

## 14V, Low Noise, Low Power, Rail-to-Rail Input/Output, Operational Amplifier

### FEATURES ( $V^+=5V$ , $V^-=0V$ , $T_a=25^\circ C$ )

- Supply Voltage 1.8V to 14V
- Low Noise 10nV/ $\sqrt{Hz}$  at 1kHz
- Low Supply Current (All Amplifiers)
  - NJM8530 320 $\mu A$  typ.
  - NJM8532 580 $\mu A$  typ.
  - NJM8534 1200 $\mu A$  typ.
- Rail-to-Rail Input and Output
- GBW 1MHz
- Slew Rate 0.4V/ $\mu s$
- Capacitive Load Drive 1000pF
- Unity Gain Stable
- Package
  - NJM8530 SOT-23-5
  - NJM8532 DMP8, SSOP8, MSOP8 (TVSP8)
  - NJM8534 SSOP14

### APPLICATIONS

- Battery-powered instruments
  - Audio, Sensor applications, Medical, Security
- High-side/Low-side Current sensing amplifiers
- Active Filters
- Analog-to-digital / Digital-to-analog Buffers
- Handheld Test Equipment

### DESCRIPTION

The NJM8530/NJM8532/NJM8534 are single/dual/quad rail to rail input and output single supply operational amplifier featuring 14V supply voltage, low noise and low power.

A wide supply voltage range from 1.8V to 14V with a rail to rail input and output allows the device to be used in wide variety of applications, such as audio amplifier, hi-side current sensing, buffering and others. Furthermore, low supply current of 580 $\mu A$  typical at NJM8532 combined with a wide bandwidth of 1MHz and low very low noise of 10nV/ $\sqrt{Hz}$  at 1kHz make NJM8530/NJM8532/NJM8534 very suitable for a variety of battery-powered applications that require a good balance between low power, low noise and wide bandwidth.

NJM8530/NJM8532/NJM8534 can drive up to approximately 1000pF, and is unity-gain stable. Operating temperature range is  $-40^\circ C$  to  $125^\circ C$ .

The NJM8530(single) is available in 5-pin SOT-23 package. NJM8532(dual) is available in 8-pin DMP, SSOP and MSOP(TVSP): meet JEDEC MO-187-DA / thin type package. NJM8534(quad) is available in 14-pin SSOP package.

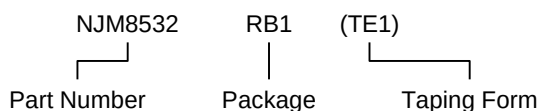
### Rail-to-Rail Input/Output Op-Amp (Bipolar)

| Supply Voltage | 6V      | 14V     |
|----------------|---------|---------|
| Single         | NJM2730 | NJM8530 |
| Dual           | NJM2732 | NJM8532 |
| Quad           | NJM2734 | NJM8534 |

## ■ PIN CONFIGURATIONS

| PIN CONFIGURATIONS |                              |                              |          |              |
|--------------------|------------------------------|------------------------------|----------|--------------|
| PRODUCT NAME       | NJM8530F                     | NJM8532M                     | NJM8532V | NJM8532RB1   |
| Package            | SOT-23-5                     | DMP8                         | SSOP8    | MSOP8(TVSP8) |
| Pin Functions      | <div><p>(Top View)</p></div> | <div><p>(Top View)</p></div> |          |              |
| PRODUCT NAME       | NJM8534V                     |                              |          |              |
| Package            | SSOP14                       |                              |          |              |
| Pin Functions      | <div><p>(Top View)</p></div> |                              |          |              |

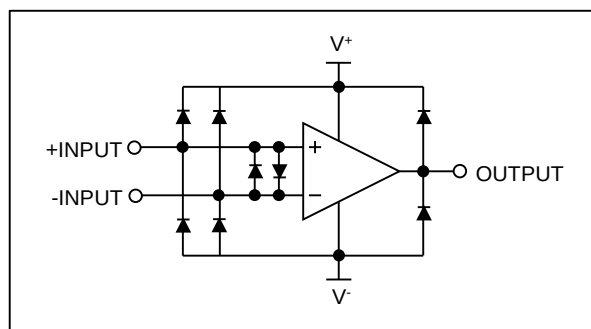
## ■ PRODUCT NAME INFORMATION



## ■ ORDERING INFORMATION

| PRODUCT NAME | PACKAGE       | RoHS | HALOGEN-FREE | TERMINAL FINISH | MARKING | WEIGHT (mg) | MOQ (pcs) |
|--------------|---------------|------|--------------|-----------------|---------|-------------|-----------|
| NJM8530F     | SOT-23-5      | ○    | -            | Sn2Bi           | A6L     | 15          | 3000      |
| NJM8532M     | DMP8          | ○    | -            | Sn2Bi           | 8532    | 95          | 2000      |
| NJM8532V     | SSOP8         | ○    | -            | Sn2Bi           | 8532    | 42          | 2000      |
| NJM8532RB1   | MSOP8 (TVSP8) | ○    | -            | Sn2Bi           | 8532    | 18          | 2000      |
| NJM8534V     | SSOP14        | ○    | ○            | Sn2Bi           | 8534    | 65          | 2000      |

## ■ BLOCK DIAGRAM



## ■ ABSOLUTE MAXIMUM RATINGS

| PARAMETER                                      | SYMBOL      | RATING                           | UNIT             |
|------------------------------------------------|-------------|----------------------------------|------------------|
| Supply Voltage                                 | $V^+ - V^-$ | 15                               | V                |
| Input Voltage                                  | $V_{IN}$    | $V^- - 0.3$ to $V^+ + 0.3^{(2)}$ | V                |
| Differential Input Voltage                     | $V_{ID}$    | $\pm 1.0^{(1)(2)}$               | V                |
| Input Current                                  | $I_{IN}$    | $2^{(2)}$                        | mA               |
| Power Dissipation ( $T_a = 25^\circ\text{C}$ ) | $P_D$       | 2-Layer / 4-Layer <sup>(3)</sup> | mW               |
| SOT-23-5                                       |             | 480 / 650                        |                  |
| DMP8                                           |             | 470 / 600                        |                  |
| SSOP8                                          |             | 430 / 540                        |                  |
| TVSP8                                          |             | 510 / 680                        |                  |
| SSOP14                                         |             | 500 / 620                        |                  |
| Storage Temperature Range                      | $T_{stg}$   | -40 to 150                       | $^\circ\text{C}$ |
| Maximum Junction Temperature                   | $T_{jmax}$  | 150                              | $^\circ\text{C}$ |

## ■ THERMAL CHARACTERISTICS

| PACKAGE                                               | SYMBOL        | VALUE                            | UNIT               |
|-------------------------------------------------------|---------------|----------------------------------|--------------------|
| Junction-to-Ambient Thermal Resistance                | $\Theta_{ja}$ | 2-Layer / 4-Layer <sup>(3)</sup> | $^\circ\text{C/W}$ |
| SOT-23-5                                              |               | 260 / 192                        |                    |
| DMP8                                                  |               | 266 / 208                        |                    |
| SSOP8                                                 |               | 291 / 231                        |                    |
| TVSP8                                                 |               | 245 / 184                        |                    |
| SSOP14                                                |               | 250 / 202                        |                    |
| Junction-to-Top of Package Characterization Parameter | $\Psi_{jt}$   | 2-Layer / 4-Layer <sup>(3)</sup> | $^\circ\text{C/W}$ |
| SOT-23-5                                              |               | 67 / 58                          |                    |
| DMP8                                                  |               | 72 / 65                          |                    |
| SSOP8                                                 |               | 46 / 45                          |                    |
| TVSP8                                                 |               | 51 / 45                          |                    |
| SSOP14                                                |               | 53 / 52                          |                    |

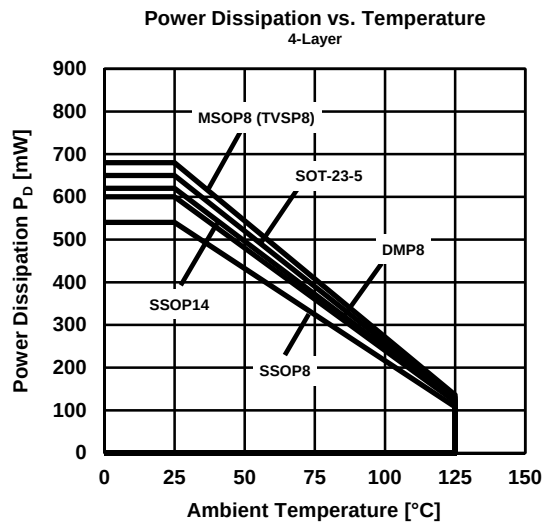
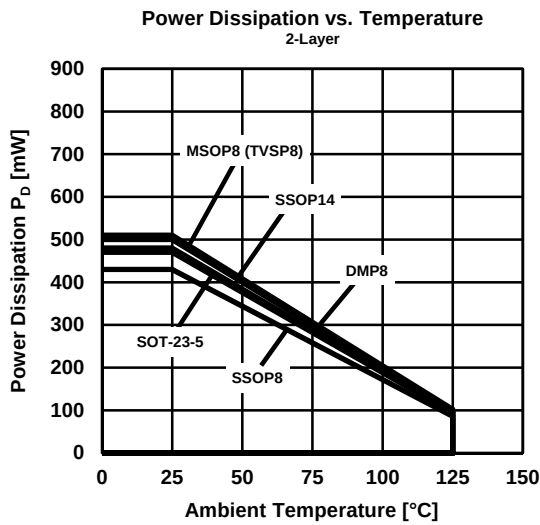
(1) Differential voltage is the voltage difference between +INPUT and -INPUT.

(2) The inputs are protected by diodes. If the differential input voltage exceeds 1.0V, the input current must be limited 2 mA or less by using a restriction resistance.

(3) 2-Layer: Mounted on glass epoxy board. (76.2×114.3×1.6mm: based on EIA/JDEC standard, 2-Layer FR-4)

4-Layer: Mounted on glass epoxy board. (76.2×114.3×1.6mm: based on EIA/JDEC standard, 4-Layer FR-4), internal Cu area: 74.2×74.2mm

## ■ POWER DISSIPATION vs. AMBIENT TEMPERATURE



## ■ RECOMMENDED OPERATING CONDITIONS

| PARAMETER                   | SYMBOL      | CONDITIONS | VALUE      | UNIT |
|-----------------------------|-------------|------------|------------|------|
| Supply Voltage              | $V^+ - V^-$ |            | 1.8 to 14  | V    |
| Operating Temperature Range | $T_{opr}$   |            | -40 to 125 | °C   |

## ■ ELECTRICAL CHARACTERISTICS ( $V^+=5V$ , $V=0V$ , $V_{COM}=2.5V$ , $T_a=25^\circ C$ , unless otherwise noted.)

| ELECTRICAL CHARACTERISTICS (V <sup>+</sup> =5V, V <sup>-</sup> =0V, V <sub>COM</sub> =2.5V, T <sub>A</sub> =25°C, unless otherwise noted.) |                      |                                                             |             |                    |                    |                |
|--------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-------------------------------------------------------------|-------------|--------------------|--------------------|----------------|
| PARAMETER                                                                                                                                  | SYMBOL               | TEST CONDITIONS                                             | MIN         | TYP                | MAX                | UNIT           |
| INPUT CHARACTERISTICS                                                                                                                      |                      |                                                             |             |                    |                    |                |
| Input Offset Voltage                                                                                                                       | V <sub>IO</sub>      |                                                             | -           | 1                  | 4                  | mV             |
| Input Offset Voltage Drift                                                                                                                 | ΔV <sub>IO</sub> /ΔT | T <sub>A</sub> =-40°C to 125°C                              | -           | 1.5                | -                  | μV/°C          |
| Input Bias Current                                                                                                                         | I <sub>B</sub>       |                                                             | -           | 50                 | 250                | nA             |
| Input Offset Current                                                                                                                       | I <sub>IO</sub>      |                                                             | -           | 5                  | 100                | nA             |
| Open-Loop Voltage Gain                                                                                                                     | A <sub>V</sub>       | R <sub>L</sub> =2kΩ to 2.5V                                 | 60          | 85                 | -                  | dB             |
| Common-Mode Rejection Ratio                                                                                                                | CMR                  | <sup>(5)</sup>                                              | 55          | 70                 | -                  | dB             |
| Common-Mode Input Voltage Range                                                                                                            | V <sub>ICM</sub>     | CMR≥55dB                                                    | 0           | -                  | 5                  | V              |
| OUTPUT CHARACTERISTICS                                                                                                                     |                      |                                                             |             |                    |                    |                |
| High-level Output Voltage                                                                                                                  | V <sub>OH</sub>      | R <sub>L</sub> =20kΩ to 2.5V<br>R <sub>L</sub> =2kΩ to 2.5V | 4.9<br>4.75 | 4.95<br>4.85       | -<br>-             | V<br>V         |
| Low-level Output Voltage                                                                                                                   | V <sub>OL</sub>      | R <sub>L</sub> =20kΩ to 2.5V<br>R <sub>L</sub> =2kΩ to 2.5V | -<br>-      | 0.05<br>0.15       | 0.1<br>0.25        | V<br>V         |
| Output Short-Circuit Current                                                                                                               | I <sub>SC</sub>      | Sourcing, Short to 2.5V<br>Sinking, Short to 2.5V           | -<br>-      | 20<br>5            | -<br>-             | mA<br>mA       |
| POWER SUPPLY                                                                                                                               |                      |                                                             |             |                    |                    |                |
| Supply Current (All Amplifiers)<br>NJM8530<br>NJM8532<br>NJM8534                                                                           | I <sub>SUPPLY</sub>  | No Signal                                                   | -<br>-<br>- | 320<br>580<br>1200 | 550<br>900<br>1800 | μA<br>μA<br>μA |
| Supply Voltage Rejection Ratio                                                                                                             | SVR                  | V <sup>+</sup> =4V to 6V                                    | 70          | 85                 | -                  | dB             |
| AC CHARACTERISTICS                                                                                                                         |                      |                                                             |             |                    |                    |                |
| Slew Rate                                                                                                                                  | SR                   | R <sub>L</sub> =2kΩ to 2.5V                                 | -           | 0.4                | -                  | V/μs           |
| Gain Bandwidth Product                                                                                                                     | GBW                  | R <sub>L</sub> =2kΩ to 2.5V                                 | -           | 1                  | -                  | MHz            |
| Phase Margin                                                                                                                               | Φ <sub>M</sub>       | R <sub>L</sub> =2kΩ to 2.5V                                 | -           | 75                 | -                  | Deg            |
| Equivalent Input Noise Voltage                                                                                                             | e <sub>n</sub>       | f=1kHz                                                      | -           | 10                 | -                  | nV/√Hz         |
| Channel Separation<br>NJM8532/NJM8534                                                                                                      | CS                   | f=1kHz                                                      | -           | -133               | -                  | dB             |

(5) CMR specified is the lower of the CMR+ and CMR-.  
 CMR+ measured with  $V^+/2 \leq V_{CM} \leq V^+$ , and CMR- measured with  $V \leq V_{CM} \leq V^+/2$ .

