

Features

- Wide Input Voltage Range:
 - 3 V to 15 V
- Fixed Output Voltage:
 - 1.25 V, 2.048 V, 2.5 V, 3 V, 3.3 V, 4.096 V, 4.5 V, and 5 V
- Low Temperature Coefficient:
 - 1 ppm/°C Typical from 0°C to 70°C
 - 2 ppm/°C Typical from -40°C to 105°C
 - 2.5 ppm/°C Typical from -40°C to 125°C
- High Initial Accuracy:
 - 0.05% Maximum
- Low Noise:
 - 3 μ Vpp/V
- Temperature Range: -40°C to 125°C
- Package Options:
 - SOP8
 - MSOP8

Applications

- Battery Test Equipment
- Industry Control
- Precision Instrumentation
- Medical Equipment

Description

The TPR50 series is a family of high-precision and low-temperature-drift voltage references with the initial accuracy of 0.05% and the temperature coefficient of 2.5 ppm/°C. All products of the TPR50 series are able to support both sinking and sourcing current of ± 10 mA and have a low dropout voltage.

The high precision and excellent temperature stability performance make the TPR50 series an ideal reference in the system with high resolution requirement.

The TPR50 series provides the 8-pin SOP and MSOP package with a wide range of output voltages. All the products are qualified to operate with the temperature range from -40°C to +125°C.

Typical Application Circuit

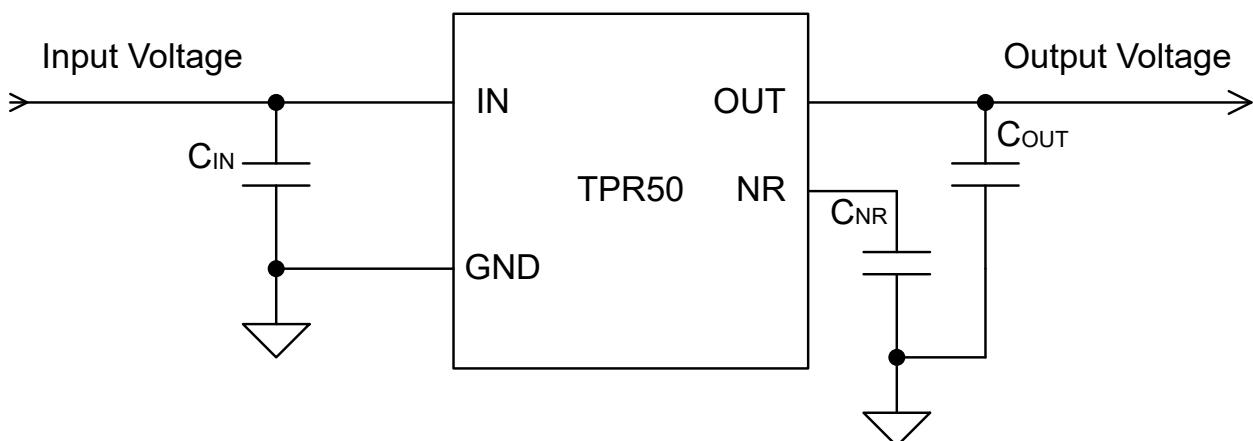


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Product Family Table

| Order Number | Output Voltage | Package |
|----------------|----------------|---------|
| TPR5012-SO1R | 1.25 V | SOP8 |
| TPR5020-SO1R | 2.048 V | SOP8 |
| TPR5025-SO1R | 2.5 V | SOP8 |
| TPR5030-SO1R | 3.0 V | SOP8 |
| TPR5033-SO1R | 3.3 V | SOP8 |
| TPR5040-SO1R | 4.096 V | SOP8 |
| TPR5045-SO1R | 4.5 V | SOP8 |
| TPR5050-SO1R | 5.0 V | SOP8 |
| TPR5012-VS1R-S | 1.25 V | MSOP8 |
| TPR5020-VS1R-S | 2.048 V | MSOP8 |
| TPR5025-VS1R-S | 2.5 V | MSOP8 |
| TPR5030-VS1R-S | 3.0 V | MSOP8 |
| TPR5033-VS1R-S | 3.3 V | MSOP8 |
| TPR5040-VS1R-S | 4.096 V | MSOP8 |
| TPR5045-VS1R-S | 4.5 V | MSOP8 |
| TPR5050-VS1R-S | 5.0 V | MSOP8 |

