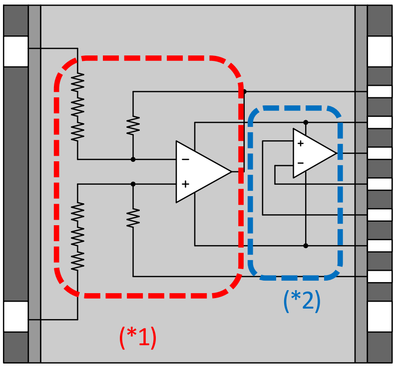
# 1000V High Voltage Monitor IC

## ■ FEATURES
- AEC-Q100 Grade 1
- 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



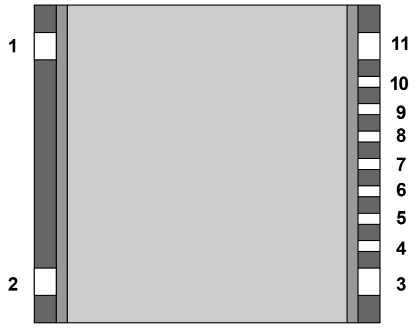

(*1) High Voltage Monitor Block
(*2) OP-Amp Block

## ■ 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 |

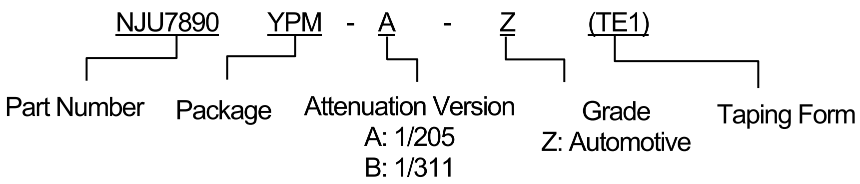
## ■ PIN CONFIGURATION

PMAP11-PM




| 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.)

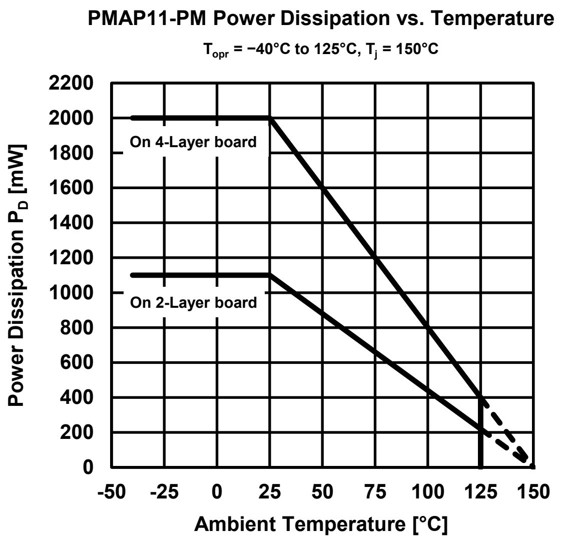
| PARAMETER | SYMBOL | RATINGS | UNIT |
|---|---|---|---|
| **GENERAL CHARACTERISTICS** | | | |
| Supply Voltage | $V^+ - V^-$ | 7 | V |
| Power Dissipation ($T_a$ = 25°C)<br>PMAP11-PM | $P_D$ | 2Layers / 4Layers<br>1100 (1) / 2000 (2) | mW |
| Junction Temperature | $T_j$ | 150 | °C |
| Storage Temperature | $T_{stg}$ | −55 to 150 | °C |
| **HIGH VOLTAGE MONITOR** | | | |
| Input Voltage 1 | $V_{IN}1$ | −1000 to 1000 | V |
| Differential Input Voltage 1 | $V_{ID}1$ | ±1000 (3) | V |
| Reference Voltage | REF | $V^-$ −0.3 to $V^+$ | V |
| **OPERATIONAL AMPLIFIER** | | | |
| Input Voltage 2 | $V_{IN}2$ | $V^-$ −0.3 to $V^+$ | V |
| Differential Input Voltage 2 | $V_{ID}2$ | ±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 | °C |

## ■ POWER DISSIPATION vs. AMBIENT TEMPERATURE



■ ELECTRICAL CHARACTERISTICS

| PARAMETER | SYMBOL | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| **GENERAL CHARACTERISTICS** ($V^+$ = 5V, $V^-$ = 0V, $T_a$ = 25°C, unless otherwise noted.) | | | | | | | |
| Supply Current | $I_{SUPPLY}$ | No signal | | - | 1.2 | 1.8 | mA |
| | | No signal, $T_a$ = −40°C to 125°C | | - | - | 1.8 | |
| **HIGH VOLTAGE MONITOR** ($V^+$ = 5V, $V^-$ = 0V, REF = 2.5V, $T_a$ = 25°C, unless otherwise noted.) | | | | | | | |
| Input Resistance | $R_{IN}$ | -HVIN to OUT, $T_a$ = −40°C to 125°C | | 30 | - | 42 | MΩ |
| | | +HVIN to REF, $T_a$ = −40°C to 125°C | | 30 | - | 42 | |
| Attenuation Rate | ATT | Aver | | −0.7% | 1/205 | +0.7% | V/V |
| | | | $T_a$ = −40°C to 125°C | −1.0% | - | +1.0% | |
| | | Bver | | −0.7% | 1/311 | +0.7% | |
| | | | $T_a$ = −40°C to 125°C | −1.0% | - | +1.0% | |
| Output Offset Voltage | $V_{OS\text{-}RTO}$ | −/+HVIN = 0V | | - | 0.04 | 0.30 | mV |
| | | −/+HVIN = 0V, $T_a$ = −40°C to 125°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_{OH}$1 | $R_L$ = 10kΩ to 2.5V | | $V^+$ −0.20 | $V^+$ −0.05 | - | V |
| Low-level Output Voltage 1 | $V_{OL}$1 | $R_L$ = 10kΩ to 2.5V | | - | $V^+$ −0.05 | $V^+$ +0.20 | V |

## ■ Calculation of output voltage

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

Calculation example

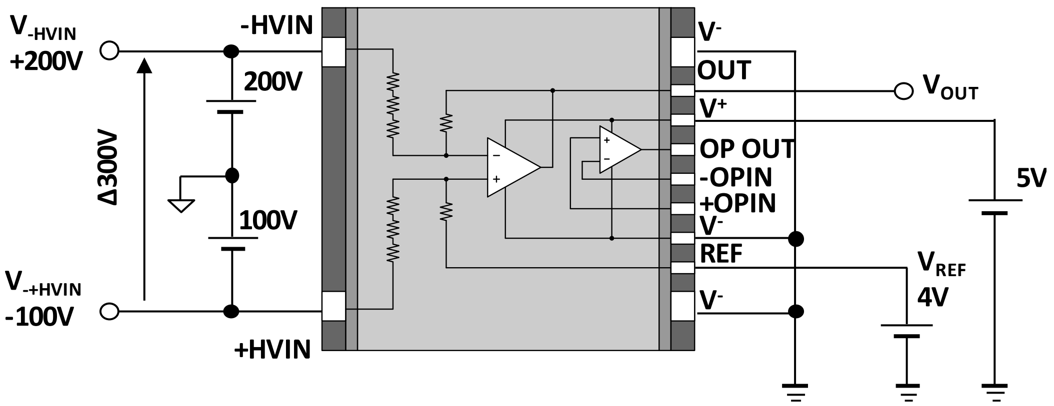
$V_{+HVIN} = -100V$, $V_{-HVIN} = 200V$, $V_{REF} = 4V$, $V^{+} = 5.2V$, $ATT = 1/205 \pm 0.7\%$ ($T_a = 25°C$), $V_{OS\text{-}RTO} = 0.3mV$, $SVR1 = 70dB$, $CMR1 = 85dB$

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

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

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 × (1 ÷ ATT) = 3.280 V by calculating the input conversion. The error rate obtained from the input conversion value can be calculated as 1.09% from 3.280V ÷ 300V. In addition to the above formula, please be aware that there is a VREF error (accuracy influence).

