

1000V High Voltage Monitor IC

■ FEATURES

- AEC-Q100 Grade 1 Qualified (only Aver)
- Operation Voltage Range 2.2V to 5.5V
- Common Mode Input Voltage Range 1000V
- Differential Input Voltage ±1000V
- High Precision Attenuation Rate
 ±1% (T_a = -40°C to 125°C)
- High Input Resistance 30MΩ min.
- Integrated EMI filter
- Operating Temperature -40°C to 125°C
- Package PMAP11-PM
 New Package for Creepage Distance (IEC/EN60664)

■ GENERAL DESCRIPTION

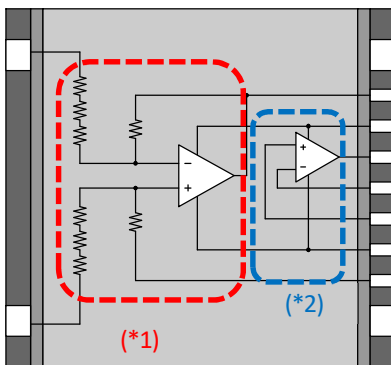
The NJU7890 is a high voltage monitor IC capable of inputting voltages up to 1000V. With our proprietary semiconductor process technology, NJU7890 realizes wide common mode / differential input voltage.

The NJU7890 is suitable for powertrain application such as HV and EV.

■ APPLICATION

- Automotive application
 Powertrain and Battery management ECU
- High-Voltage Monitoring Applications

■ BLOCK DIAGRAM



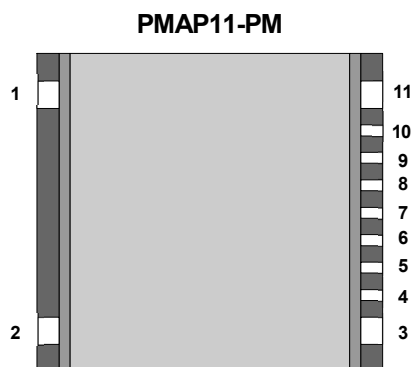
(*1) High Voltage Monitor Block

(*2) OP-Amp Block

■ ATTENUATION RATE VERSION

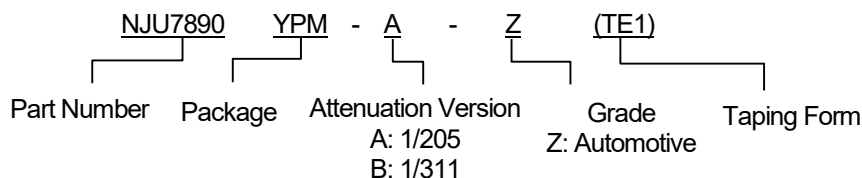
PRODUCT NAME	INPUT RESISTANCE	ATTENUATION VERSION	GAIN	PACKAGE
NJU7890YPM-A-Z	30MΩ	A	1/205	PMAP11-PM
NJU7890YPM-B-Z	30MΩ	B	1/311	PMAP11-PM

■ PIN CONFIGURATION



PIN NO.	SYMBOL
1	-HVIN
2	+HVIN
3	V ⁻
4	REF
5	V ⁻
6	+OPIN
7	-OPIN
8	OP OUT
9	V ⁺
10	OUT
11	V ⁻

■ PRODUCT NAME INFORMATION



■ ORDERING INFORMATION

PRODUCT NAME	PACKAGE	RoHS	HALOGEN-FREE	TERMINAL FINISH	MARKING	WEIGHT (mg)	MOQ (pcs)
NJU7890YPM-A-Z (TE1)	PMAP11-PM	Yes	Yes	Sn2Bi	90AZ	300	2000
NJU7890YPM-B-Z (TE1)	PMAP11-PM	Yes	Yes	Sn2Bi	90BZ	300	2000

■ **ABSOLUTE MAXIMUM RATINGS** (REF = 0V, unless otherwise noted.)

PARAMETER	SYMBOL	RATINGS	UNIT
GENERAL CHARACTERISTICS			
Supply Voltage	$V^+ - V^-$	7	V
Power Dissipation ($T_a = 25^\circ\text{C}$) PMAP11-PM	P_D	2Layers / 4Layers 1100 ⁽¹⁾ / 2000 ⁽²⁾	mW
Junction Temperature	T_j	150	$^\circ\text{C}$
Storage Temperature	T_{stg}	-55 to 150	$^\circ\text{C}$
HIGH VOLTAGE MONITOR			
Input Voltage 1	V_{IN1}	-1000 to 1000	V
Differential Input Voltage 1	V_{ID1}	± 1000 ⁽³⁾	V
Reference Voltage	REF	$V^- - 0.3$ to V^+	V
OPERATIONAL AMPLIFIER			
Input Voltage 2	V_{IN2}	$V^- - 0.3$ to V^+	V
Differential Input Voltage 2	V_{ID2}	± 7	V

(1) 2-Layer: Mounted on glass epoxy board (76.2 mm × 114.3 mm × 1.6 mm: based on EIA/JEDEC standard, 2-layer FR-4).

(2) 4-Layer: 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.

(3) Differential voltage is the voltage difference between +HVIN and -HVIN

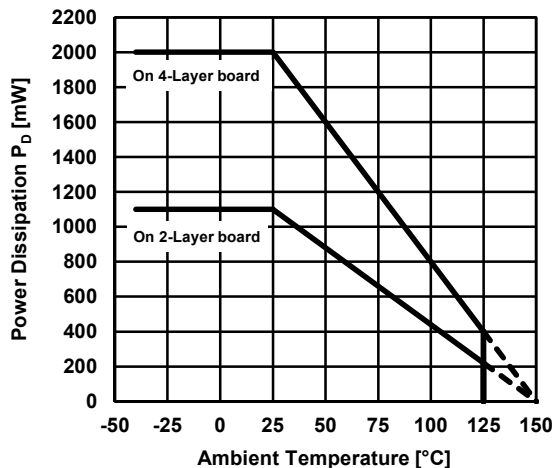
■ **RECOMMENDED OPERATING CONDITIONS**

PARAMETER	SYMBOL	RATINGS	UNIT
Supply Voltage	$V^+ - V^-$	2.2 to 5.5	V
Reference Voltage	REF	V^- to $V^+ - 0.85$	V
Operating Temperature	T_{opr}	-40 to 125	$^\circ\text{C}$

■ **POWER DISSIPATION vs. AMBIENT TEMPERATURE**

PMP11-PM Power Dissipation vs. Temperature

$T_{opr} = -40^\circ\text{C}$ to 125°C , $T_j = 150^\circ\text{C}$



■ ELECTRICAL CHARACTERISTICS

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT	
GENERAL CHARACTERISTICS ($V^+ = 5V$, $V^- = 0V$, $T_a = 25^\circ C$, unless otherwise noted.)							
Supply Current	I_{SUPPLY}	No signal	-	1.2	1.8	mA	
		No signal, $T_a = -40^\circ C$ to $125^\circ C$	-	-	1.8		
HIGH VOLTAGE MONITOR ($V^+ = 5V$, $V^- = 0V$, $REF = 2.5V$, $T_a = 25^\circ C$, unless otherwise noted.)							
Input Resistance	R_{IN}	$-HVIN$ to OUT , $T_a = -40^\circ C$ to $125^\circ C$	30	-	42	$M\Omega$	
		$+HVIN$ to REF , $T_a = -40^\circ C$ to $125^\circ C$	30	-	42		
Attenuation Rate	ATT	Aver		-0.7%	1/205	+0.7%	V/V
			$T_a = -40^\circ C$ to $125^\circ C$	-1.0%	-	+1.0%	
		Bver		-0.7%	1/311	+0.7%	
			$T_a = -40^\circ C$ to $125^\circ C$	-1.0%	-	+1.0%	
Output Offset Voltage	V_{OS-RT0}	$-/+HVIN = 0V$	-	0.04	0.30	mV	
		$-/+HVIN = 0V$, $T_a = -40^\circ C$ to $125^\circ C$	-	-	0.80		
Supply Voltage Rejection Ratio 1	SVR1	$V^+ = 2.2V$ to $5.5V$, Referred to output	70	80	-	dB	
Common Mode Rejection Ratio1	CMR1	Aver	$V_{ICM} = -/+HVIN = 0V$ to $660V$, Referred to output, $V^+ = 5V$, $V^- = 0V$, $REF = 0.5V$	85	100	-	dB
		Bver	$V_{ICM} = -/+HVIN = 0V$ to $1000V$, Referred to output, $V^+ = 5V$, $V^- = 0V$, $REF = 0.5V$	85	100	-	
High-level Output Voltage 1	V_{OH1}	$R_L = 10k\Omega$ to $2.5V$	$V^+ - 0.20$	$V^+ - 0.05$	-	V	
Low-level Output Voltage 1	V_{OL1}	$R_L = 10k\Omega$ to $2.5V$	-	$V^+ - 0.05$	$V^+ + 0.20$	V	