■ ELECTRICAL CHARACTERISTICS ( $V^+=3V$ ,  $V^-=0V$ ,  $V_{COM}=1.5V$ ,  $T_a=25^\circ C$ , unless otherwise noted.)

| ELECTRICAL CHARACTERISTICS (V <sup>+</sup> =5V, V <sup>-</sup> =0V, V <sub>COM</sub> =1.5V, T <sub>A</sub> =25°C, unless otherwise noted.) |                      |                                                             |             |                    |                    |                |
|--------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-------------------------------------------------------------|-------------|--------------------|--------------------|----------------|
| PARAMETER                                                                                                                                  | SYMBOL               | TEST CONDITIONS                                             | MIN         | TYP                | MAX                | UNIT           |
| INPUT CHARACTERISTICS                                                                                                                      |                      |                                                             |             |                    |                    |                |
| Input Offset Voltage                                                                                                                       | V <sub>IO</sub>      |                                                             | -           | 1                  | 4                  | mV             |
| Input Offset Voltage Drift                                                                                                                 | ΔV <sub>IO</sub> /ΔT | T <sub>A</sub> =-40°C to 125°C                              | -           | 1.8                | -                  | μV/°C          |
| Input Bias Current                                                                                                                         | I <sub>B</sub>       |                                                             | -           | 50                 | 250                | nA             |
| Input Offset Current                                                                                                                       | I <sub>IO</sub>      |                                                             | -           | 5                  | 100                | nA             |
| Open-Loop Voltage Gain                                                                                                                     | A <sub>V</sub>       | R <sub>L</sub> =2kΩ to 1.5V                                 | 60          | 84                 | -                  | dB             |
| Common-Mode Rejection Ratio                                                                                                                | CMR                  | <sup>(5)</sup>                                              | 48          | 63                 | -                  | dB             |
| Common-Mode Input Voltage Range                                                                                                            | V <sub>ICM</sub>     | CMR≥48dB                                                    | 0           | -                  | 3                  | V              |
| OUTPUT CHARACTERISTICS                                                                                                                     |                      |                                                             |             |                    |                    |                |
| High-level Output Voltage                                                                                                                  | V <sub>OH</sub>      | R <sub>L</sub> =20kΩ to 1.5V<br>R <sub>L</sub> =2kΩ to 1.5V | 2.9<br>2.75 | 2.95<br>2.85       | -<br>-             | V<br>V         |
| Low-level Output Voltage                                                                                                                   | V <sub>OL</sub>      | R <sub>L</sub> =20kΩ to 1.5V<br>R <sub>L</sub> =2kΩ to 1.5V | -<br>-      | 0.05<br>0.15       | 0.1<br>0.25        | V<br>V         |
| Output Short-Circuit Current                                                                                                               | I <sub>SC</sub>      | Sourcing, Short to 1.5V<br>Sinking, Short to 1.5V           | -<br>-      | 18<br>4.8          | -<br>-             | mA<br>mA       |
| POWER SUPPLY                                                                                                                               |                      |                                                             |             |                    |                    |                |
| Supply Current (All Amplifiers)<br>NJM8530<br>NJM8532<br>NJM8534                                                                           | I <sub>SUPPLY</sub>  | No Signal                                                   |             | 270<br>510<br>1000 | 460<br>880<br>1800 | μA<br>μA<br>μA |
| Supply Voltage Rejection Ratio                                                                                                             | SVR                  | V <sup>+</sup> =2.4V to 4V                                  | 68          | 83                 | -                  | dB             |
| AC CHARACTERISTICS                                                                                                                         |                      |                                                             |             |                    |                    |                |
| Slew Rate                                                                                                                                  | SR                   | R <sub>L</sub> =2kΩ to 1.5V                                 | -           | 0.35               | -                  | V/μs           |
| Gain Bandwidth Product                                                                                                                     | GBW                  | R <sub>L</sub> =2kΩ to 1.5V                                 | -           | 1                  | -                  | MHz            |
| Phase Margin                                                                                                                               | Φ <sub>M</sub>       | R <sub>L</sub> =2kΩ to 1.5V                                 | -           | 75                 | -                  | Deg            |
| Equivalent Input Noise Voltage                                                                                                             | e <sub>n</sub>       | f=1kHz                                                      | -           | 10                 | -                  | nV/√Hz         |
| Channel Separation<br>NJM8532/NJM8534                                                                                                      | CS                   | f=1kHz                                                      | -           | -130               | -                  | dB             |

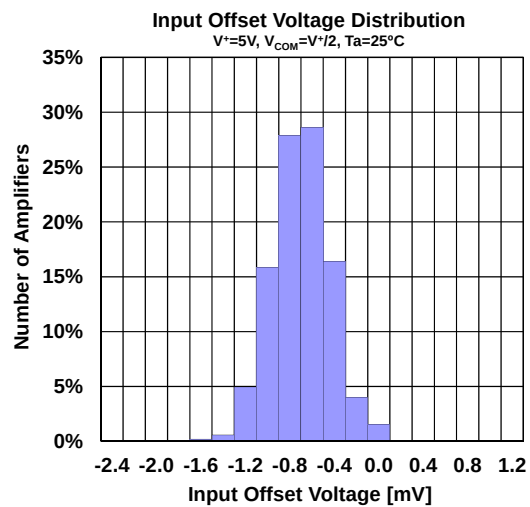
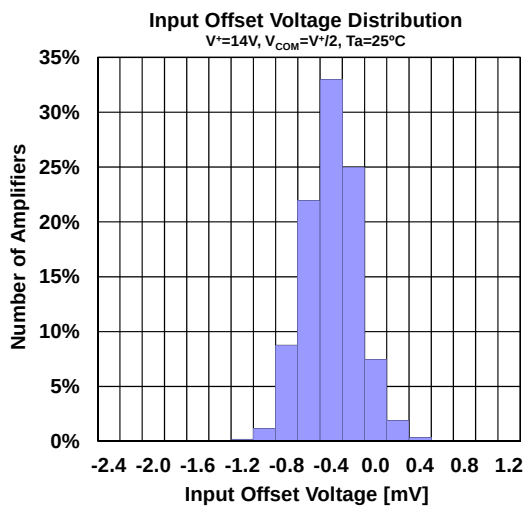
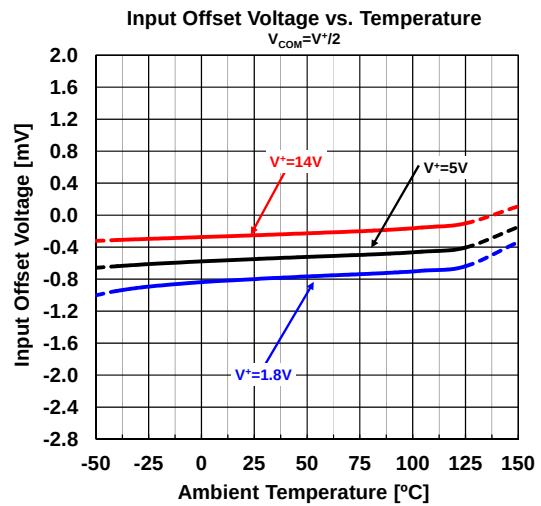
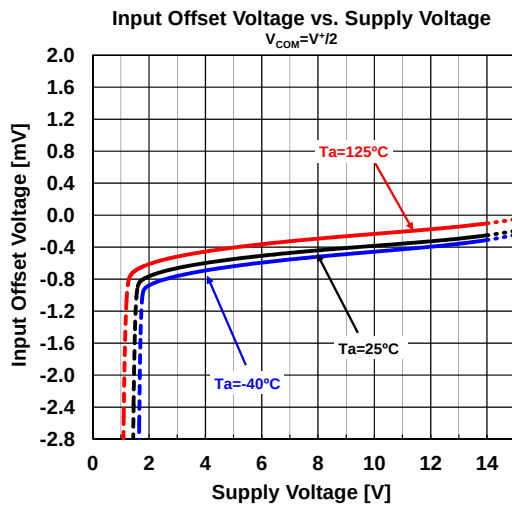
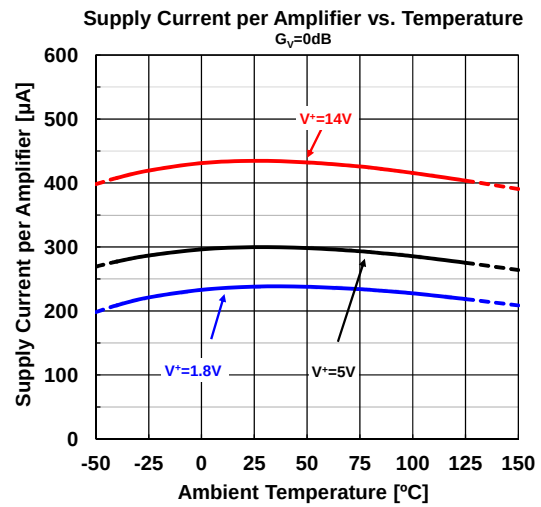
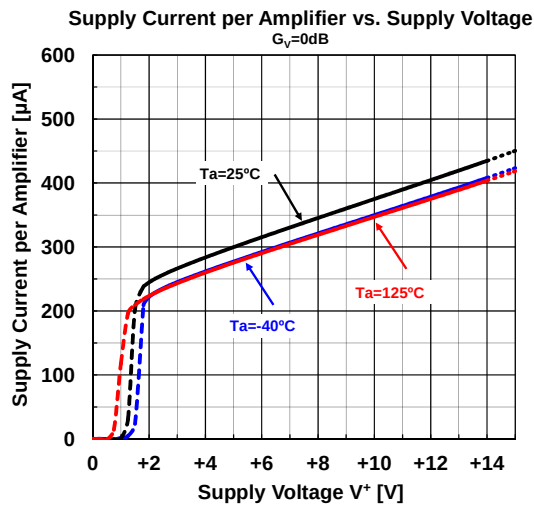
(5) CMR specified is the lower of the CMR+ and CMR-.  
 CMR+ measured with  $V^+/2 \leq V_{CM} \leq V^+$ , and CMR- measured with  $V^- \leq V_{CM} \leq V^+/2$ .

■ **ELECTRICAL CHARACTERISTICS** ( $V^+=1.8V$ ,  $V^-=0V$ ,  $V_{COM}=0.9V$ ,  $T_a=25^\circ C$ , unless otherwise noted.)

| ELECTRICAL CHARACTERISTICS (V <sup>+</sup> =1.8V, V <sup>-</sup> =0V, V <sub>COM</sub> =0.9V, T <sub>a</sub> =25°C, unless otherwise noted.) |                      |                                                             |             |                   |                    |                |
|----------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-------------------------------------------------------------|-------------|-------------------|--------------------|----------------|
| PARAMETER                                                                                                                                    | SYMBOL               | TEST CONDITIONS                                             | MIN         | TYP               | MAX                | UNIT           |
| INPUT CHARACTERISTICS                                                                                                                        |                      |                                                             |             |                   |                    |                |
| Input Offset Voltage                                                                                                                         | V <sub>IO</sub>      |                                                             | -           | 1                 | 4                  | mV             |
| Input Offset Voltage Drift                                                                                                                   | ΔV <sub>IO</sub> /ΔT | T <sub>a</sub> =-40°C to 125°C                              | -           | 2.4               | -                  | μV/°C          |
| Input Bias Current                                                                                                                           | I <sub>B</sub>       |                                                             | -           | 50                | 250                | nA             |
| Input Offset Current                                                                                                                         | I <sub>IO</sub>      |                                                             | -           | 5                 | 100                | nA             |
| Open-Loop Voltage Gain                                                                                                                       | A <sub>V</sub>       | R <sub>L</sub> =2kΩ to 0.9V                                 | 60          | 83                | -                  | dB             |
| Common-Mode Rejection Ratio                                                                                                                  | CMR                  | <sup>(5)</sup>                                              | 40          | 55                | -                  | dB             |
| Common-Mode Input Voltage Range                                                                                                              | V <sub>ICM</sub>     | CMR≥40dB                                                    | 0           | -                 | 1.8                | V              |
| OUTPUT CHARACTERISTICS                                                                                                                       |                      |                                                             |             |                   |                    |                |
| High-level Output Voltage                                                                                                                    | V <sub>OH</sub>      | R <sub>L</sub> =20kΩ to 0.9V<br>R <sub>L</sub> =2kΩ to 0.9V | 1.7<br>1.55 | 1.75<br>1.65      | -<br>-             | V<br>V         |
| Low-level Output Voltage                                                                                                                     | V <sub>OL</sub>      | R <sub>L</sub> =20kΩ to 0.9V<br>R <sub>L</sub> =2kΩ to 0.9V | -<br>-      | 0.05<br>0.15      | 0.1<br>0.25        | V<br>V         |
| Output Short-Circuit Current                                                                                                                 | I <sub>SC</sub>      | Sourcing, Short to 0.9V<br>Sinking, Short to 0.9V           | -<br>-      | 18<br>4.7         | -<br>-             | mA<br>mA       |
| POWER SUPPLY                                                                                                                                 |                      |                                                             |             |                   |                    |                |
| Supply Current (All Amplifiers)<br>NJM8530<br>NJM8532<br>NJM8534                                                                             | I <sub>SUPPLY</sub>  | No Signal                                                   |             | 240<br>460<br>900 | 430<br>800<br>1600 | μA<br>μA<br>μA |
| Supply Voltage Rejection Ratio                                                                                                               | SVR                  | V <sup>+</sup> =1.8V to 2.4V                                | 65          | 80                | -                  | dB             |
| AC CHARACTERISTICS                                                                                                                           |                      |                                                             |             |                   |                    |                |
| Slew Rate                                                                                                                                    | SR                   | R <sub>L</sub> =2kΩ to 0.9V                                 | -           | 0.3               | -                  | V/μs           |
| Gain Bandwidth Product                                                                                                                       | GBW                  | R <sub>L</sub> =2kΩ to 0.9V                                 | -           | 1                 | -                  | MHz            |
| Phase Margin                                                                                                                                 | Φ <sub>M</sub>       | R <sub>L</sub> =2kΩ to 0.9V                                 | -           | 75                | -                  | Deg            |
| Equivalent Input Noise Voltage                                                                                                               | e <sub>n</sub>       | f=1kHz                                                      | -           | 10                | -                  | nV/√Hz         |
| Channel Separation<br>NJM8532/NJM8534                                                                                                        | CS                   | f=1kHz                                                      | -           | -125              | -                  | dB             |