Revision History

| Date | Revision | Notes |
|------------|-----------|--|
| 2022-08-15 | Rev.Pre.0 | Preliminary revision. |
| 2023-02-15 | Rev.A.0 | Initial released. |
| 2023-05-15 | Rev.A.1 | 1. Added MSOP8 Package Products. 2. Updated Thermal Information. 3. Updated Thermal Hysteresis. 4. Updated Capacitive Load Condition. |

Pin Configuration and Functions

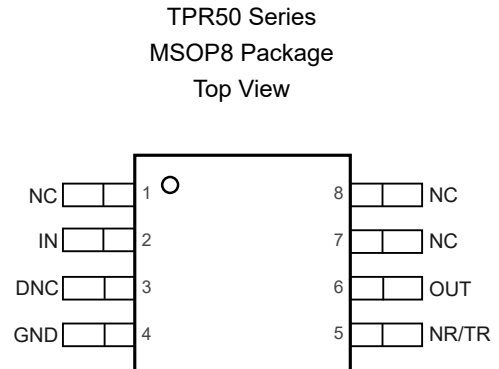
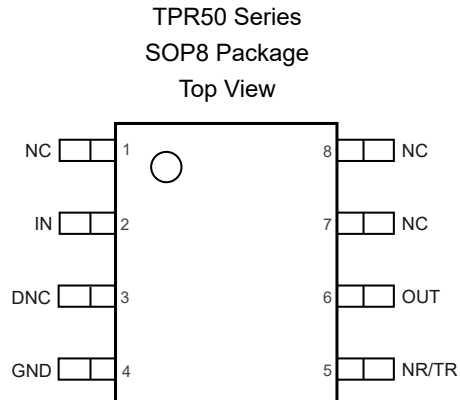


Table 1. Pin Functions: TPR50

| Pin Number | Pin Name | I/O | Description |
|------------|----------|-----|---|
| 3 | DNC | – | Do not connect. Left this pin open or connected to the ground. |
| 4 | GND | – | Ground. |
| 2 | IN | I | Supply voltage input pin. |
| 1, 7,8 | NC | – | No internal connection. |
| 5 | NR/TR | I | Noise reduction pin. A 10-nF or larger capacitor from NR to GND (as close as possible to NR pin) is recommended to minimize the output noise level. |
| 6 | OUT | O | Reference voltage output pin. |

Low-Noise, Low-Drift, Precision Voltage Reference
Specifications
Absolute Maximum Ratings ⁽¹⁾

| Parameter | | Min | Max | Unit |
|------------------|-------------------------------------|------|-----|------|
| V _{IN} | Supply Voltage | -0.3 | 20 | V |
| T _J | Maximum Junction Temperature | -40 | 150 | °C |
| T _A | Operating Temperature Range | -40 | 125 | °C |
| T _{STG} | Storage Temperature Range | -65 | 150 | °C |
| T _L | Lead Temperature (Soldering 10 sec) | | 260 | °C |

(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.

(2) All voltage values are with respect to ground.

ESD, Electrostatic Discharge Protection

| Parameter | | Condition | Minimum Level | Unit |
|-----------|--------------------------|---------------------------------------|---------------|------|
| HBM | Human Body Model ESD | ANSI/ESDA/JEDEC JS-001 ⁽¹⁾ | ±2000 | V |
| CDM | Charged Device Model ESD | ANSI/ESDA/JEDEC JS-002 ⁽²⁾ | ±1000 | V |

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

Recommended Operating Conditions

| Parameter | | Min | Typ | Max | Unit |
|------------------|----------------------------|-----|-----|-----|------|
| V _{IN} | | 3 | | 15 | V |
| I _{OUT} | | -10 | | 10 | mA |
| C _{OUT} | | 0.1 | 10 | 100 | μF |
| T _J | Junction Temperature Range | -40 | | 125 | °C |

Thermal Information

| Package Type | θ _{JA} | θ _{JC,top} | θ _{JB} | θ _{JC,bottom} | Unit |
|--------------|-----------------|---------------------|-----------------|------------------------|------|
| SOP8 | 115.2 | 60.8 | 61.1 | 64.2 | °C/W |
| MSOP8 | 138.0 | 54.6 | 84.5 | 88.1 | °C/W |

Electrical Characteristics

All test condition is at $T_A = 25^\circ\text{C}$. $V_{IN} = V_{OUT(NOM)} + 0.5\text{ V}$ or 5 V , whichever is grater, $C_{OUT} = 1\ \mu\text{F}$, unless otherwise noted.

