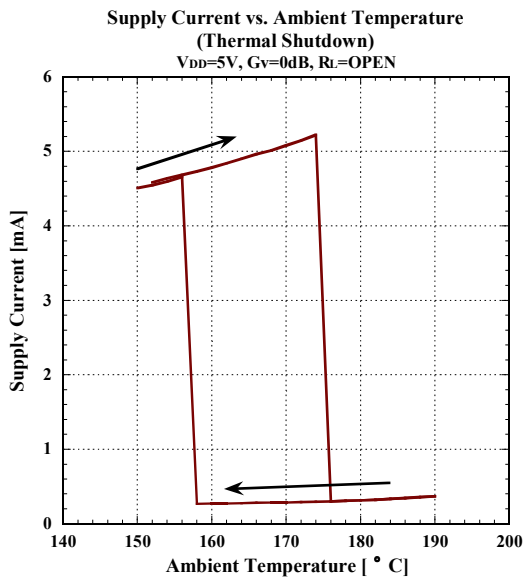
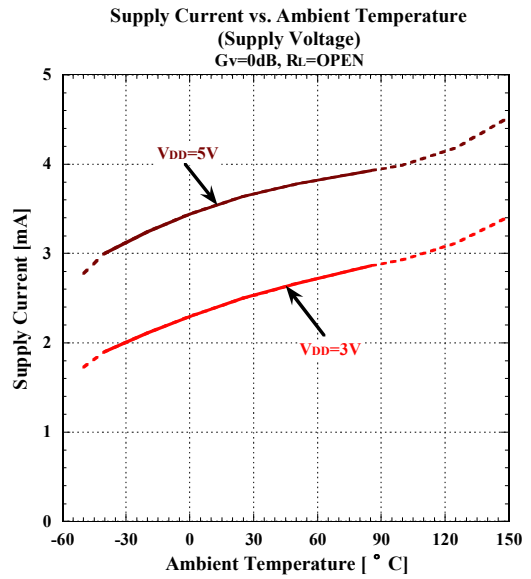
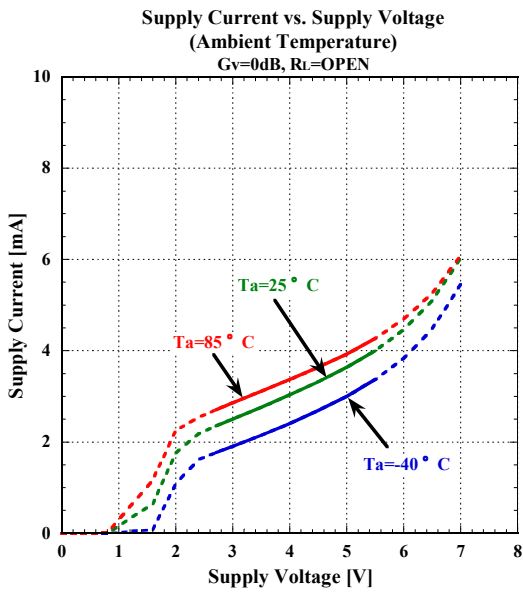
### Thermal Protection

The NJU7036 is designed with Thermal Shut Down (TSD) circuitry that protects itself from damage caused by overload condition. The TSD circuitry is operated when the junction temperature reaches approximately  $180^\circ\text{C}$ , and the actual measurement of dissipation power is reduced by the stopped output current. When the junction temperature cools to approximately  $150^\circ\text{C}$ , the output circuitry is automatically re-enabled. Continuously running the NJU7036 into the thermal shutdown possibly damages device since the TSD circuit doesn't have active cooling function such as heat sinking. To sustain the steady state operation, the NJU7036 should be operated in lower than the Dissipation Power of the actual dissipation power.

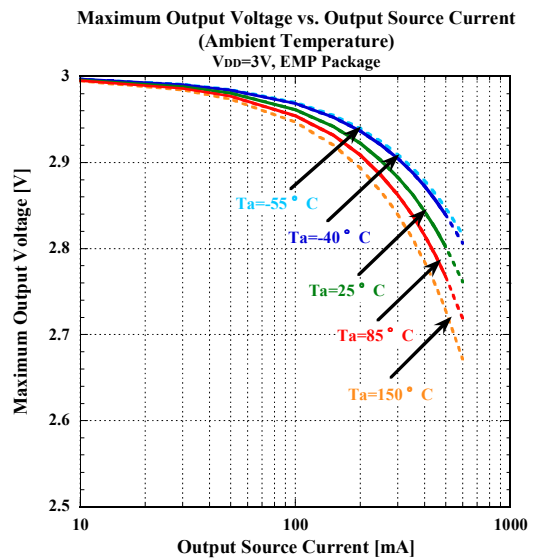
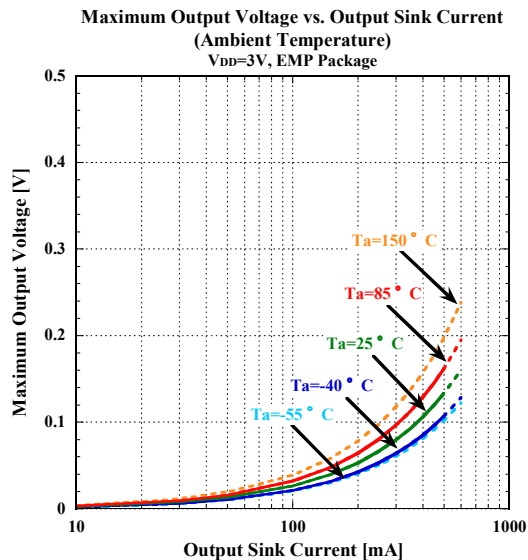
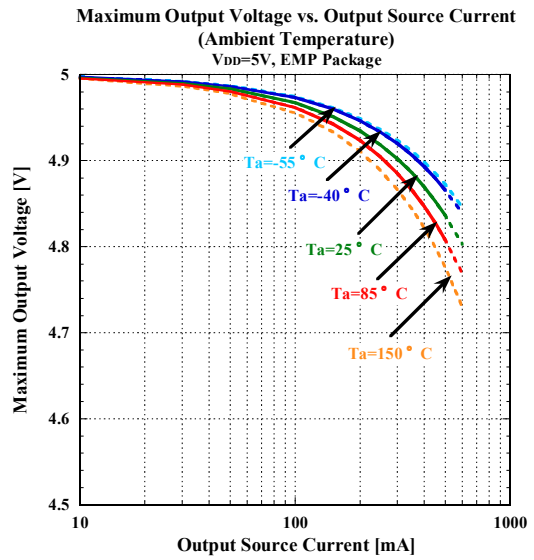
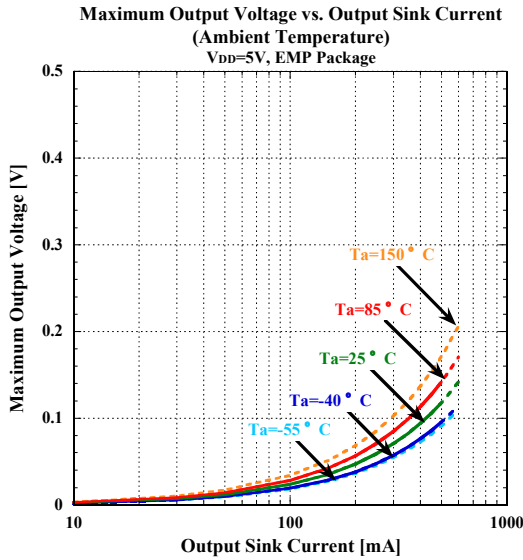
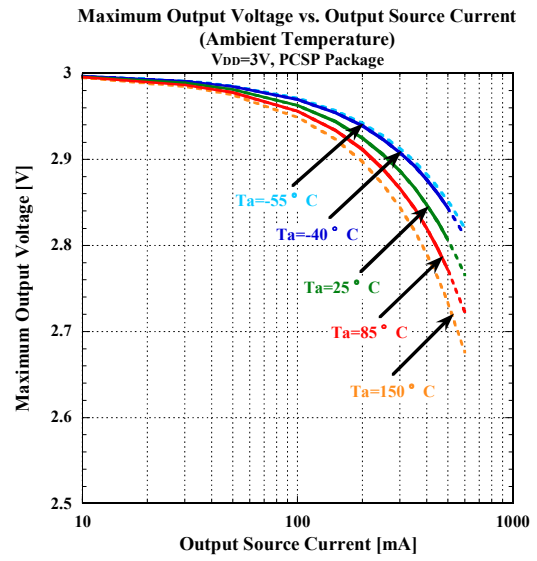
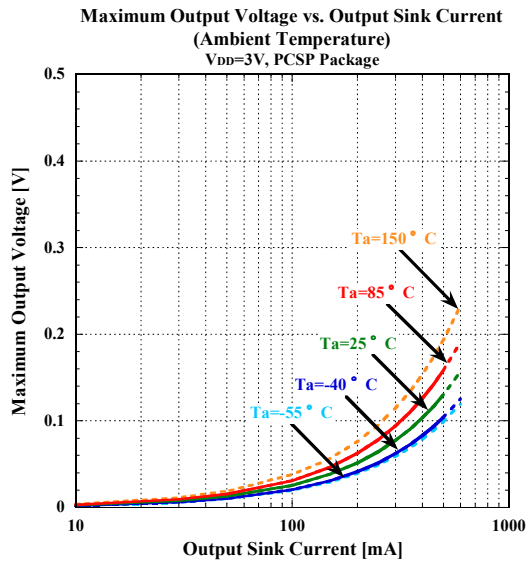
### Current Limit