Evaluation circuit example



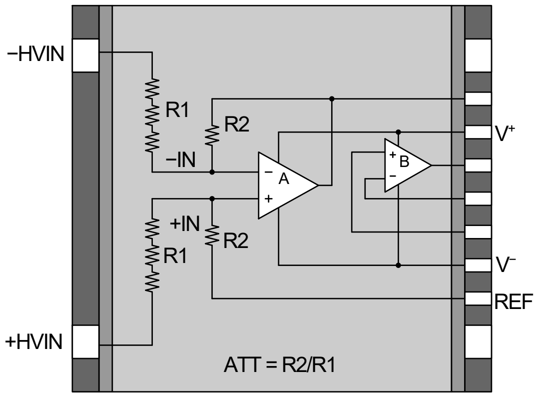
■ **+HVIN input Voltage Range**

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

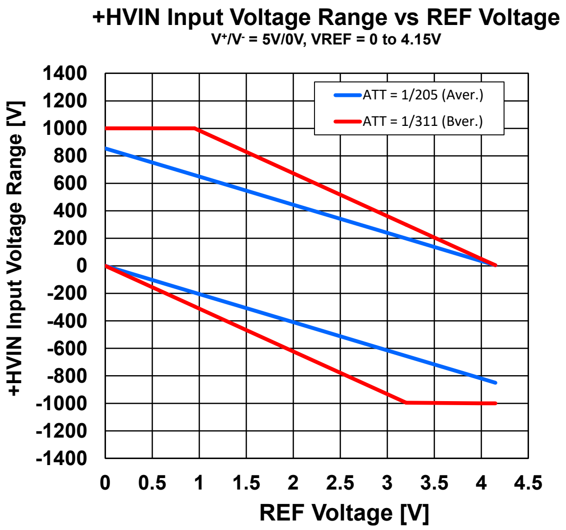
$V_{REF}$ = 4V, $V^+ / V^-$ = 5V / 0V, ATT = 1/205

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

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

Characteristics example

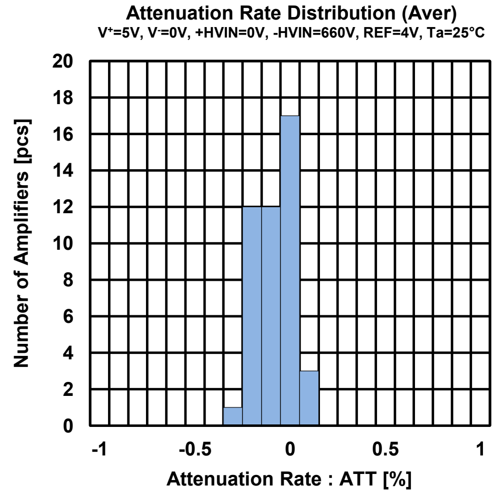
The figure below shows an example of characteristics when the attenuation rate is set to 1/205 (Aver) and 1/311 (Bver).
The range indicated by the graph is the input voltage range of the +HVIN.

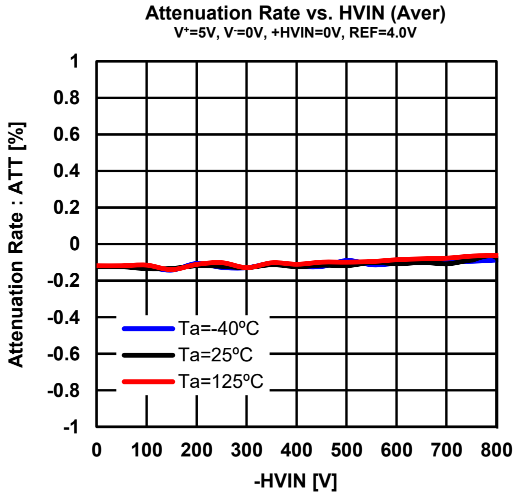


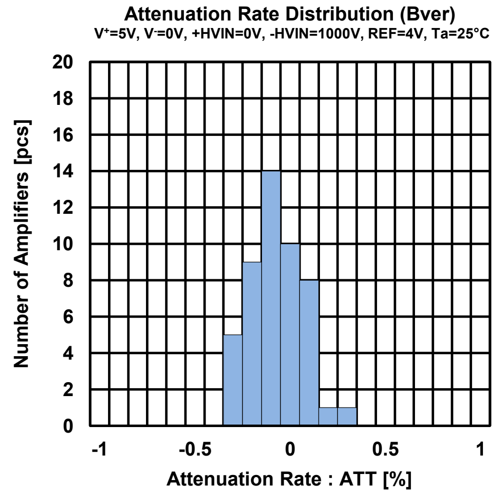
■ **ELECTRICAL CHARACTERISTICS**

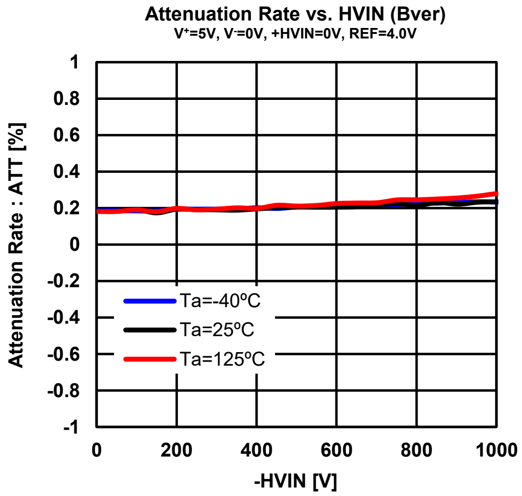
| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **OPERATIONAL AMPLIFIER** ($V^+$ = 5V, $V^-$ = 0V, $T_a$ = 25°C, unless otherwise noted.) | | | | | | |
| Input Offset Voltage | $V_{IO}$ | | - | 0.04 | 0.30 | mV |
| | | $T_a$ = −40°C to 125°C | - | - | 0.80 | |
| Input Offset Voltage Drift | $\Delta V_{IO}/\Delta T$ | $T_a$ = −40°C to 125°C | - | 0.5 | - | µV/°C |
| Input Bias Current | $I_B$ | −/+OPIN | - | 1 | - | pA |
| Input Offset Current | $I_{IO}$ | −/+OPIN | - | 1 | - | pA |
| Open-Loop Voltage Gain | $A_V$ | $R_L$ ≥ 10kΩ to 2.5V, OP OUT = 2.5V ±2V | 100 | 130 | - | dB |
| | | $R_L$ ≥ 10kΩ to 2.5V, OP OUT = 2 .5V ±2V, $T_a$ = −40°C to 125°C | 100 | - | - | |
| High-level Output Voltage 2 | $V_{OH}2$ | $R_L$ = 10kΩ to 2.5V | 4.95 | 4.98 | - | V |
| | | $R_L$ = 10kΩ to 2.5V, $T_a$ = −40°C to 125°C | 4.95 | - | - | |
| Low-level Output Voltage 2 | $V_{OL}2$ | $R_L$ = 10kΩ to 2.5V | - | 0.02 | 0.05 | V |
| | | $R_L$ = 10kΩ to 2.5V, $T_a$ = −40°C to 125°C | - | - | 0.05 | |
| High-level Output Voltage 3 | $V_{OH}3$ | $R_L$ = 600kΩ to 2.5V | 4.85 | 4.92 | - | V |
| | | $R_L$ = 600kΩ to 2.5V, $T_a$ = −40°C to 125°C | 4.85 | - | - | |
| Low-level Output Voltage 3 | $V_{OL}3$ | $R_L$ = 600Ω to 2.5V | - | 0.08 | 0.15 | V |
| | | $R_L$ = 600Ω to 2.5V, $T_a$ = −40°C to 125°C | - | - | 0.20 | |
| Output Current | $I_{OUT}$ | $V_{OH}$ ≥ 4.85V, $V_{OL}$ ≤ 0.15V | 2 | 3 | - | mA |
| | | $V_{OH}$ ≥ 4.85V, $V_{OL}$ ≤ 0.15V, $T_a$ = −40°C to 125°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°C to 125°C | 70 | - | - | |
| Common Mode Input Voltage Range | $V_{ICM}$ | CMR ≥ 70dB, −/+OPIN | 0 | - | 4 | V |
| | | CMR ≥ 70dB, −/+OPIN, $T_a$ = −40°C to 125°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°C to 125°C | 70 | - | - | |
| 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 | $\phi_M$ | $G_V$ = 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 |
| Slew Rate | SR | $G_V$ = 0dB, $R_L$ = 10kΩ to 2.5V, $C_L$ = 20pF, $V_{IN}$ = 3$V_{PP}$ | - | 0.5 | - | V/µs |

