## Features

- Supply Voltage: 3 V to 36 V
- Low Supply Current: Maximum 1000 μA per channel
- Differential Input Voltage Range to Supply Rail, can Work as Comparator
- Input Rail to $-V_S$, Rail to Rail Output
- Fast Response: 3.5-MHz Bandwidth, 15-V/μs Slew Rate, 100-ns Overload Recovery
- Low Offset Voltage:
  ±2 mV Maximum at 25°C,
  ±4 mV Maximum at -40°C to 125°C
- Excellent EMIRR: 60 dB at 900 MHz
- –40°C to 125°C Operation Temperature Range
- Qualified for Automotive Applications with AEC-Q100 Reliability Test

## Applications

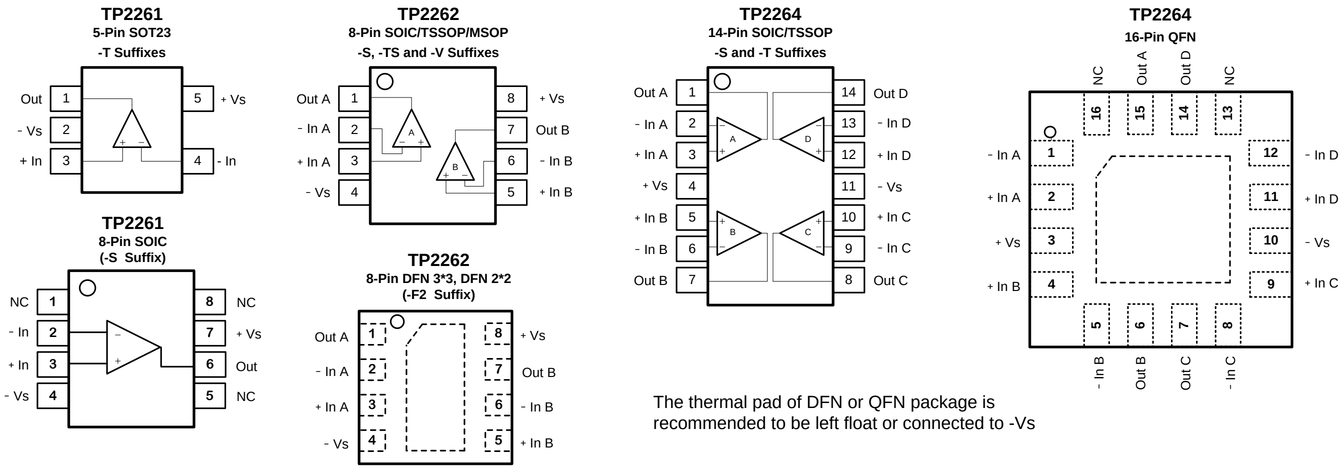
- Motor Control
- Industrial Control
- Automotive

## Description

The TP226x series of amplifiers are the newest high supply voltage amplifiers with low offset, low power, and stable high-frequency response. They incorporate 3PEAK's proprietary and patented design techniques to achieve very good AC performance with 3.5-MHz bandwidth, 15-V/μs slew rate, and low distortion while drawing only typical 700 μA of quiescent current per amplifier. The input common-mode voltage range extends to V–, and the outputs swing rail-to-rail. The TP226x family can be used as plug-in replacements for many commercially available op-amps to reduce power and improve input/output range and performance.

The combination of features makes the TP226x ideal choices for industrial control, motor control, portable audio amplification, sound ports, and other consumer audio.

## Pin Configuration




The thermal pad of DFN or QFN package is recommended to be left float or connected to -Vs

# Table of Contents



# Revision History

| Revision | Notes |
|---|---|
| Rev.Pre.0 | Pre-Version |
| Rev.Pre.1 | Fixed specification |
| Rev.Pre.2 | Added part number: TP2261L1-S5TR-S |
| Rev.A.0 | Initial Version |

## Order Information

| Order Number | Operating Temperature Range | Package | Marking Information | MSL | Transport Media, Quantity |
|---|---|---|---|---|---|
| TP2261L1-S5TR-S | -40 to 125°C | SOT23-5 | 226 | 3 | Tape and Reel, 3000 |
| TP2262L1-SO1R-S | -40 to 125°C | SOP8 | TP2262 | 1 | Tape and Reel, 4000 |
| TP2264L1-SO2R-S (1) | -40 to 125°C | SOP14 | TP2264 | 1 | Tape and Reel, 2500 |

Note 1: For future products, contact 3PEAK factory for more information and samples.

## Absolute Maximum Ratings (1)

| Parameters | Rating |
| --- | --- |
| Supply Voltage, $(+V_S)–(-V_S)$ | 40 V |
| Input Voltage | $(-V_S)$ – 0.3 to $(+V_S)$ + 0.3 |
| Differential Input Voltage | $(+V_S)$ - $(-V_S)$ |
| Input Current: +IN, –IN Note 2 | ±10mA |
| Output Short-Circuit Duration Note 3 | Infinite |
| Maximum Junction Temperature | 150°C |
| Operating Temperature Range | –40 to 125°C |
| Storage Temperature Range | –65 to 150°C |
| Lead Temperature (Soldering, 10 sec) | 260°C |

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Note 2: The inputs are protected by ESD protection diodes to each power supply. If the input extends more than 300 mV beyond the power supply, the input current should be limited to less than 10 mA.

Note 3: A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

## ESD Rating

| Symbol | Parameter | Condition | Minimum Level | Unit |
| --- | --- | --- | --- | --- |
| HBM | Human Body Model ESD | ANSI/ESDA/JEDEC JS-001 | 2 | kV |
| CDM | Charged Device Model ESD | ANSI/ESDA/JEDEC JS-002 | 1 | kV |

## Thermal Information

| Package Type | $\theta_{JA}$ | $\theta_{JC}$ | Unit |
| --- | --- | --- | --- |
| SOT23-5 | 250 | 81 | °C/W |
| SOP8 | 158 | 43 | °C/W |
| SOP14 | 120 | 36 | °C/W |

## Electrical Characteristics

All test conditions: $V_S$ = (+$V_S$) – (-$V_S$) = 30 V, $T_A$ = 25°C, $R_L$ = 10 kΩ to $V_S$/2, unless otherwise noted.