■ Calculation of output voltage

$$V_{OUT} = (V_{+HVIN} - V_{-HVIN}) \times ATT + V_{REF} + V_{OS-RTO} + \frac{|5V - V^+|}{SVR1} + \frac{|V_{+HVIN}|}{CMR1}$$

Calculation example

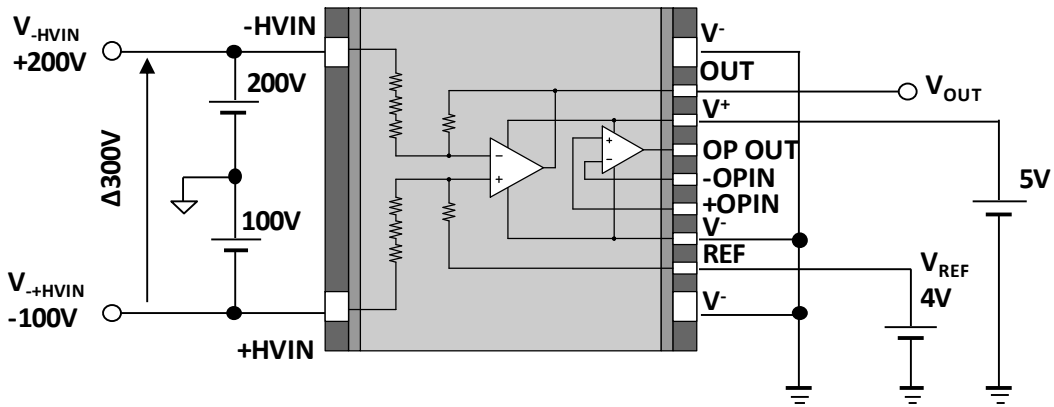
$V_{+HVIN} = -100V, V_{-HVIN} = 200V, V_{REF} = 4V, V^+ = 5.2V, ATT = 1/205 \pm 0.7\% (T_a = 25^\circ C), V_{OS-RTO} = 0.3mV, SVR1 = 70dB, CMR1 = 85dB$

$$V_{OUT} = (-100V - 200V) \times \left(\frac{1}{205} \pm 0.7\% \right) + 4V + 0.3mV + \frac{|-0.2V|}{70dB} + \frac{|-100V|}{85dB}$$

$$V_{OUT} = -300V \times \left(\frac{1}{205} \pm 0.7\% \right) + 4V + 0.3mV + 0.06mV + 5.6mV = 2.553V$$

Without the error component of the calculation example above, the output voltage is 2.537V. The error 0.016V obtained from the calculation example is $0.016V \times (1 \div ATT) = 3.280V$ by calculating the input conversion. The error rate obtained from the input conversion value can be calculated as 1.09% from $3.280V \div 300V$. In addition to the above formula, please be aware that there is a VREF error (accuracy influence).

Evaluation circuit example



■ +HVIN input Voltage Range

In order for this IC to operate normally, the positive input terminal voltage (V_{+IN}) of operational amplifier A must be within the common mode input voltage range of operational amplifier A.

Operational amplifier A: common mode input voltage range

$$V^- \leq V_{+IN} \leq V^+ - 0.85V$$

Therefore, it is necessary to satisfy the following formula expressed by V^+/V^- (supply voltage), V_{+HVIN} (+HVIN terminal voltage), V_{REF} (REF terminal voltage), ATT (attenuation rate).

Calculation

$$V^- \leq \frac{1}{1 + ATT^{-1}} \times V_{+HVIN} + \frac{1}{1 + ATT} \times V_{REF} \leq V^+ - 0.85V$$

Calculation example

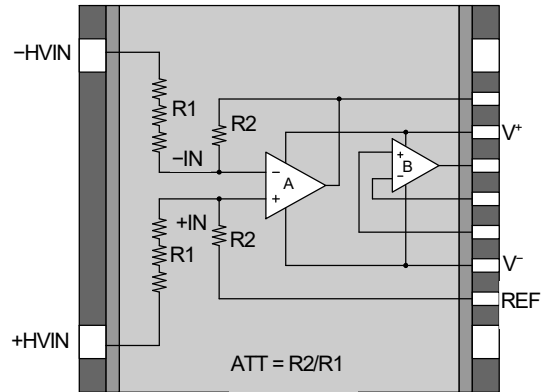
$$V_{REF} = 4V, V^+ / V^- = 5V / 0V, ATT = 1/205$$

$$0V \leq \frac{1}{1 + 205} \times V_{+HVIN} + \frac{1}{1 + 1/205} \times 4V \leq 5V - 0.85V$$

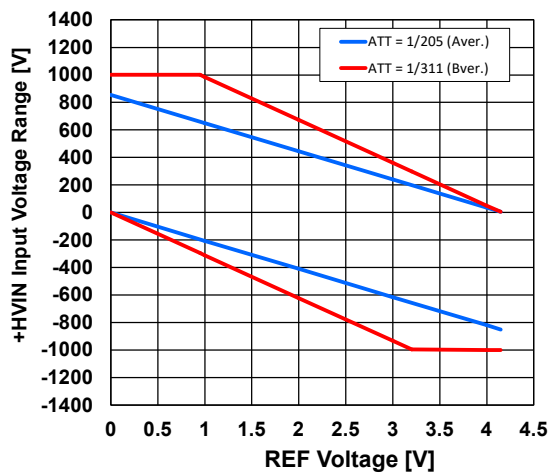
$$-820V \leq V_{+HVIN} \leq 34.9V$$

Characteristics example

The figure below shows an example of characteristics when the attenuation rate is set to 1/205 (Aver) and 1/311 (Bver). The range indicated by the graph is the input voltage range of the +HVIN.