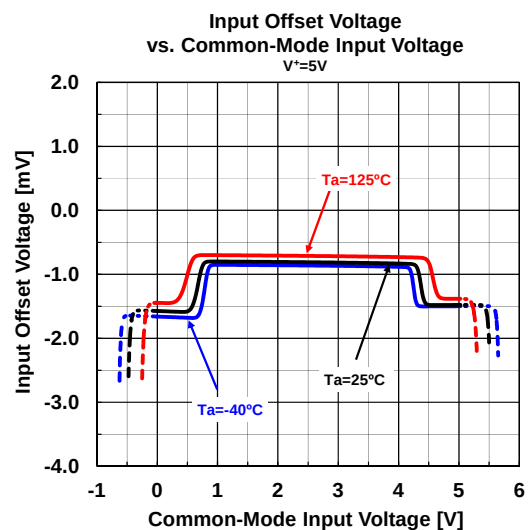
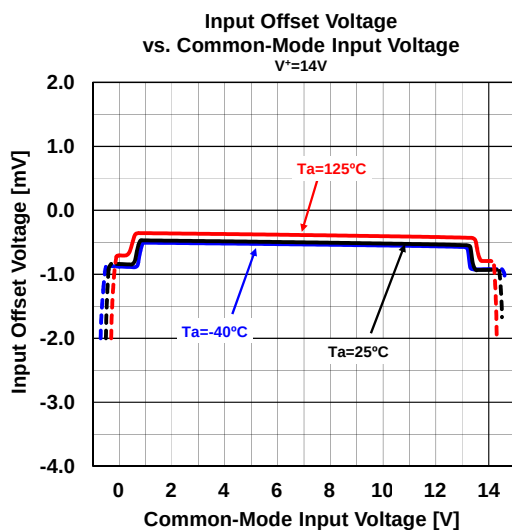
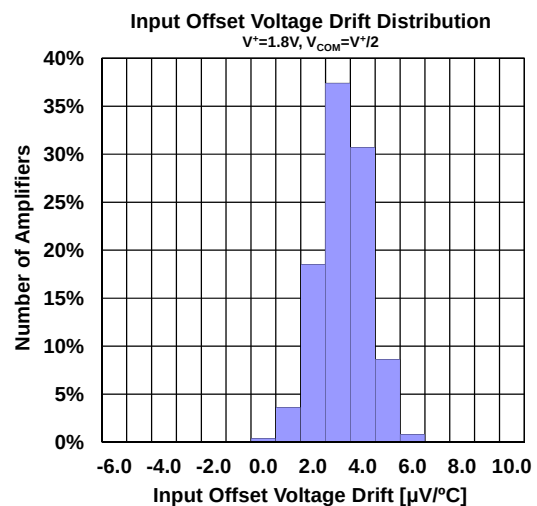
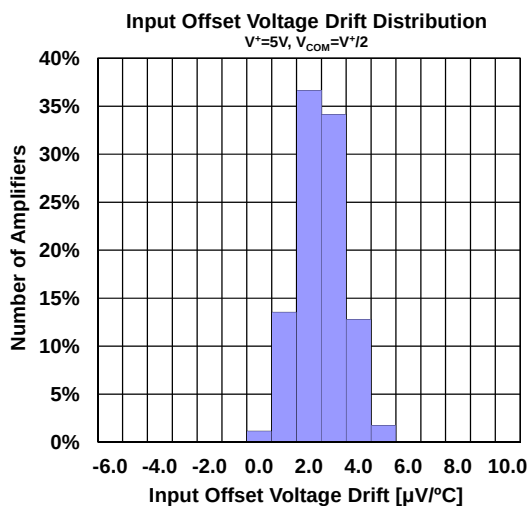
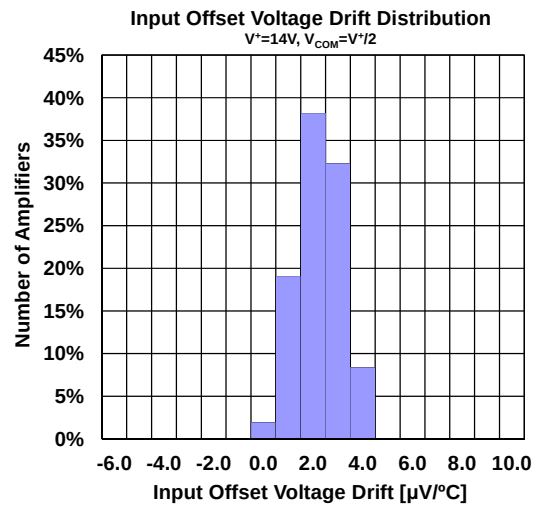
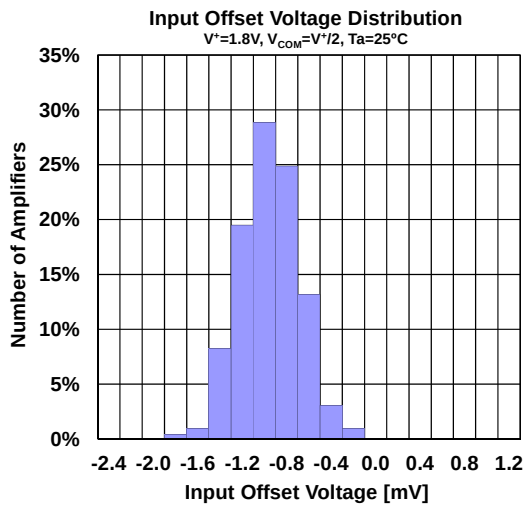
(5) CMR specified is the lower of the CMR+ and CMR-.  
 CMR+ measured with  $V^+/2 \leq V_{CM} \leq V^+$ , and CMR- measured with  $V \leq V_{CM} \leq V^+/2$ .

■ TYPICAL CHARACTERISTICS ( $V=0V$ ,  $T_a=25^\circ\text{C}$ , unless otherwise noted.)

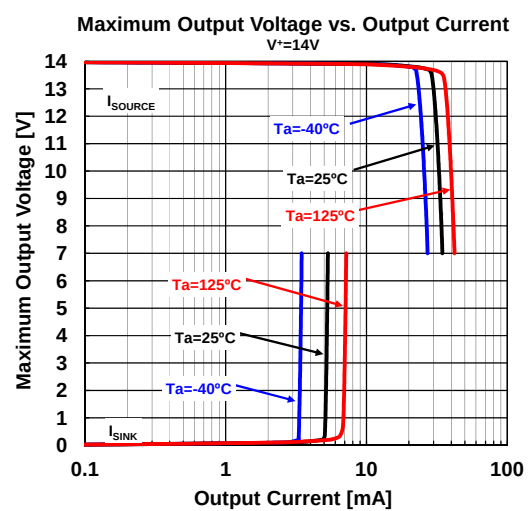
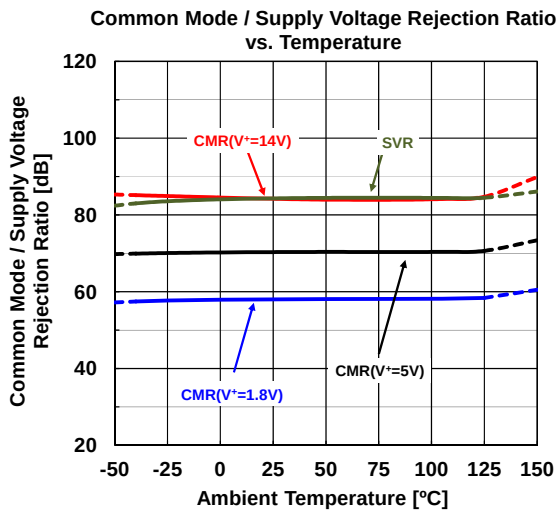
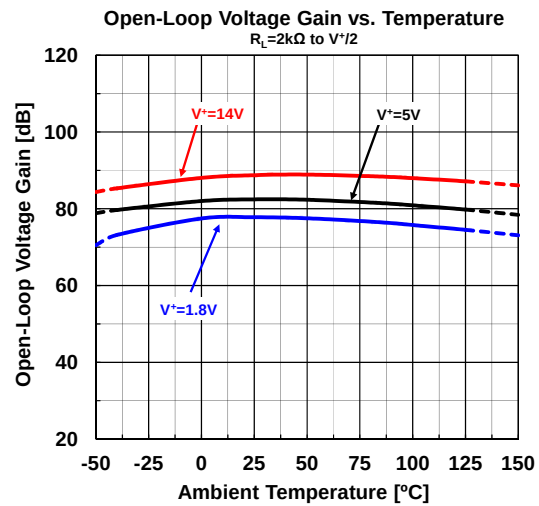
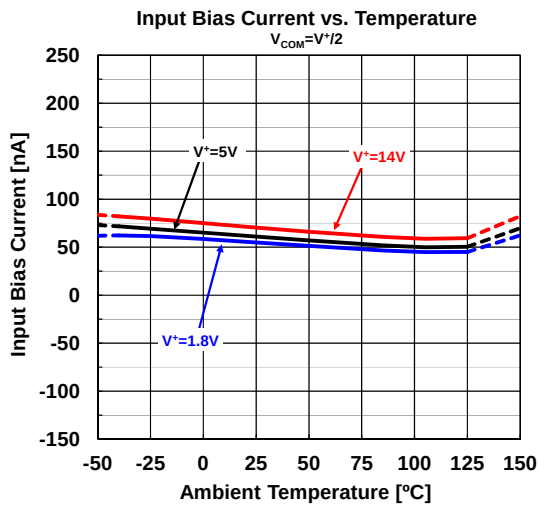
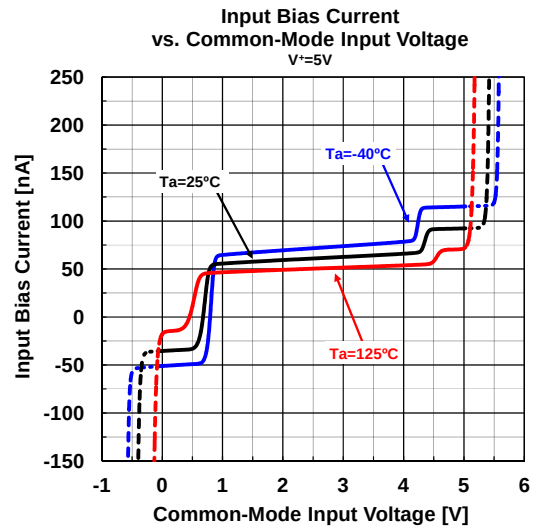
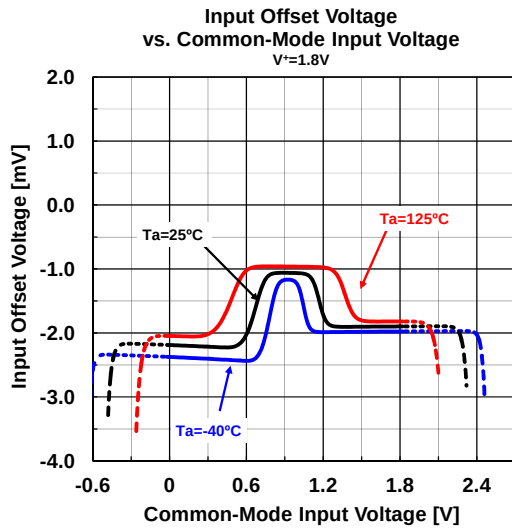




