# 1000V High Voltage Monitor IC

## ■ FEATURES

- AEC-Q100 Grade 1 Qualified
- 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

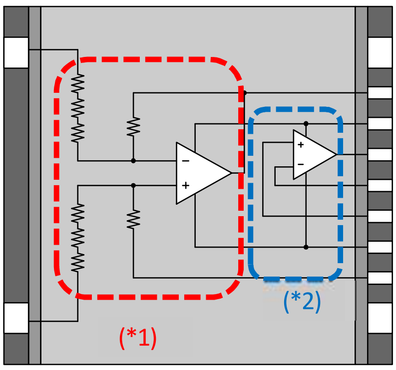
The NJU7890 is a high voltage monitor IC capable of inputting voltages up to 1000V. With our proprietary semiconductor process technology, NJU7890 realizes wide common mode / differential input voltage.

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



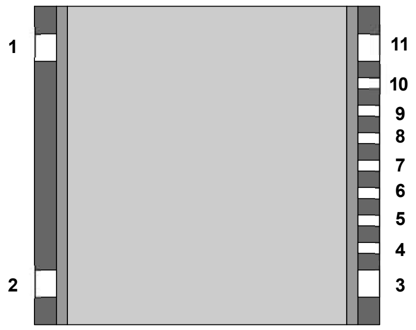

(*1) High Voltage Monitor Block
(*2) OP-Amp Block

## ■ 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

NJU7890 YPM - A - Z (TE1)

- NJU7890: Part Number
- YPM: Package
- A: Attenuation Version
  - A: 1/205
  - B: 1/311
- Z: Grade
  - Z: Automotive
- (TE1): Taping Form

## ■ 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.)

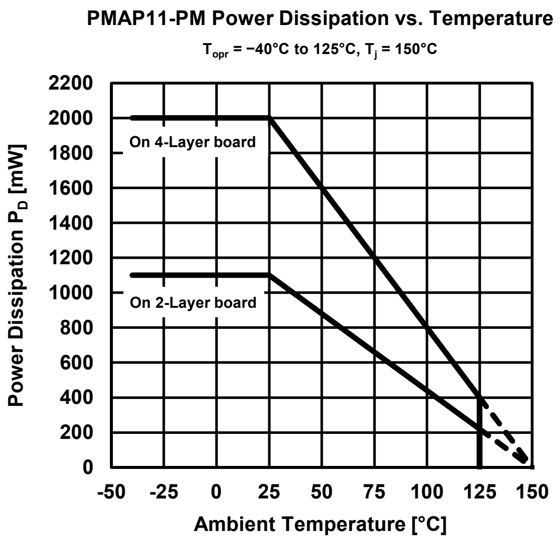
| PARAMETER | SYMBOL | RATINGS | UNIT |
|---|---|---|---|
| **GENERAL CHARACTERISTICS** | | | |
| Supply Voltage | $V^+ - V^-$ | 7 | V |
| Power Dissipation ($T_a$ = 25°C)<br>PMAP11-PM | $P_D$ | 2Layers / 4Layers<br>1100 (1) / 2000 (2) | mW |
| Junction Temperature | $T_j$ | 150 | °C |
| Storage Temperature | $T_{stg}$ | −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

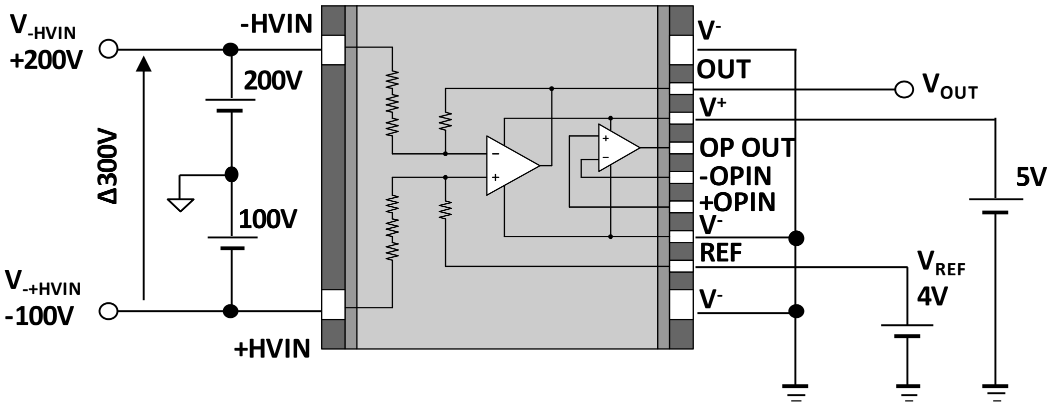
$V_{+HVIN} = -100V$, $V_{-HVIN} = 200V$, $V_{REF} = 4V$, $V^{+} = 5.2V$, $ATT = 1/205 \pm 0.7\%$ ($T_a = 25°C$), $V_{OS\text{-}RTO} = 0.3mV$, $SVR1 = 70dB$, $CMR1 = 85dB$

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

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

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).

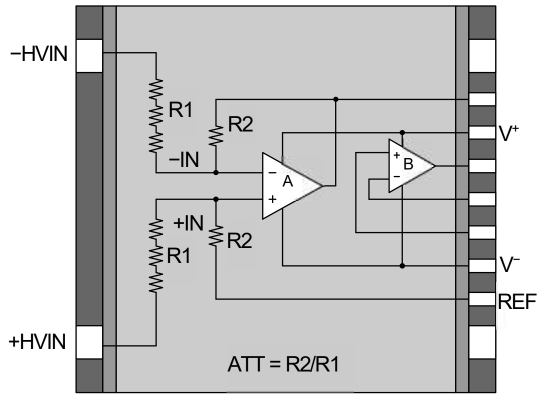
Evaluation circuit example



■ +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

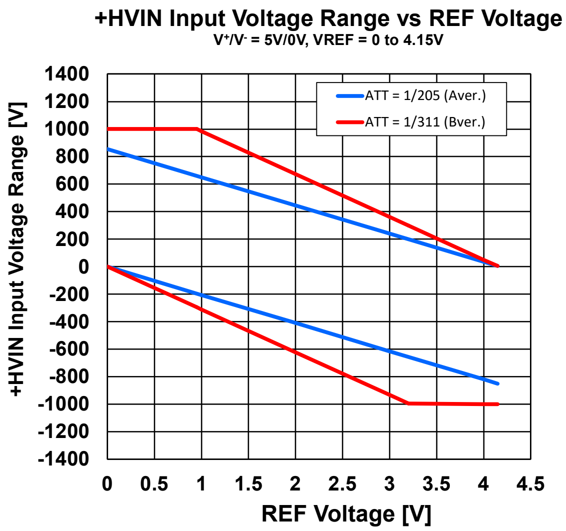
$V_{REF}$ = 4V, $V^+ / V^-$ = 5V / 0V, ATT = 1/205