| Symbol | Parameter | Conditions | $T_A$ | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| Power Supply | | | | | | | |
| $V_S$ | Supply Voltage Range | | | 3 | | 36 | V |
| $I_Q$ | Quiescent Current per Amplifier | $V_S$ = 30 V, TP2261 | | | 1000 | 1500 | μA |
| | | | -40°C to 125°C | | | 2500 | μA |
| | | $V_S$ = 5 V, TP2261 | | | 850 | 1300 | μA |
| | | | -40°C to 125°C | | | 2000 | μA |
| | | $V_S$ = 30 V, TP2262/TP2264 | | | 700 | 1000 | μA |
| | | | -40°C to 125°C | | | 2000 | uA |
| | | $V_S$ = 5 V, TP2262/TP2264 | | | 600 | 850 | μA |
| | | | -40°C to 125°C | | | 1500 | μA |
| PSRR | Power Supply Rejection Ratio | $V_S$ = 3 V to 36 V | | 95 | 120 | | dB |
| | | | -40°C to 125°C | 80 | | | dB |
| Input Characteristics | | | | | | | |
| $V_{OS}$ | Input Offset Voltage | $V_S$ = 30 V, $V_{CM}$ = 0 V to 28 V | | -2 | 0.1 | 2 | mV |
| | | | -40°C to 125°C | -4 | | 4 | mV |
| | | $V_S$ = 30 V, $V_{CM}$ = 28.5 V | | -3 | | 3 | mV |
| | | | -40°C to 125°C | -5 | | 5 | mV |
| | | $V_S$ = 5 V, $V_{CM}$ = 2.5 V | | -2 | 0.1 | 2 | mV |
| | | | -40°C to 125°C | -4 | | 4 | mV |
| $V_{OS}$ TC | Input Offset Voltage Drift | | -40°C to 125°C | | 2 | | μV/°C |
| $I_B$ | Input Bias Current | | | -250 | 25 | 250 | pA |
| | | | -40°C to 125°C | | 1 | 10 | nA |
| $I_{OS}$ | Input Offset Current (1) | | | -250 | 25 | 250 | pA |
| | | | -40°C to 125°C | | 1 | 10 | nA |
| $I_{IN}$ | Different Input Current | $V_S$ = 36 V, $V_{ID}$ = 36 V | | | 10 | | nA |
| | | | -40°C to 125°C | | 100 | | nA |
| $C_{IN}$ | Input Capacitance | Differential Mode | | | 5 | | pF |
| | | Common Mode | | | 5 | | pF |
| Av | Open-loop Voltage Gain | | | 105 | 120 | | dB |
| | | | -40°C to 125°C | 90 | | | dB |
| $V_{CMR}$ | Common-mode Input Voltage Range | | | (V-) | | (V+) – 1.5 | V |
| CMRR | Common Mode Rejection Ratio | $V_{CM}$ = 0 V to 28 V | | 105 | 130 | | dB |
| | | | -40°C to 125°C | 90 | | | dB |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Output Characteristics | | | | | | | |
| $V_{OH}$ | Output Swing from Positive Rail | $R_{LOAD}$ = 10 kΩ to $V_S$/2 | | | 200 | 300 | mV |
| | | | -40°C to 125°C | | | 600 | mV |
| | | $R_{LOAD}$ = 2 kΩ to $V_S$/2 | | | 1.1 | 1.4 | V |
| | | | -40°C to 125°C | | | 2.8 | V |
| $V_{OL}$ | Output Swing from Negative Rail | $R_{LOAD}$ = 10 kΩ to $V_S$/2 | | | 200 | 300 | mV |
| | | | -40°C to 125°C | | | 600 | mV |
| | | $R_{LOAD}$ = 2 kΩ to $V_S$/2 | | | 0.8 | 1 | V |
| | | | -40°C to 125°C | | | 2 | V |
| $I_{SC}$ | Output Short-Circuit Current | | | 25 | 32 | | mA |
| | | | -40°C to 125°C | 10 | | | mA |
| AC Specifications | | | | | | | |
| GBW | Gain-Bandwidth Product | | | | 3.5 | | MHz |
| SR | Slew Rate | G = 1, 10 V step | | | 15 | | V/μs |
| | | Open Loop | | 9 | 15 | | V/μs |
| | | | -40°C to 125°C | 6 | | | V/μs |
| $t_{OR}$ | Overload Recovery | | | | 100 | | ns |
| $t_S$ | Settling Time, 0.1% | G = -1, 10 V step | | | 0.8 | | μs |
| | Settling Time, 0.01% | | | | 1 | | μs |
| PM | Phase Margin | $V_S$ = 36 V, $R_L$=10 K, $C_L$=100 pF | | | 60 | | ° |
| GM | Gain Margin | $V_S$ = 36 V, $R_L$=10 K, $C_L$=100 pF | | | 15 | | dB |
| Noise Performance | | | | | | | |
| $E_N$ | Input Voltage Noise | f = 0.1 Hz to 10 Hz | | | 1.7 | | $μV_{RMS}$ |
| $e_N$ | Input Voltage Noise Density | f = 1 kHz | | | 30 | | nV/√Hz |
| $i_N$ | Input Current Noise | f = 1 kHz | | | 2 | | fA/√Hz |
| THD+N | Total Harmonic Distortion and Noise | f = 1 kHz, G =1, $R_L$ = 10 kΩ, $V_{OUT}$ = 6 $V_{RMS}$ | | | 0.0005 | | % |

(1) Provided by bench test and design simulation.

## Typical Performance Characteristics

$V_S$ = ±15V, $V_{CM}$ = 0V, $R_L$ = 10kΩ, unless otherwise specified.