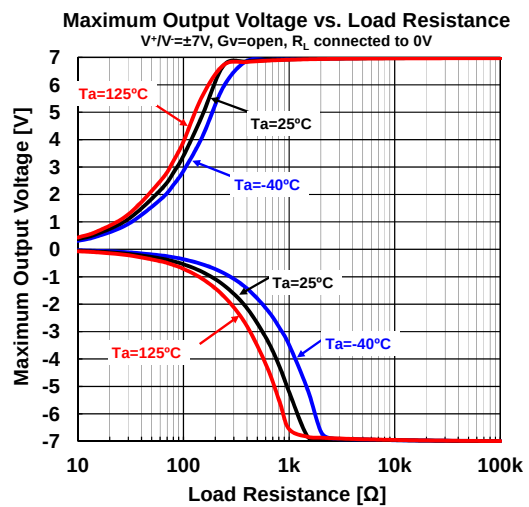
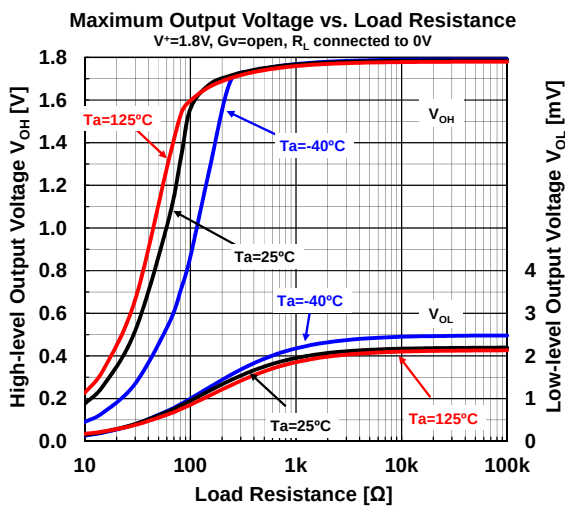
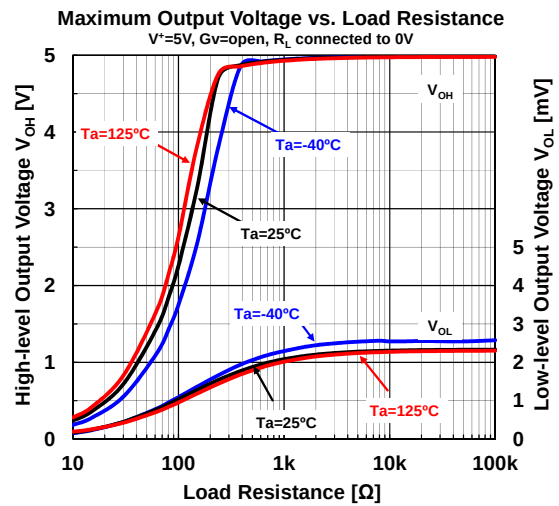
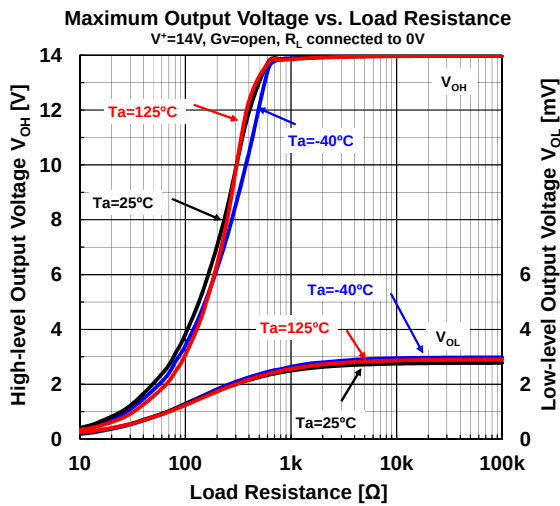
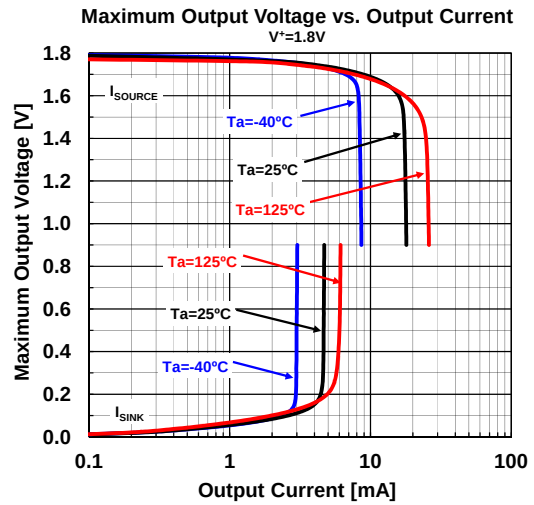
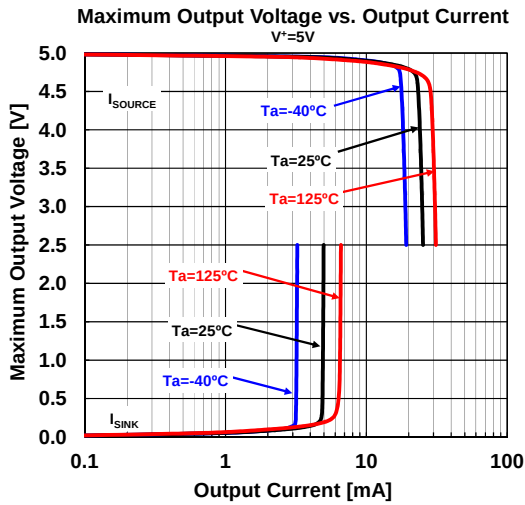
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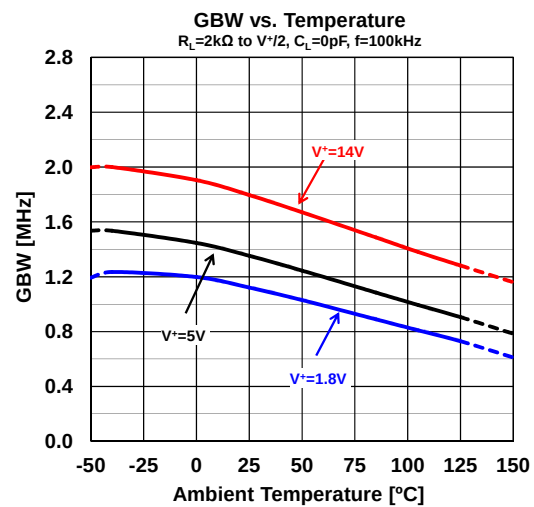
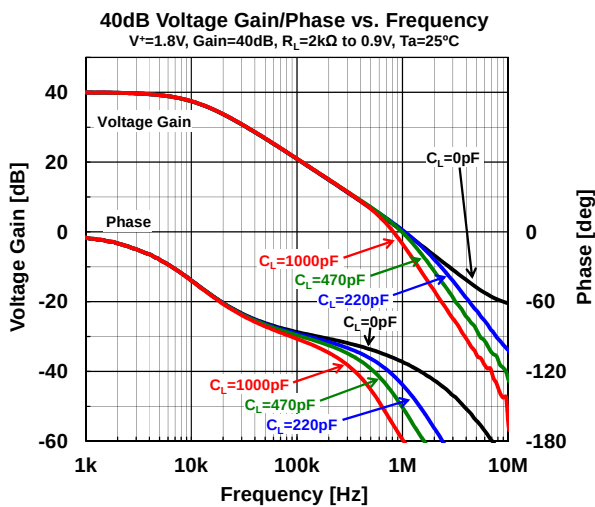
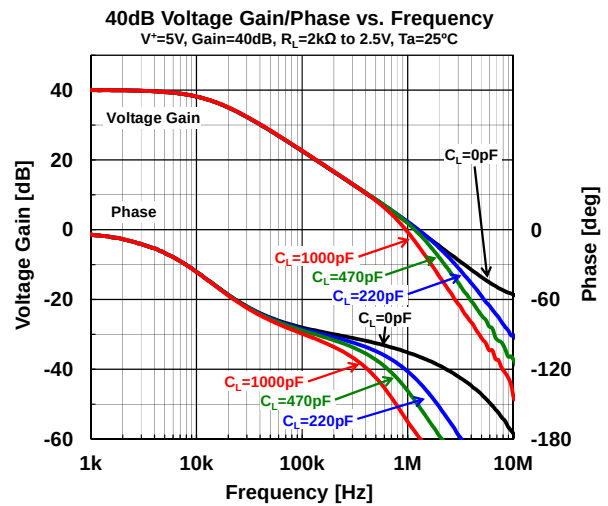
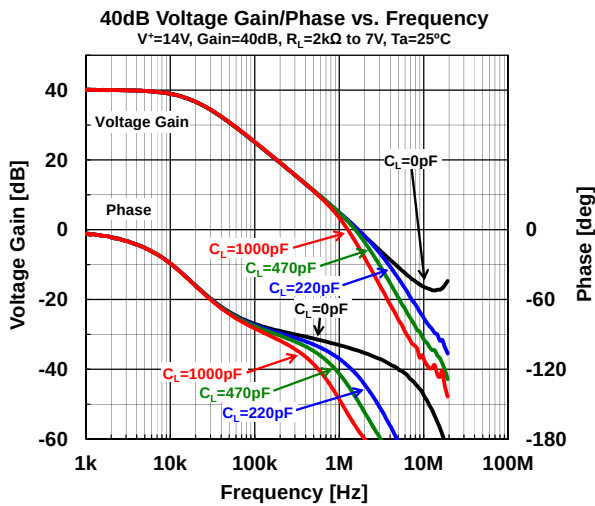
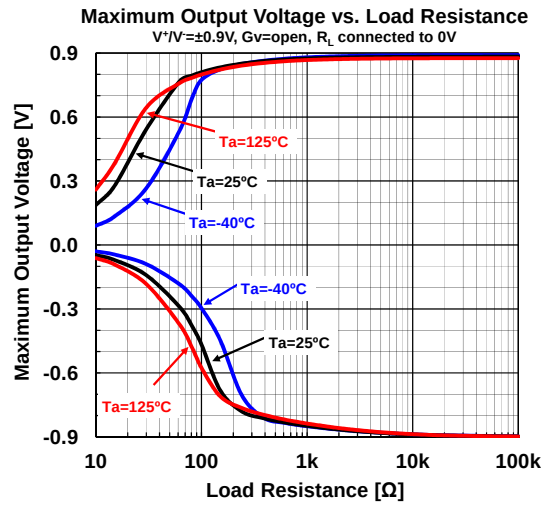
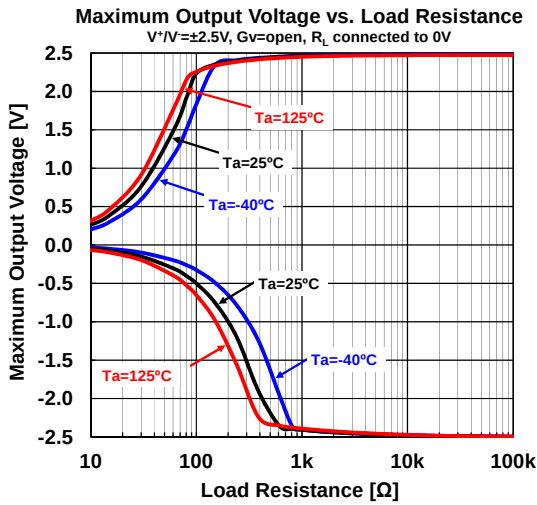
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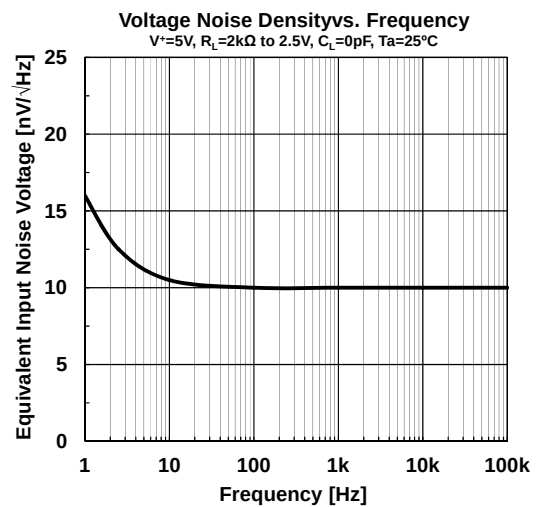
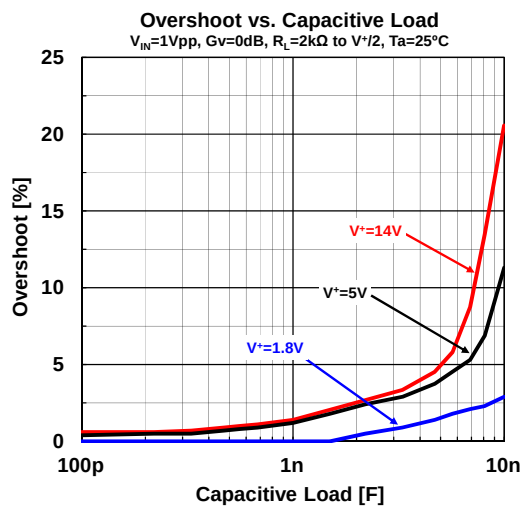
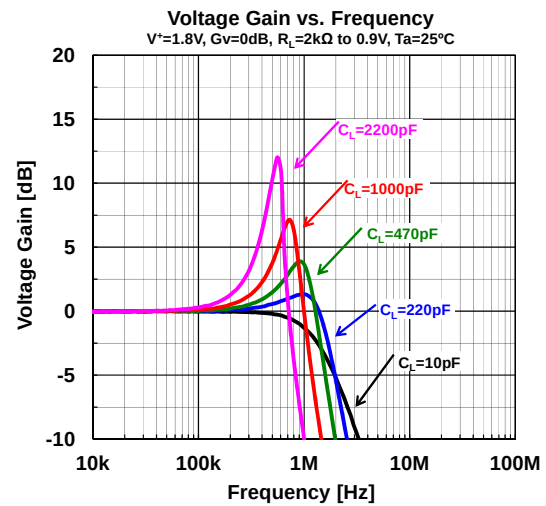
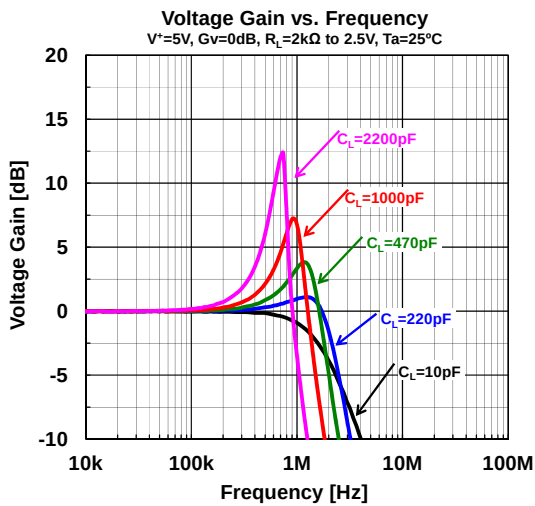
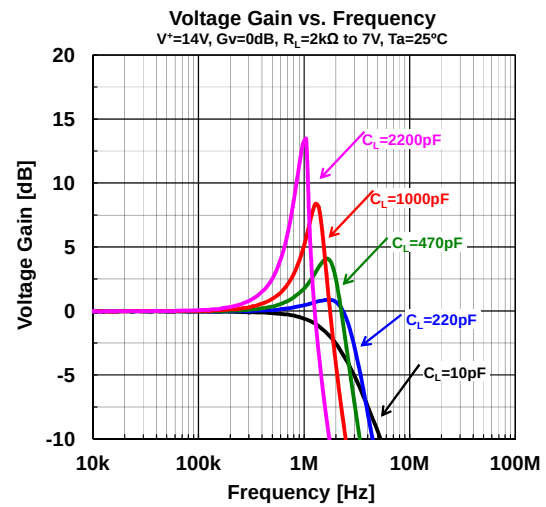
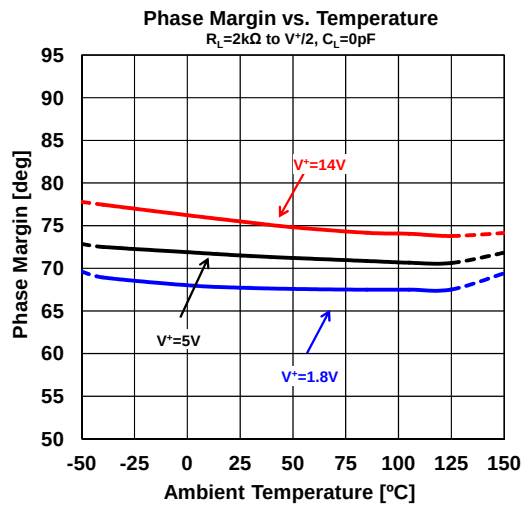
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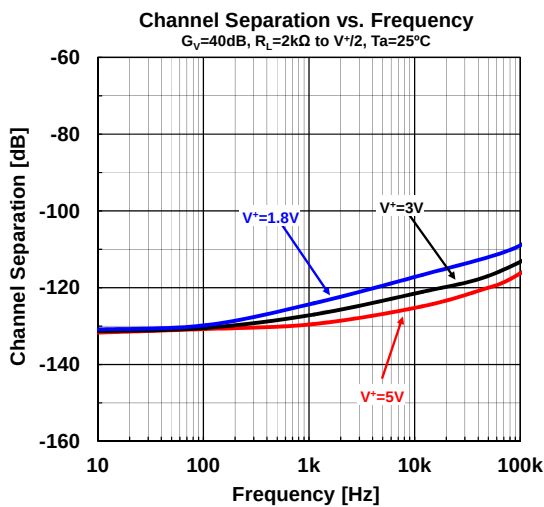
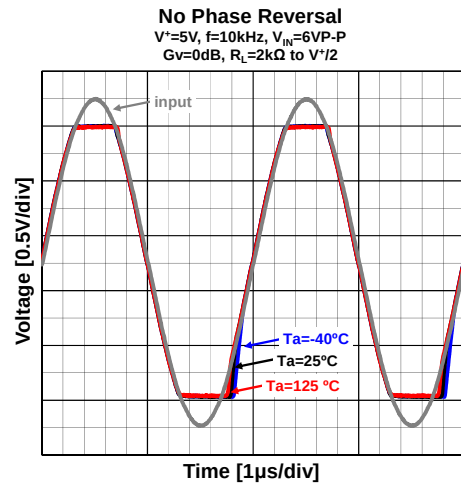
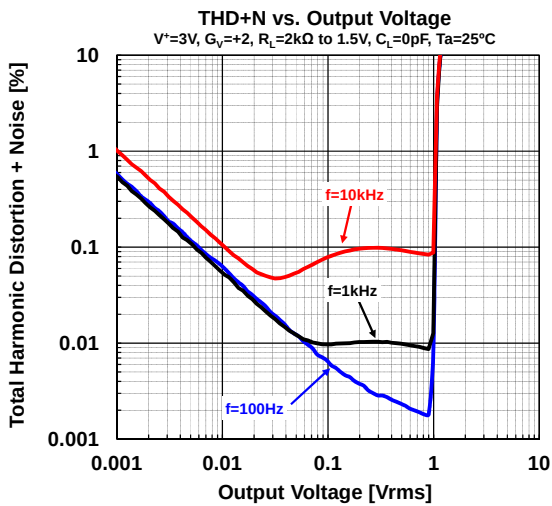
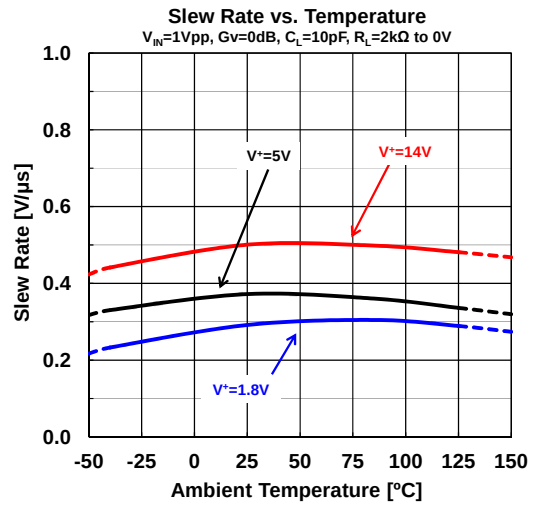
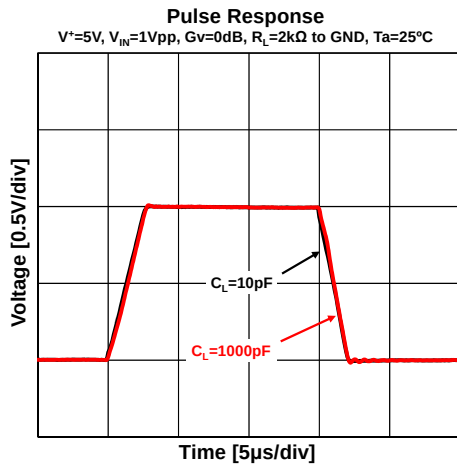
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■ TYPICAL CHARACTERISTICS ( $V=0V$ ,  $T_a=25^\circ C$ , unless otherwise noted.)