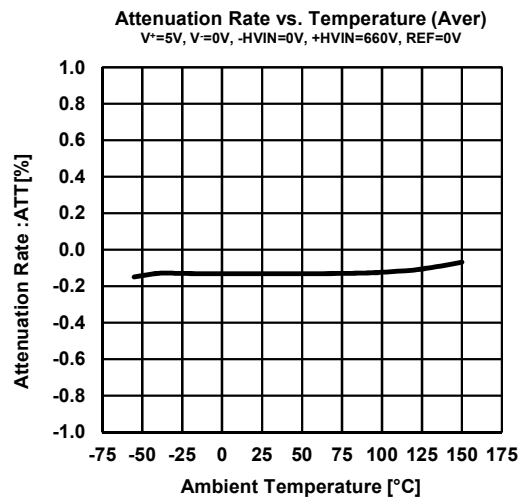
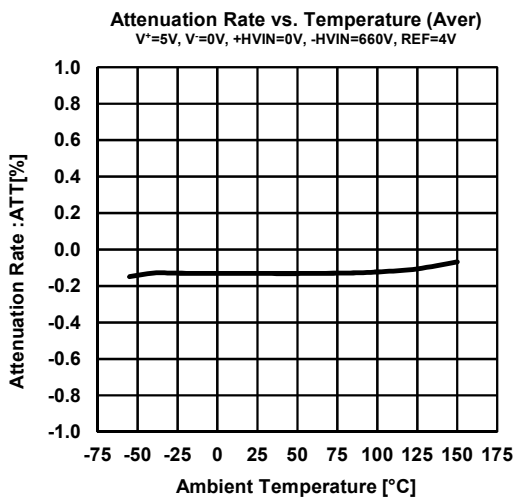
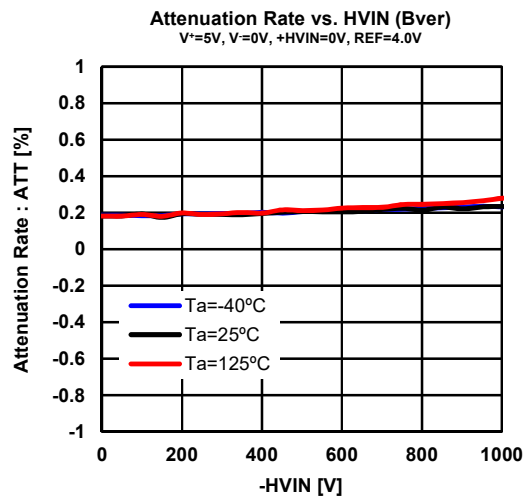
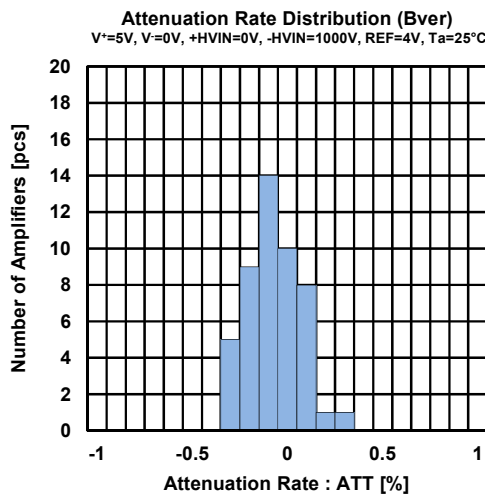
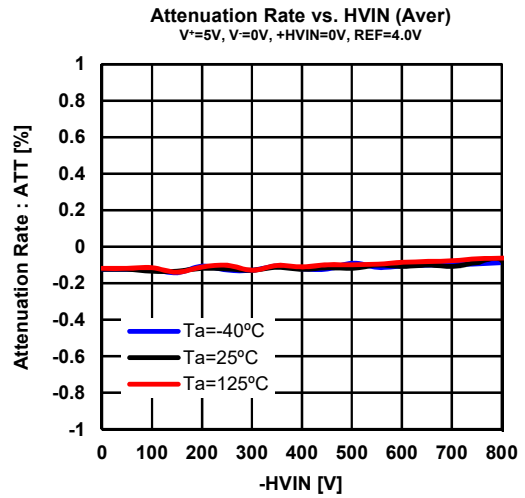
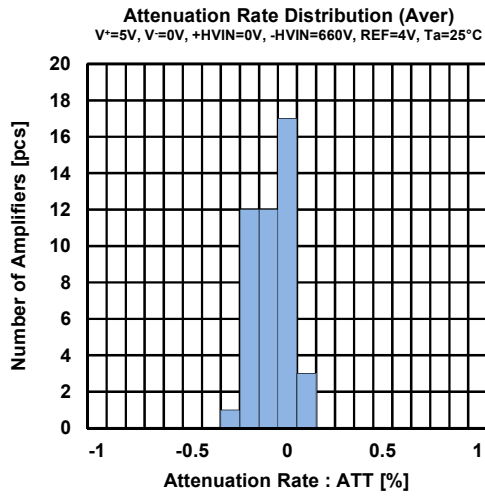
+HVIN Input Voltage Range vs REF Voltage
 $V^+/V^- = 5V/0V, V_{REF} = 0 \text{ to } 4.15V$



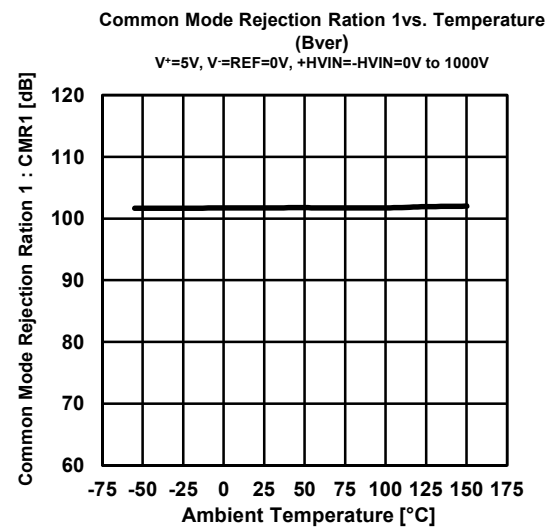
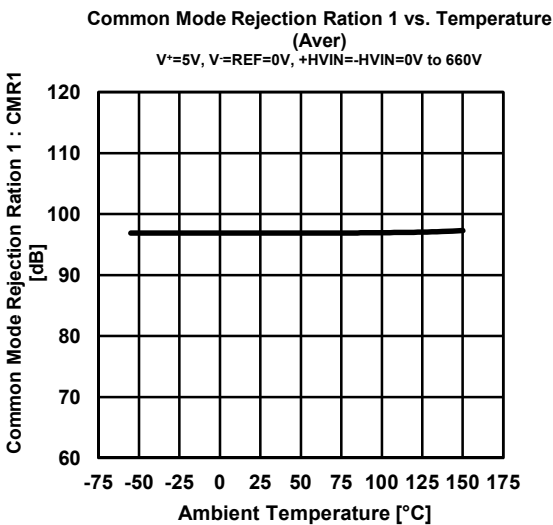
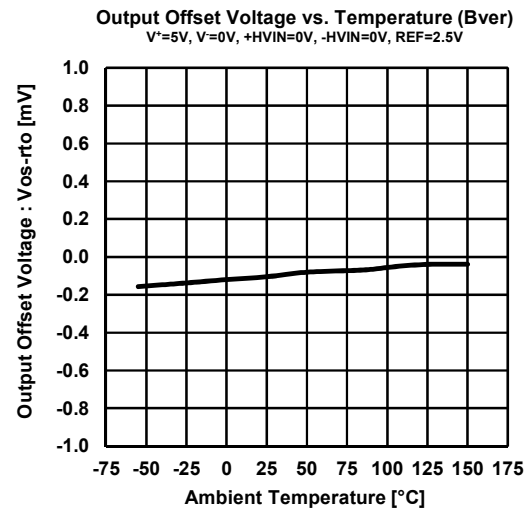
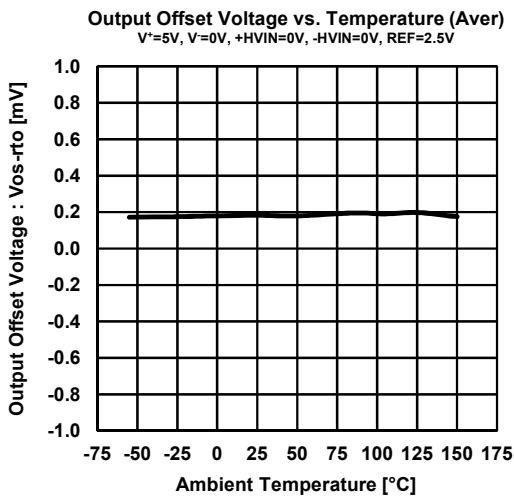
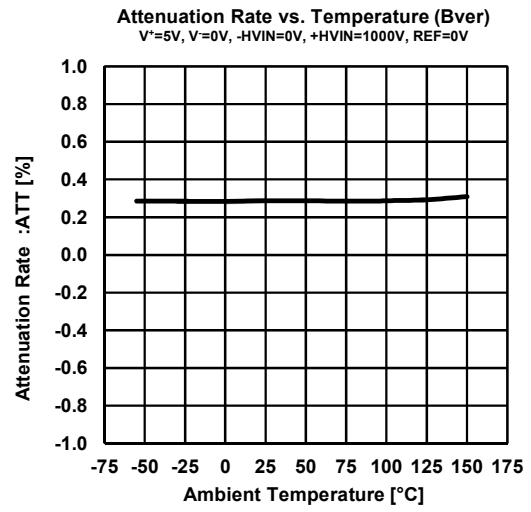
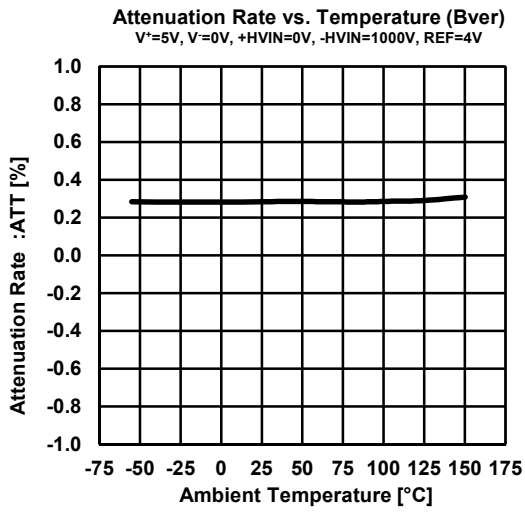
■ ELECTRICAL CHARACTERISTICS