The NJU7036 should be operated in lower than  $500\text{mA}$  of output current. The NJU7036 has current limiting circuitry that prevents from exceeding output current caused by grounding in order to enhance the safety of operation. The circuitry limits output current to approximately  $1\text{A}$ . Although the output current is lower than  $500\text{mA}$ , the device possibly gets damage due to heating by output current. To sustain the steady state operation, the NJU7036 should be operated in lower than  $500\text{mA}$  of output current and lower than the Dissipation Power of the actual dissipation power.

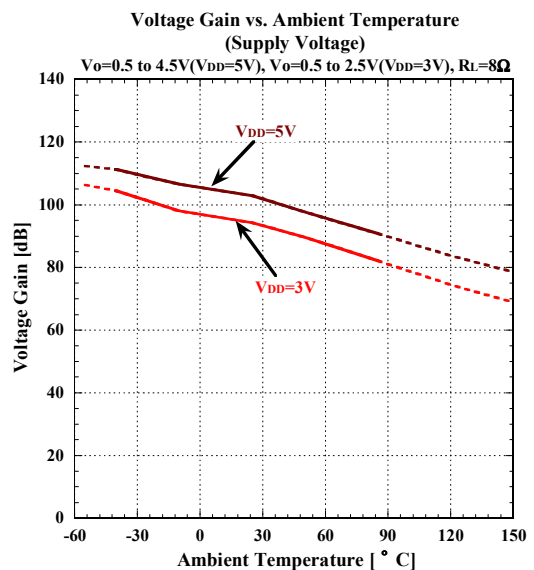
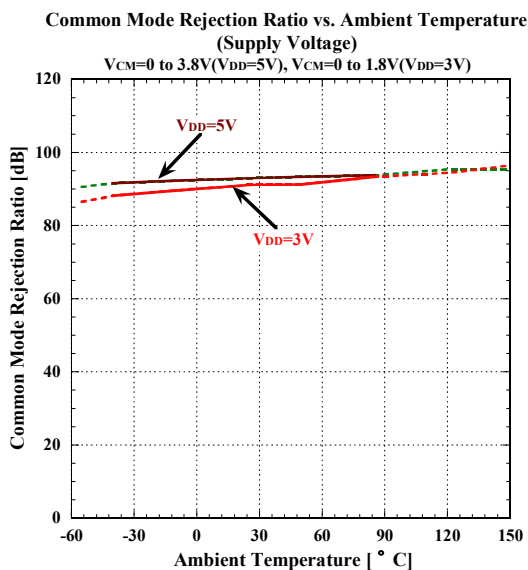
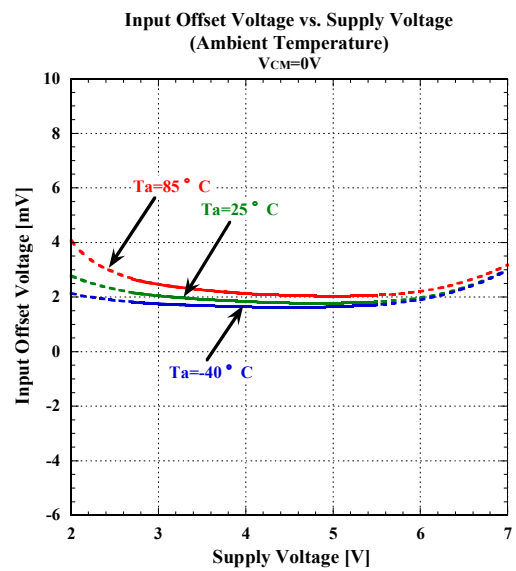
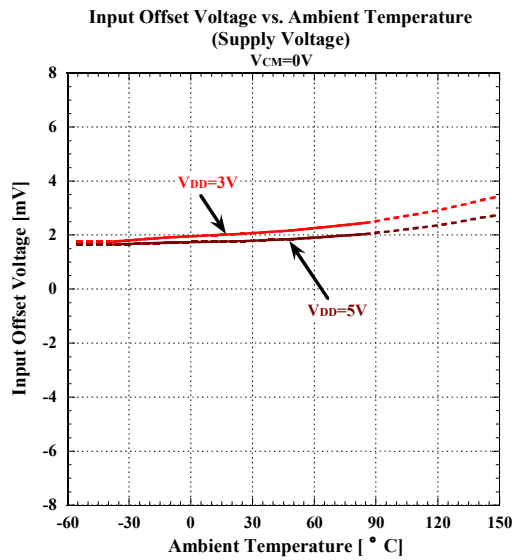
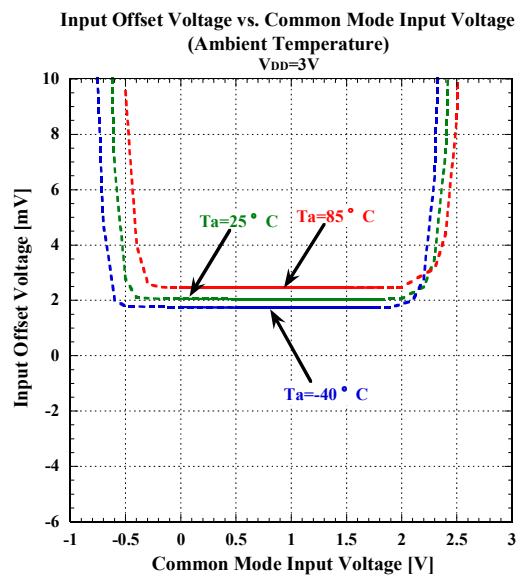
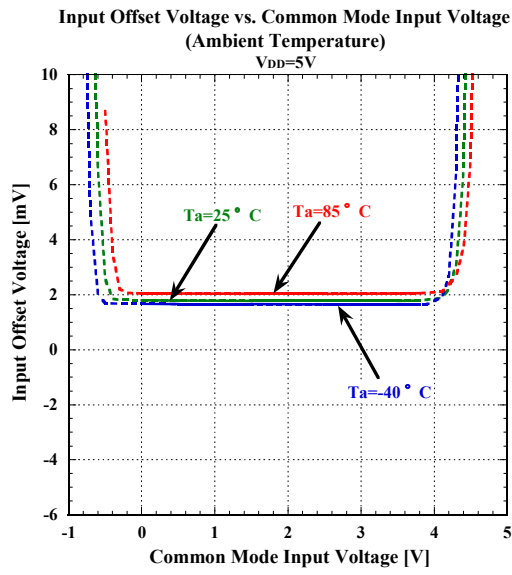
■ TYPICAL CHARACTERISTICS