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

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

Characteristics example

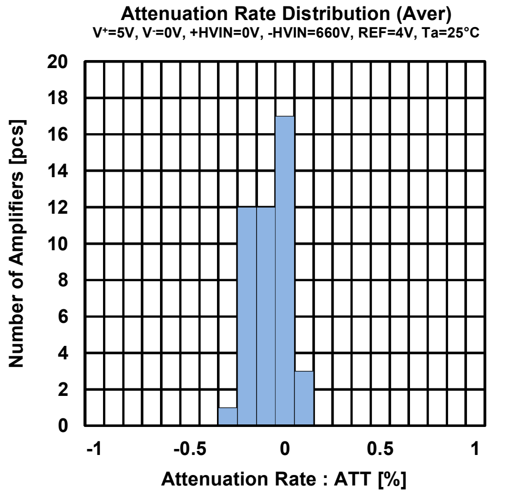
The figure below shows an example of characteristics when the attenuation rate is set to 1/205 (Aver) and 1/311 (Bver).
The range indicated by the graph is the input voltage range of the +HVIN.

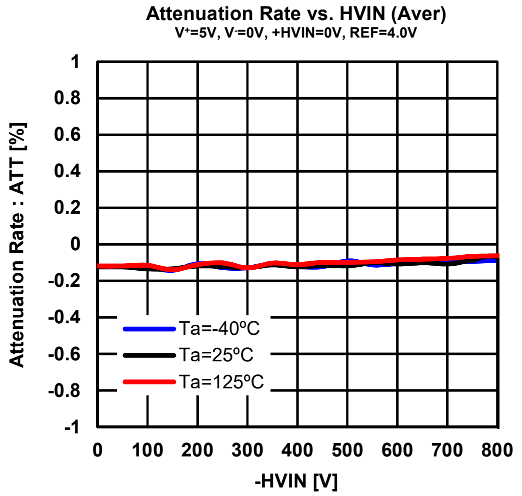


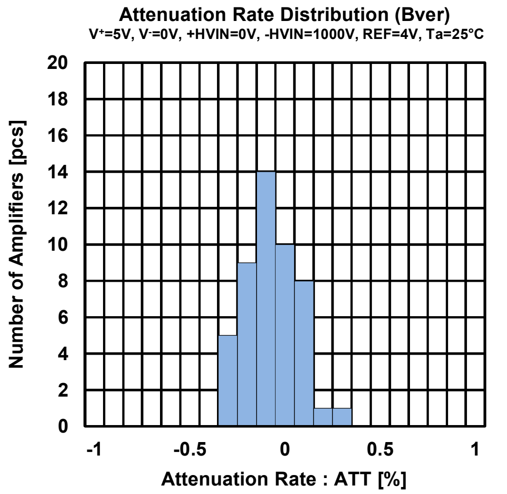
■ ELECTRICAL CHARACTERISTICS

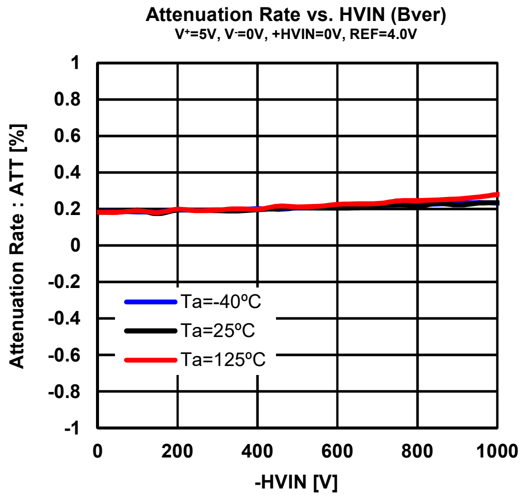
| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **OPERATIONAL AMPLIFIER** ($V^+$ = 5V, $V^-$ = 0V, $T_a$ = 25°C, unless otherwise noted.) | | | | | | |
| Input Offset Voltage | $V_{IO}$ | | - | 0.04 | 0.30 | mV |
| | | $T_a$ = −40°C to 125°C | - | - | 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, $V_{IN}$ = $3V_{PP}$ | - | 0.5 | - | V/μs |

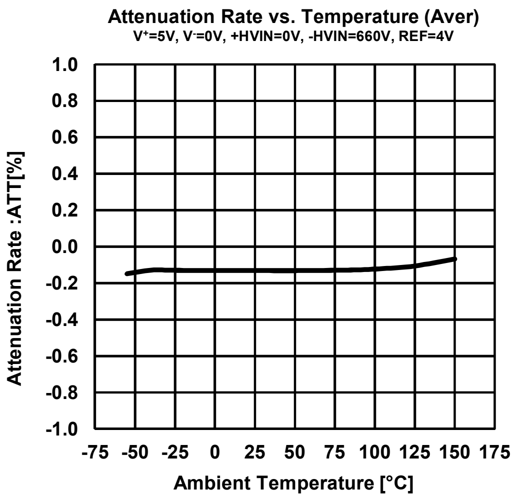
■ TYPICAL CHARACTERISTICS (General Characteristics/High Voltage Monitor)