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
OPERATIONAL AMPLIFIER ($V^+ = 5V$, $V^- = 0V$, $T_a = 25^\circ C$, unless otherwise noted.)						
Input Offset Voltage	V_{IO}		-	0.04	0.30	mV
		$T_a = -40^\circ C$ to $125^\circ C$	-	-	0.80	
Input Offset Voltage Drift	$\Delta V_{IO}/\Delta T$	$T_a = -40^\circ C$ to $125^\circ C$	-	0.5	-	$\mu V/^\circ C$
Input Bias Current	I_B	-/+OPIN	-	1	-	pA
Input Offset Current	I_{IO}	-/+OPIN	-	1	-	pA
Open-Loop Voltage Gain	A_v	$R_L \geq 10k\Omega$ to 2.5V, OP OUT = 2.5V $\pm 2V$	100	130	-	dB
		$R_L \geq 10k\Omega$ to 2.5V, OP OUT = 2.5V $\pm 2V$, $T_a = -40^\circ C$ to $125^\circ C$	100	-	-	
High-level Output Voltage 2	V_{OH2}	$R_L = 10k\Omega$ to 2.5V	4.95	4.98	-	V
		$R_L = 10k\Omega$ to 2.5V, $T_a = -40^\circ C$ to $125^\circ C$	4.95	-	-	
Low-level Output Voltage 2	V_{OL2}	$R_L = 10k\Omega$ to 2.5V	-	0.02	0.05	V
		$R_L = 10k\Omega$ to 2.5V, $T_a = -40^\circ C$ to $125^\circ C$	-	-	0.05	
High-level Output Voltage 3	V_{OH3}	$R_L = 600k\Omega$ to 2.5V	4.85	4.92	-	V
		$R_L = 600k\Omega$ to 2.5V, $T_a = -40^\circ C$ to $125^\circ C$	4.85	-	-	
Low-level Output Voltage 3	V_{OL3}	$R_L = 600\Omega$ to 2.5V	-	0.08	0.15	V
		$R_L = 600\Omega$ to 2.5V, $T_a = -40^\circ C$ to $125^\circ C$	-	-	0.20	
Output Current	I_{OUT}	$V_{OH} \geq 4.85V$, $V_{OL} \leq 0.15V$	2	3	-	mA
		$V_{OH} \geq 4.85V$, $V_{OL} \leq 0.15V$, $T_a = -40^\circ C$ to $125^\circ C$	2	-	-	
Common Mode Rejection Ratio 2	CMR2	$V_{ICM} = -/+OPIN = 0V$ to 4V	70	90	-	dB
		$V_{ICM} = -/+OPIN = 0V$ to 4V, $T_a = -40^\circ C$ to $125^\circ C$	70	-	-	
Common Mode Input Voltage Range	V_{ICM}	CMR $\geq 70dB$, -/+OPIN	0	-	4	V
		CMR $\geq 70dB$, -/+OPIN, $T_a = -40^\circ C$ to $125^\circ C$	0	-	4	
Supply Voltage Rejection Ratio 2	SVR2	$V^+ = 2.2V$ to 5.5V	70	90	-	dB
		$V^+ = 2.2V$ to 5.5V, $T_a = -40^\circ C$ to $125^\circ C$	70	-	-	
Gain Bandwidth Product	GBW	$G_V = 40dB$, $R_F = 100k\Omega$, $R_L = 10k\Omega$ to 2.5V, $C_L = 20pF$, $f = 100kHz$	-	1.3	-	MHz
Phase Margin	ϕ_M	$G_V = 40dB$, $R_F = 100k\Omega$, $R_L = 10k\Omega$ to 2.5V, $C_L = 20pF$	-	60	-	deg
Gain Margin	G_M	$G_V = 40dB$, $R_F = 100k\Omega$, $R_L = 10k\Omega$ to 2.5V, $C_L = 20pF$	-	12	-	dB
Slew Rate	SR	$G_V = 0dB$, $R_L = 10k\Omega$ to 2.5V, $C_L = 20pF$, $V_{IN} = 3V_{PP}$	-	0.5	-	V/ μs

■ TYPICAL CHARACTERISTICS (General Characteristics/High Voltage Monitor)



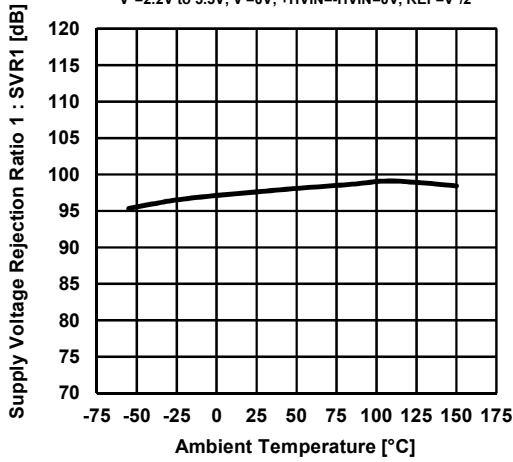
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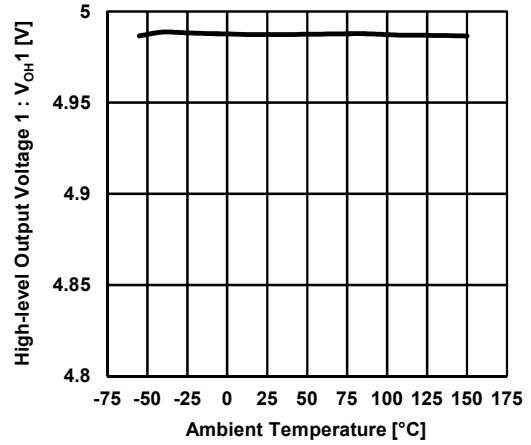
Supply Voltage Rejection Ratio 1 vs. Temperature
(Common to each ver)

$V^+=2.2V$ to $5.5V$, $V=0V$, $+HVIN=-HVIN=0V$, $REF=V^+/2$



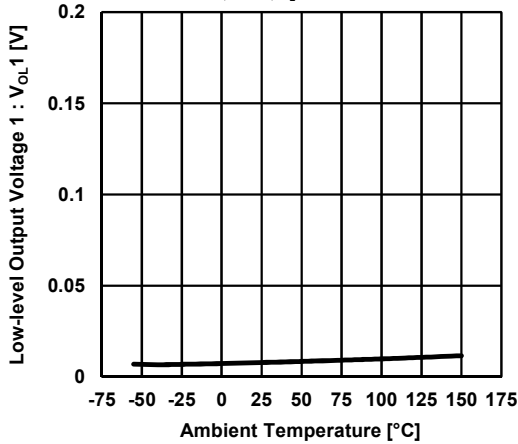
High-level Output Voltage 1 vs. Temperature
(Common to each ver)

$V^+=5V$, $V=0V$, $R_L=10k\Omega$ to $2.5V$



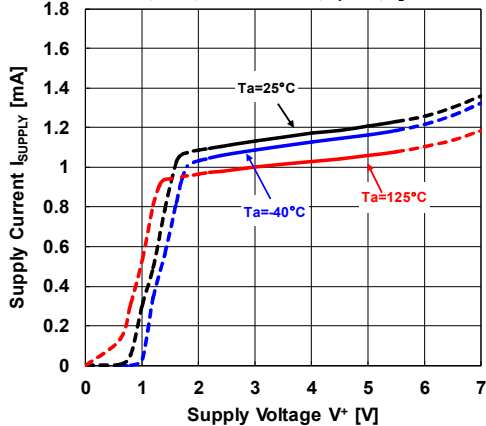
Low-level Output Voltage 1 vs. Temperature
(Common to each ver)