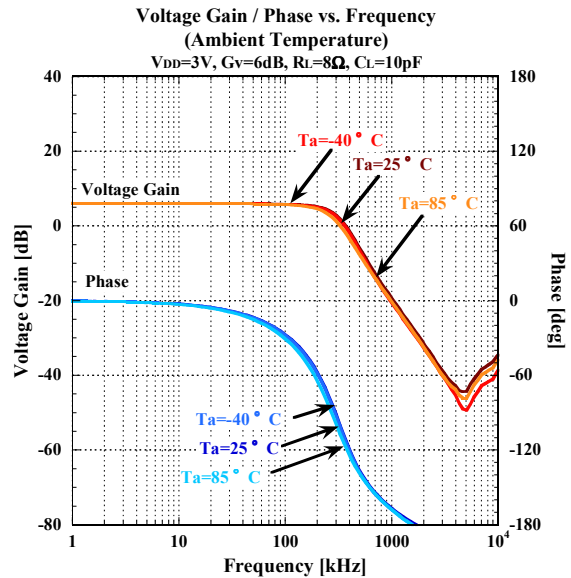
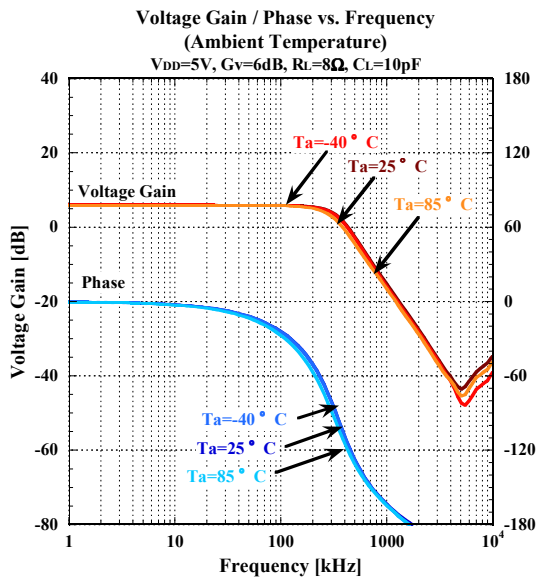
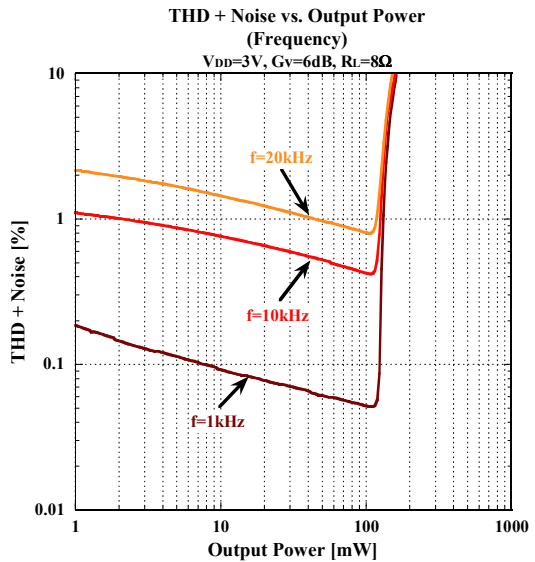
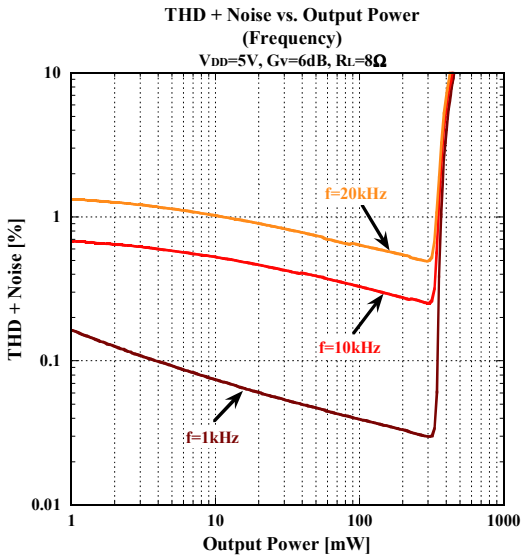
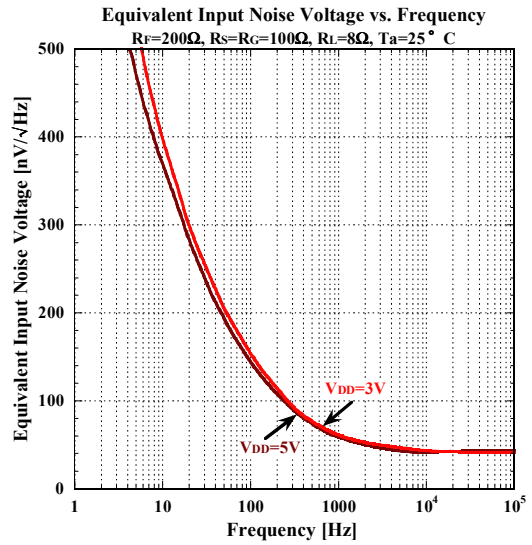
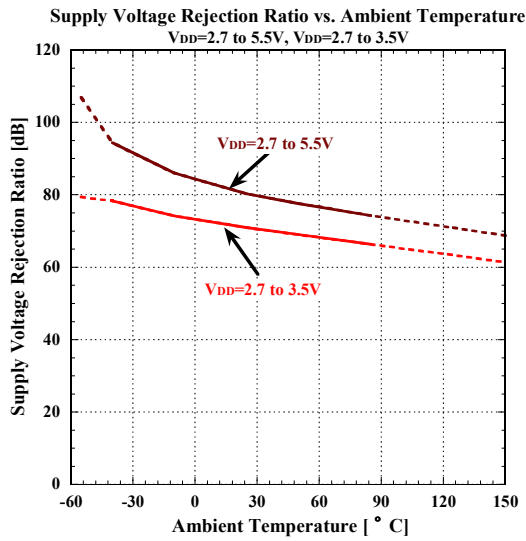