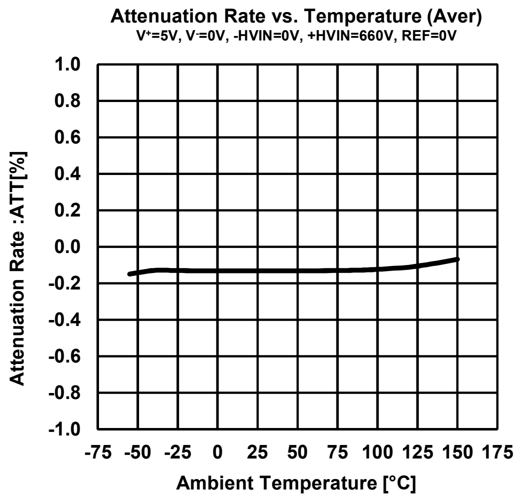


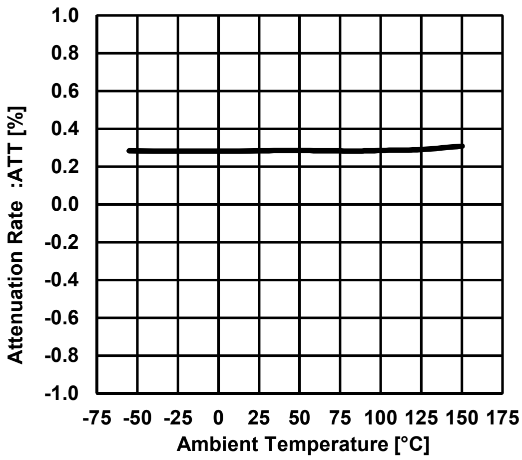



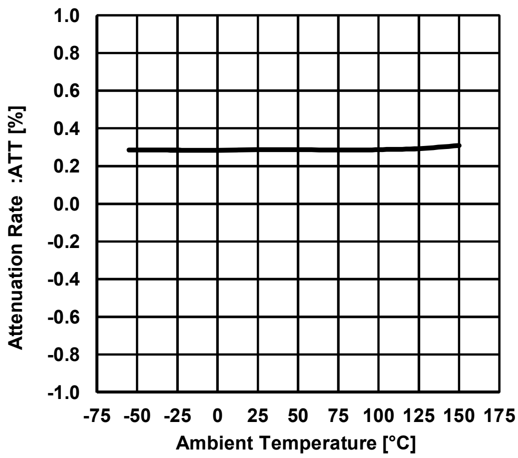



## ■ TYPICAL CHARACTERISTICS (General Characteristics /High Voltage Monitor)

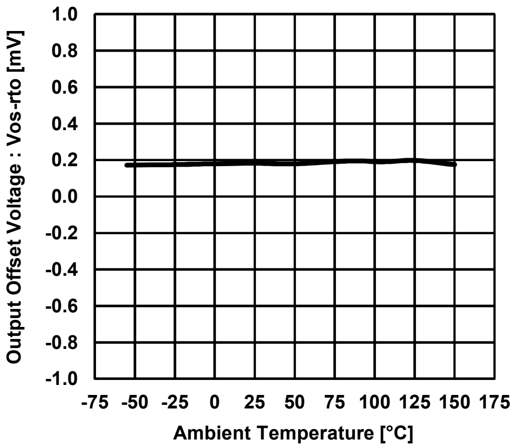
**Attenuation Rate vs. Temperature (Bver)**
$V^+$=5V, $V^-$=0V, +HVIN=0V, -HVIN=1000V, REF=4V