$V^+=5V$, $V=0V$, $R_L=10k\Omega$ to $2.5V$



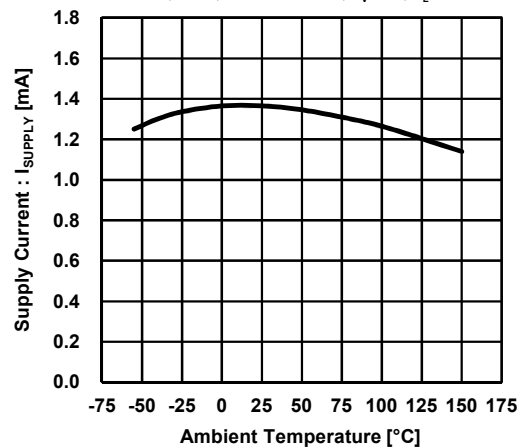
Supply Current vs. Supply Voltage
(Common to each ver)

$V^+=5V$, $V=0V$, $+HVIN=-HVIN=0V$, $G_V=0dB$, $R_L=OPEN$

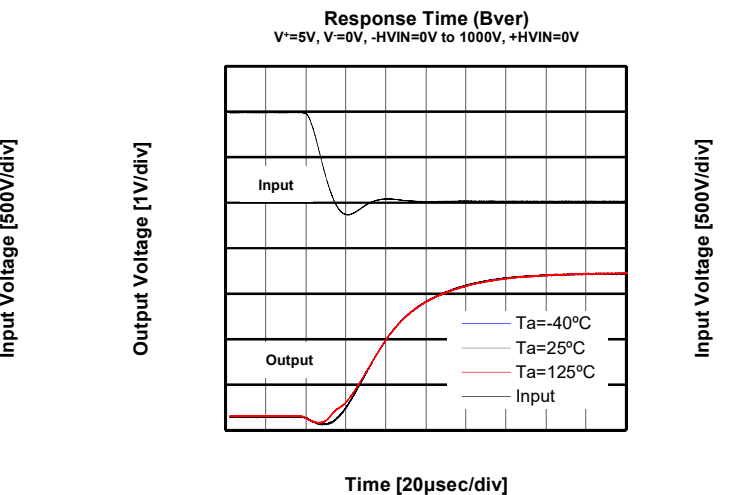
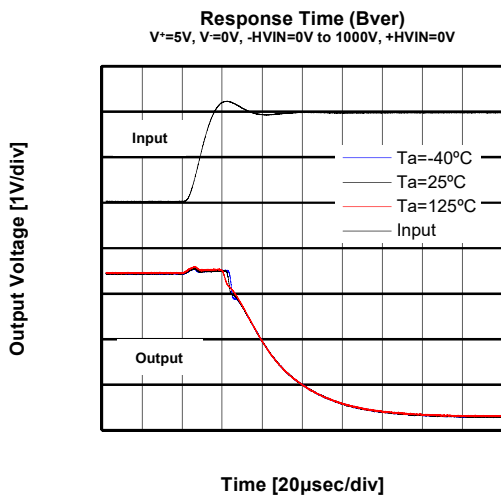
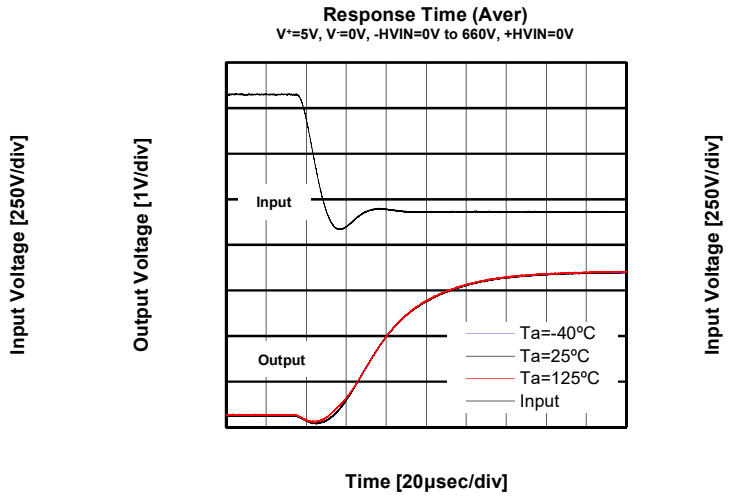
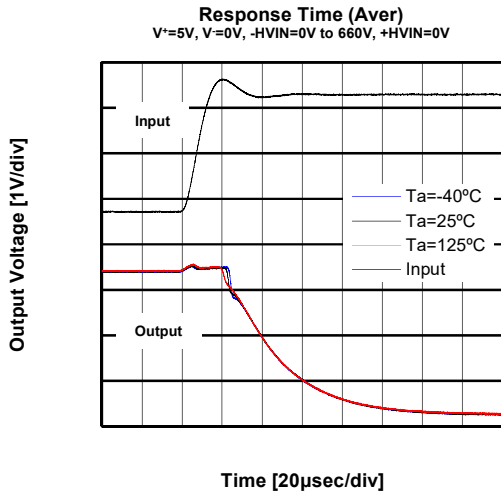


Supply Current vs. Temperature
(Common to each ver)

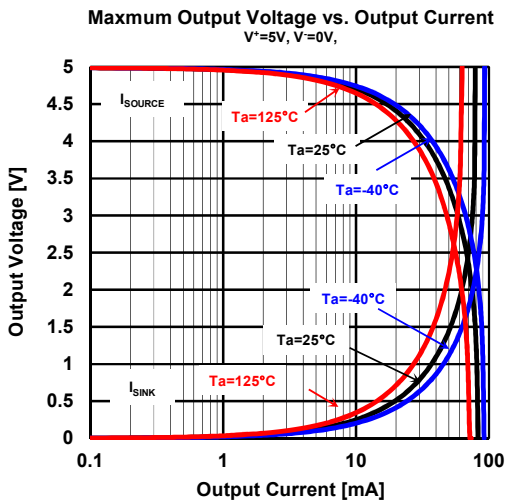
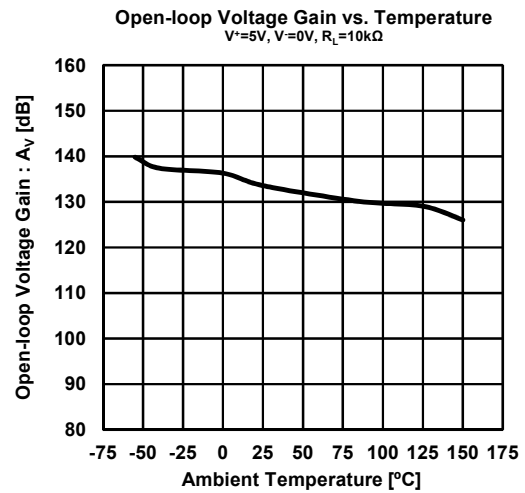
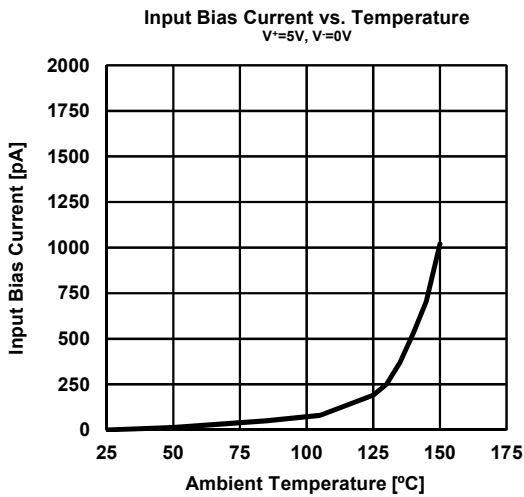
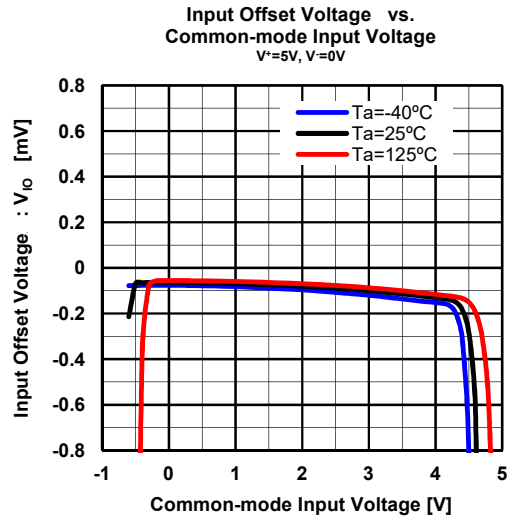
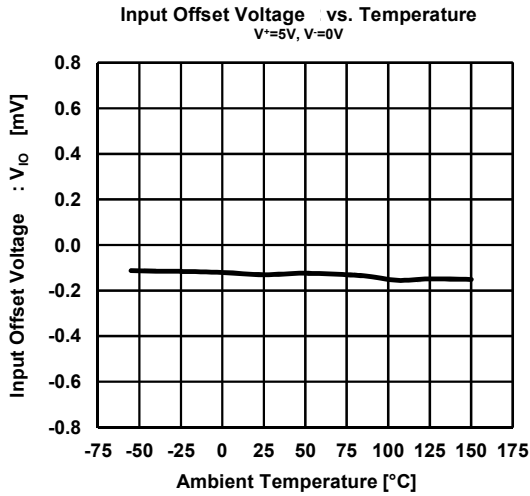
$V^+=5V$, $V=0V$, $+HVIN=-HVIN=0V$, $G_V=0dB$, $R_L=OPEN$