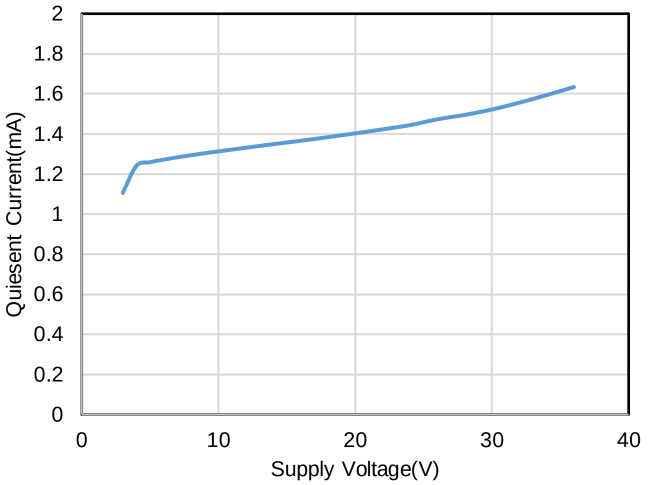



Figure 1. Quiescent Current vs. Supply Voltage, 2ch TP2262

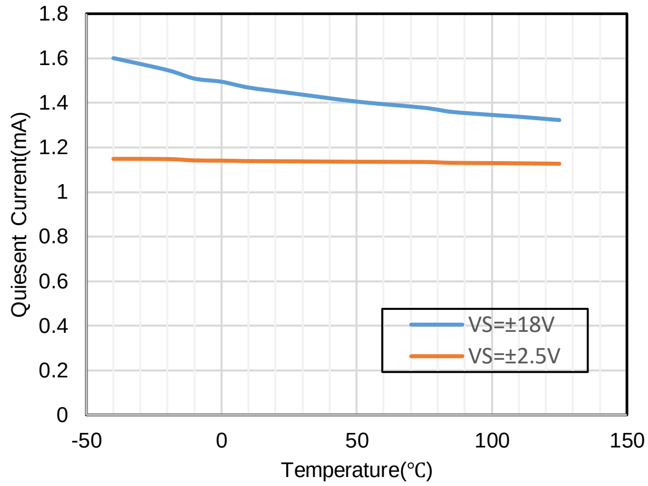



Figure 2. Quiescent Current vs. Temperature, 2ch TP2262

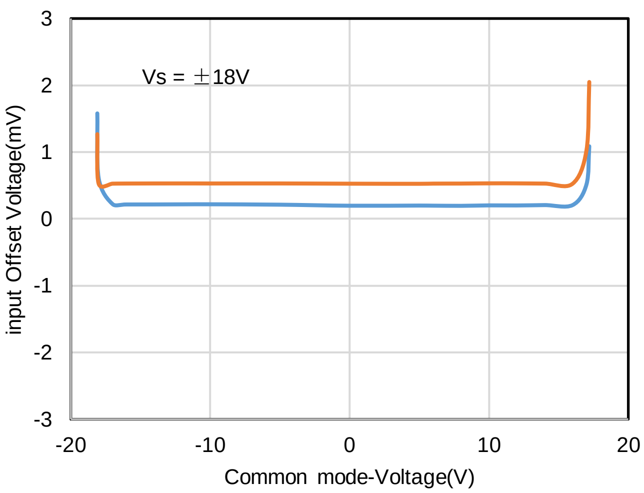



Figure 3. Offset Voltage vs. Common Mode Voltage

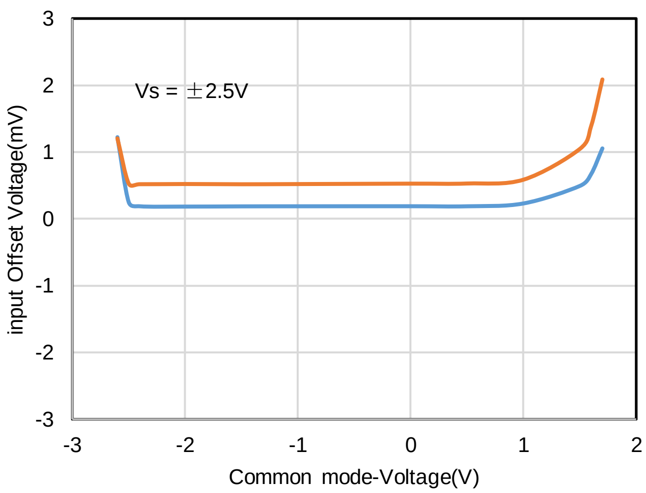



Figure 4. Offset Voltage vs. Common Mode Voltage

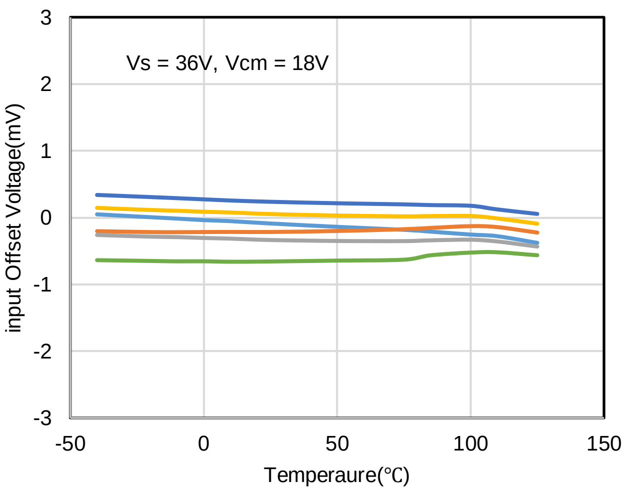



Figure 5. $V_{OS}$ vs. Temperature

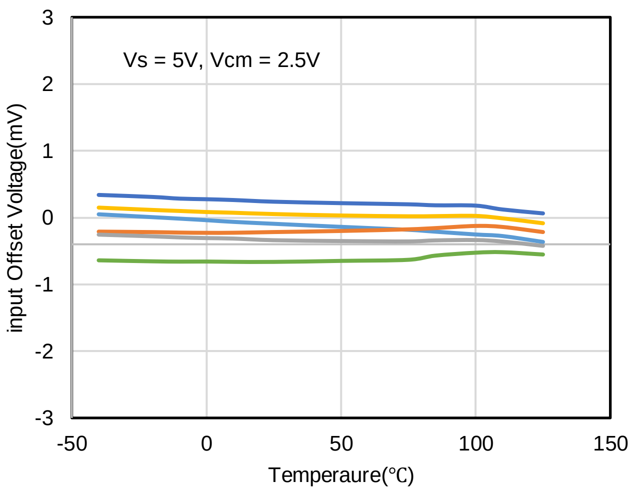



Figure 6. $V_{OS}$ vs. Temperature

$V_S$ = ±15V, $V_{CM}$ = 0V, $R_L$ = 10kΩ, unless otherwise specified.