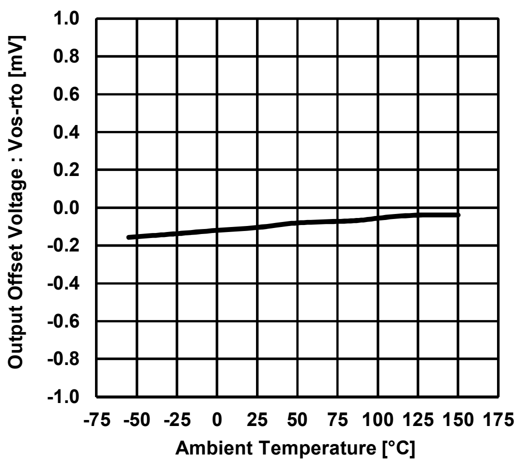

**Attenuation Rate vs. Temperature (Bver)**
$V^+$=5V, $V^-$=0V, -HVIN=0V, +HVIN=1000V, REF=0V



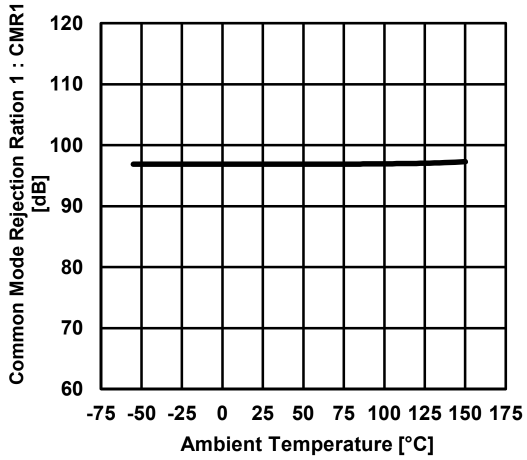

**Output Offset Voltage vs. Temperature (Aver)**
$V^+$=5V, $V^-$=0V, +HVIN=0V, -HVIN=0V, REF=2.5V



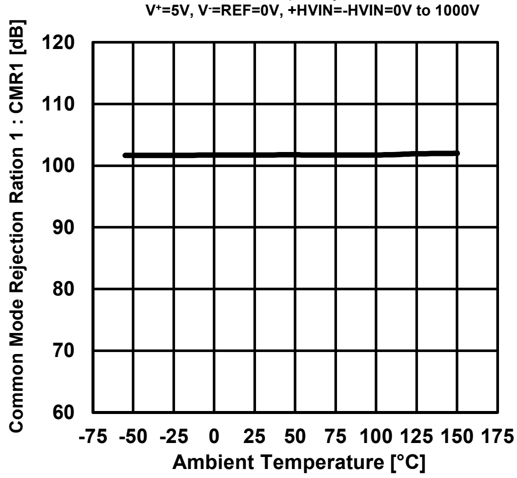

**Output Offset Voltage vs. Temperature (Bver)**
$V^+$=5V, $V^-$=0V, +HVIN=0V, -HVIN=0V, REF=2.5V



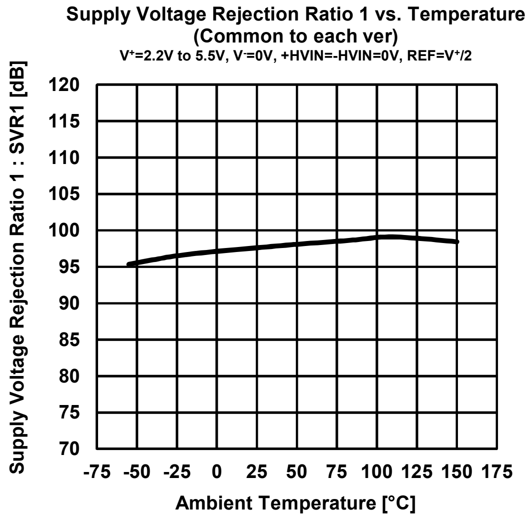

**Common Mode Rejection Ration 1 vs. Temperature (Aver)**
$V^+$=5V, $V^-$=REF=0V, +HVIN=-HVIN=0V to 660V

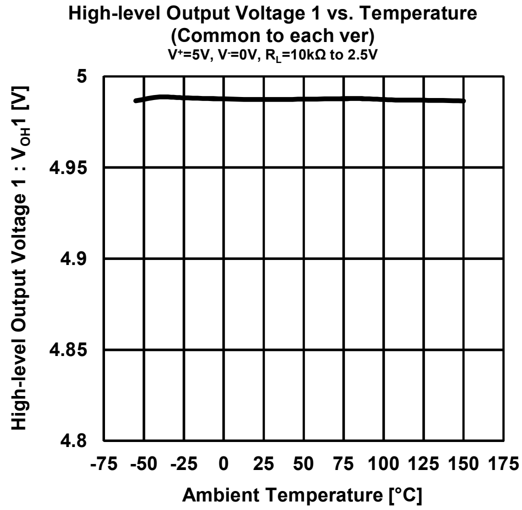


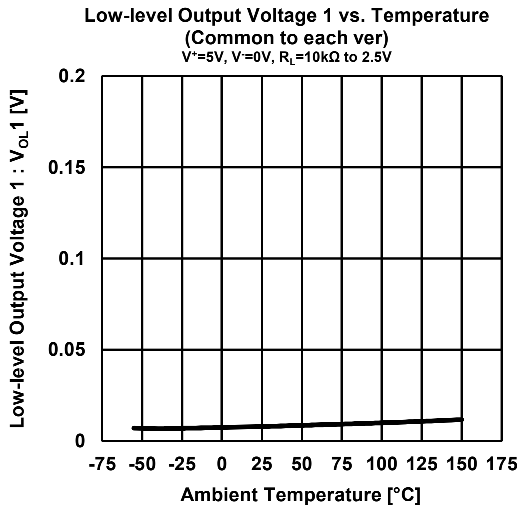

**Common Mode Rejection Ration 1vs. Temperature (Bver)**
$V^+$=5V, $V^-$=REF=0V, +HVIN=-HVIN=0V to 1000V

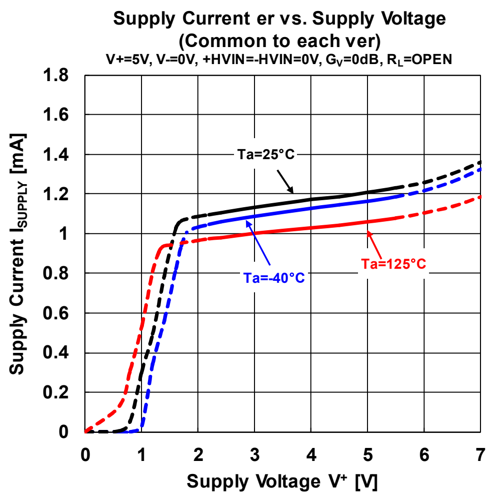


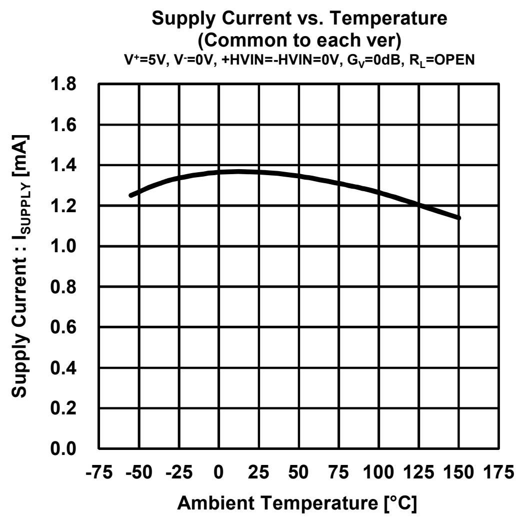
## ■ TYPICAL CHARACTERISTICS (General Characteristics/High Voltage Monitor)



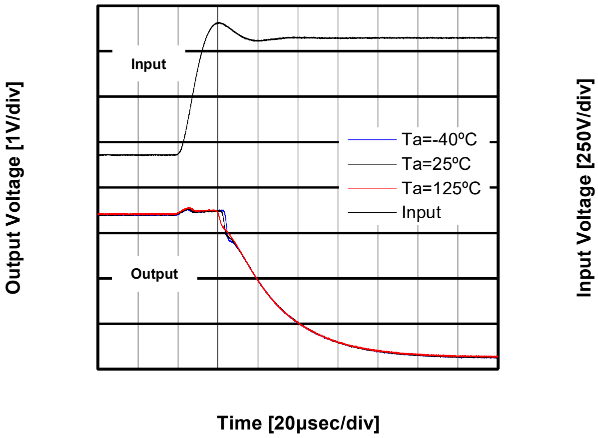



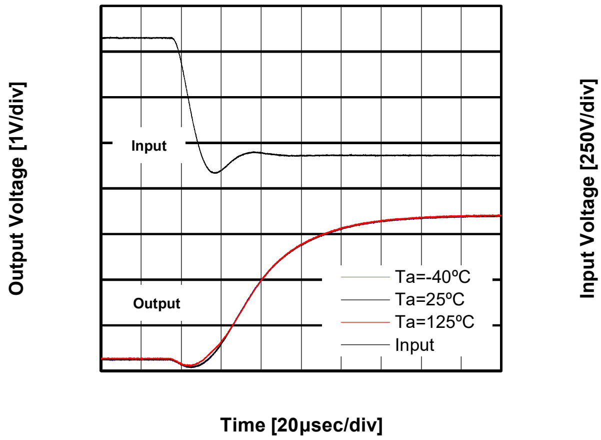



## ■ TYPICAL CHARACTERISTICS (General Characteristics High Voltage Monitor)

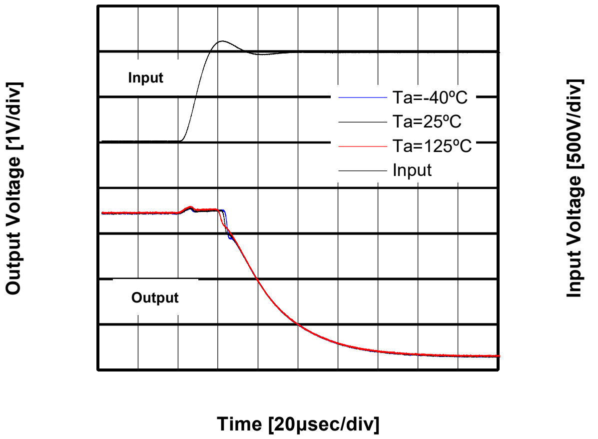
**Response Time (Aver)**
$V^+$=5V, $V^-$=0V, -HVIN=0V to 660V, +HVIN=0V