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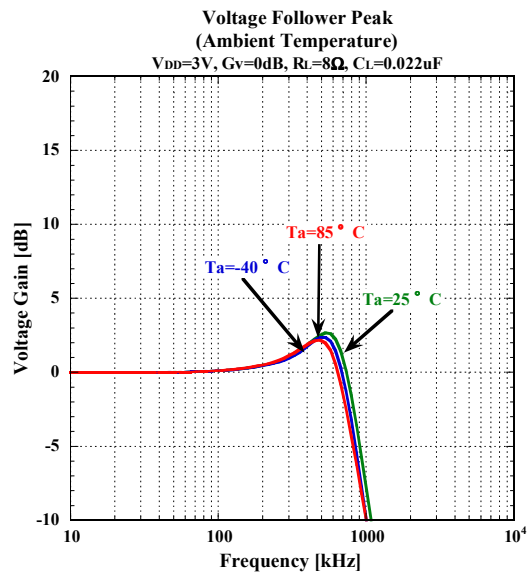
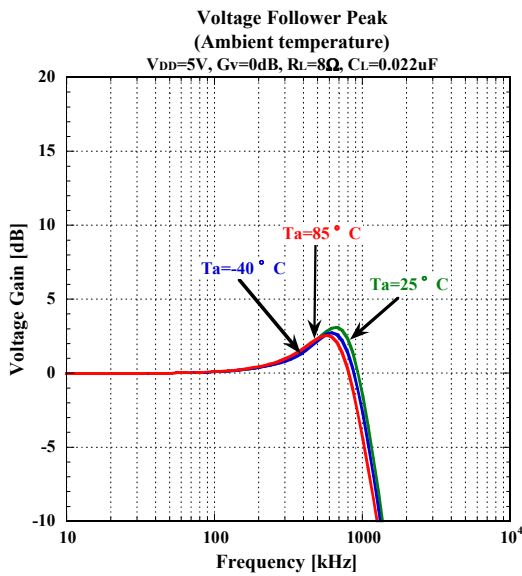
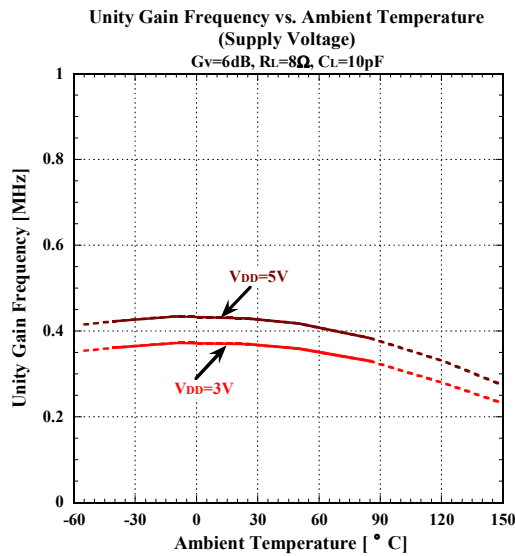
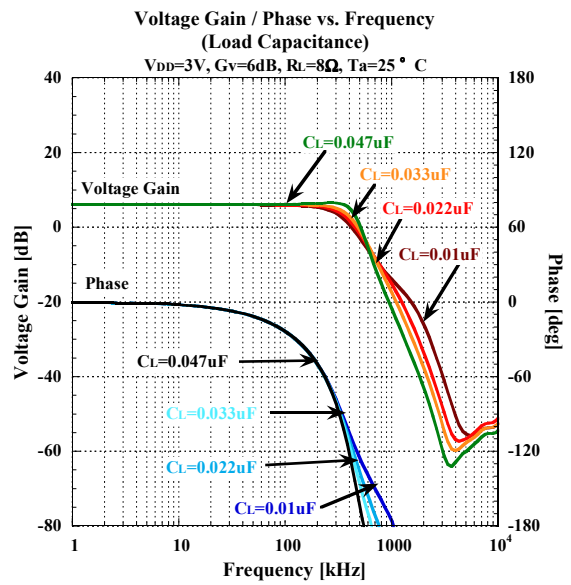
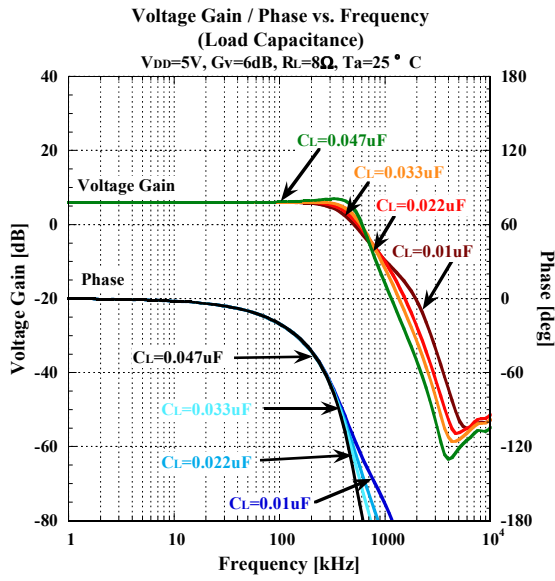