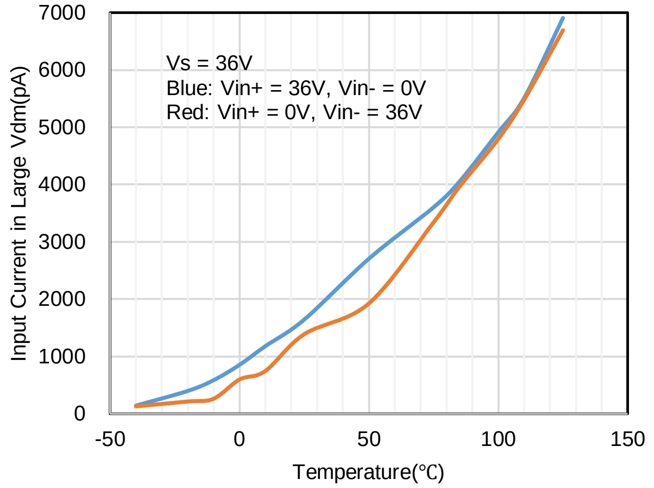



Figure 7. Input Current in Large Vdm vs. Temperature

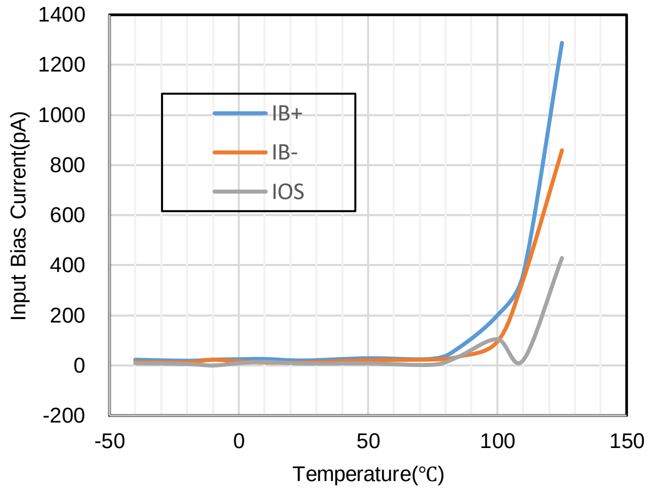



Figure 8. $I_B$ vs. Temperature

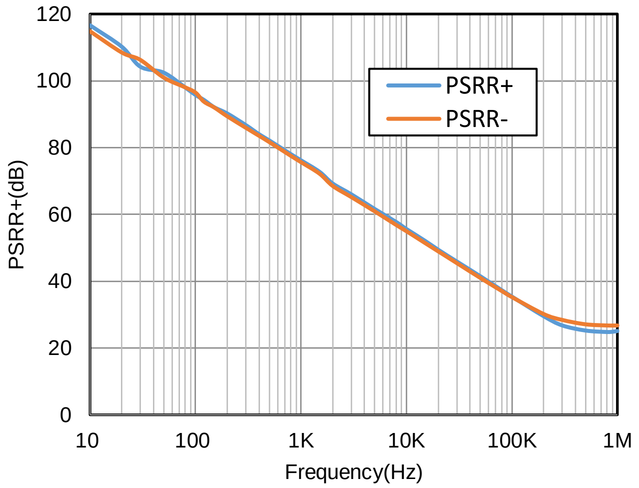



Figure 9. PSRR vs. Frequency

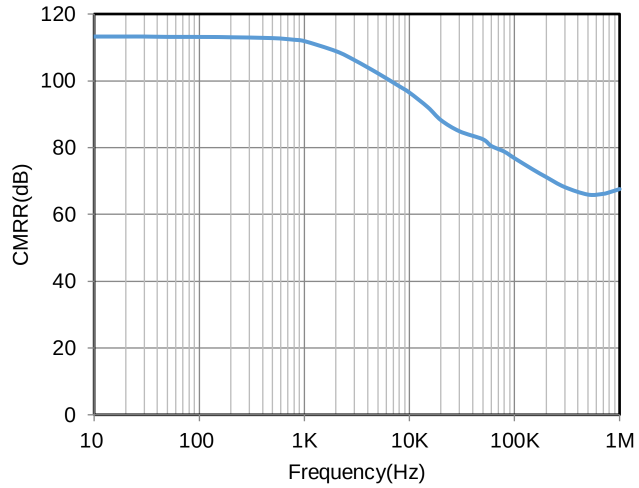



Figure 10. CMRR vs. Frequency

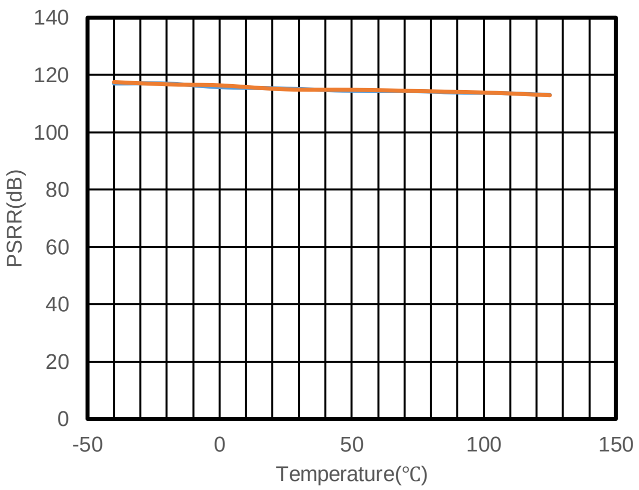



Figure 11. PSRR vs. Temperature

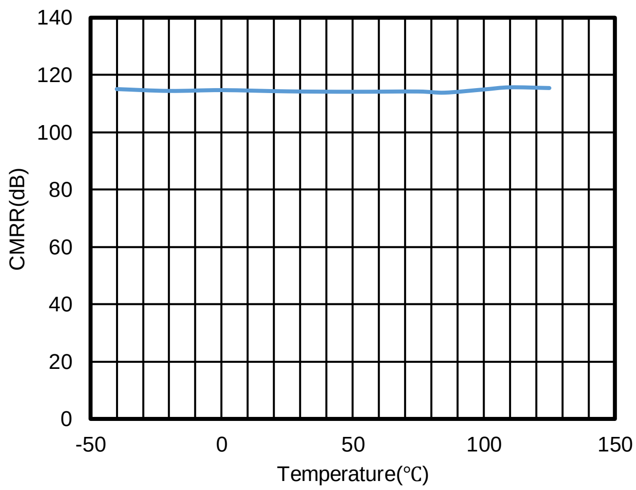



Figure 12. CMRR vs. Temperature

$V_S$ = ±15V, $V_{CM}$ = 0V, $R_L$ = 10kΩ, unless otherwise specified.