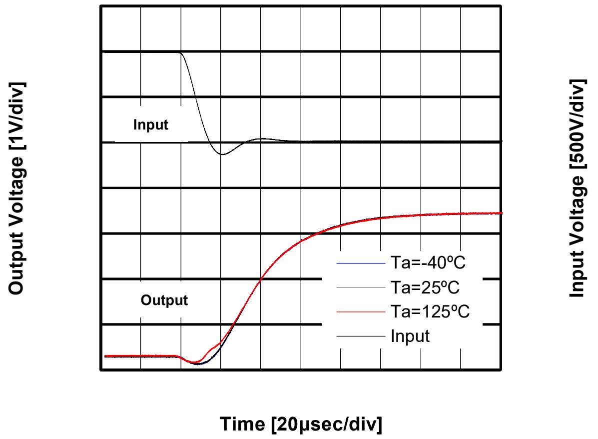

**Response Time (Aver)**
$V^+$=5V, $V^-$=0V, -HVIN=0V to 660V, +HVIN=0V



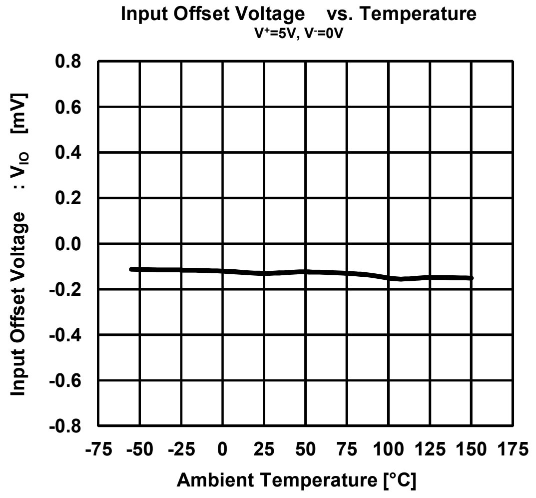

**Response Time (Bver)**
$V^+$=5V, $V^-$=0V, -HVIN=0V to 1000V, +HVIN=0V

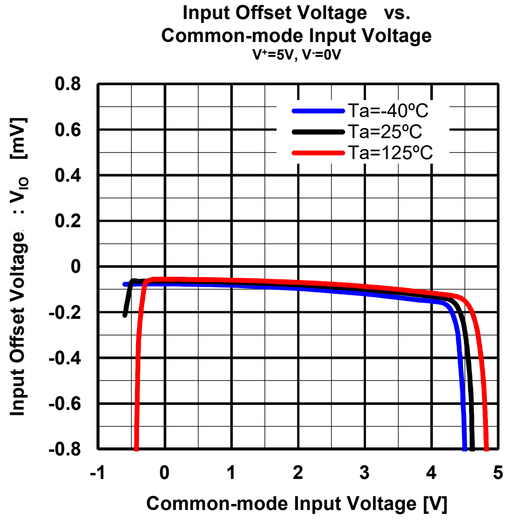


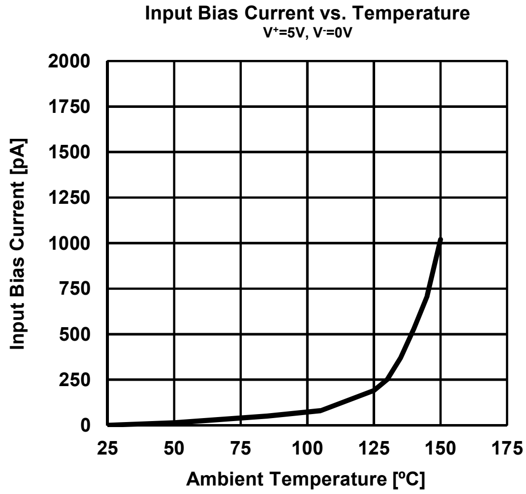

**Response Time (Bver)**
$V^+$=5V, $V^-$=0V, -HVIN=0V to 1000V, +HVIN=0V

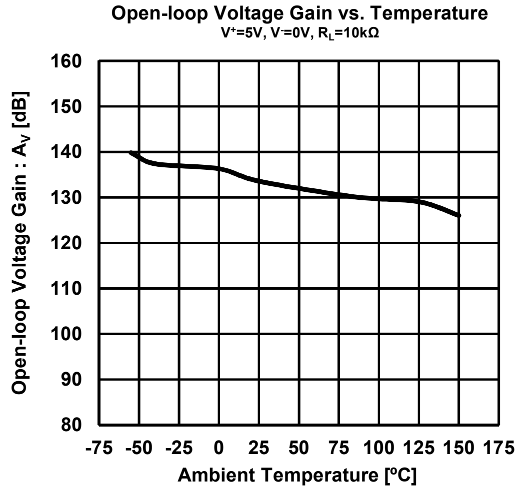


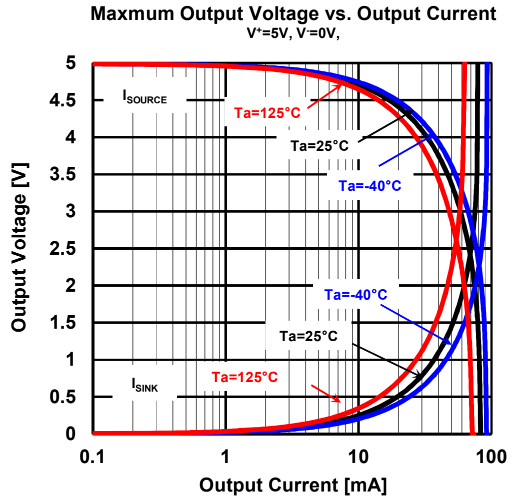
■ TYPICAL CHARACTERISTICS (Operational Amplifier)