| Parameter | | Conditions | Min | Typ | Max | Unit |
|---|-------------------------------------|---|--------------------|-------|-----------------------------|-----------------------|
| Output Voltage | | | | | | |
| V_{OUT} | Output Voltage | TPR5012 | | 1.25 | | V |
| | | TPR5020 | | 2.048 | | V |
| | | TPR5025 | | 2.5 | | V |
| | | TPR5030 | | 3 | | V |
| | | TPR5033 | | 3.3 | | V |
| | | TPR5040 | | 4.096 | | V |
| | | TPR5045 | | 4.5 | | V |
| | | TPR5050 | | 5 | | V |
| | Initial Accuracy | | -0.05% | | +0.05% | |
| Output Noise | $f = 0.1\text{ Hz to }10\text{ Hz}$ | | 3 | | $\mu\text{V}_{PP}/\text{V}$ | |
| Input Voltage and Current | | | | | | |
| V_{IN} | Input Voltage | | $V_{IN,MIN}^{(1)}$ | | 15 | V |
| I_Q | Quiescent Current | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | 0.6 | 1 | mA |
| Dropout Voltage | | | | | | |
| V_{DO} | Dropout Voltage ⁽²⁾ | $I_{OUT} = \pm 5\text{ mA}$, $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | | 200 | mV |
| | | $I_{OUT} = \pm 10\text{ mA}$, $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | | 400 | mV |
| Output Voltage Temperature Drift | | | | | | |
| TC | Temperature Coefficient | $T_A = 0\text{ to }70^\circ\text{C}$ | | 1 | | ppm/ $^\circ\text{C}$ |
| | | $T_A = -40^\circ\text{C to }105^\circ\text{C}$ | | 2 | 5 | ppm/ $^\circ\text{C}$ |
| | | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | 2.5 | 6 | ppm/ $^\circ\text{C}$ |
| Outout Regulation | | | | | | |
| $\frac{\Delta V_{OUT}}{\Delta V_{IN}}$ | Line Regulation | $V_{IN} = V_{IN,MIN}$ to 15 V , $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | 0.1 | | ppm/V |
| | | $V_{IN} = 6\text{ V to }15\text{ V}$, $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | 0.1 | | ppm/V |
| | | $V_{IN} = V_{IN,MIN}$ to 6 V , $V_{OUT} = 1.25\text{ V}$, 2.048 V , 2.5 V and 3 V , $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | | 20 | ppm/V |
| | | $V_{IN} = V_{IN,MIN}$ to 6 V , $V_{OUT} = 3.3\text{ V}$ and 4.096 V , $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | | 25 | ppm/V |
| $\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$ | Load Regulation | $V_{IN} = V_{IN,MIN}$, $-10\text{ mA} < I_{OUT} < 10\text{ mA}$ | | 2.5 | 20 | ppm/mA |
| | | $V_{IN} = V_{IN,MIN}$, $-10\text{ mA} < I_{OUT} < 10\text{ mA}$, $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | 2.5 | 20 | ppm/mA |