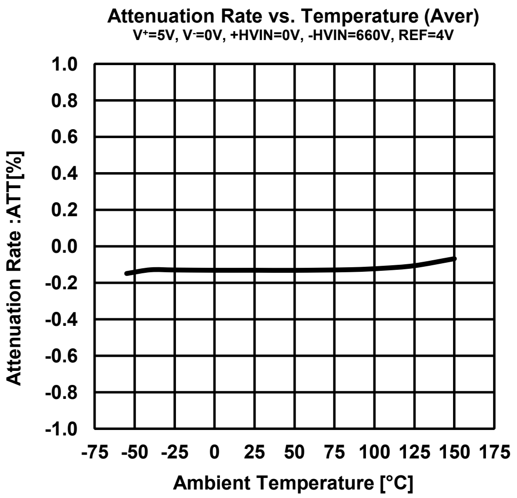
## ■ TYPICAL CHARACTERISTICS (General Characteristics/High Voltage Monitor)

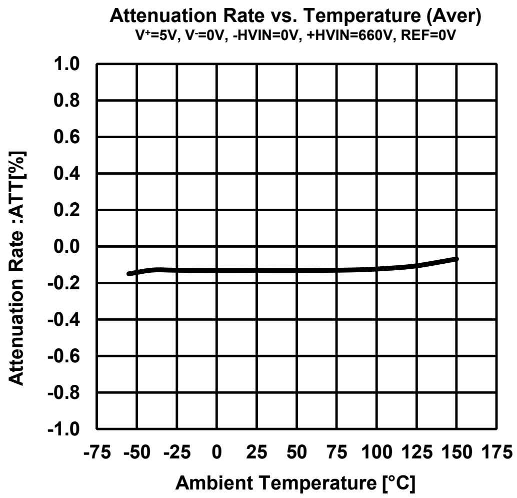


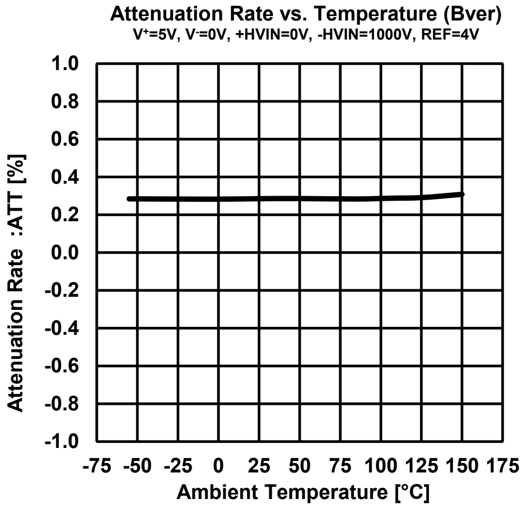



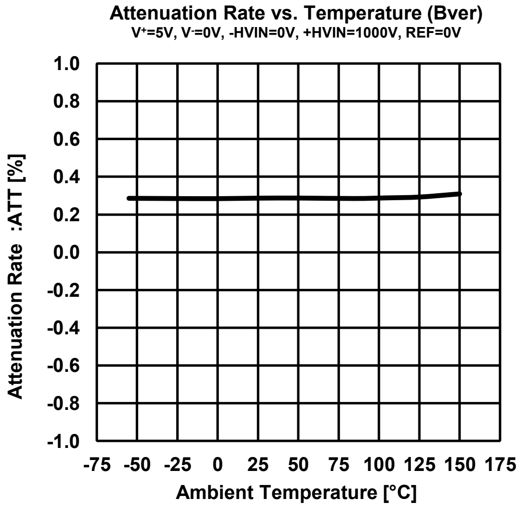



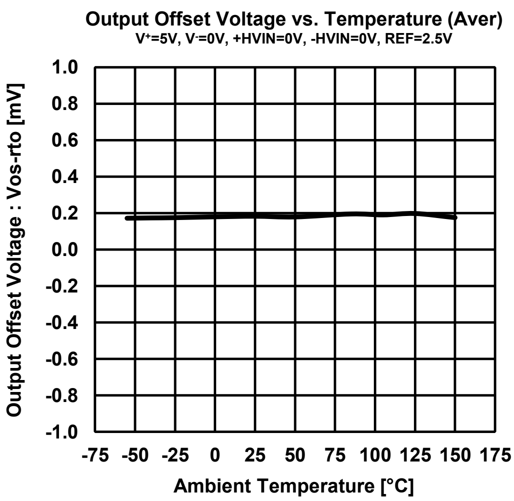



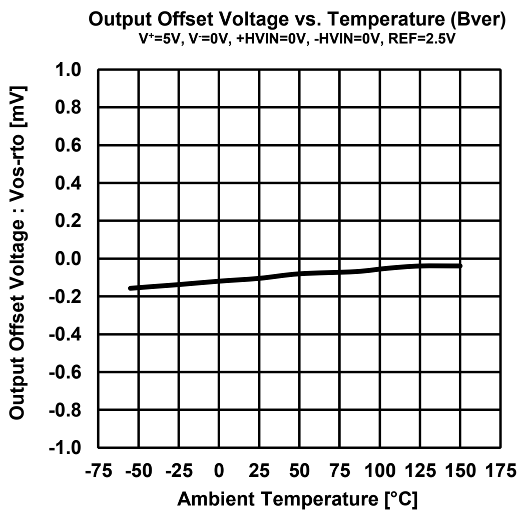



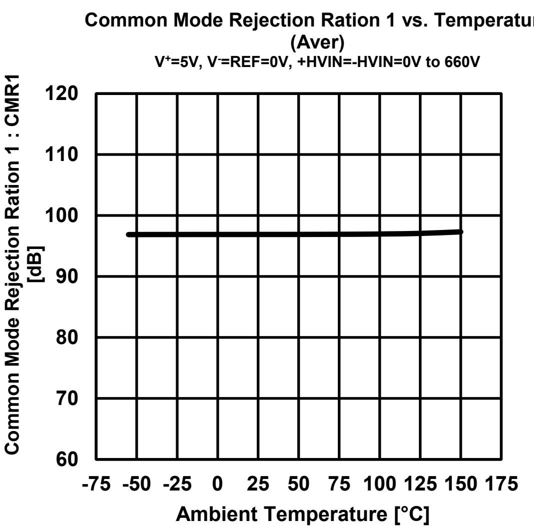
■ TYPICAL CHARACTERISTICS (General Characteristics /High Voltage Monitor)