■ TYPICAL CHARACTERISTICS (General Characteristics High Voltage Monitor)

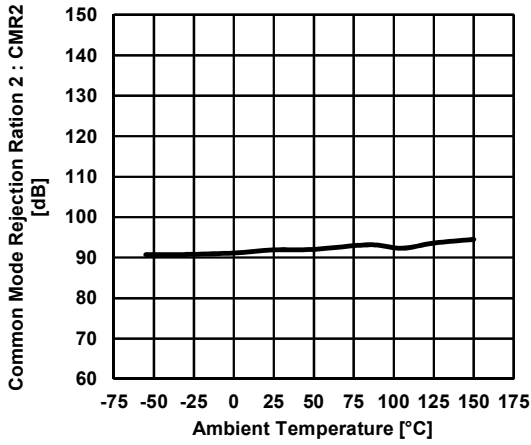


■ TYPICAL CHARACTERISTICS (Operational Amplifier)

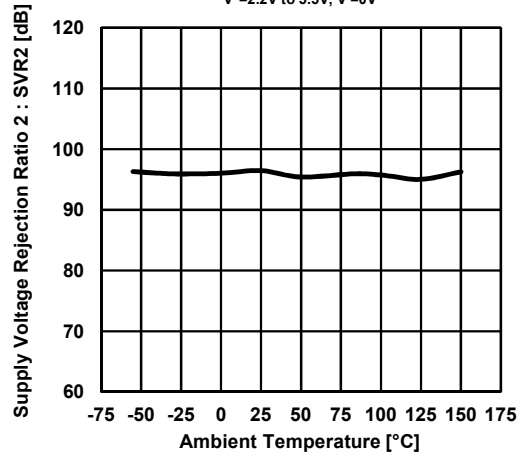


■ TYPICAL CHARACTERISTICS (Operational Amplifier)

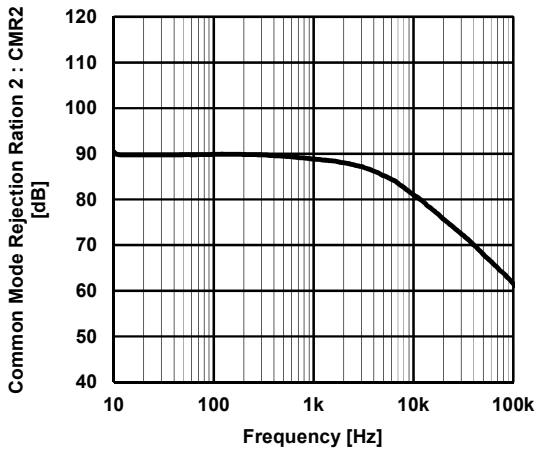
Common Mode Rejection Ratio 2 vs. Temperature
 $V^+=5V, V^-=0V, +OPIN=0V$ to $4V$



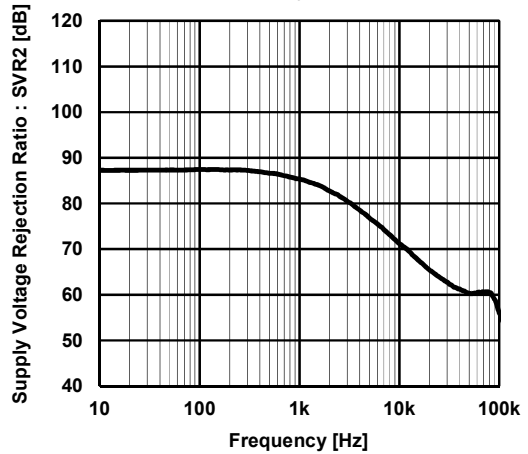
Supply Voltage Rejection Ratio 2 vs. Temperature
 $V^+=2.2V$ to $5.5V, V^-=0V$



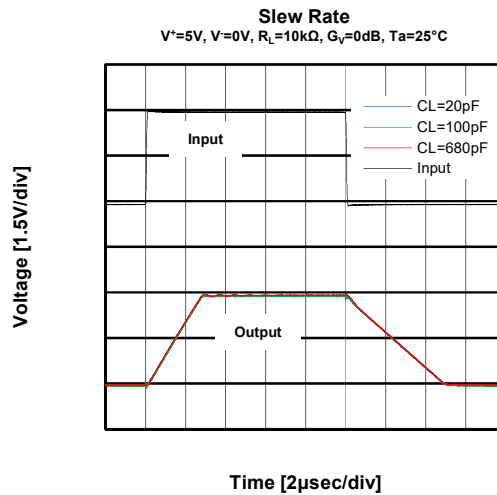
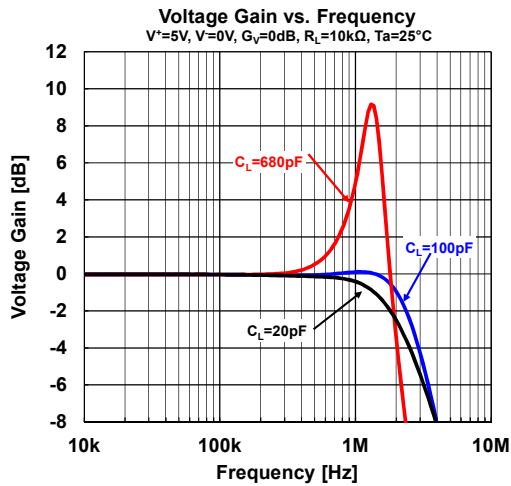
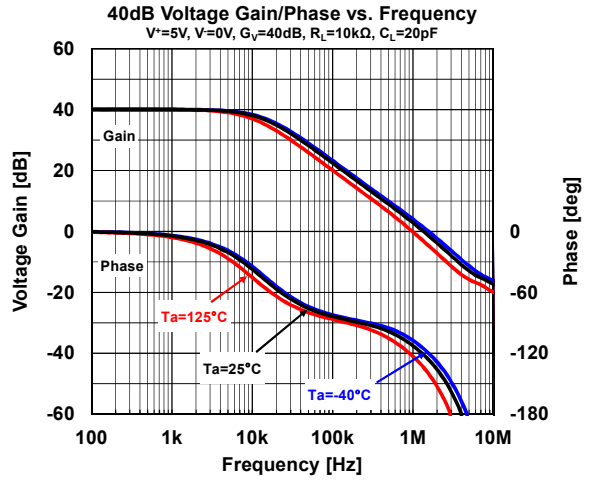
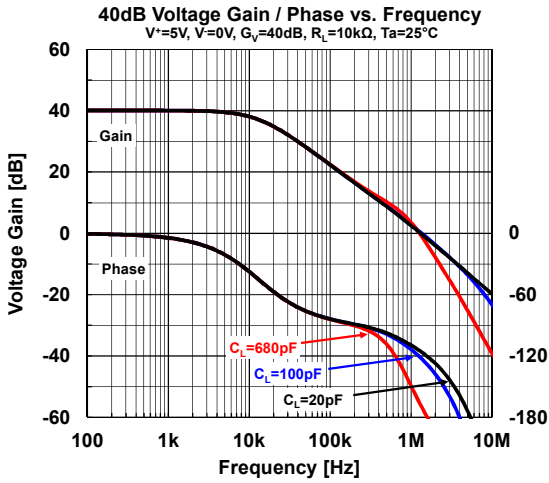
Common Mode Rejection Ratio 2 vs. Frequency
 $V^+=5V, V^-=0V, V_{IN}=1V_{pp}, R_S=100\Omega, R_F=10k\Omega, T_a=25^\circ C$