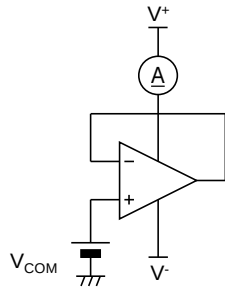


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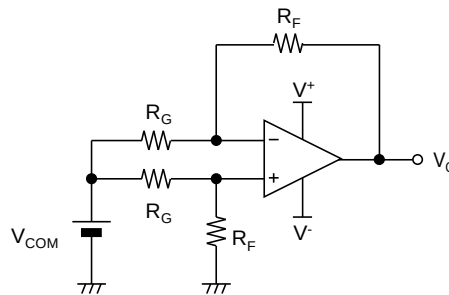
## ■ TEST CIRCUITS

### • $I_{SUPPLY}$



### • $V_{IO}$ , CMR, SVR

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



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

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

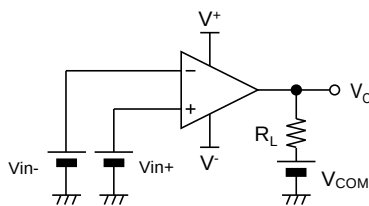
$$SVR = 20 \log \frac{\Delta V_S \left(1 + \frac{R_F}{R_G}\right)}{\Delta V_O}$$

$V_S = V^+ - V^-$

### • $V_{OH}$ , $V_{OL}$

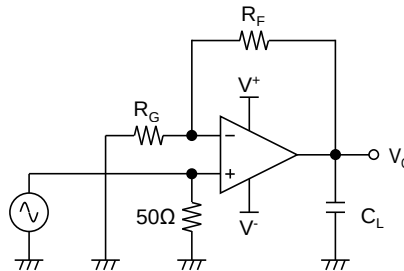
$V_{OH}$ :  $V_{in+} = 1V$ ,  $V_{in-} = 0V$ ,  $V_{COM} = V^+/2$

$V_{OL}$ :  $V_{in+} = 0V$ ,  $V_{in-} = 1V$ ,  $V_{COM} = V^+/2$



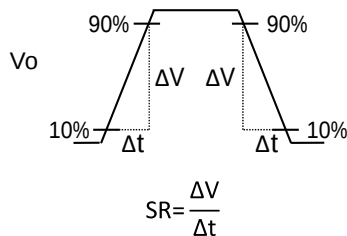
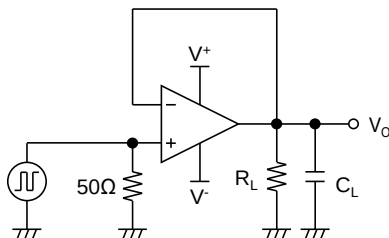
### • GBW

$R_G=100\Omega$ ,  $R_F=10k\Omega$ ,  $C_L=0pF$



### • SR

$R_L=2k\Omega$ ,  $C_L=10pF$



## ■ APPLICATION NOTE

### Single and Dual Supply Voltage Operation

The NJM8530/NJM8532/NJM8534 works with both single supply and dual supply when the voltage supplied is between  $V^+$  and  $V^-$ . These amplifiers operate from single 1.8 to 14V supply and dual  $\pm 0.9V$  to  $\pm 7V$  supply.

### Common-Mode Input Voltage Range

When the supply voltage does not meet the condition of electrical characteristics, the range of common-mode input voltage is as follows:

$V_{ICM} (typ.) = V^-$  to  $V^+$  ( $T_a = 25^\circ C$ )

Difference of  $V_{ICM}$  when Temperature change, refer to typical characteristic graph.

During designing, consider variations in characteristics for use with allowance.

### Maximum Output Voltage Range

When the supply voltage does not meet the condition of electrical characteristics, the range of the typ. value of the maximum output voltage is as follows:

$V_{OM} (typ.) = V^+ + 50mV$  to  $V^+ - 50mV$  ( $R_L = 20k\Omega$ ,  $T_a = 25^\circ C$ )

During designing, consider variations in characteristics and temperature characteristics for use with allowance. In addition, also note that the output voltage range becomes narrow as shown in typical characteristics graph when an output current increases.

### Rail-to-Rail Input

The input stage of NJM8530/NJM8532/NJM8534 has two input differential pairs, PNP-transistor and NPN-transistor (Figure1). When the common-mode input voltage is at the low end of the negative supply voltage, typically ( $V^-$ ) to ( $V^-$ )+0.6V, the PNP-transistor input differential pair is active and amplifies the input signal. As the common-mode input voltage is increased above the typically ( $V^-$ )+0.6V, the NPN-transistor differential pair gradually turns on, thus both pairs are active. When the Common-Mode Input voltage continues increasing near the positive supply voltage, typically ( $V^+$ )-0.6V to positive supply voltage, the PNP-transistor differential pair gradually turns off and amplifies the input signal by NPN-transistor differential pair only. The transition occurs at approximately 0.6V away from both supply rails and results in a change in offset voltage due to the different offset voltage of the differential pairs as shown in figure2.

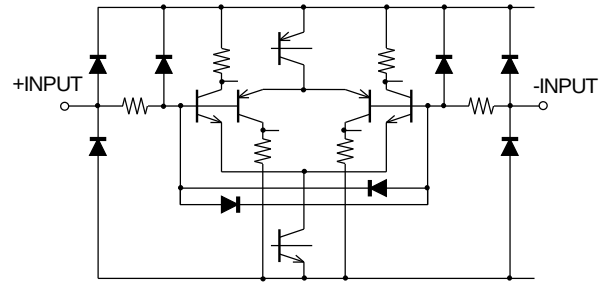


Figure1. Simplified Schematic of Input Stage

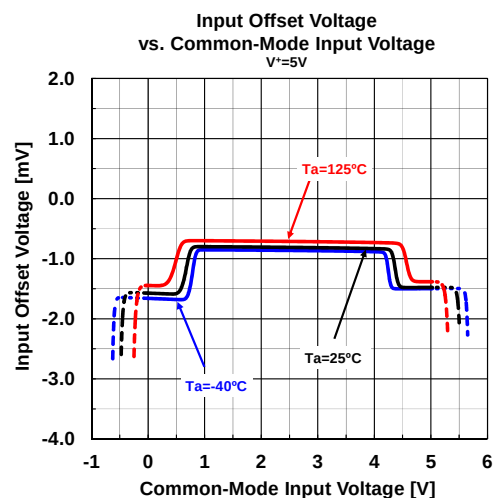


Figure2. Offset Voltage change with common-mode input voltage.

### Input Voltage Exceeding the Supply Voltage

Inputs of the NJM8530/NJM8532/NJM8534 are protected by ESD diodes (shown in Figure1) that will conduct if the input voltages exceed the power supplies by more than approximately 300mV. Momentary voltages greater than 300mV beyond the power supply, inputs can be tolerated if the current is limited to 2mA. Figure3 is easily accomplished with an input resistor. If the input voltage exceeds the supply voltage, the input current must be limited 2mA or less by using a restriction resistance ( $R_{LIMIT}$ ) as shown in figure3.

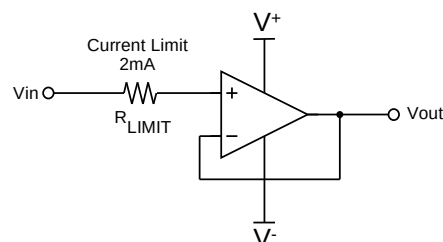


Figure3. Input Current Protection for Voltages Exceeding the Supply Voltage.



## ■ APPLICATION NOTE

### Differential Input Voltage

The NJM8530/NJM8532/NJM8534 has internal protection circuitry that prevents damage to the input stage from large differential input voltages. This protection circuitry consists of two diodes and two resistors as shown in figure1. The diodes limit the differential voltage applied to the amplifiers' internal circuitry to no more than diodes' forward-voltage drop ( $V_F$ ). Input bias current is specified typically 50nA for small differential input voltages. For large differential input voltage above the  $V_F$ , this protection circuitry increases the input current at +INPUT and -INPUT. The maximum differential input voltage is 1.0V, but if the differential input voltage exceeds 1.0V, the input current must be limited 2 mA or less by using a restriction resistance.

### Capacitive load

The NJM8530/NJM8532/NJM8534 can use at unity gain follower, but the unity gain follower is the most sensitive configuration to capacitive loading. The combination of capacitive load placed directly on the output of an amplifier along with the output impedance of the amplifier creates a phase lag which in turn reduces the phase margin of the amplifier. If phase margin is significantly reduced, the response will cause overshoot and ringing in the step response.

The NJM8530/NJM8532/NJM8534 is unity gain stable for capacitive loads of 1000pF (see the overshoot vs. capacitive load graph). To drive heavier capacitive loads, an isolation resistor,  $R_{ISO}$  as shown Figure4, should be used.  $R_{ISO}$  improves the feedback loop's phase margin by making the output load resistive at higher frequencies. The larger the value of  $R_{ISO}$ , the more stable the output voltage will be. However, larger values of  $R_{ISO}$  result in reduced output swing, reduced output current drive and reduced frequency bandwidth.

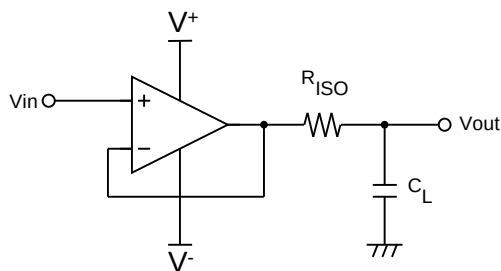
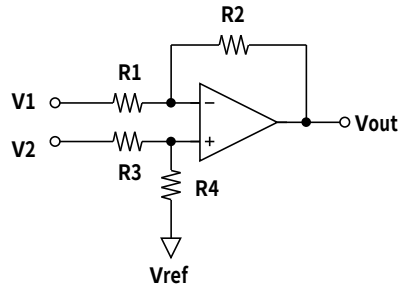


Figure4. Isolating capacitive load

### Differential Amplifier

Figure5 shows a one op-amp differential amplifier that consists of the single op-amp and four external resistors. Differential amplifier amplifies the difference between its two input pins, and rejects the common-mode input voltage at both input pins. This is used in variety of applications including current sensing, differential to single-end converter, isolation amplifier to remove common-mode noise.



$$V_{out} = \left( \frac{R1+R2}{R3+R4} \right) \frac{R4}{R1} V2 - \frac{R2}{R1} V1 + \left( \frac{R1+R2}{R3+R4} \right) \frac{R3}{R1} V_{ref}$$

$$R1=R3, R2=R4$$

$$V_{out} = \frac{R2}{R1} (V2 - V1) + V_{ref}$$

Figure5. Differential Amplifier

The differential amplifier's common-mode rejection ratio (CMR) is primarily determined by resistor mismatches, not by the op-amp's CMR. Ideally, the resistors are chosen such that  $R2/R1 = R4/R3$ . The CMR due to the resistors in differential amplifier can be calculated using the below formula:

$$CMR_{R_{error}} \approx 20 \log \left( \frac{1 + \frac{R2}{R1}}{4 R_{error}} \right)$$

$$CMR_{R_{error}} = \text{CMR due only to the resistors}$$

$$R_{error} = \text{Resistor's tolerance}$$

Example:

$R2/R1=1$  and  $R_{error}=0.1\%$ , then  $CMR=54dB$

$R2/R1=1$  and  $R_{error}=1\%$ , then  $CMR=34dB$

If using resistors with 1% tolerance and gain=1, the CMR will only be 34dB.

## ■ APPLICATION NOTE

### Current Sensing

Current sensing applications are one such application in a wide range of electronic applications and mostly used for feedback control systems, including power metering battery life indicators and chargers, over-current protection and supervising circuit, automotive, and medical equipment. In such applications, it is desirable to use a shunt with very low resistance to minimize the series voltage drop and minimizes wasted power, and allows the measurement of high current. The NJM8530/NJM8532/NJM8534 is ideal for these current sensing applications.

Figure6 shows a high-side current sensing circuit, and Figure7 shows a low-side current sensing circuit. The NJM8530/NJM8532/NJM8534 has rail-to-rail input and output characteristics, thus allows the both of high-side and low-side current sensing circuit. Furthermore, low supply current of  $290\mu\text{A/ch}$  can save the power at battery applications.

The NJM8530/NJM8532/NJM8534 operates up to 14V, and rail-to-rail feature allows the output voltage close to 14V (almost reach the power supply of op-amp). For example, if using a typical shunt resistor of  $0.1\Omega$ , allows the current sensing up to approximately 1.4A of current. The differential amplifier's common-mode rejection ratio (CMR) is primarily determined by resistor mismatches. For details, refer to Differential Amplifiers in the Applications Information.