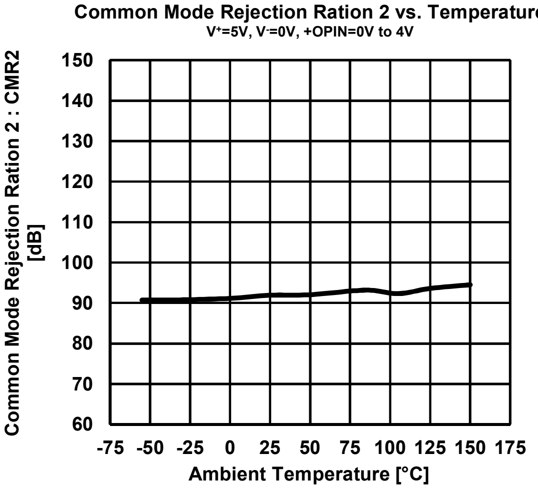



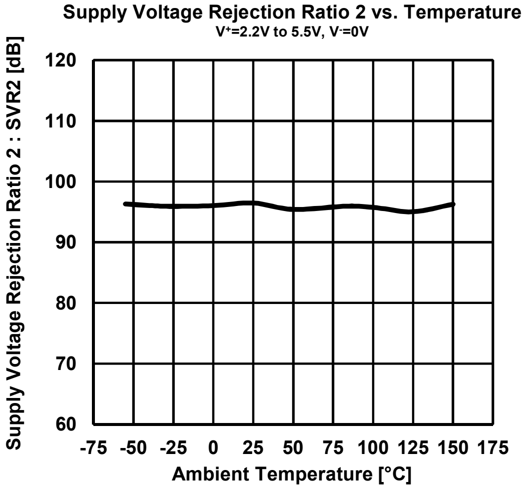



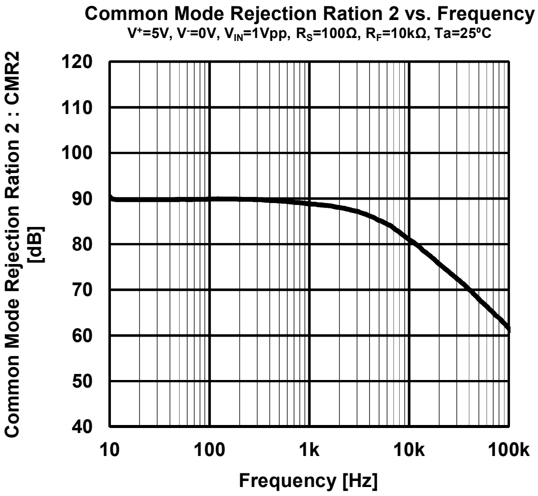



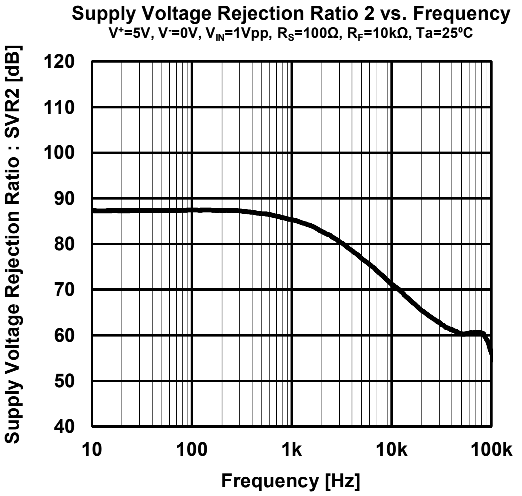



■ TYPICAL CHARACTERISTICS (Operational Amplifier)

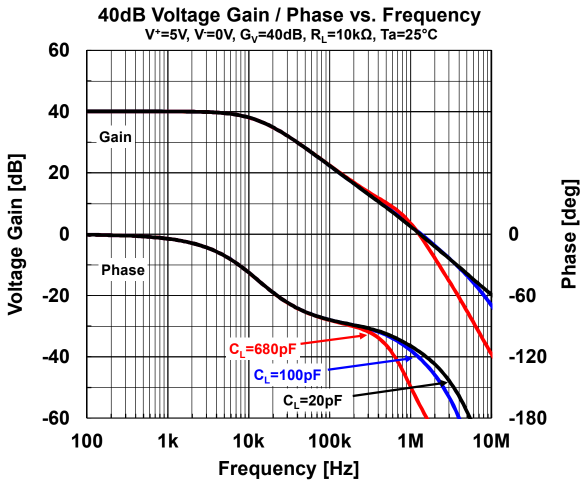


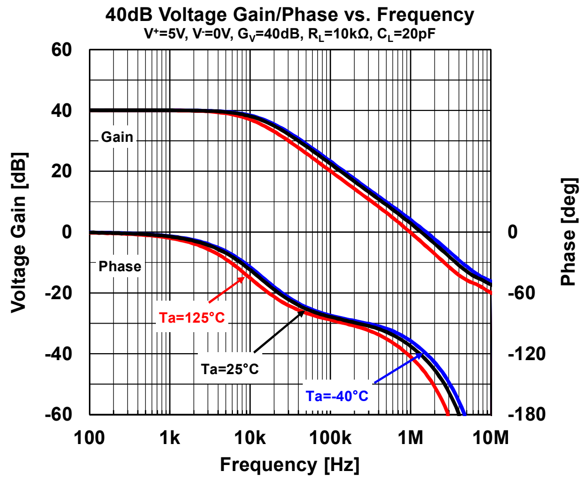



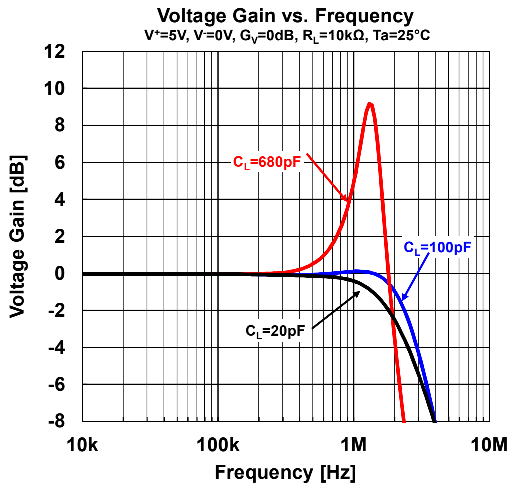



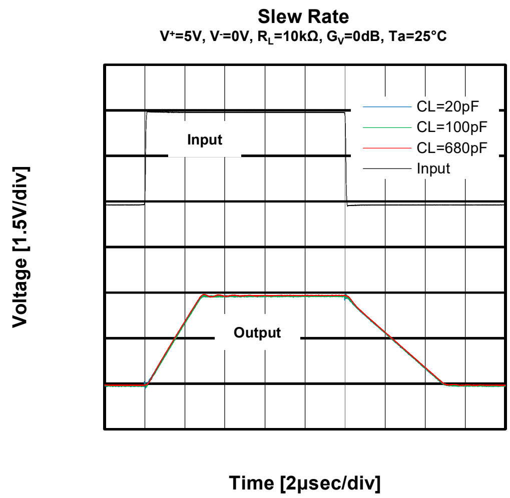



■ TYPICAL CHARACTERISTICS (Operational Amplifier)



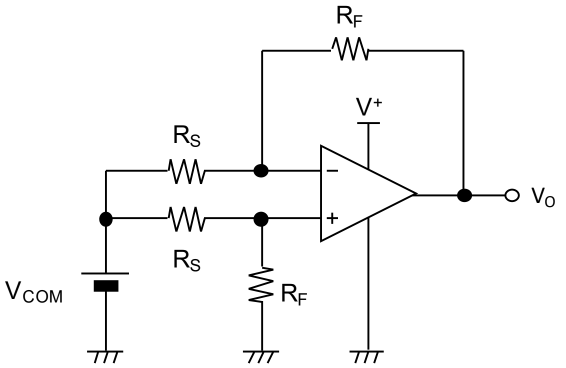



■ **TEST CIRCUITS**

● $V_{IO}$, CMR2, SVR2

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




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

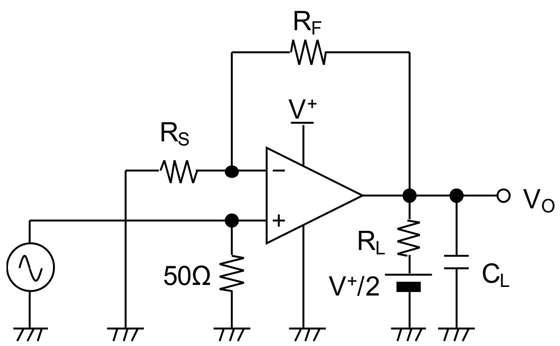
$$CMR2 = 20\log \frac{\Delta V_{COM}\left(1 + \frac{R_F}{R_S}\right)}{\Delta V_O}$$