Supply Voltage Rejection Ratio 2 vs. Frequency
 $V^+=5V, V^-=0V, V_{IN}=1V_{pp}, R_S=100\Omega, R_F=10k\Omega, T_a=25^\circ C$



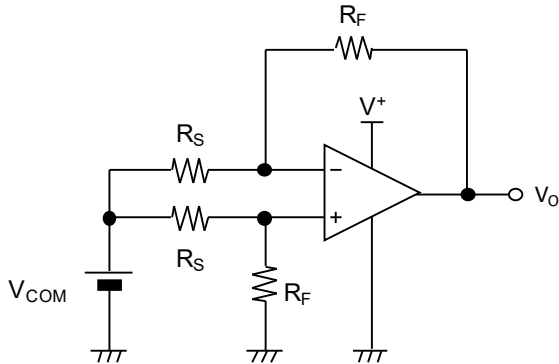
■ TYPICAL CHARACTERISTICS (Operational Amplifier)



TEST CIRCUITS

- V_{IO} , CMR2, SVR2

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



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

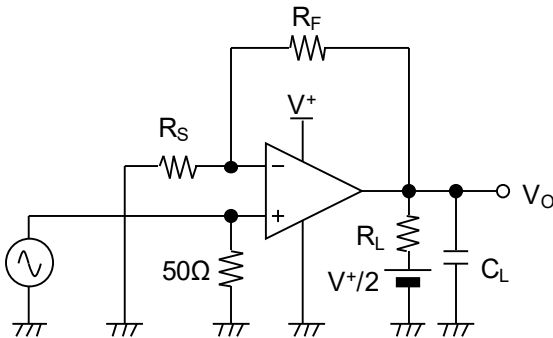
$$CMR2 = 20 \log \frac{\Delta V_{COM} \left(1 + \frac{R_F}{R_S}\right)}{\Delta V_O}$$

$$SVR2 = 20 \log \frac{\Delta V_S \left(1 + \frac{R_F}{R_S}\right)}{\Delta V_O}$$

$$V_S = V^+ - V^-$$

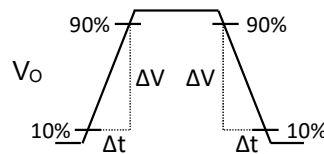
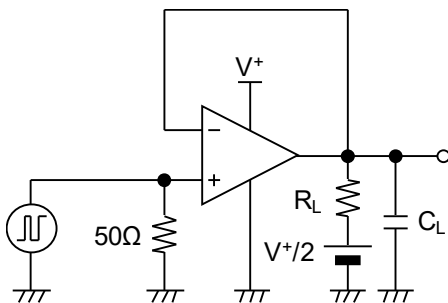
- GBW

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



- SR

$C_L = 20pF$, $R_L = 10k\Omega$



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

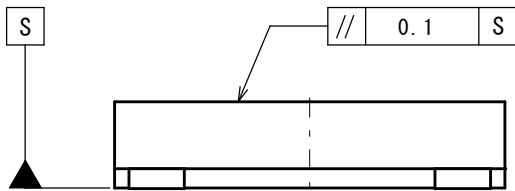
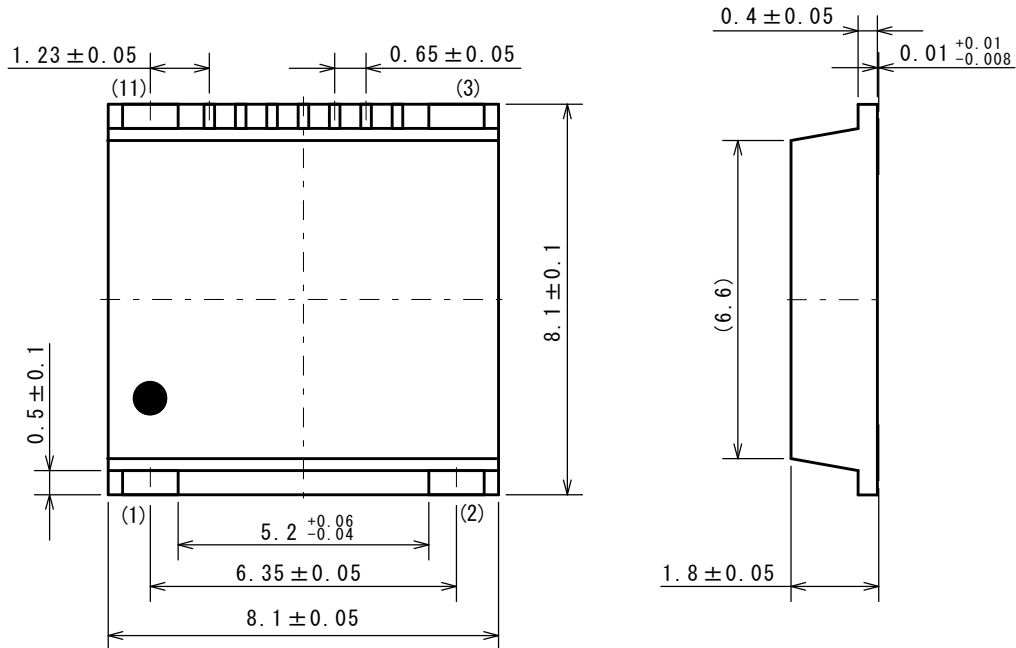
Note on using NJU7890

This part handles high voltage, therefore it needs sufficient consideration to avoid unforeseen critical failures. Please make sure that implement and verify fail-safe and/or redundant and secure design in customer own actual application to prevent personal injury, fire and social damage. The FMEA document of this part is a highly recommended reference for application design .