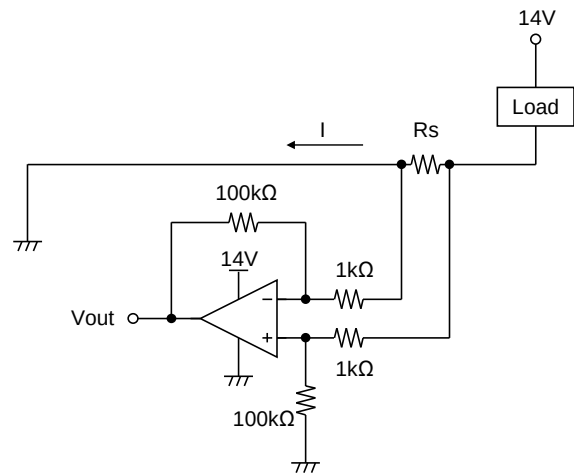


Figure7. Low-Side Current Sensing

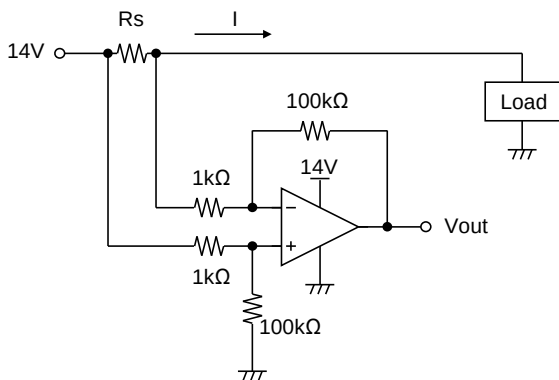
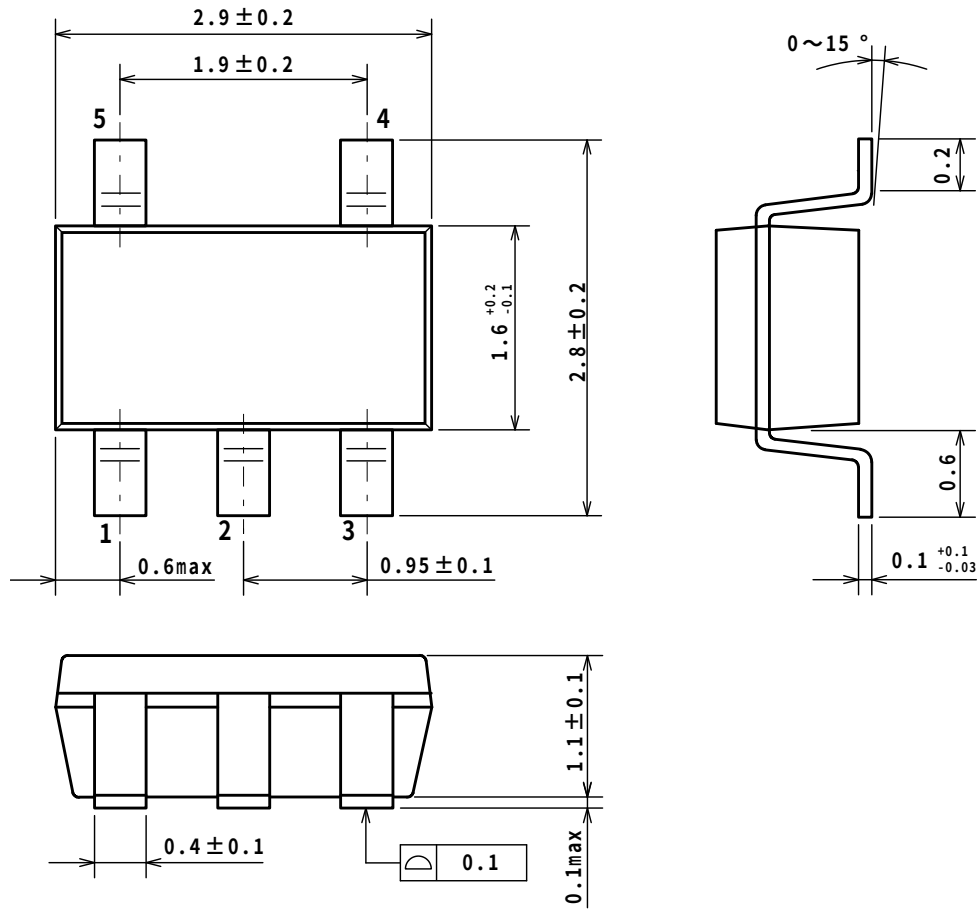


Figure6. High-Side Current Sensing

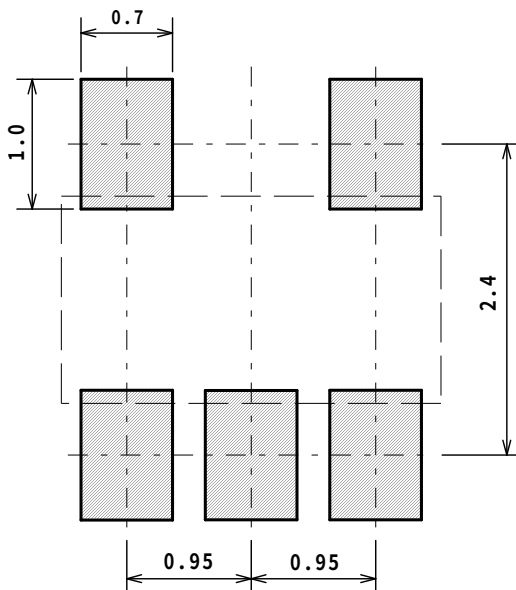
## SOT-23-5

Unit: mm

### PACKAGE DIMENSIONS



### EXAMPLE OF SOLDER PADS DIMENSIONS



## Unit: mm

Technical drawing of a 4-pin D-subminiature connector. The drawing includes a top view and a side view.

**Top View Dimensions:**

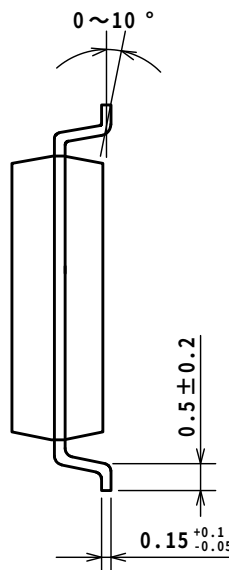
- Overall width:  $5.0 \pm 0.3$
- Pin pitch (center-to-center):  $1.27$
- Pin width:  $0.74\text{max}$
- Overall height:  $6.8 \pm 0.3$
- Body height (excluding pins):  $5.0 \pm 0.2$

**Side View Dimensions:**

- Overall height:  $1.6 \pm 0.15$
- Pin height:  $0.15 \pm 0.1$

**Pin Details:**

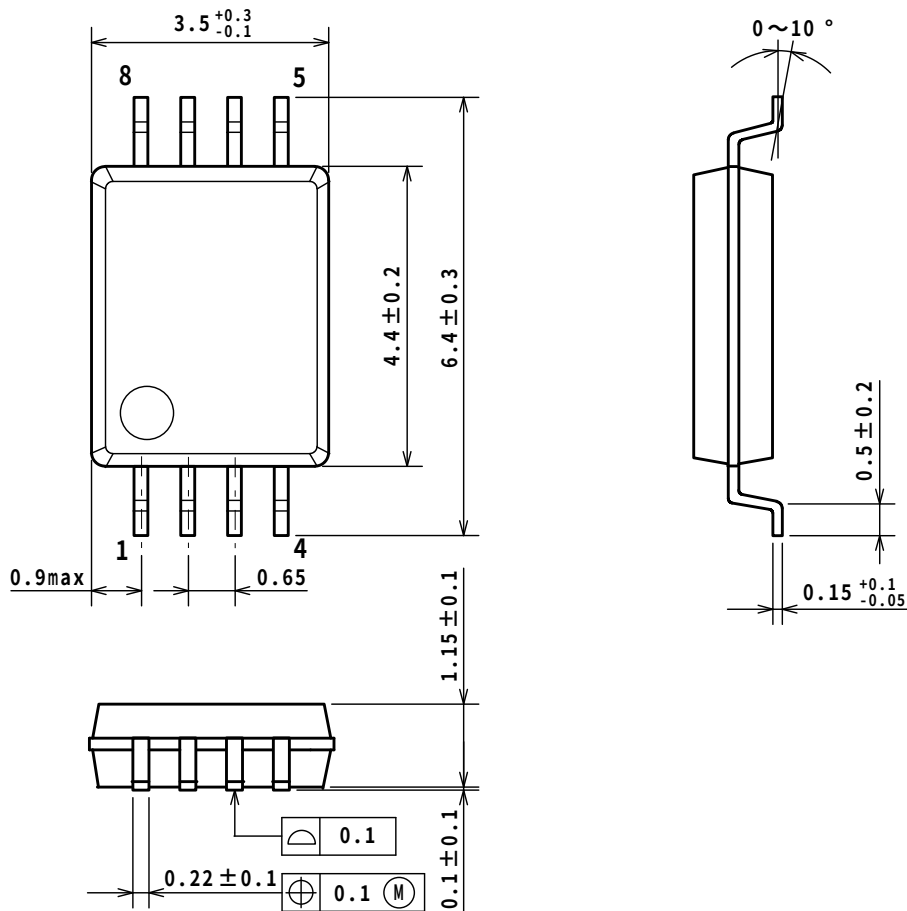
- Pin diameter:  $0.12$  (M)
- Pin length:  $0.35 \pm 0.1$



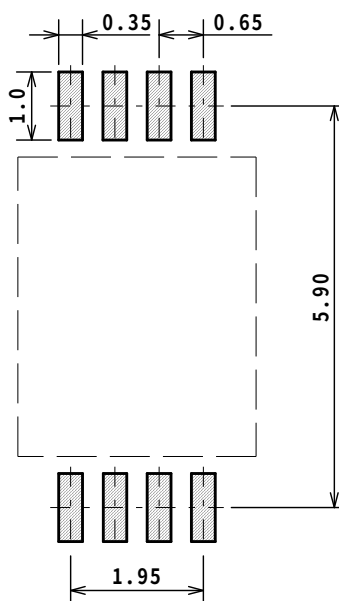
## SSOP8

Unit: mm

### ■ PACKAGE DIMENSIONS



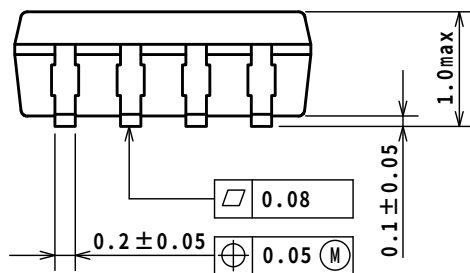
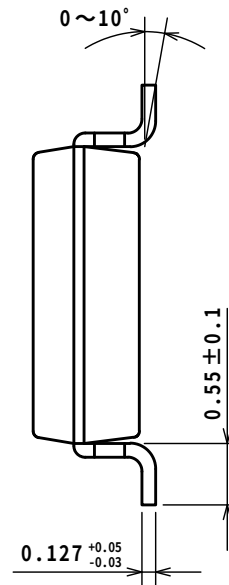
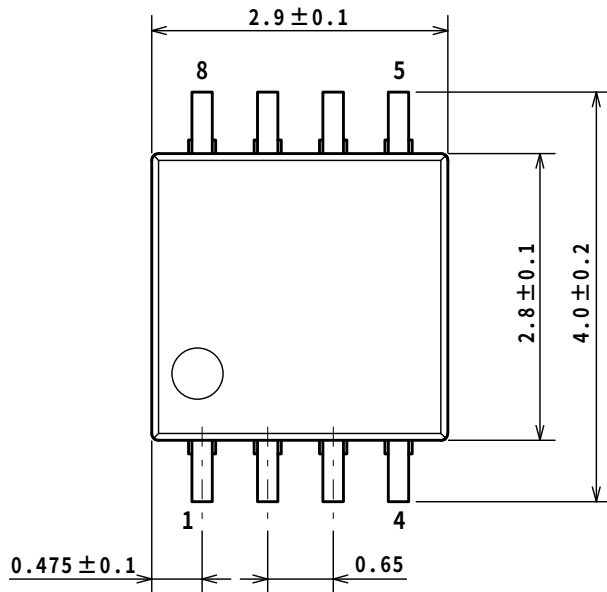
### ■ EXAMPLE OF SOLDER PADS DIMENSIONS



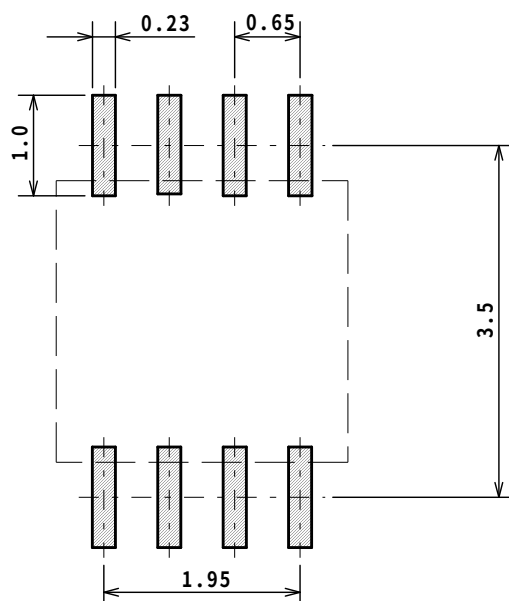
## MSOP8 (TVSP8) JEDEC MO-187-DA/THIN TYPE