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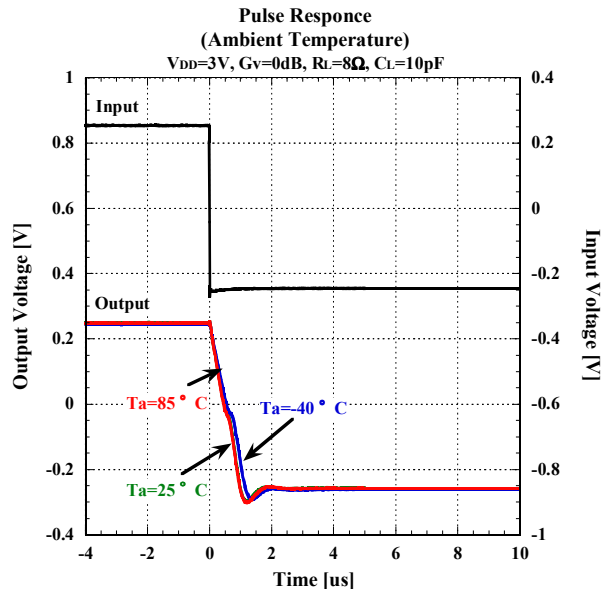
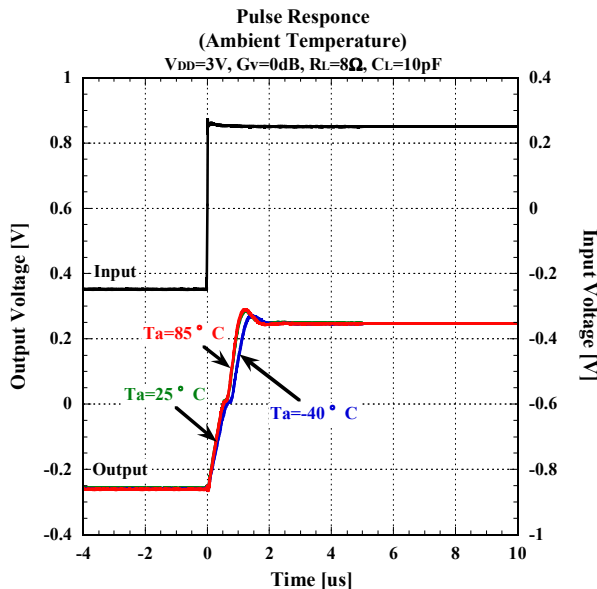
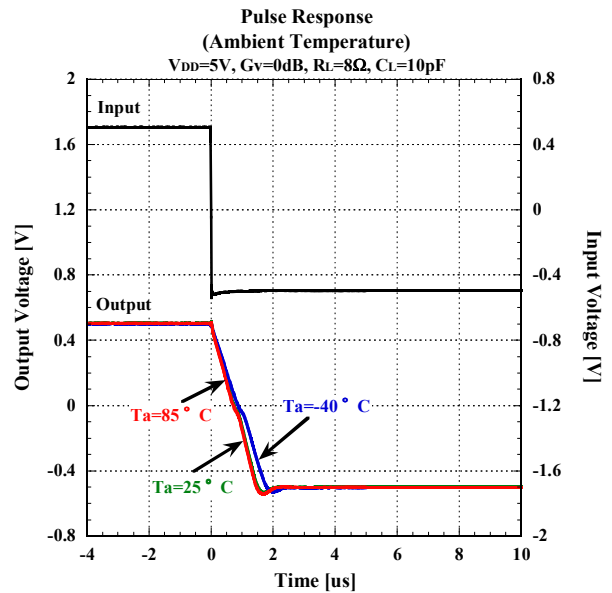
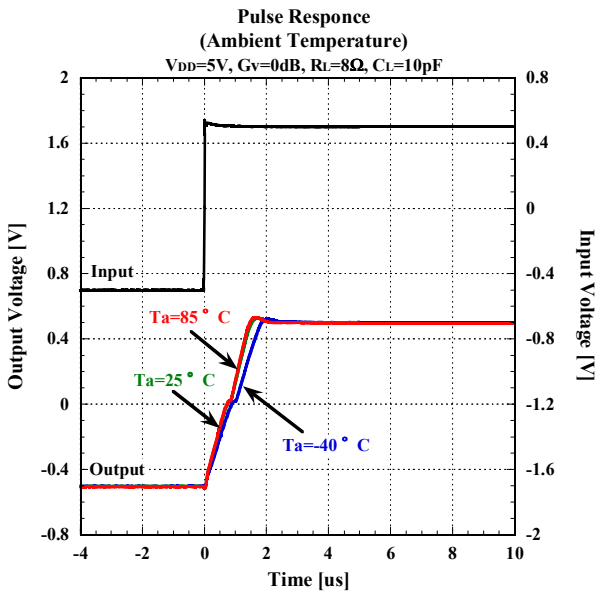
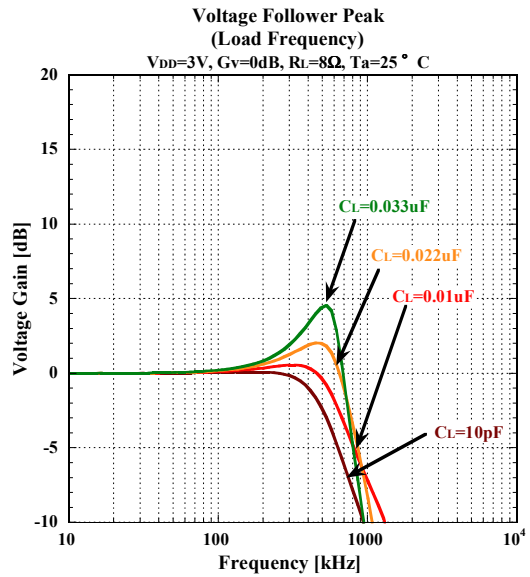
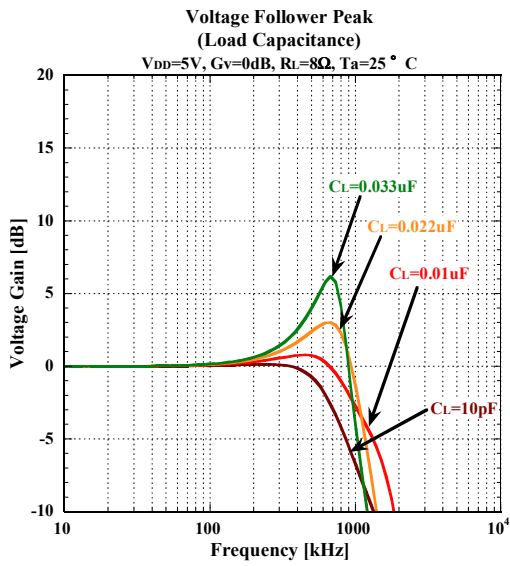