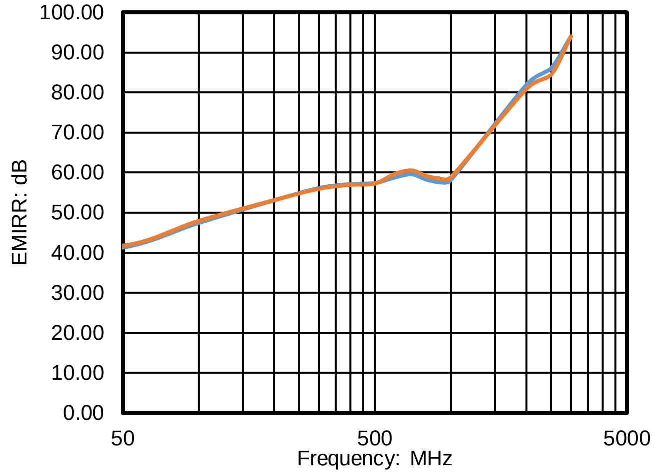



Figure 13. EMIRR+- vs. Frequency

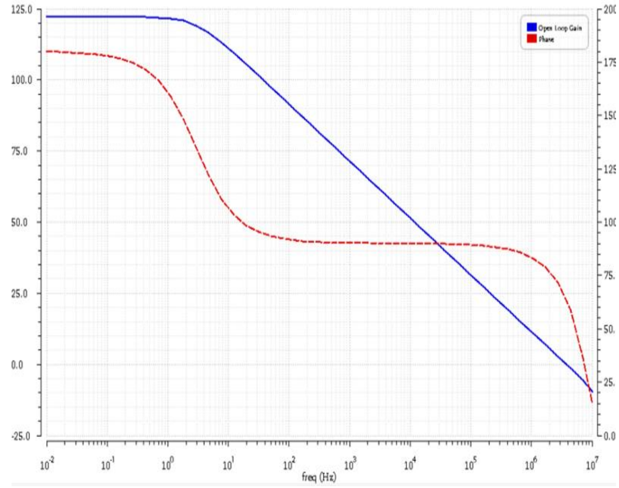



Figure 14. Open Loop Gain and Phase vs. Frequency

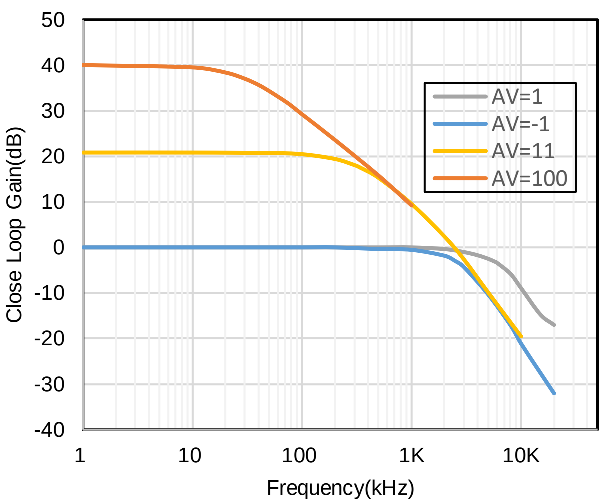
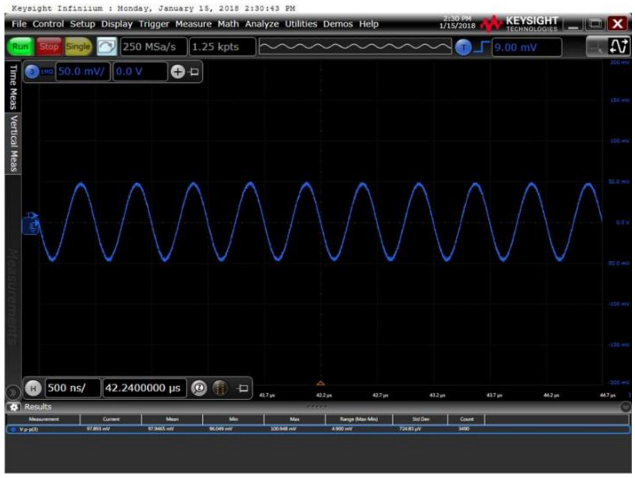



Figure 15. Close Loop Gain and Phase vs. Frequency



$V_S$ = ±1.5 V, $V_{IN}$ = 100 $mV_{PP}$, $R_L$ = 10 K, $C_L$ = 100 pF, G = 1

Figure 16. Waveform under 3V Supply Voltage

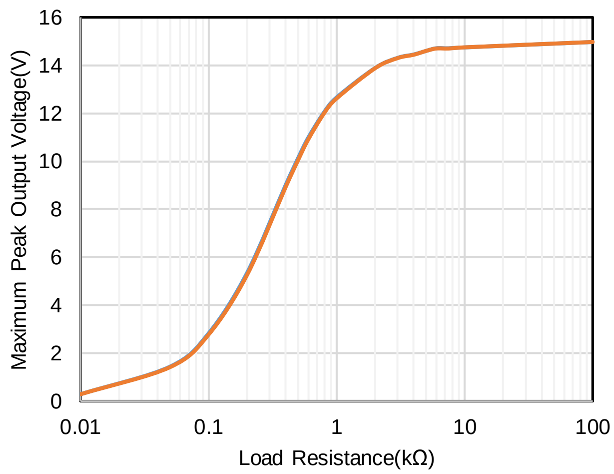



Figure 17. Maximum Peak Output Voltage vs. Load Resistance

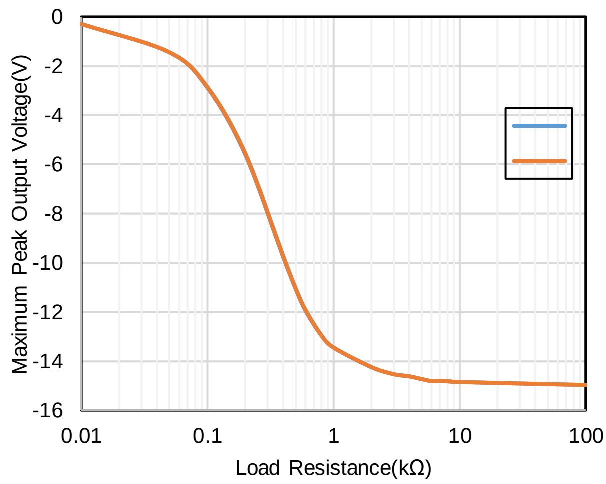



Figure 18. Maximum Peak Output Voltage vs. Load Resistance

$V_S$ = ±15V, $V_{CM}$ = 0V, $R_L$ = 10kΩ, unless otherwise specified.