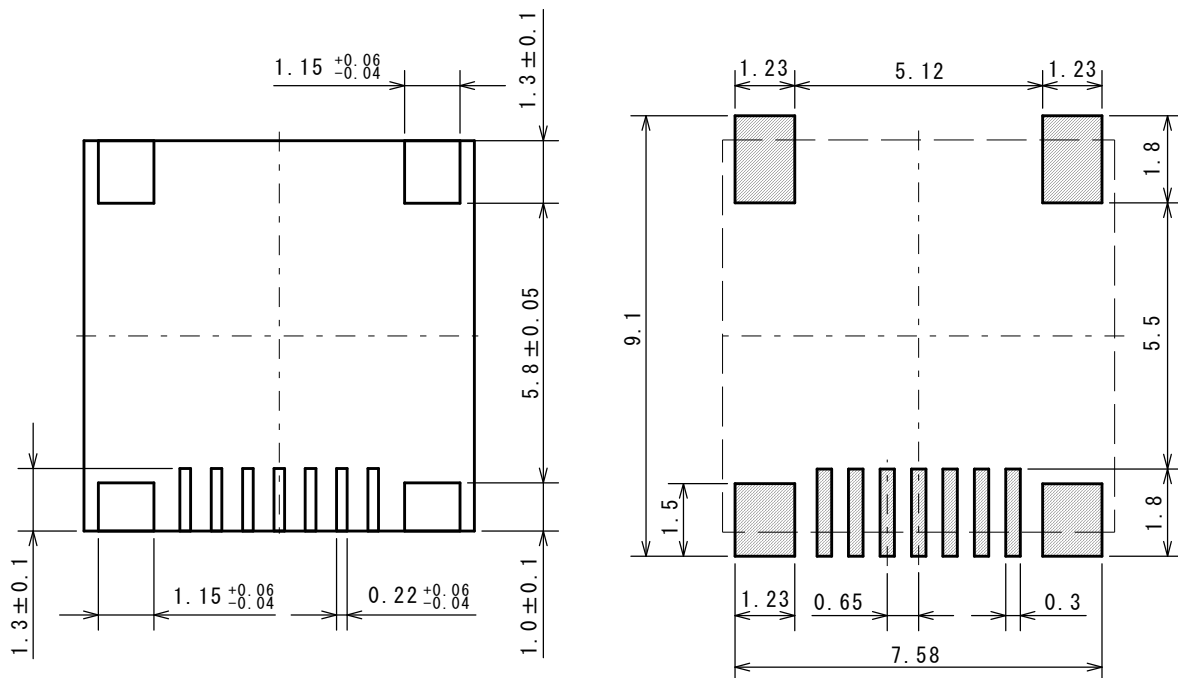
PMAP11-PM

Unit: mm

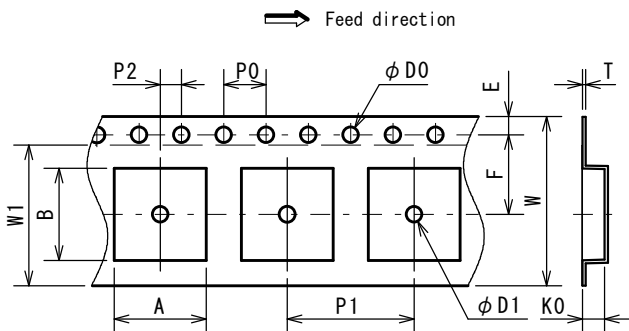
■ PACKAGE DIMENSIONS



■ EXAMPLE OF SOLDER PADS DIMENSIONS

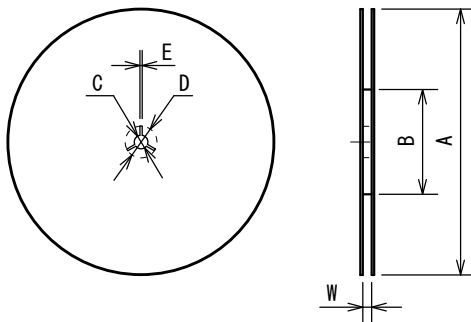


PACKING SPEC TAPING DIMENSIONS



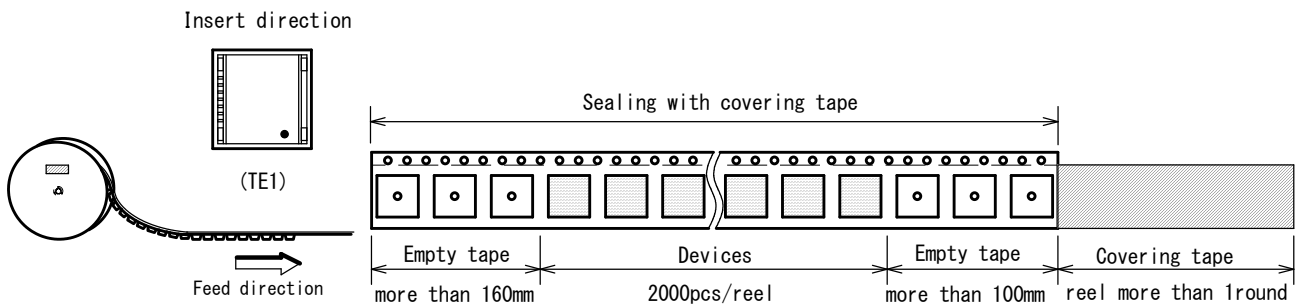
SYMBOL	DIMENSION	REMARKS
A	8.7±0.1	BOTTOM DIMENSION
B	8.7±0.1	BOTTOM DIMENSION
D0	1.5 ^{+0.1} ₀	
D1	1.5 ^{+0.1} ₀	
E	1.75±0.1	
F	7.5±0.1	
P0	4.0±0.1	
P1	12.0±0.1	
P2	2.0±0.1	
K0	2.1±0.1	
T	0.3±0.1	
W	16.0 ^{+0.3} _{-0.1}	
W1	13.3±0.1	THICKNESS 0.1max

REEL DIMENSIONS

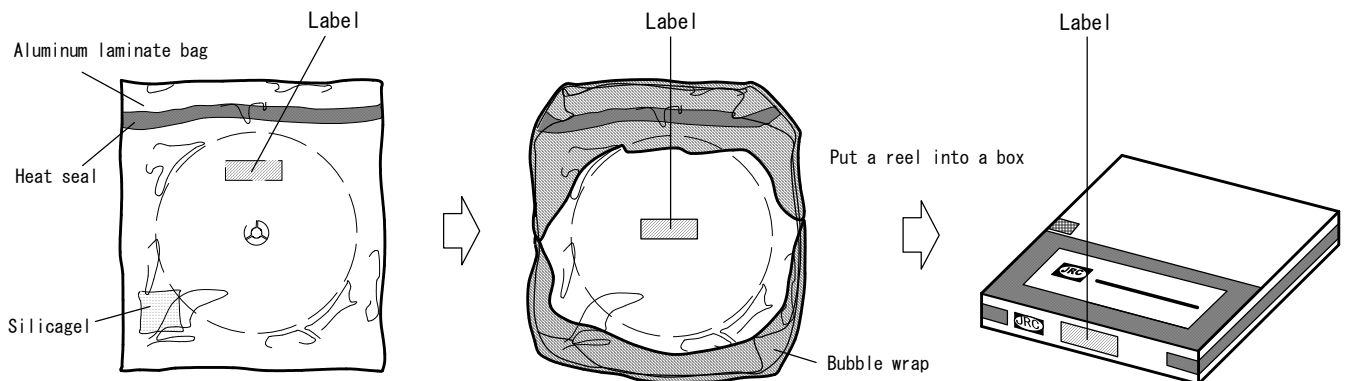


SYMBOL	DIMENSION
A	φ 330±2
B	φ 100±1
C	φ 13±0.2
D	21±0.8
E	2±0.5
W	17.5±1

TAPING STATE

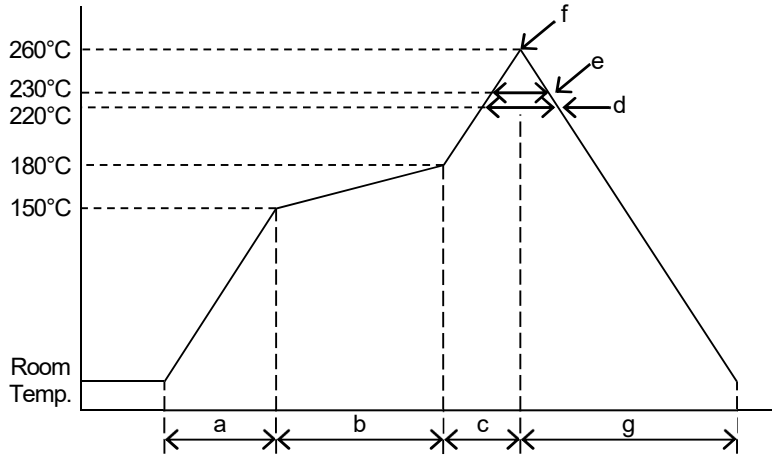


PACKING STATE



■ 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.

■ REVISION HISTORY

DATE	REVISION	CHANGES
February 9, 2021	Ver.1.0	Initial release

[CAUTION]

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 - Power Generator Control Equipment (Nuclear, steam, hydraulic, etc.)
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9. The product specifications and descriptions listed in this datasheet are subject to change at any time, without notice.