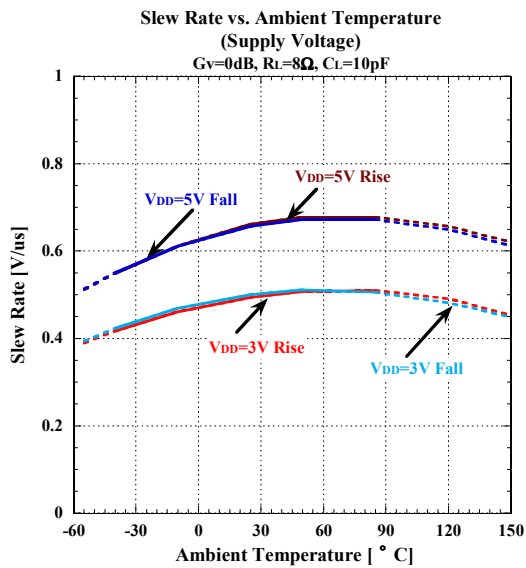
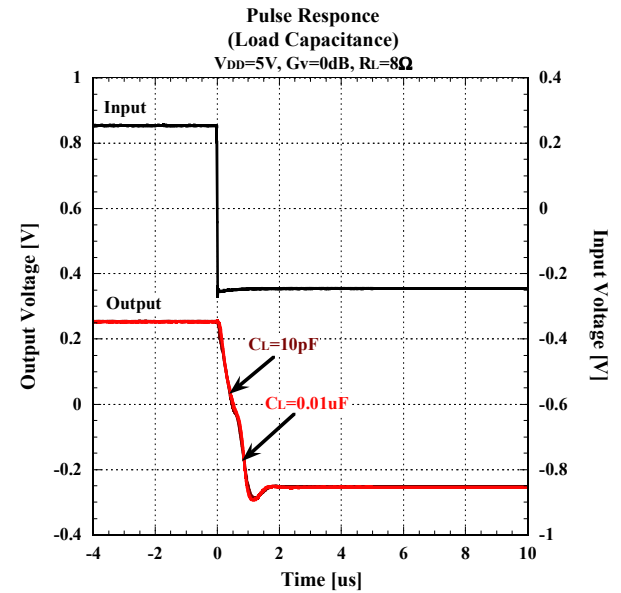
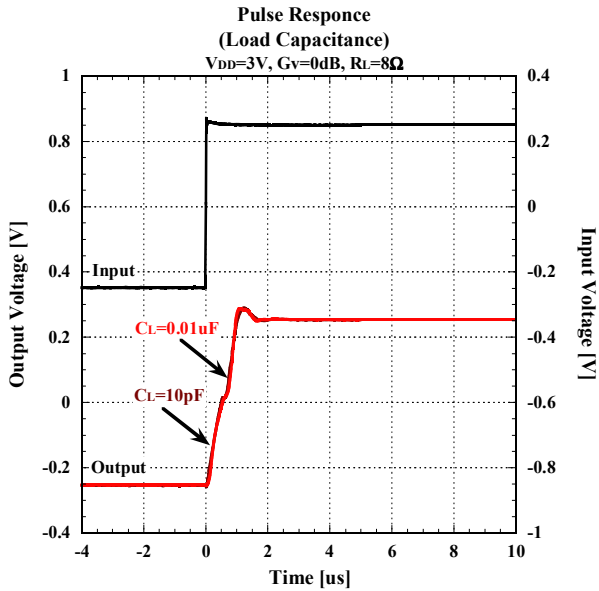
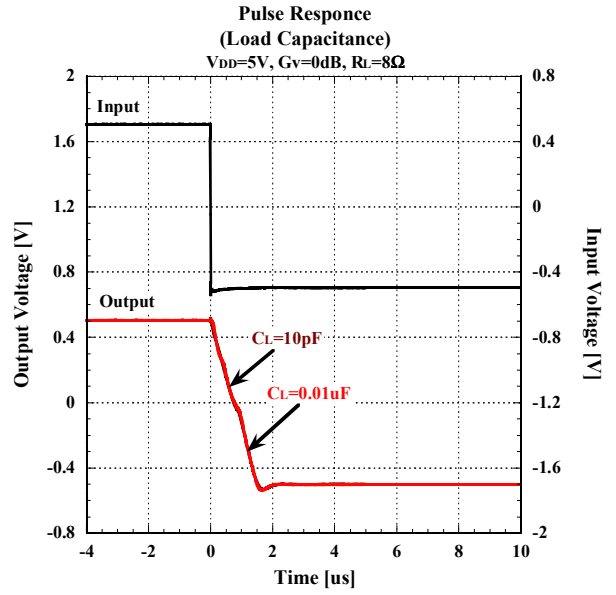
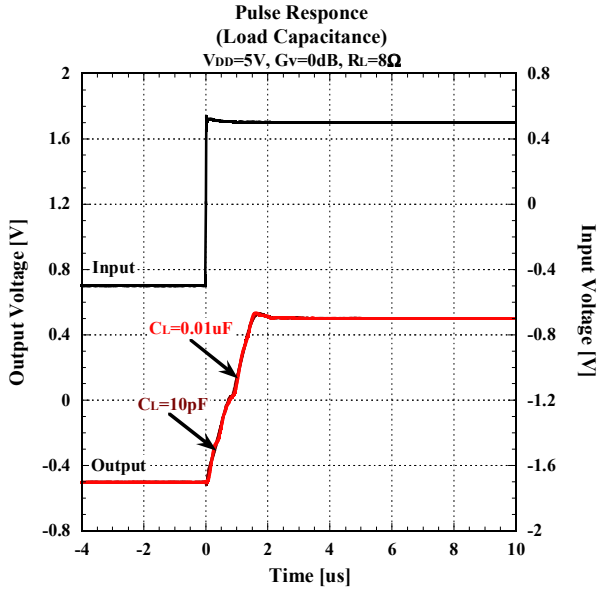
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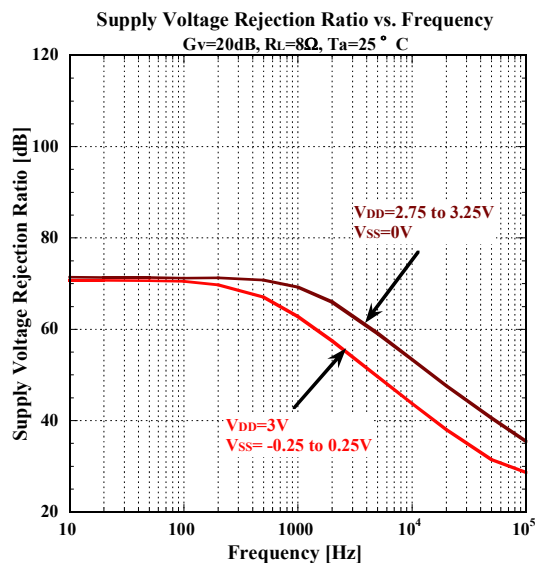