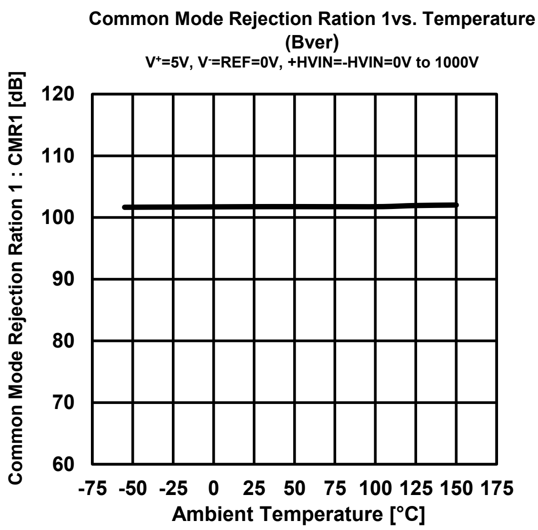


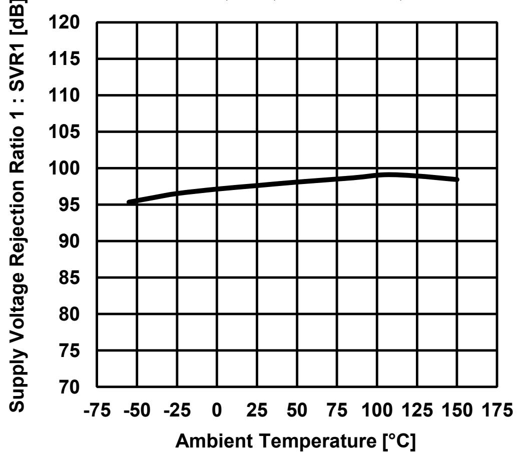



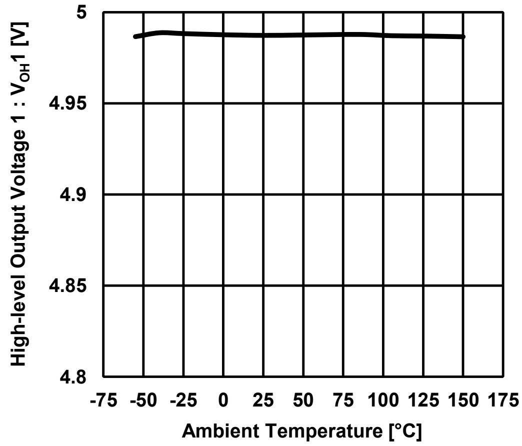



## ■ TYPICAL CHARACTERISTICS (General Characteristics/High Voltage Monitor)

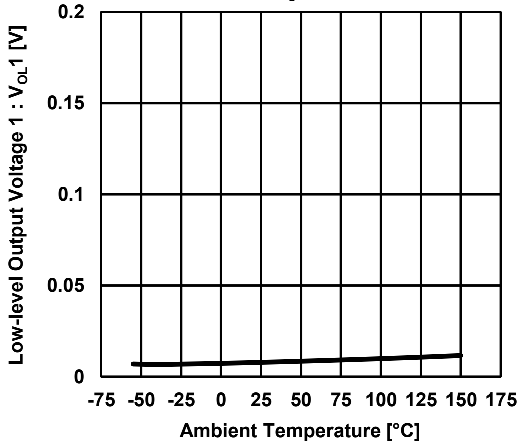
Supply Voltage Rejection Ratio 1 vs. Temperature
(Common to each ver)
V+=2.2V to 5.5V, V-=0V, +HVIN=-HVIN=0V, REF=V+/2



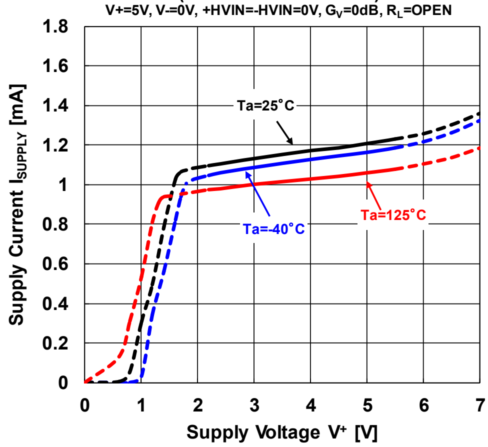

High-level Output Voltage 1 vs. Temperature
(Common to each ver)
V+=5V, V-=0V, RL=10kΩ to 2.5V



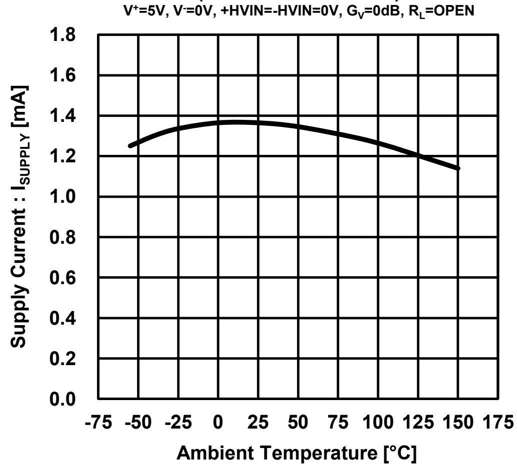

Low-level Output Voltage 1 vs. Temperature
(Common to each ver)
V+=5V, V-=0V, RL=10kΩ to 2.5V




Supply Current er vs. Supply Voltage
(Common to each ver)
V+=5V, V-=0V, +HVIN=-HVIN=0V, GV=0dB, RL=OPEN

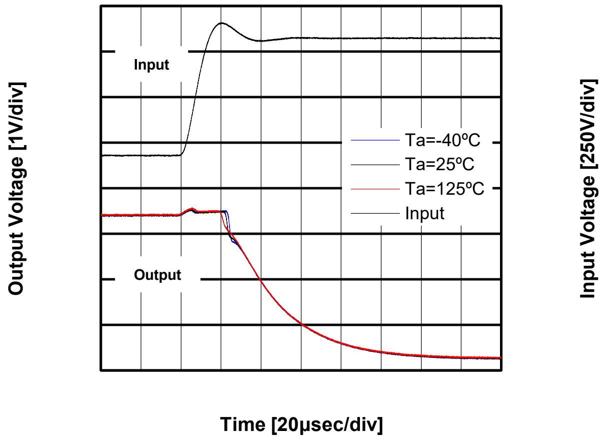



Supply Current vs. Temperature
(Common to each ver)
V+=5V, V-=0V, +HVIN=-HVIN=0V, GV=0dB, RL=OPEN