Unit: mm

### ■ PACKAGE DIMENSIONS



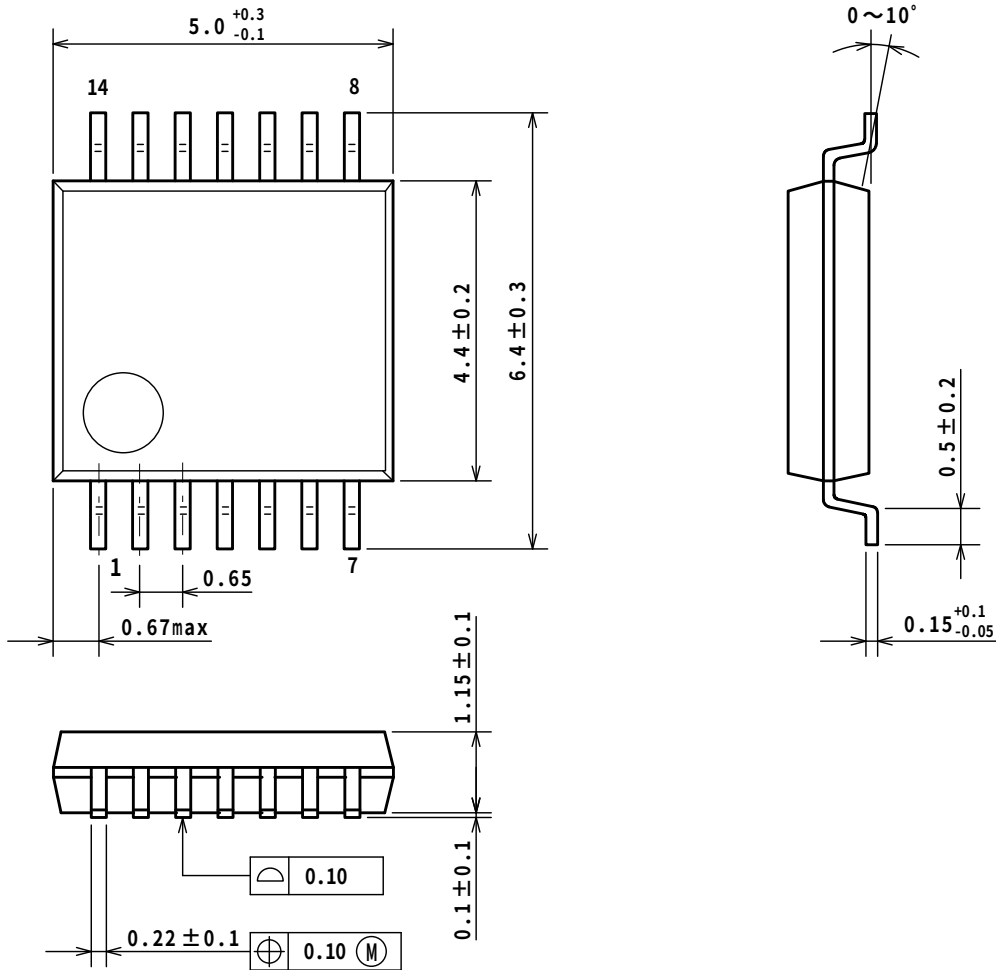
### ■ EXAMPLE OF SOLDER PADS DIMENSIONS



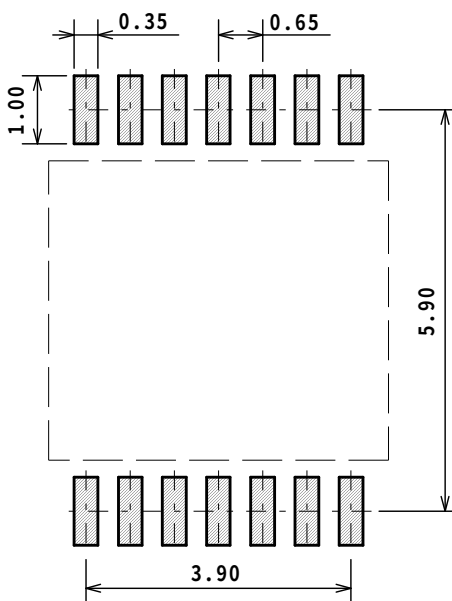
## SSOP14

Unit: mm

### ■ PACKAGE DIMENSIONS



### ■ EXAMPLE OF SOLDER PADS DIMENSIONS

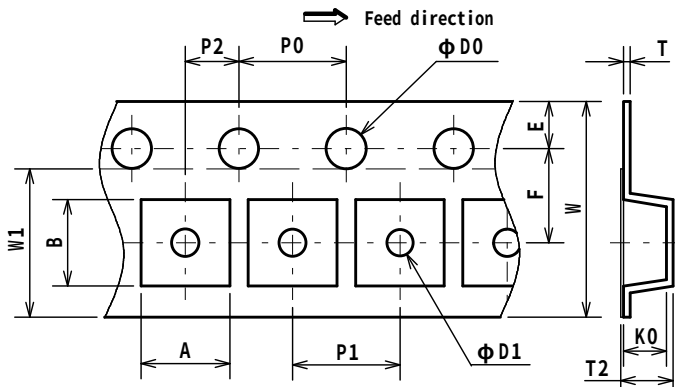


## SOT-23-5

### PACKING SPEC

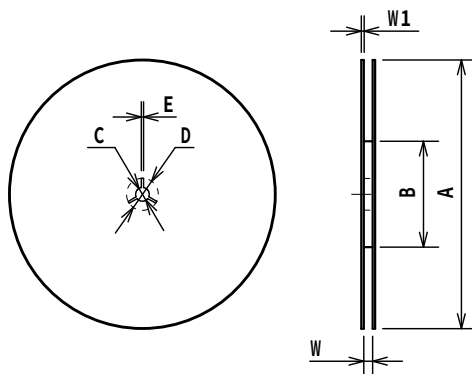
Unit: mm

#### TAPING DIMENSIONS



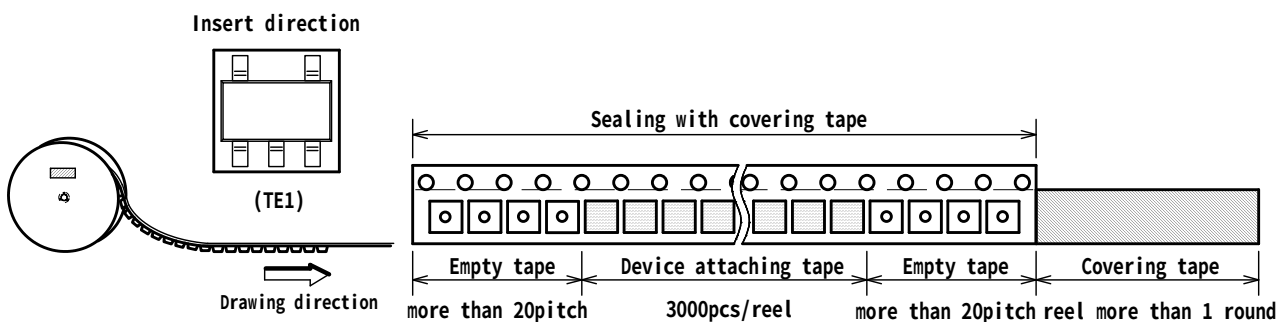
| SYMBOL | DIMENSION       | REMARKS          |
|--------|-----------------|------------------|
| A      | $3.3 \pm 0.1$   | BOTTOM DIMENSION |
| B      | $3.2 \pm 0.1$   | BOTTOM DIMENSION |
| D0     | 1.55            |                  |
| D1     | 1.05            |                  |
| E      | $1.75 \pm 0.1$  |                  |
| F      | $3.5 \pm 0.05$  |                  |
| P0     | $4.0 \pm 0.1$   |                  |
| P1     | $4.0 \pm 0.1$   |                  |
| P2     | $2.0 \pm 0.05$  |                  |
| T      | $0.25 \pm 0.05$ |                  |
| T2     | 1.82            |                  |
| K0     | $1.5 \pm 0.1$   |                  |
| W      | $8.0 \pm 0.3$   |                  |
| W1     | 5.5             | THICKNESS 0.1MAX |

#### REEL DIMENSIONS

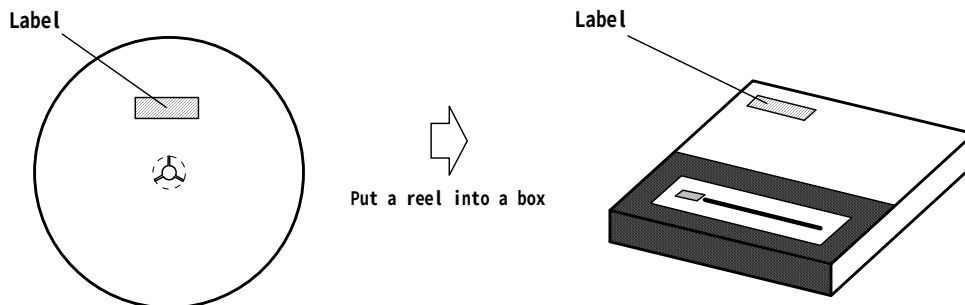


| SYMBOL | DIMENSION         |
|--------|-------------------|
| A      | $\phi 180 \pm 1$  |
| B      | $\phi 60 \pm 1$   |
| C      | $\phi 13 \pm 0.2$ |
| D      | $\phi 21 \pm 0.8$ |
| E      | $2 \pm 0.5$       |
| W      | $9 \pm 0.5$       |
| W1     | $1.2 \pm 0.2$     |

#### TAPING STATE



#### PACKING STATE



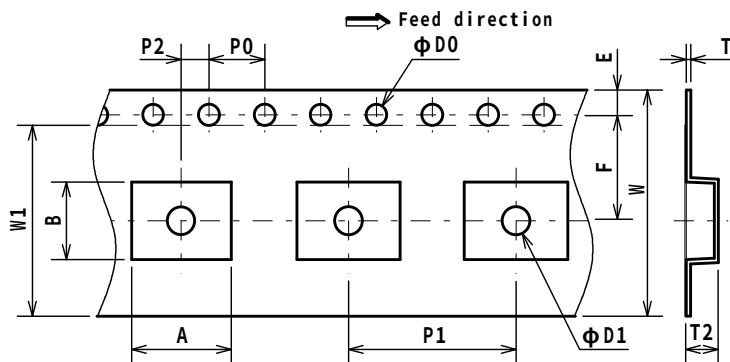


## DMP8

### PACKING SPEC

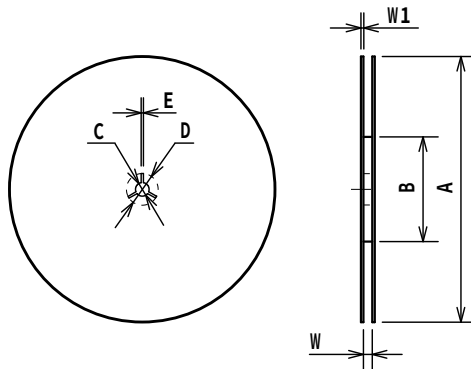
Unit: mm

#### TAPING DIMENSIONS



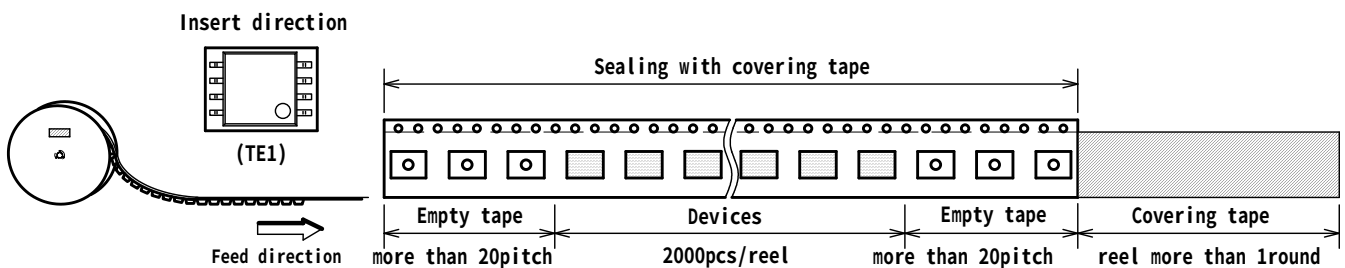
| SYMBOL | DIMENSION       | REMARKS          |
|--------|-----------------|------------------|
| A      | 7.1             | BOTTOM DIMENSION |
| B      | 5.4             | BOTTOM DIMENSION |
| D0     | $1.55 \pm 0.05$ |                  |
| D1     | $2.05 \pm 0.1$  |                  |
| E      | $1.75 \pm 0.1$  |                  |
| F      | $7.5 \pm 0.1$   |                  |
| P0     | $4.0 \pm 0.1$   |                  |
| P1     | $12.0 \pm 0.1$  |                  |
| P2     | $2.0 \pm 0.1$   |                  |
| T      | $0.3 \pm 0.05$  |                  |
| T2     | 2.3             |                  |
| W      | $16.0 \pm 0.3$  |                  |
| W1     | 13.5            | THICKNESS 0.1max |

#### REEL DIMENSIONS

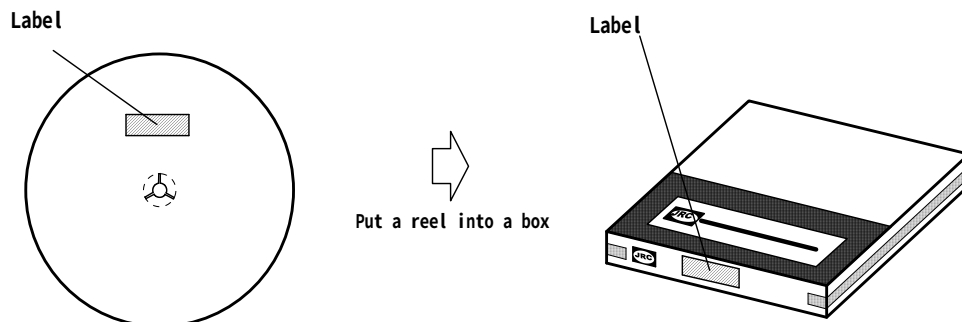


| SYMBOL | DIMENSION         |
|--------|-------------------|
| A      | $\phi 330 \pm 2$  |
| B      | $\phi 80 \pm 1$   |
| C      | $\phi 13 \pm 0.2$ |
| D      | $\phi 21 \pm 0.8$ |
| E      | $2 \pm 0.5$       |
| W      | $17.5 \pm 0.5$    |
| W1     | $2 \pm 0.2$       |