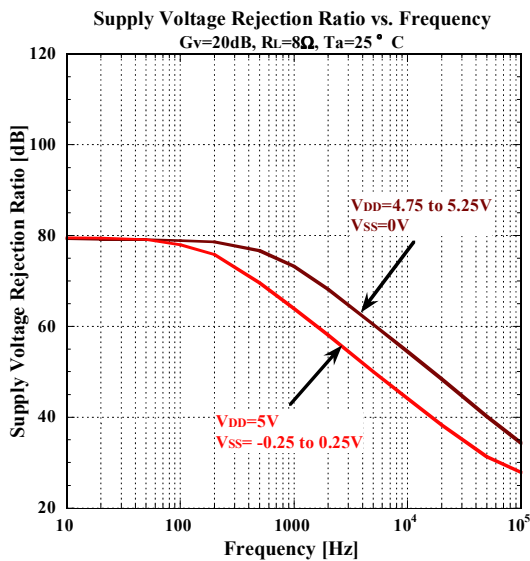
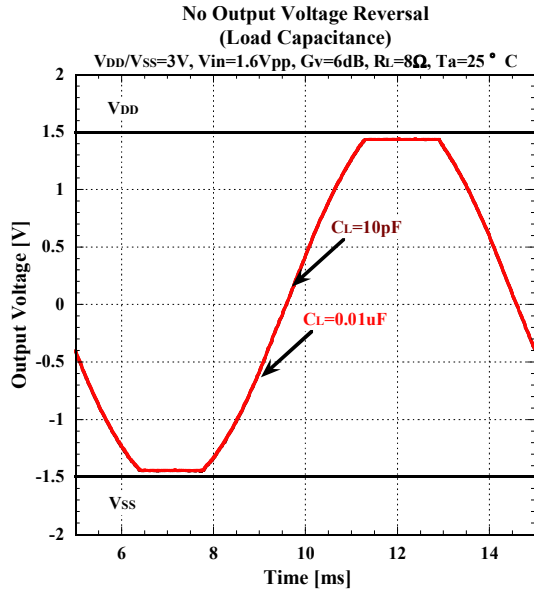
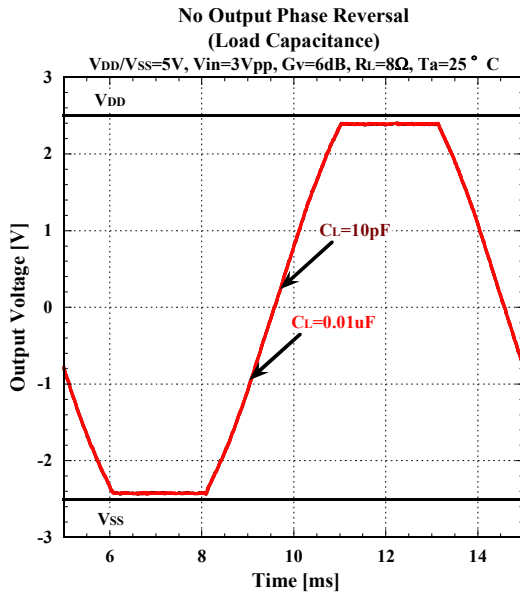
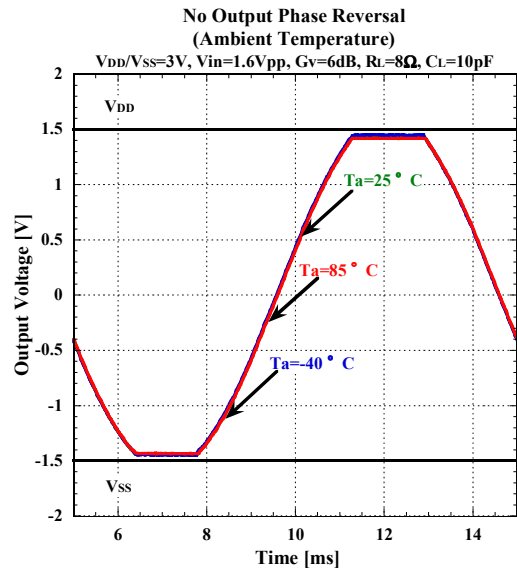
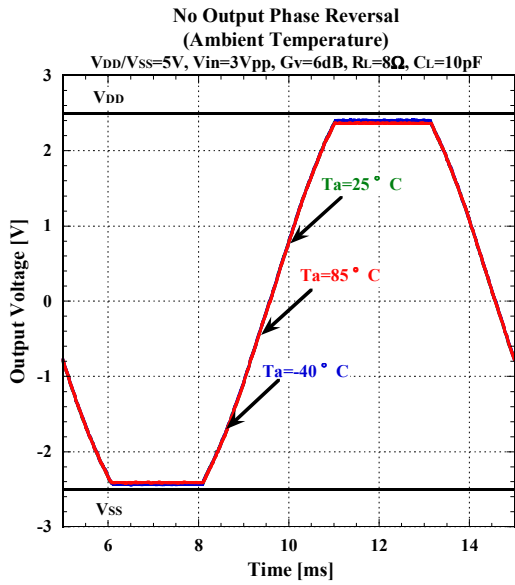
## TYPICAL CHARACTERISTICS