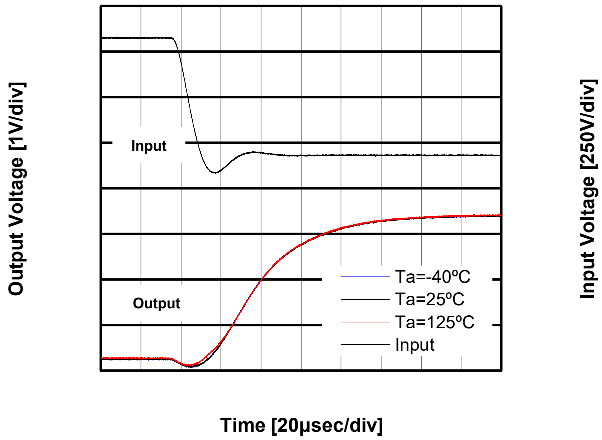


■ **TYPICAL CHARACTERISTICS (General Characteristics High Voltage Monitor)**

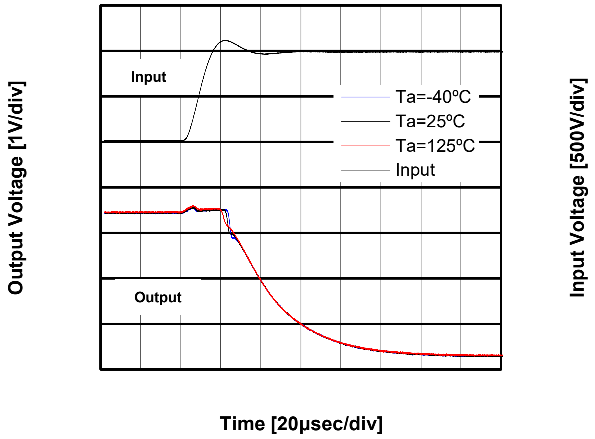
**Response Time (Aver)**
$V^+$=5V, $V^-$=0V, -HVIN=0V to 660V, +HVIN=0V



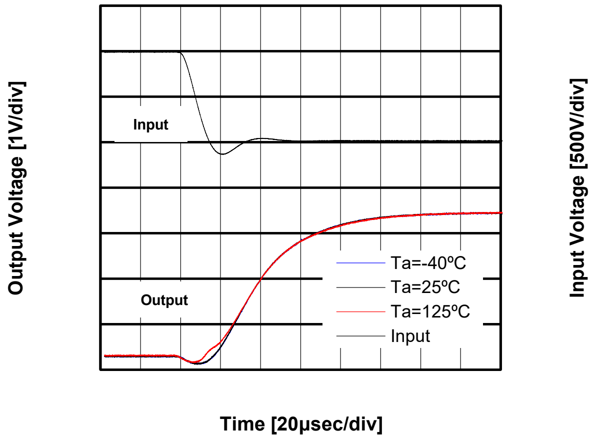

**Response Time (Aver)**
$V^+$=5V, $V^-$=0V, -HVIN=0V to 660V, +HVIN=0V




**Response Time (Bver)**
$V^+$=5V, $V^-$=0V, -HVIN=0V to 1000V, +HVIN=0V

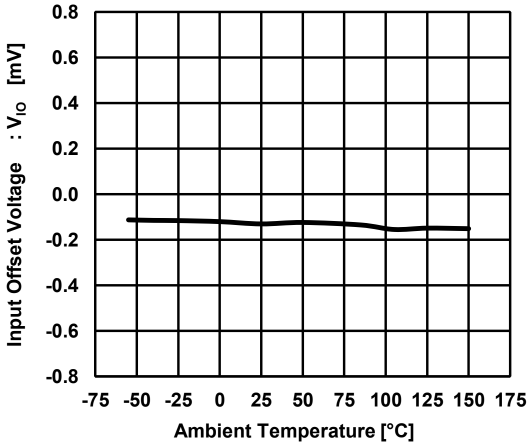



**Response Time (Bver)**
$V^+$=5V, $V^-$=0V, -HVIN=0V to 1000V, +HVIN=0V

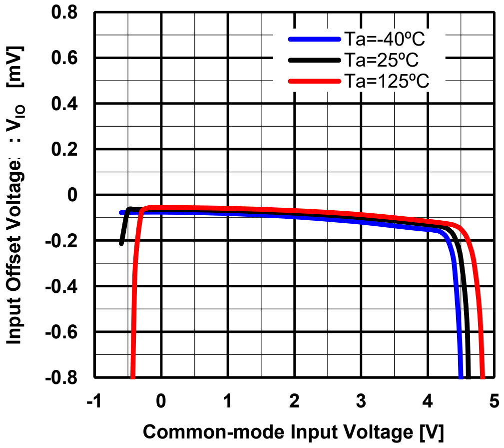


## ■ TYPICAL CHARACTERISTICS (Operational Amplifier)

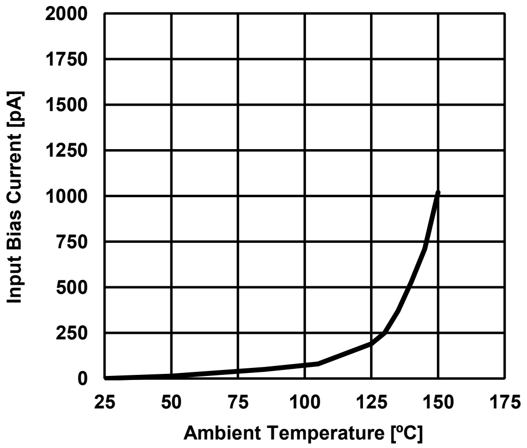
Input Offset Voltage vs. Temperature
$V^+$=5V, $V^-$=0V