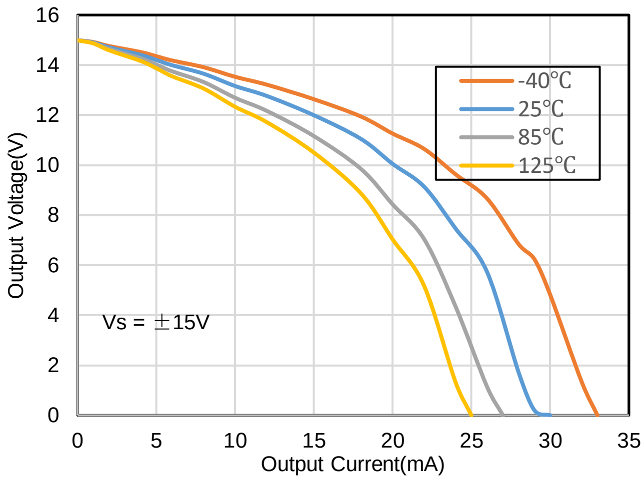



Figure 19. Positive Output Voltage vs. Output Current

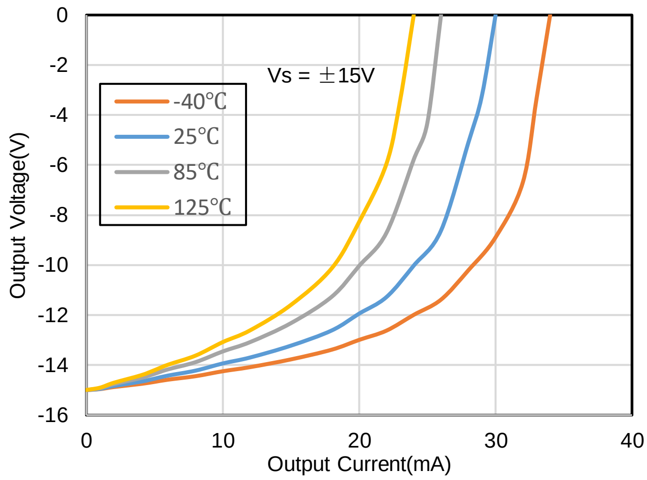



Figure 20. Negative Output Voltage vs. Output Current

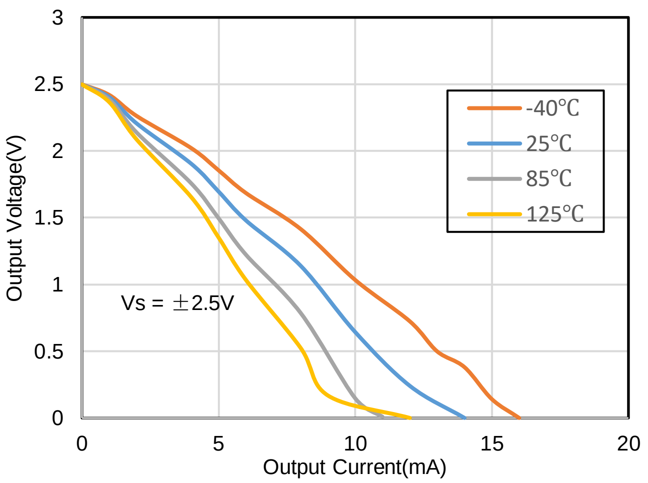



Figure 21. Positive Output Voltage vs. Output Current

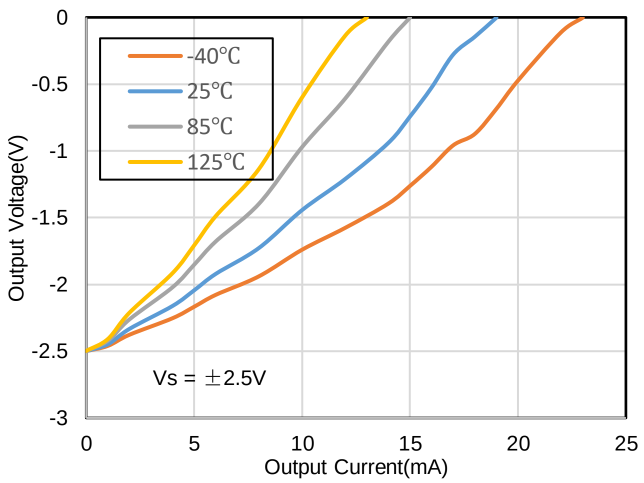



Figure 22. Negative Output Voltage vs. Output Current

Voltage: 1 V/div, Time: 200 ns/div

$V_S$ = 5 V, $V_{IN}$ = 2 V, $R_L$ = Open, G = 3

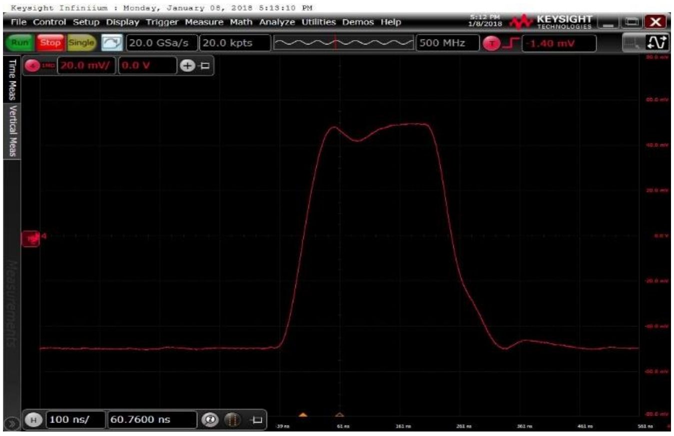
Figure 23. Positive Overload Recovery

Voltage: 1 V/div, Time: 200 ns/div

$V_S$ = 5 V, $V_{IN}$ = 2 V, $R_L$ = Open, G = 3

Figure 24. Negative Overload Recovery

$V_S$ = ±15V, $V_{CM}$ = 0V, $R_L$ = 10kΩ, unless otherwise specified.



Voltage: 20 mV/div, Time: 100 ns/div

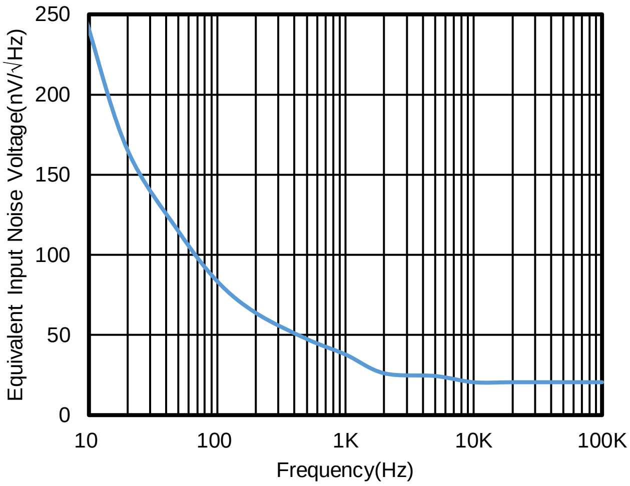
$V_S$ = ±15 V, $R_L$ = 2K, $C_L$ = 100 pF, G=1

Figure 25. 100-mV Signal Step Response

Voltage: 2 V/div, Time: 1 μs/div

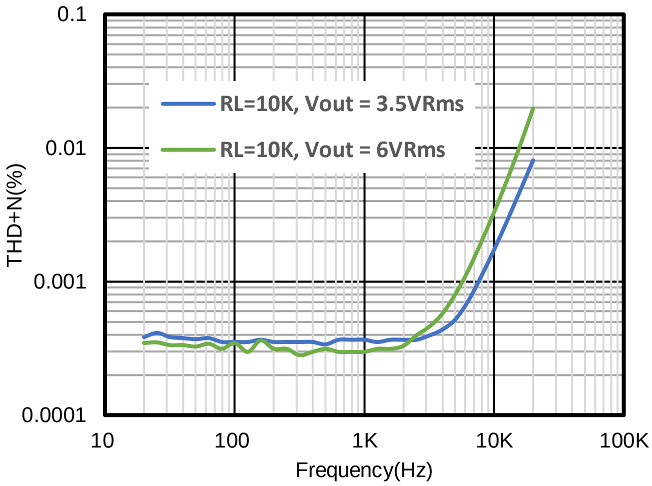
$V_S$ = ±15 V, $R_L$ = 2 K, $C_L$ = 100 pF, G=1