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

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

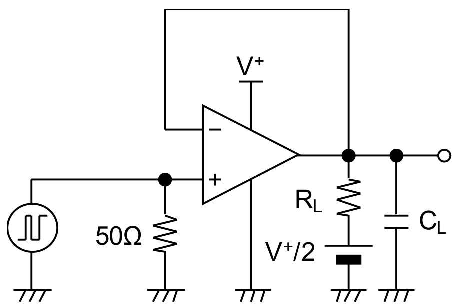
● GBW

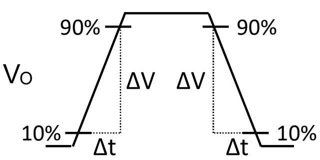
$R_S = 1k\Omega$, $R_F = 100k\Omega$




● SR

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




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

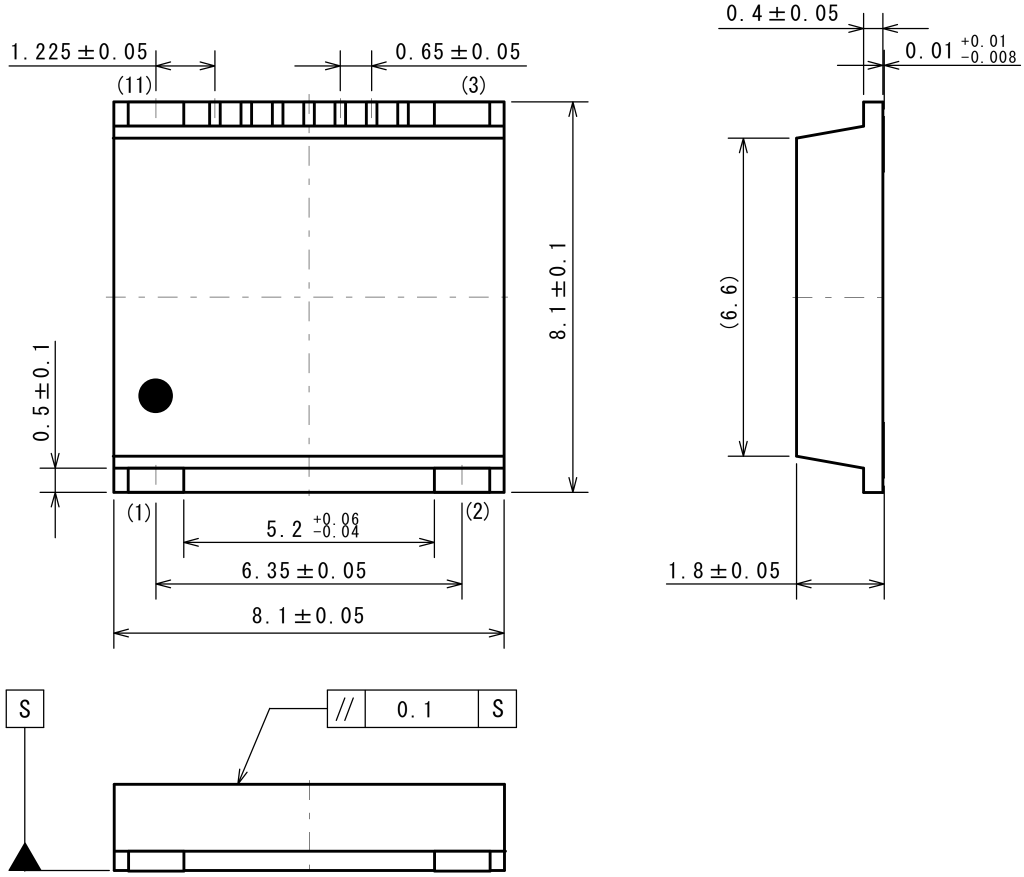
**Note on using NJU7890**

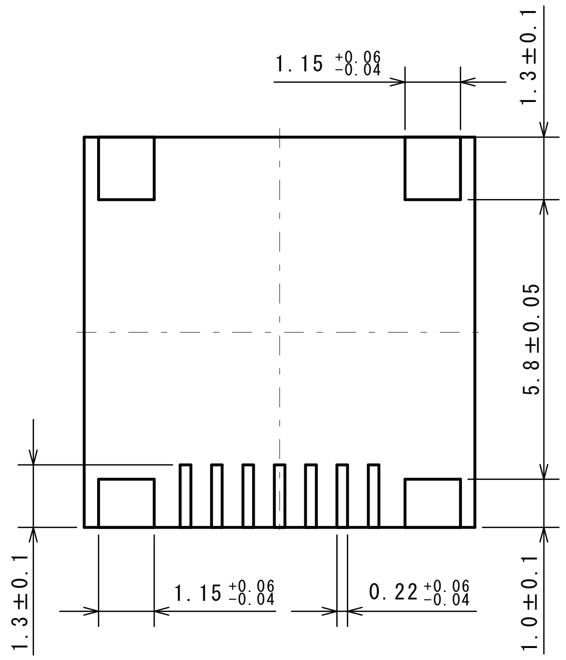
This part handles high voltage, therefore it needs sufficient consideration to avoid unforeseen critical failures. Please make sure that implement and verify fail-safe and/or redundant and secure design in customer own actual application to prevent personal injury, fire and social damage. The FMEA document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