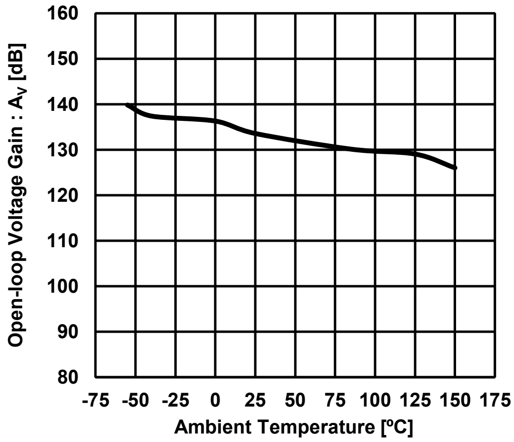

Input Offset Voltage vs. Common-mode Input Voltage
$V^+$=5V, $V^-$=0V



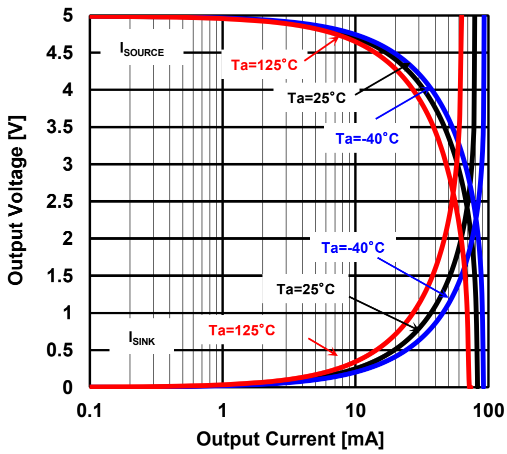

Input Bias Current vs. Temperature
$V^+$=5V, $V^-$=0V



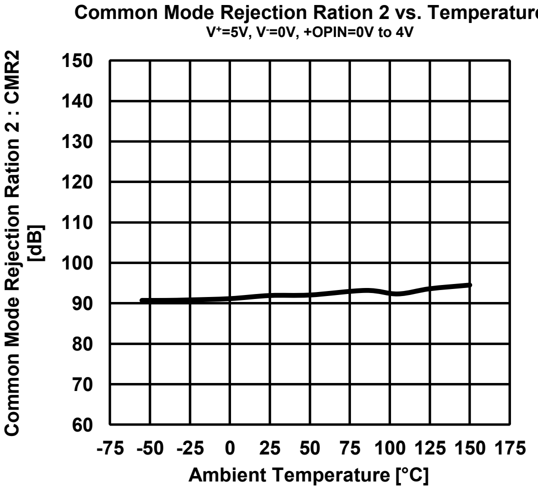

Open-loop Voltage Gain vs. Temperature
$V^+$=5V, $V^-$=0V, $R_L$=10kΩ

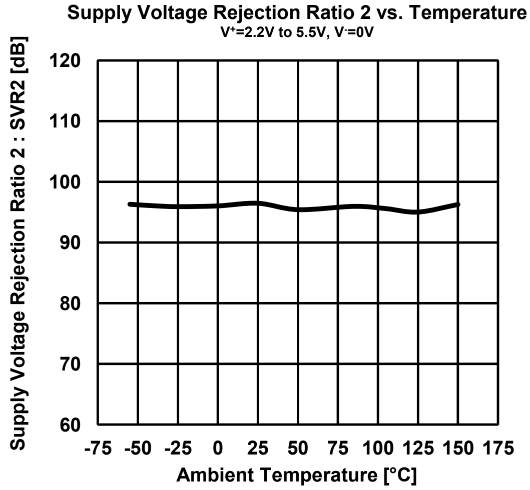


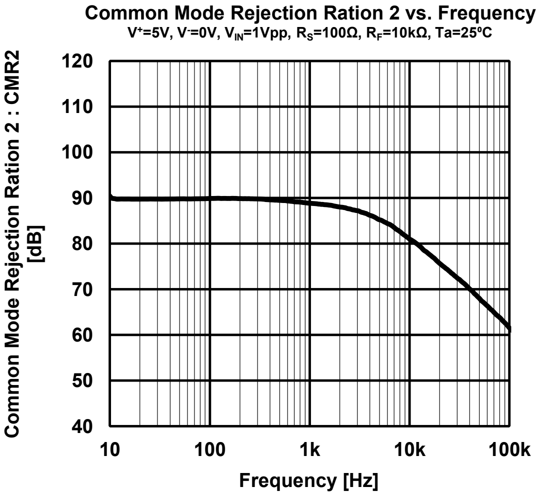

Maxmum Output Voltage vs. Output Current
$V^+$=5V, $V^-$=0V,

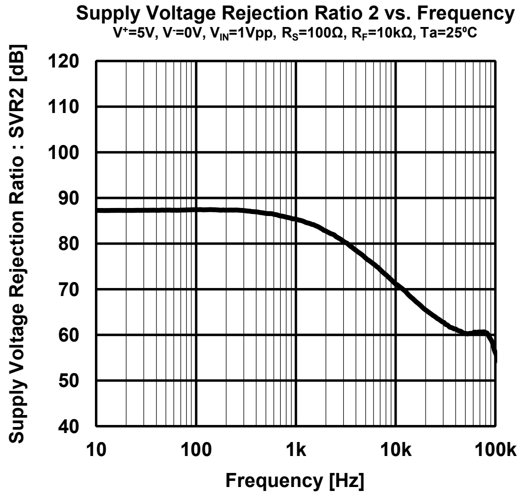


■ TYPICAL CHARACTERISTICS (Operational Amplifier)



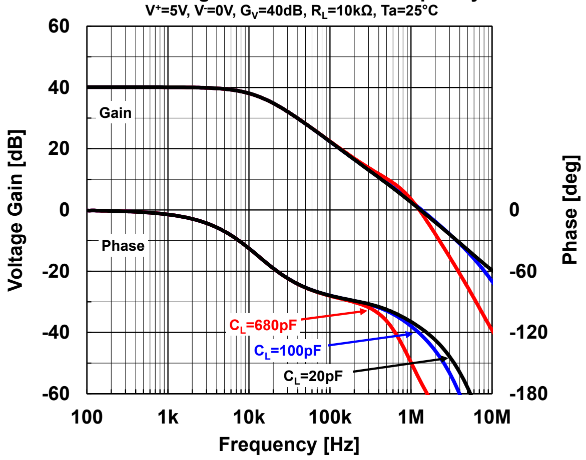



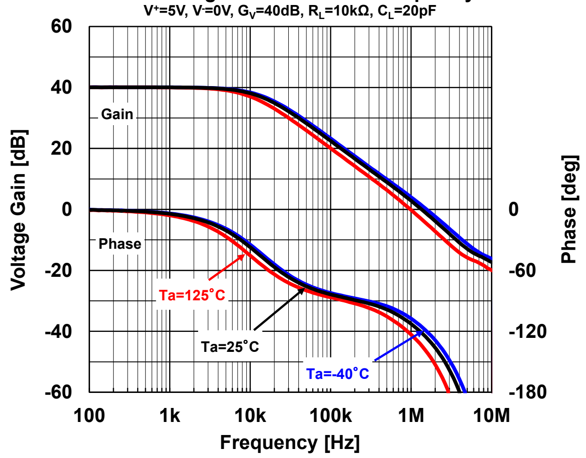



## ■ TYPICAL CHARACTERISTICS (Operational Amplifier)

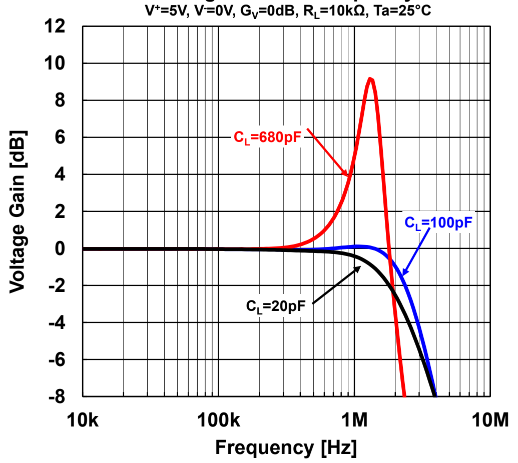
**40dB Voltage Gain / Phase vs. Frequency**
$V^+$=5V, $V^-$=0V, $G_V$=40dB, $R_L$=10kΩ, Ta=25°C



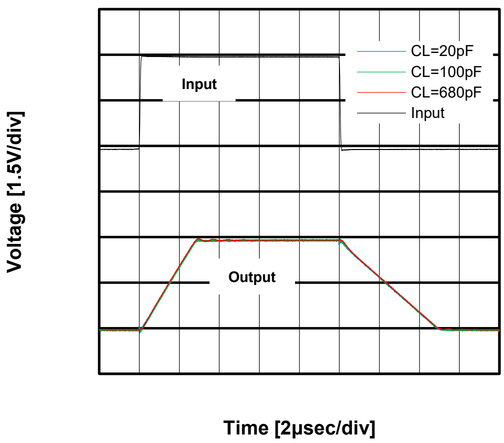

**40dB Voltage Gain/Phase vs. Frequency**
$V^+$=5V, $V^-$=0V, $G_V$=40dB, $R_L$=10kΩ, $C_L$=20pF




**Voltage Gain vs. Frequency**
$V^+$=5V, $V^-$=0V, $G_V$=0dB, $R_L$=10kΩ, Ta=25°C



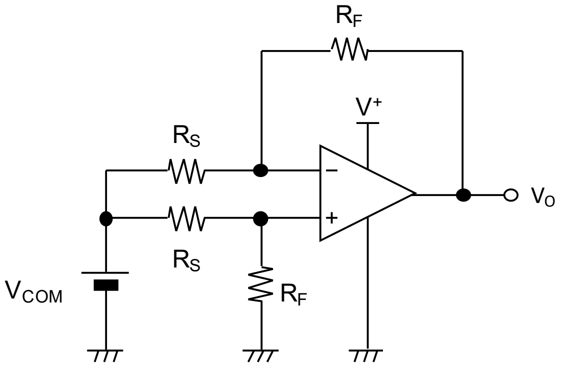

**Slew Rate**
$V^+$=5V, $V^-$=0V, $R_L$=10kΩ, $G_V$=0dB, Ta=25°C



## ■ TEST CIRCUITS

● $V_{IO}$, CMR2, SVR2

$R_S$ = 50Ω, $R_F$ = 50kΩ




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

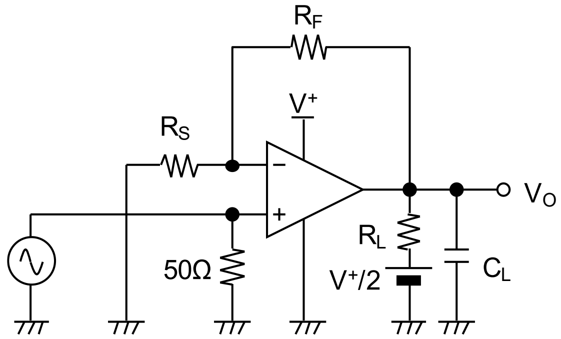
$$CMR2 = 20\log \frac{\Delta V_{COM}\left(1 + \frac{R_F}{R_S}\right)}{\Delta V_O}$$