#### TAPING STATE



#### PACKING STATE

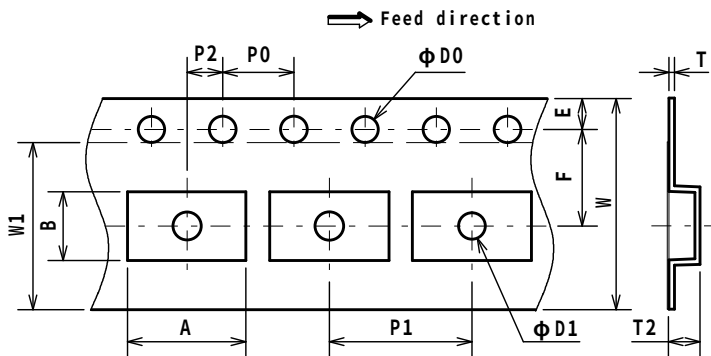


## SSOP8

### PACKING SPEC

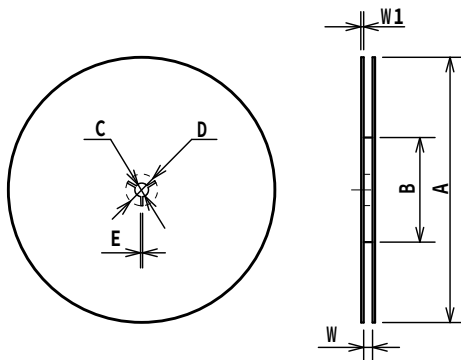
Unit: mm

#### TAPING DIMENSIONS



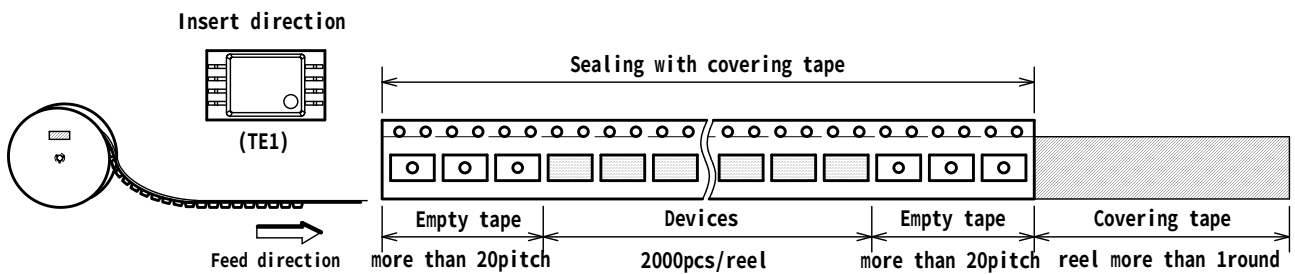
| SYMBOL | DIMENSION       | REMARKS          |
|--------|-----------------|------------------|
| A      | 6.7             | BOTTOM DIMENSION |
| B      | 3.9             | BOTTOM DIMENSION |
| D0     | $1.55 \pm 0.05$ |                  |
| D1     | $1.55 \pm 0.1$  |                  |
| E      | $1.75 \pm 0.1$  |                  |
| F      | $5.5 \pm 0.05$  |                  |
| P0     | $4.0 \pm 0.1$   |                  |
| P1     | $8.0 \pm 0.1$   |                  |
| P2     | $2.0 \pm 0.05$  |                  |
| T      | $0.3 \pm 0.05$  |                  |
| T2     | 2.2             |                  |
| W      | $12.0 \pm 0.3$  |                  |
| W1     | 9.5             | THICKNESS 0.1max |

#### REEL DIMENSIONS

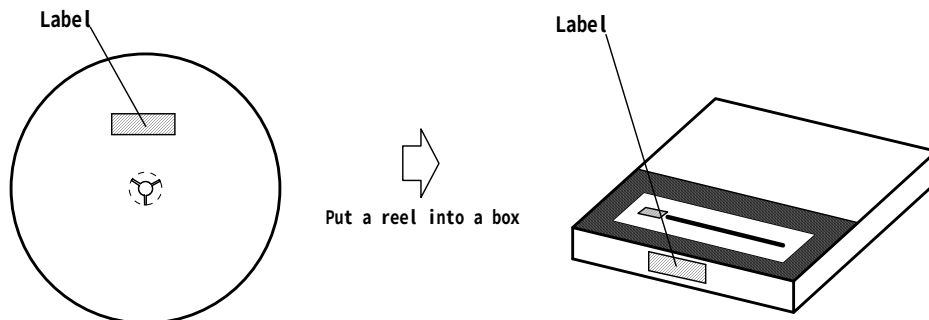


| SYMBOL | DIMENSION         |
|--------|-------------------|
| A      | $\phi 254 \pm 2$  |
| B      | $\phi 100 \pm 1$  |
| C      | $\phi 13 \pm 0.2$ |
| D      | $\phi 21 \pm 0.8$ |
| E      | $2 \pm 0.5$       |
| W      | $13.5 \pm 0.5$    |
| W1     | $2 \pm 0.2$       |

#### TAPING STATE



#### PACKING STATE

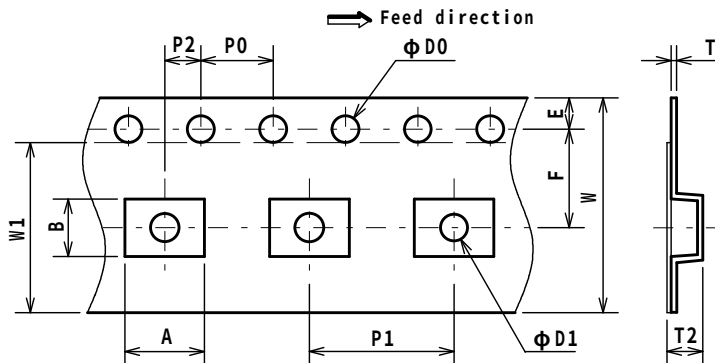


## MSOP8 (TVSP8) MEET JEDEC MO-187-DA/THIN TYPE

### ■ PACKING SPEC

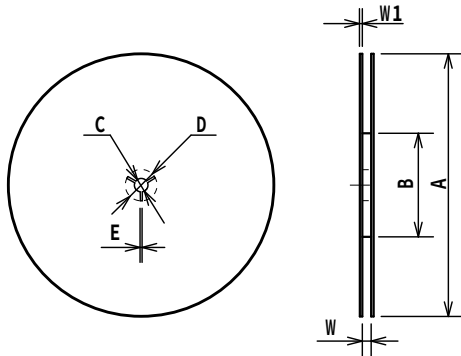
Unit: mm

#### TAPING DIMENSIONS



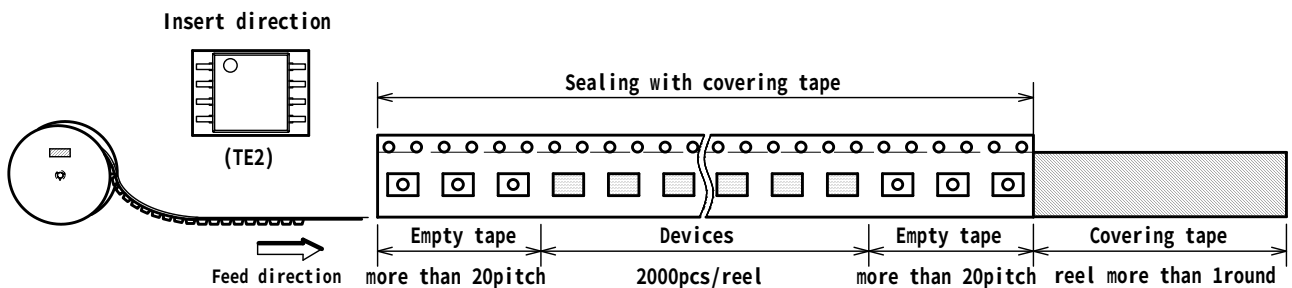
| SYMBOL | DIMENSION                        | REMARKS          |
|--------|----------------------------------|------------------|
| A      | 4.4                              | BOTTOM DIMENSION |
| B      | 3.2                              | BOTTOM DIMENSION |
| D0     | 1.5 <sup>+0.1</sup> <sub>0</sub> |                  |
| D1     | 1.5 <sup>+0.1</sup> <sub>0</sub> |                  |
| E      | 1.75±0.1                         |                  |
| F      | 5.5±0.05                         |                  |
| P0     | 4.0±0.1                          |                  |
| P1     | 8.0±0.1                          |                  |
| P2     | 2.0±0.05                         |                  |
| T      | 0.30±0.05                        |                  |
| T2     | 1.75 (MAX.)                      |                  |
| W      | 12.0±0.3                         |                  |
| W1     | 9.5                              | THICKNESS 0.1max |

#### REEL DIMENSIONS

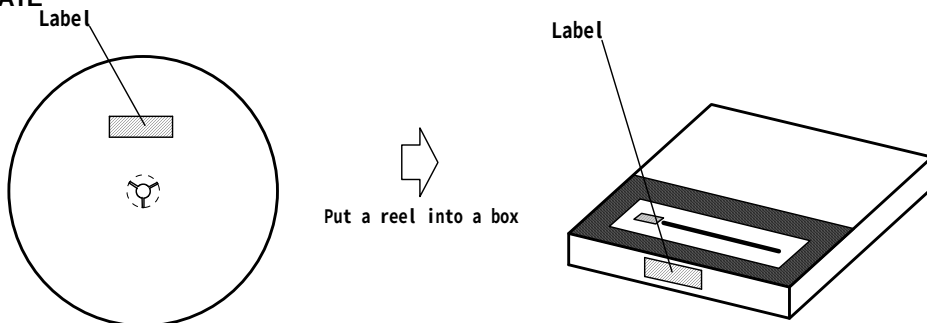


| SYMBOL | DIMENSION |
|--------|-----------|
| A      | Φ254±2    |
| B      | Φ100±1    |
| C      | Φ 13±0.2  |
| D      | Φ 21±0.8  |
| E      | 2±0.5     |
| W      | 13.5±0.5  |
| W1     | 2.0±0.2   |

#### TAPING STATE



#### PACKING STATE

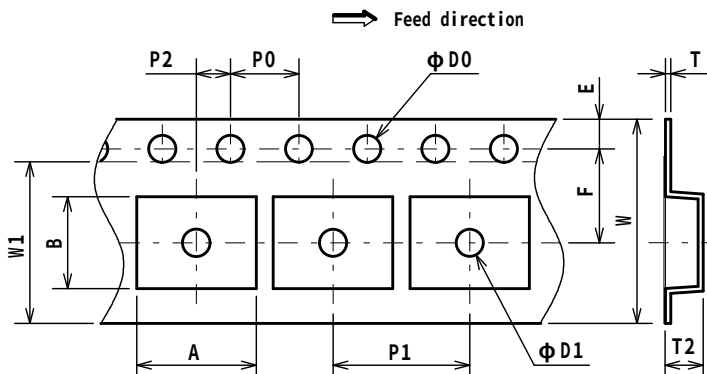


## SSOP14

### PACKING SPEC

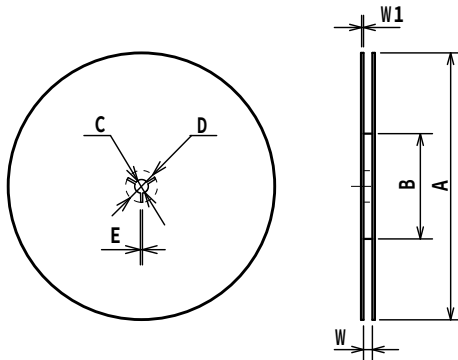
Unit: mm

#### TAPING DIMENSIONS



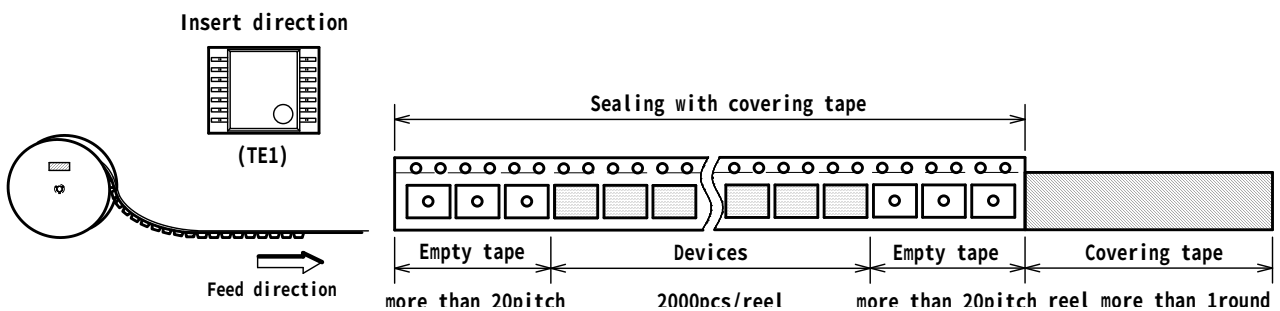
| SYMBOL | DIMENSION       | REMARKS          |
|--------|-----------------|------------------|
| A      | 6.95            | BOTTOM DIMENSION |
| B      | 5.4             | BOTTOM DIMENSION |
| D0     | $1.55 \pm 0.05$ |                  |
| D1     | $1.55 \pm 0.1$  |                  |
| E      | $1.75 \pm 0.1$  |                  |
| F      | $5.5 \pm 0.05$  |                  |
| P0     | $4.0 \pm 0.1$   |                  |
| P1     | $8.0 \pm 0.1$   |                  |
| P2     | $2.0 \pm 0.05$  |                  |
| T      | $0.3 \pm 0.05$  |                  |
| T2     | 2.2             |                  |
| W      | $12.0 \pm 0.3$  |                  |
| W1     | 9.5             | THICKNESS 0.1max |

#### REEL DIMENSIONS

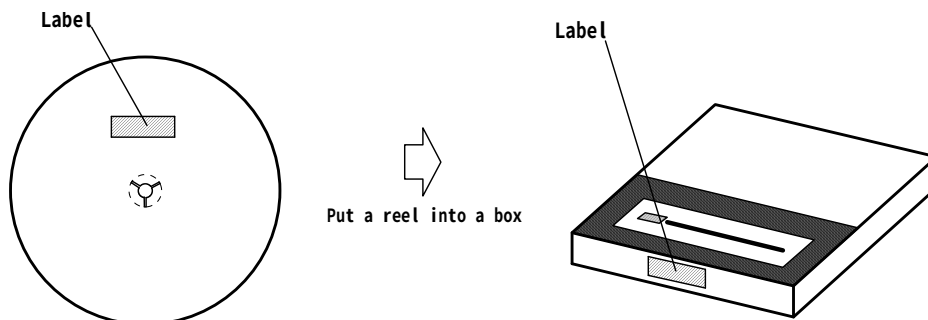


| SYMBOL | DIMENSION         |
|--------|-------------------|
| A      | $\phi 254 \pm 2$  |
| B      | $\phi 100 \pm 1$  |
| C      | $\phi 13 \pm 0.2$ |
| D      | $\phi 21 \pm 0.8$ |
| E      | $2 \pm 0.5$       |
| W      | $13.5 \pm 0.5$    |
| W1     | $2 \pm 0.2$       |

#### TAPING STATE

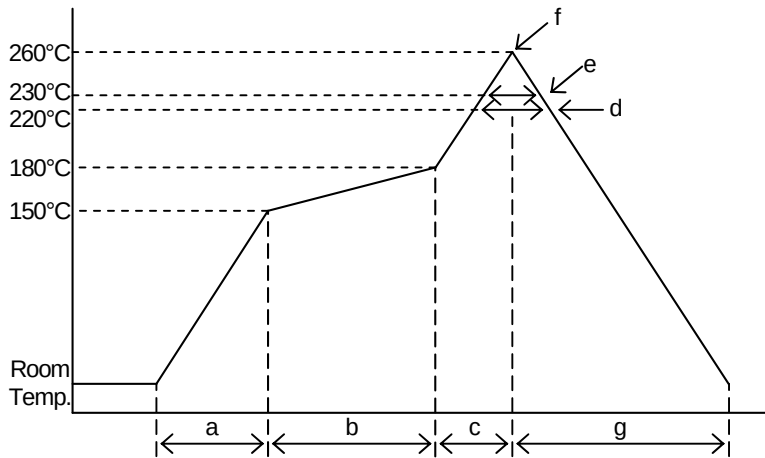


#### PACKING STATE



## ■ 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                             |
|--------------|----------|-------------------------------------|
| July 1, 2019 | 5        | Changed design of datasheet format. |

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