## PMAP11-PM

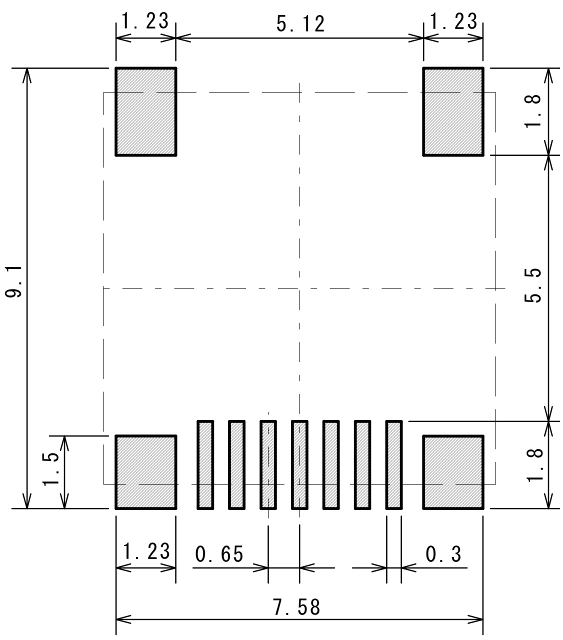
■ **PACKAGE DIMENSIONS**

Unit: mm




■ **EXAMPLE OF SOLDER PADS DIMENSIONS**

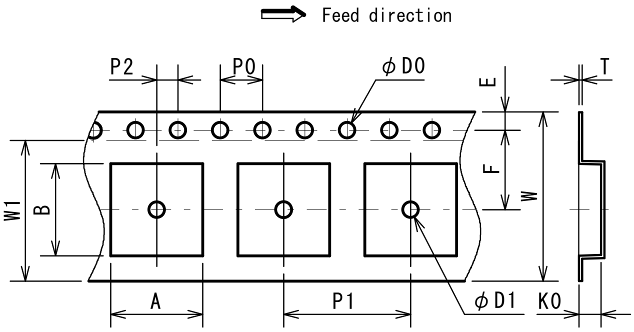


## PMAP11-PM

Unit: mm

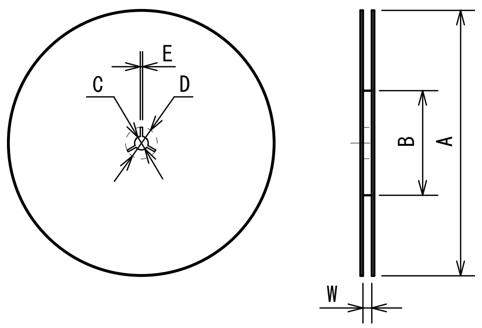
## ■ PACKING SPEC

### TAPING DIMENSIONS



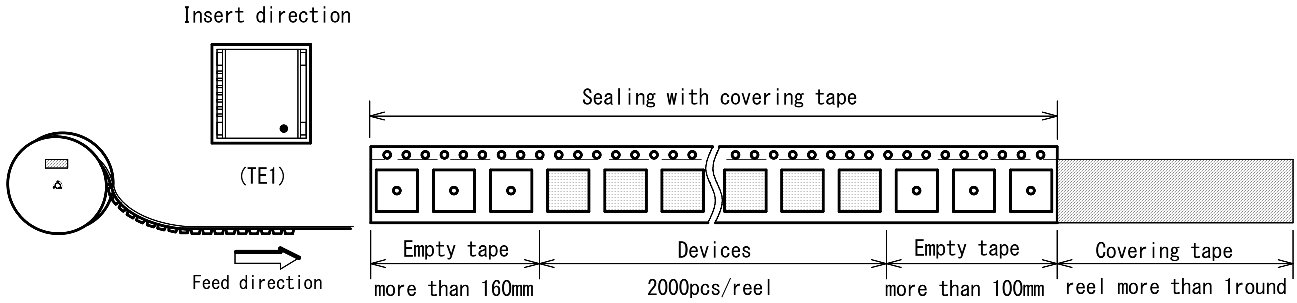

| SYMBOL | DIMENSION | REMARKS |
|---|---|---|
| A | 8.7±0.1 | BOTTOM DIMENSION |
| B | 8.7±0.1 | BOTTOM DIMENSION |
| D0 | $1.5^{+0.1}_{0}$ | |
| D1 | $1.5^{+0.1}_{0}$ | |
| E | 1.75±0.1 | |
| F | 7.5±0.1 | |
| P0 | 4.0±0.1 | |
| P1 | 12.0±0.1 | |
| P2 | 2.0±0.1 | |
| K0 | 2.1±0.1 | |
| T | 0.3±0.1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

### REEL DIMENSIONS

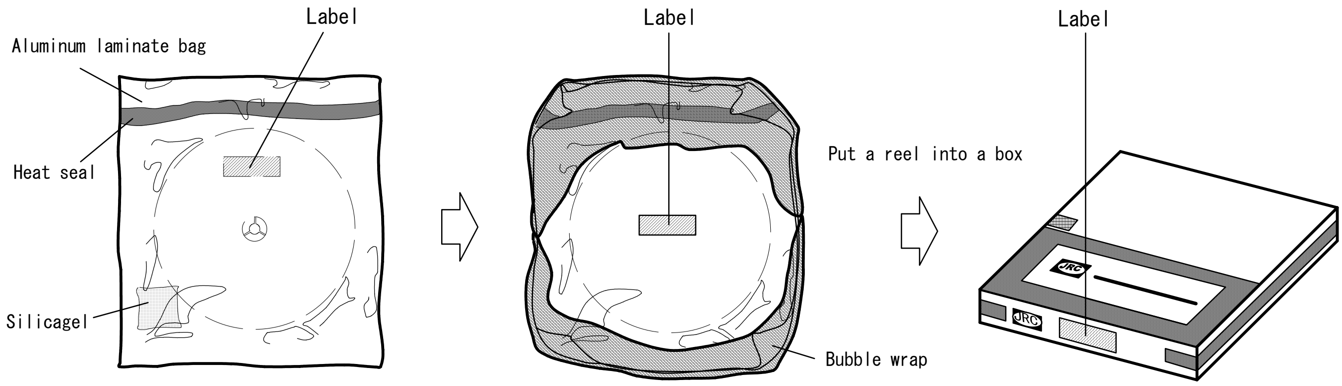



| SYMBOL | DIMENSION |
|---|---|
| A | ϕ330±2 |
| B | ϕ100±1 |
| C | ϕ 13±0.2 |
| D | 21±0.8 |
| E | 2±0.5 |
| W | 17.5±1 |

### TAPING STATE

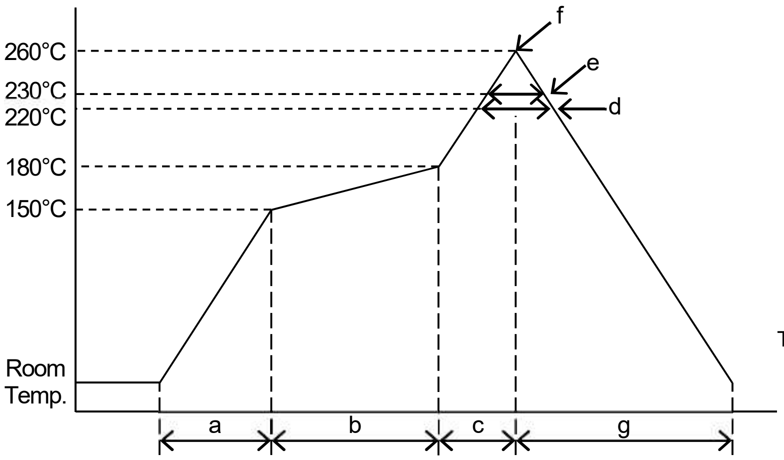



### PACKING STATE



■ RECOMMENDED MOUNTING METHOD

INFRARED REFLOW SOLDERING PROFILE




| | | |
|---|---|---|
| a | Temperature ramping rate | 1 to 4°C/s |
| b | Pre-heating temperature | 150 to 180°C |
| | Pre-heating time | 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 |

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   ・Aerospace Equipment
   ・Equipment Used in the Deep Sea
   ・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

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9. The product specifications and descriptions listed in this datasheet are subject to change at any time, without notice.