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

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

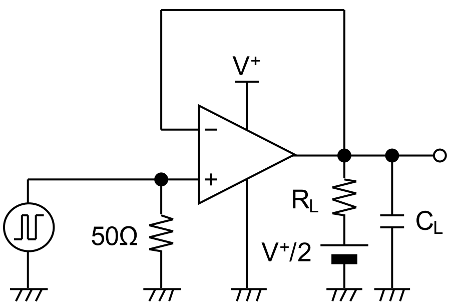
● GBW

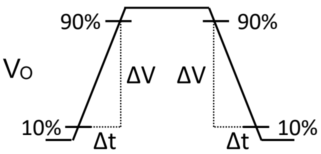
$R_S$ = 1kΩ, $R_F$ = 100kΩ




● SR

$C_L$ = 20pF, $R_L$ = 10kΩ




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

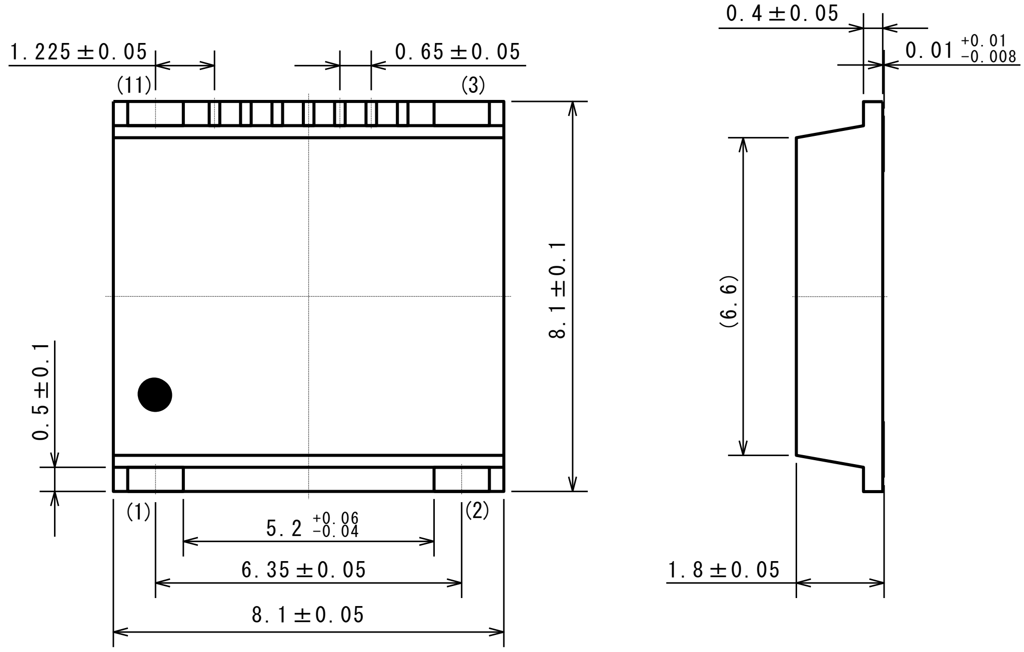
**Note on using NJU7890**

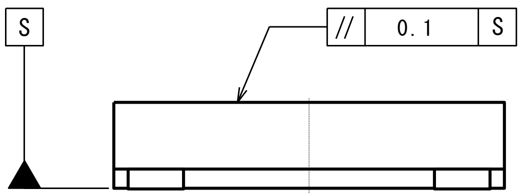
This part handles high voltage, therefore it needs sufficient consideration to avoid unforeseen critical failures. Please make sure that implement and verify fail-safe and/or redundant and secure design in customer own actual application to prevent personal injury, fire and social damage. The FMEA document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