Low-Noise, Low-Drift, Precision Voltage Reference

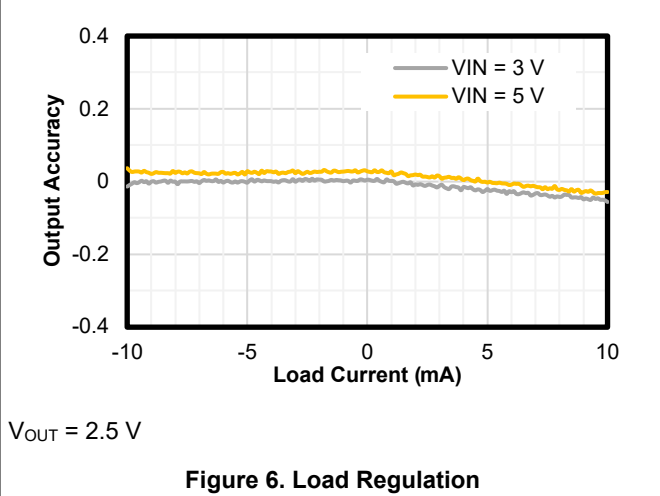
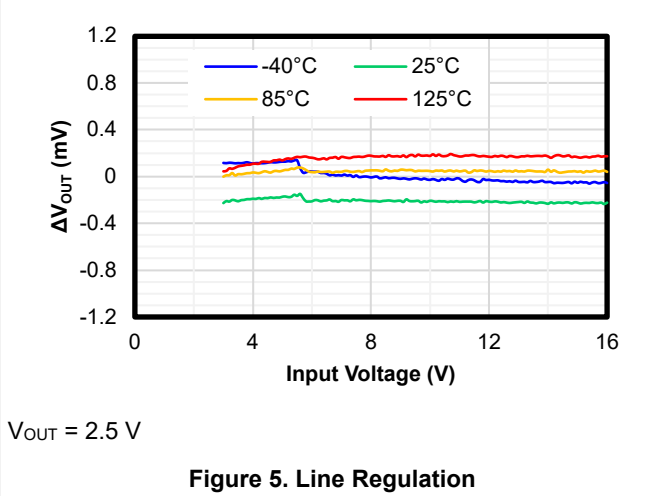
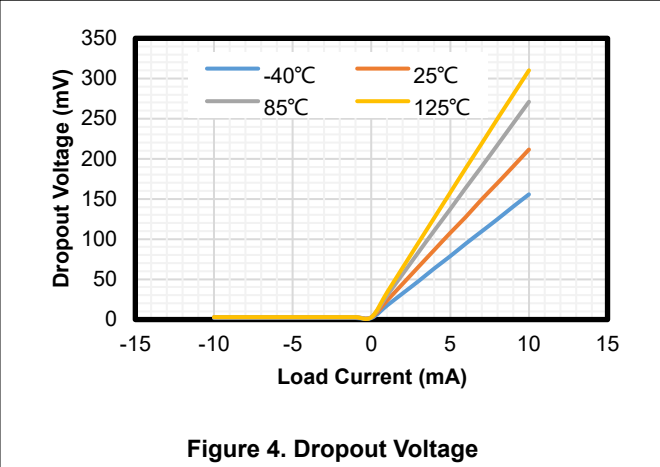
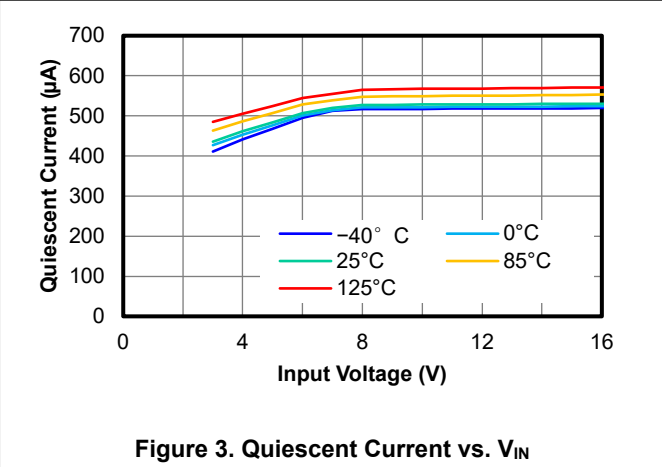
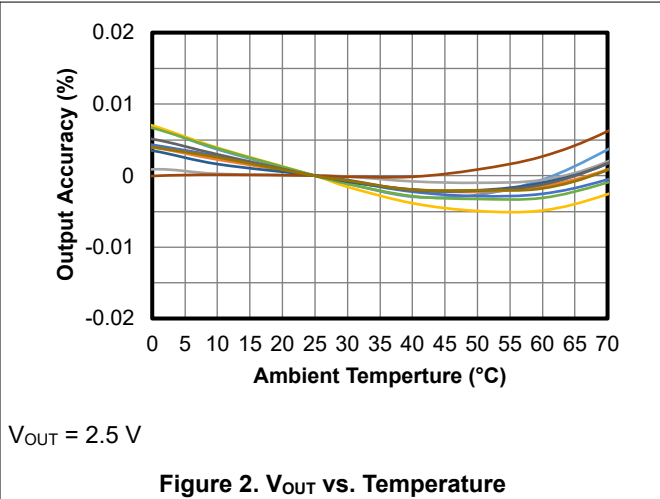
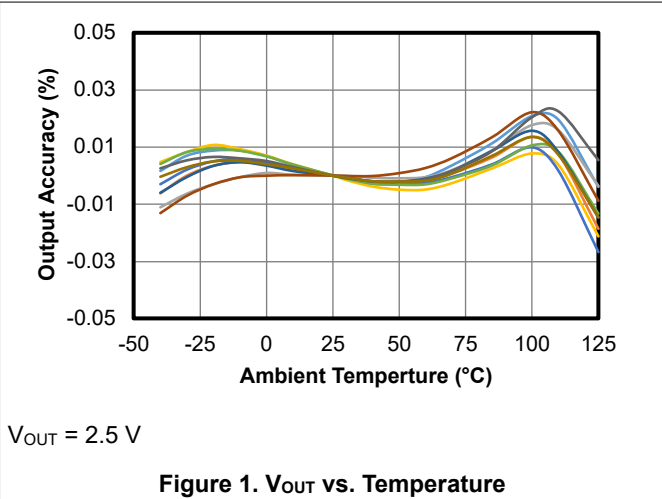
| Parameter | | Conditions | Min | Typ | Max | Unit |
|------------------------------|-----------------------|---|-----|-----|-----|------|
| Thermal Hysteresis | | | | | | |
| THYS | Thermal Hysteresis | Cycle 1 (+25°C to +125°C to -40°C to 25 °C) | | 99 | | ppm |
| | | Cycle 2 (+25°C to +125°C to -40°C to 25 °C) | | 29 | | ppm |
| | | Cycle 1 (+25°C to +70°C to 0°C to 25 °C) | | 56 | | ppm |
| | | Cycle 2 (+25°C to +70°C to 0°C to 25 °C) | | 11 | | ppm |
| Long-Term Stability | | | | | | |
| LTS | Long-Term Stability | 1000 hours, SOP8 Package | | 30 | | ppm |
| | | 2000 hours, SOP8 Package | | | | ppm |
| Turn-On Settling Time | | | | | | |
| t _{ON} | Turn-on Settling Time | To 0.1% with CL = 1 μF | | 150 | | μs |
| Short-Circuit Current | | | | | | |
| I _{SC} | Short-Circuit Current | V _{OUT} = 0 V | | 121 | | mA |
| Capacitive Load | | | | | | |
| C _L | | | 0.1 | | 100 | μF |