Figure 26. 10-V Signal Step Response



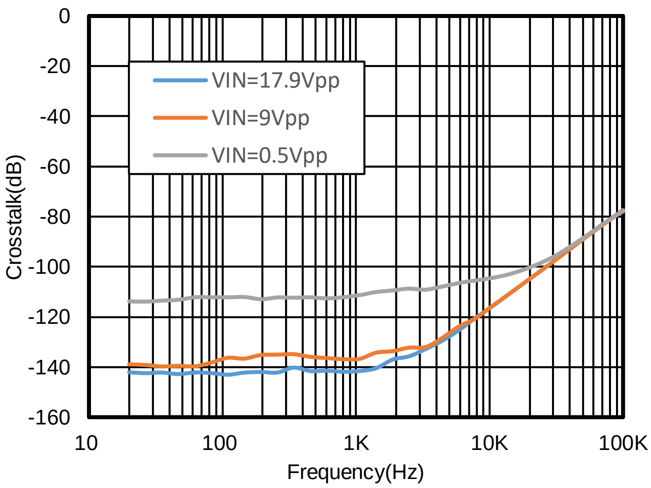

$V_S$ = ±15V, $V_{CM}$ = 0 V

Figure 27. Voltage Noise Spectral Density vs. Frequency




$V_S$ = ±15 V, $V_{CM}$ = 0 V, G = 1

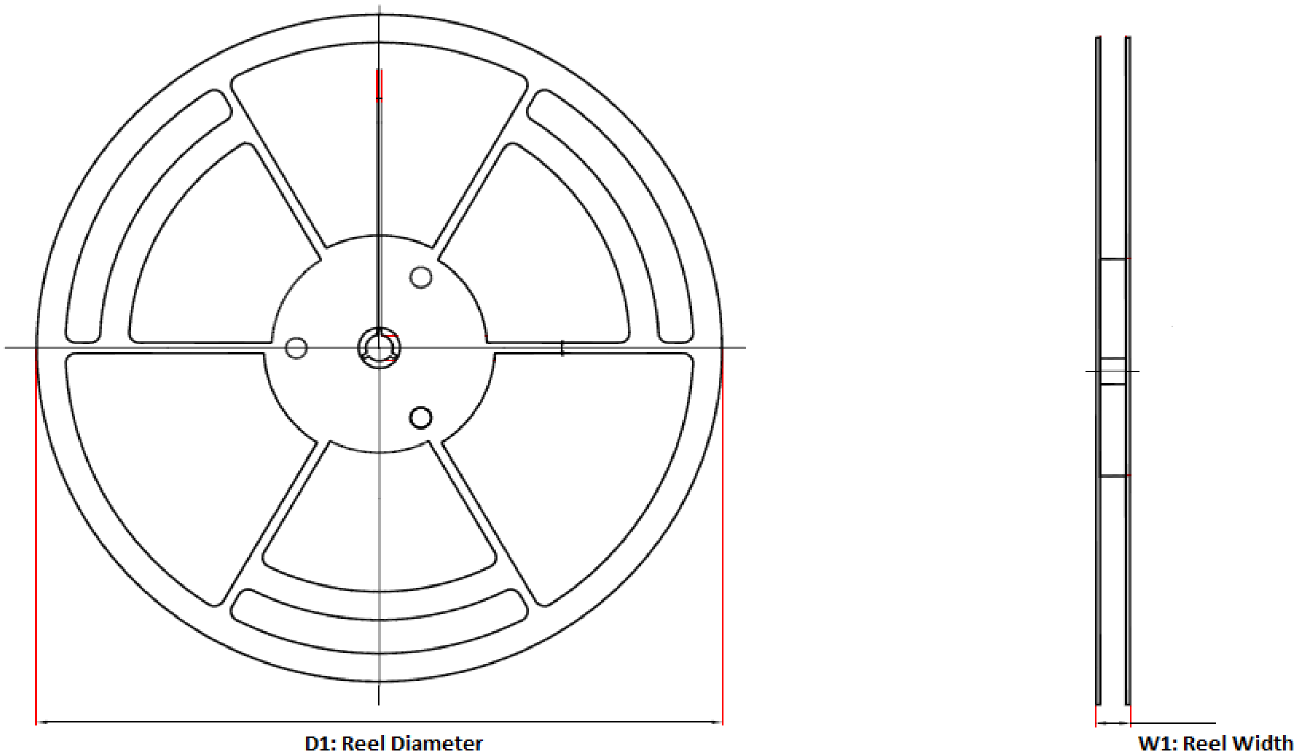
Figure 28. THD+N vs. Frequency

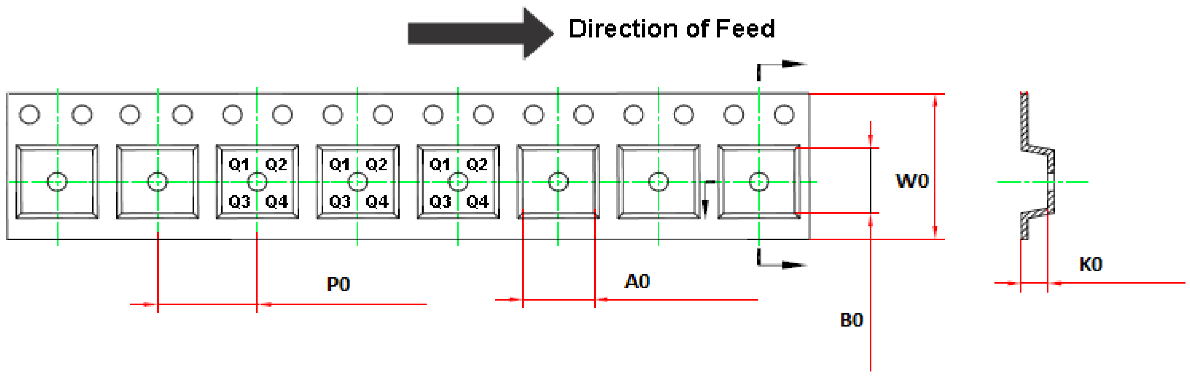



$V_S$ = ±15 V, $V_{CM}$ = 0 V

Figure 29. Crosstalk vs. Frequency

## Tape and Reel Information



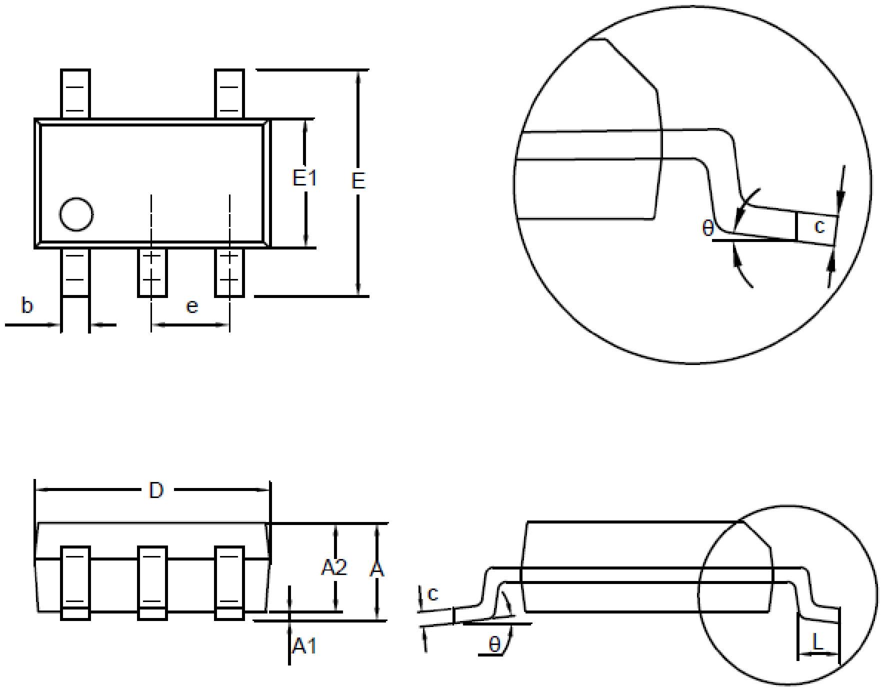




| Order Number | Package | D1 | W1 | A0 | B0 | K0 | P0 | W0 | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|---|
| TP2261L1-S5TR-S | SOT23-5 | 179.0 | 12.0 | 3.3 | 3.25 | 1.4 | 4.0 | 8.0 | Q3 |
| TP2262L1-SO1R-S | SOP8 | 330.0 | 17.6 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |
| TP2264L1-SO2R-S | SOP14 | 330.0 | 21.6 | 6.5 | 9.1 | 1.8 | 8.0 | 16.0 | Q1 |