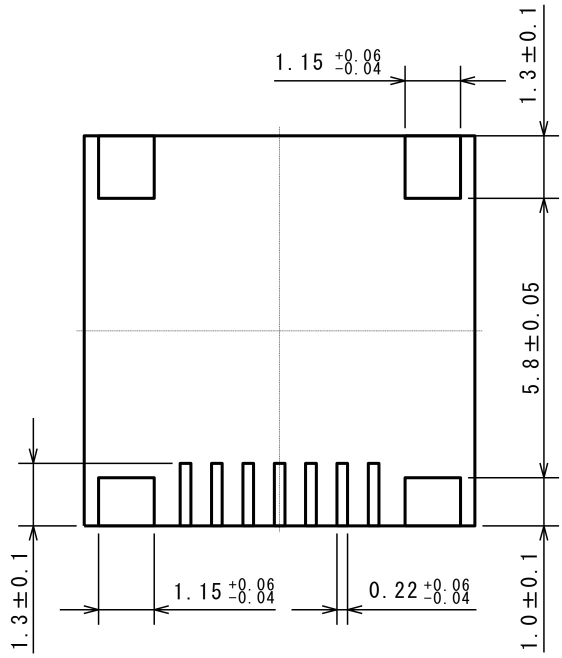
## PMAP11-PM

■ PACKAGE DIMENSIONS

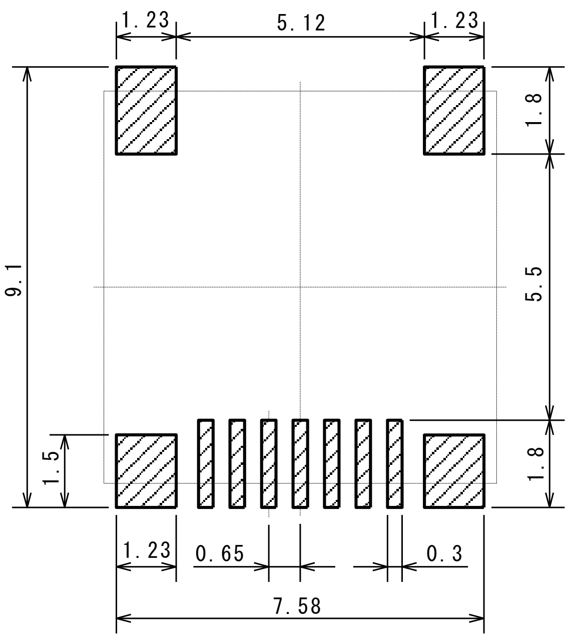
Unit: mm




■ EXAMPLE OF SOLDER PADS DIMENSIONS

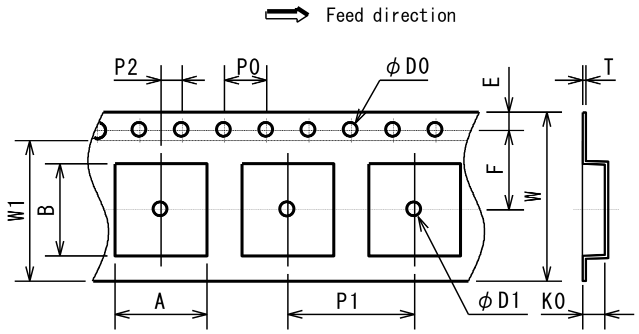


## PMAP11-PM

Unit: mm

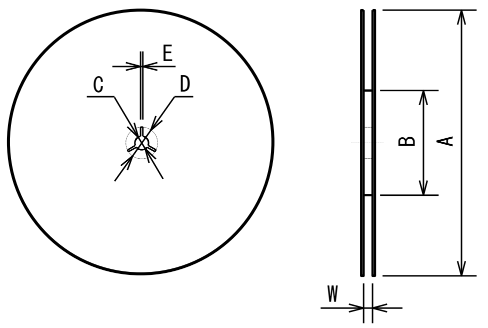
## ■ PACKING SPEC

### TAPING DIMENSIONS



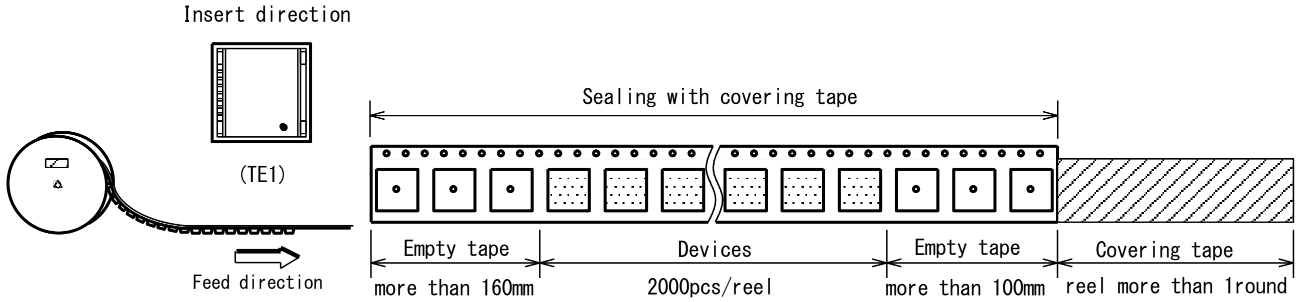

| SYMBOL | DIMENSION | REMARKS |
|---|---|---|
| A | 8.7±0.1 | BOTTOM DIMENSION |
| B | 8.7±0.1 | BOTTOM DIMENSION |
| D0 | $1.5^{+0.1}_{0}$ | |
| D1 | $1.5^{+0.1}_{0}$ | |
| E | 1.75±0.1 | |
| F | 7.5±0.1 | |
| P0 | 4.0±0.1 | |
| P1 | 12.0±0.1 | |
| P2 | 2.0±0.1 | |
| K0 | 2.1±0.1 | |
| T | 0.3±0.1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

### REEL DIMENSIONS

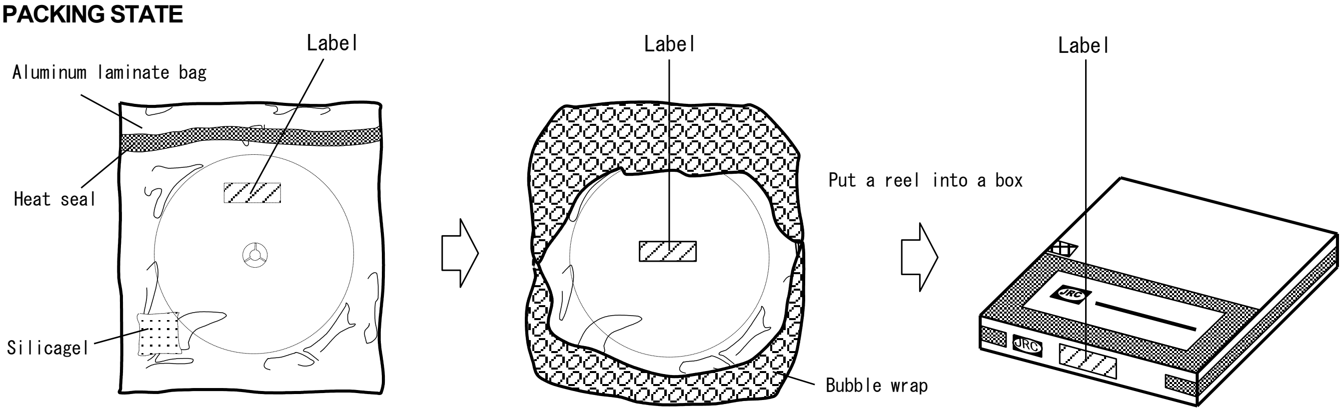



| SYMBOL | DIMENSION |
|---|---|
| A | φ330±2 |
| B | φ100±1 |
| C | φ 13±0.2 |
| D | 21±0.8 |
| E | 2±0.5 |
| W | 17.5±1 |

### TAPING STATE

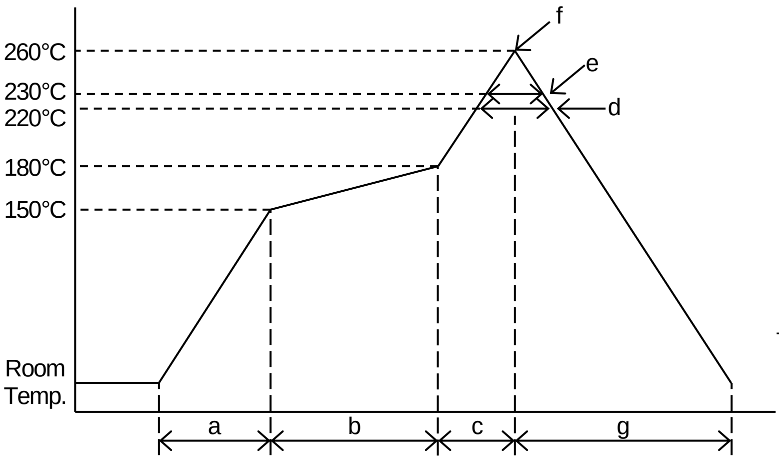



### PACKING STATE



■ **RECOMMENDED MOUNTING METHOD**

**INFRARED REFLOW SOLDERING PROFILE**




| | | |
|---|---|---|
| a | Temperature ramping rate | 1 to 4°C/s |
| b | Pre-heating temperature<br>Pre-heating time | 150 to 180°C<br>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 |
| June 29,2021 | Ver.2.0 | Corrected FEATURES and PACKAGE DIMENSIONS |
| October 1,2024 | Ver.3.0 | Company name and logo changed to Nisshinbo Microdevices Inc. |

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

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   8-1. Quality Warranty Period

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

   8-2. Quality Warranty Remedies

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

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

   8-3. Remedies after Quality Warranty Period

   With respect to any defect of this product found after the quality warranty period, the defect will be analyzed by us. On the basis of the defect analysis results, the scope and amounts of damage shall be determined by mutual agreement of both parties. Then we will deal with upper limit in Section 8-2. This provision is not intended to limit any legal rights of your company.
9. Anti-radiation design is not implemented in the products described in this document.
10. The X-ray exposure can influence functions and characteristics of the products. Confirm the product functions and characteristics in the evaluation stage.
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12. Warning for handling Gallium and Arsenic (GaAs) products (Applying to GaAs MMIC, Photo Reflector). These products use Gallium (Ga) and Arsenic (As) which are specified as poisonous chemicals by law. For the prevention of a hazard, do not burn, destroy, or process chemically to make them as gas or power. When the product is disposed of, please follow the related regulation and do not mix this with general industrial waste or household waste.
13. Please contact our sales representatives should you have any questions or comments concerning the products or the technical information.

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