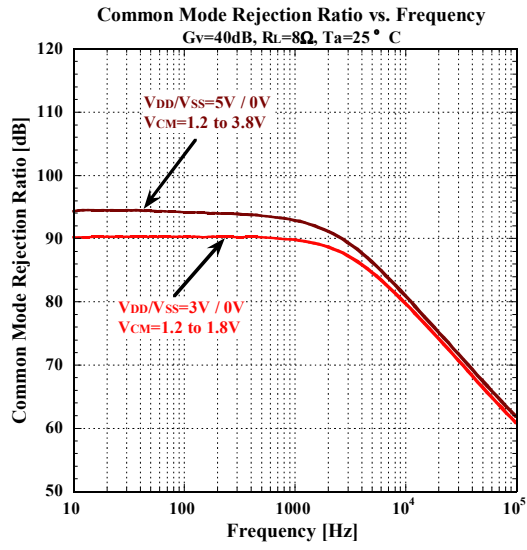
■ TYPICAL CHARACTERISTICS



## ■ TYPICAL CHARACTERISTICS

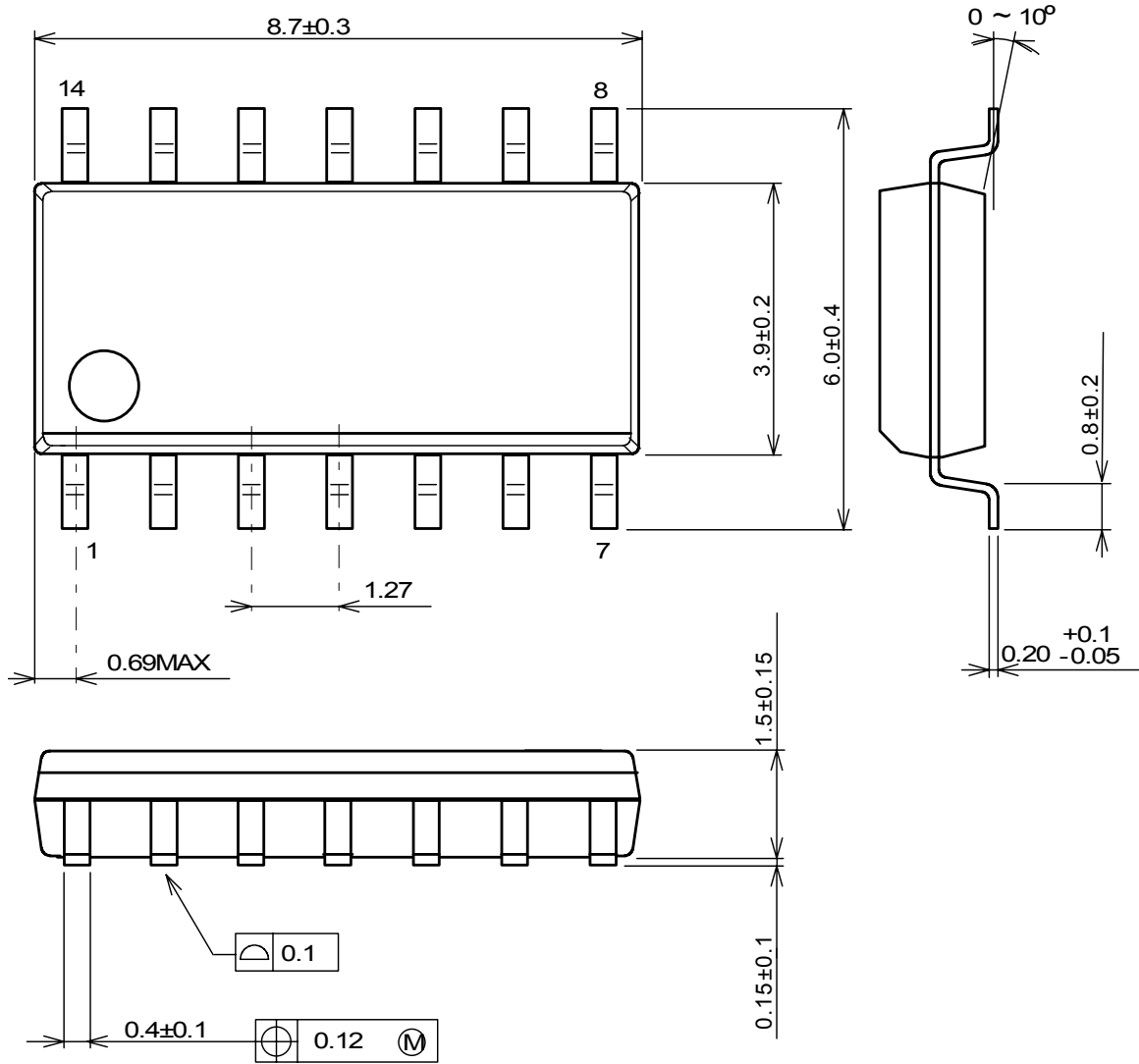


■ TYPICAL CHARACTERISTICS

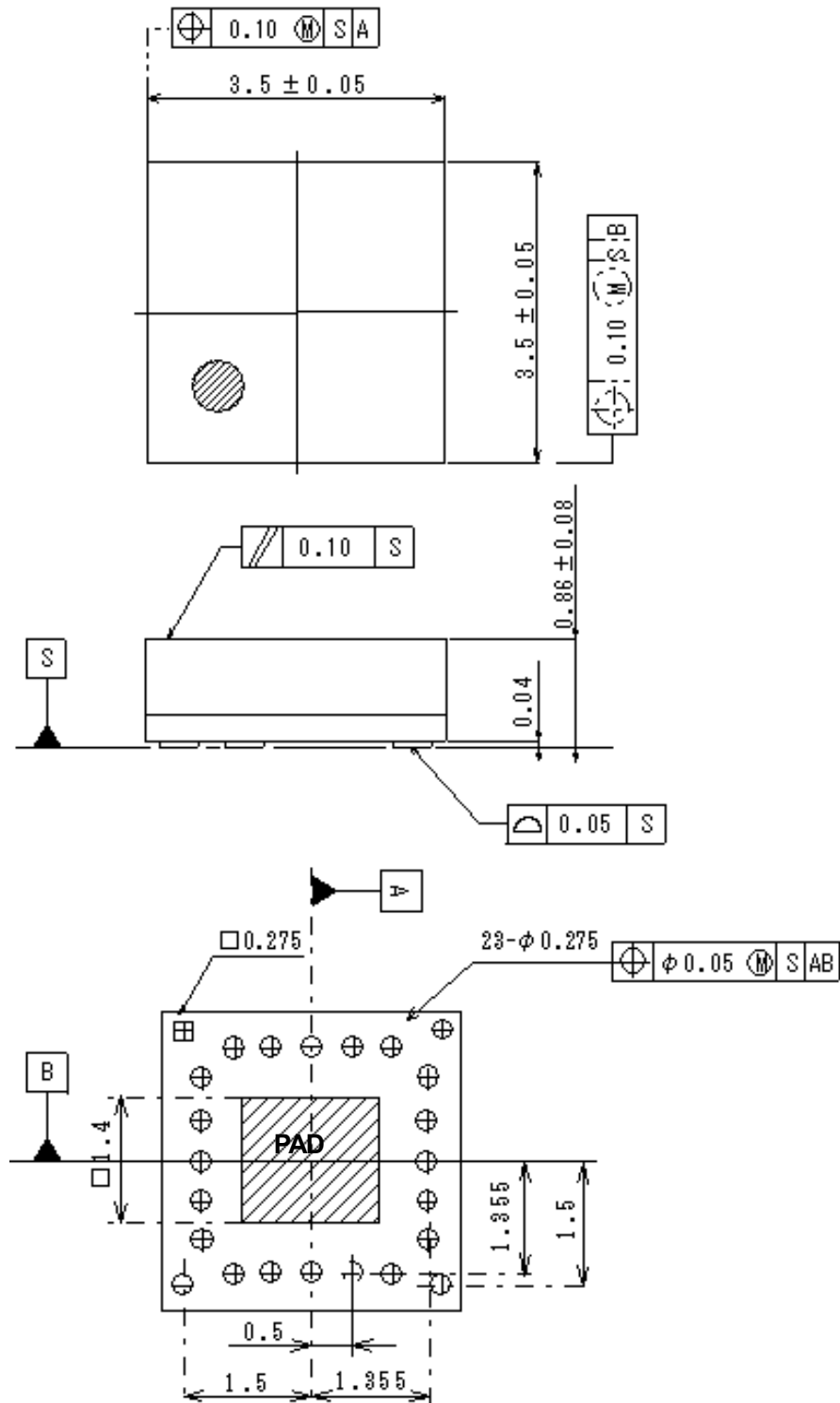


■ PACKAGE DIMENSIONS

EMP-14



PCSP-20E3



The PAD is electrically not connected to the backside of the die.  
 Moreover, Please mount PAD on plain GND to give heat radiation.

[CAUTION]  
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