## Package Outline Dimensions

### SOT23-5

Package Outline Dimensions S5T(SOT23-5-A)



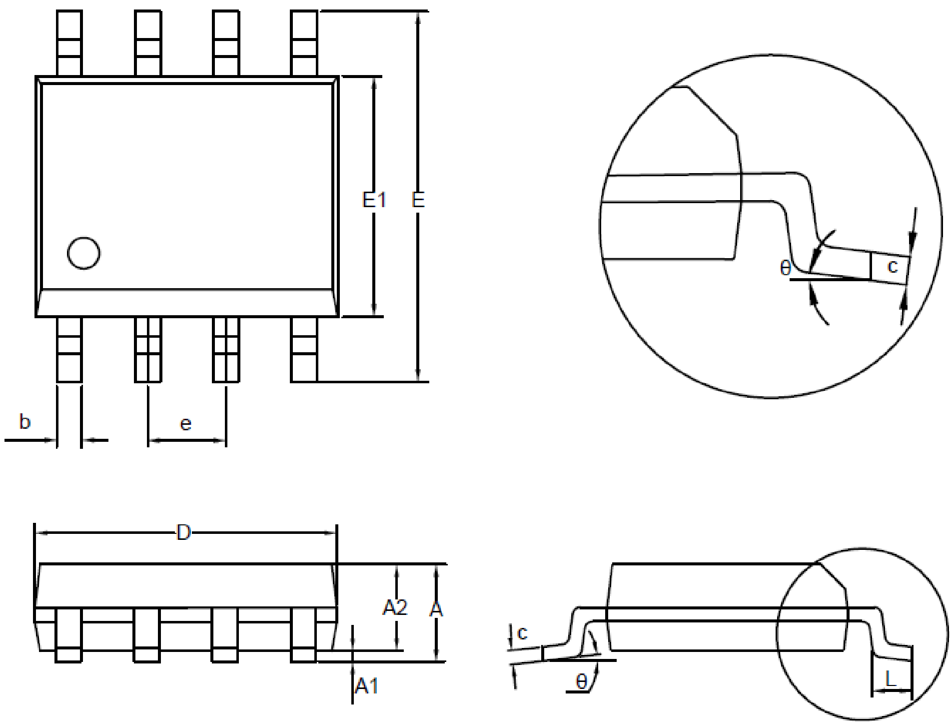

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.150 | 0.000 | 0.006 |
| A2 | 1.000 | 1.200 | 0.039 | 0.047 |
| b | 0.280 | 0.500 | 0.011 | 0.020 |
| c | 0.100 | 0.230 | 0.004 | 0.009 |
| D | 2.820 | 3.020 | 0.111 | 0.119 |
| E | 2.600 | 3.000 | 0.102 | 0.118 |
| E1 | 1.500 | 1.720 | 0.059 | 0.068 |
| e | 0.950 BSC | | 0.037 BSC | |
| L | 0.300 | 0.600 | 0.012 | 0.024 |
| θ | 0 | 8° | 0 | 8° |

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

## SOP8

Package Outline Dimensions SO1(SOP-8-A)



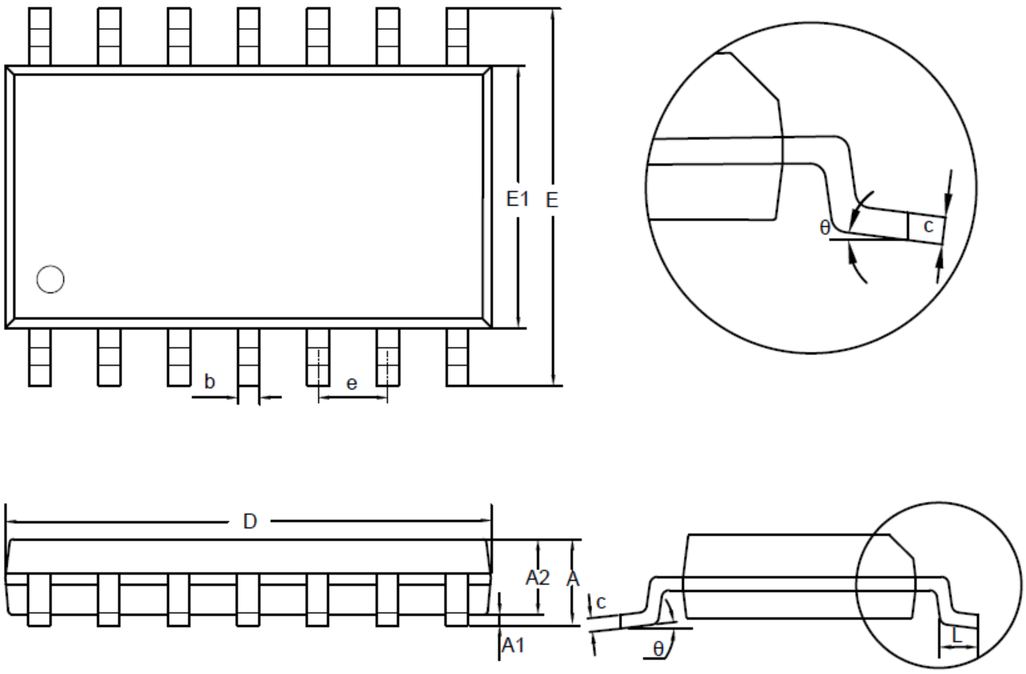

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.050 | 0.250 | 0.002 | 0.010 |
| A2 | 1.250 | 1.550 | 0.049 | 0.061 |
| b | 0.330 | 0.510 | 0.013 | 0.020 |
| c | 0.170 | 0.250 | 0.007 | 0.010 |
| D | 4.700 | 5.100 | 0.185 | 0.201 |
| E | 5.800 | 6.200 | 0.228 | 0.244 |
| E1 | 3.800 | 4.000 | 0.150 | 0.157 |
| e | 1.270 BSC | | 0.050 BSC | |
| L | 0.400 | 1.000 | 0.016 | 0.039 |
| θ | 0 | 8° | 0 | 8° |

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

## SOIC-14

Package Outline Dimensions SO2(SOP-14-A)




| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.050 | 0.250 | 0.002 | 0.010 |
| A2 | 1.250 | 1.650 | 0.049 | 0.065 |
| b | 0.310 | 0.510 | 0.012 | 0.020 |
| c | 0.100 | 0.250 | 0.004 | 0.010 |
| D | 8.450 | 8.850 | 0.333 | 0.348 |
| E | 5.800 | 6.200 | 0.228 | 0.244 |
| E1 | 3.800 | 4.000 | 0.150 | 0.157 |
| e | 1.270 BSC | | 0.050 BSC | |
| L | 0.400 | 1.270 | 0.016 | 0.050 |
| θ | 0 | 8° | 0 | 8° |

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.