(1) $V_{IN,MIN} = V_{OUT(NOM)} + 0.4 \text{ V}$ or 3 V, whichever is greater.

(2) Dropout voltage is not tested for the output voltage below 3 V.

Typical Performance Characteristics

All test conditions: $V_{IN} = V_{OUT(NOM)} + 0.5\text{ V}$ or 3 V , whichever is greater; $I_{OUT} = 0\text{ mA}$, $C_{IN} = C_{OUT} = 1\text{ }\mu\text{F}$, $T_J = 25^\circ\text{C}$, unless otherwise noted.



Low-Noise, Low-Drift, Precision Voltage Reference

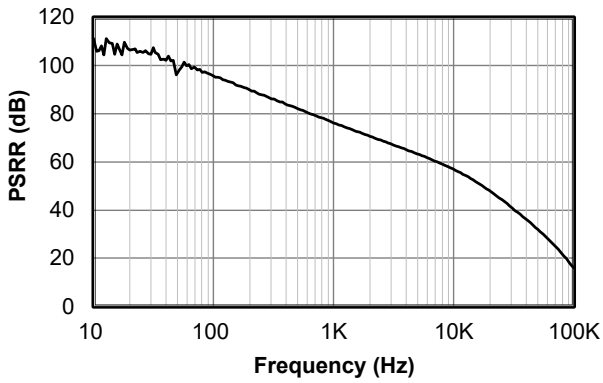


Figure 7. PSRR

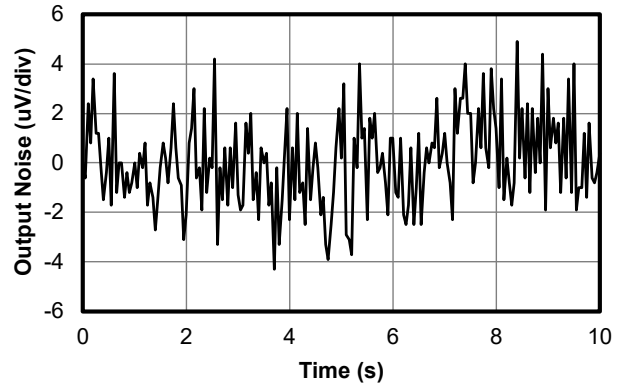
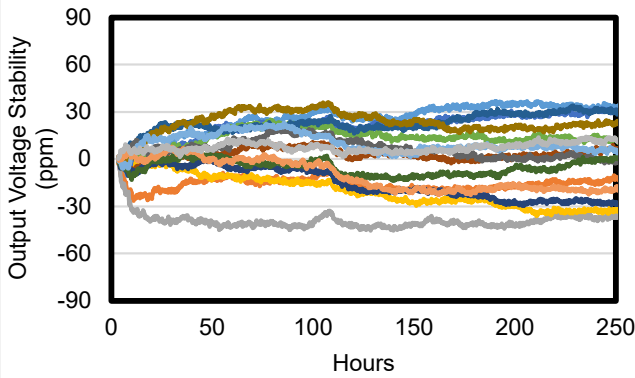
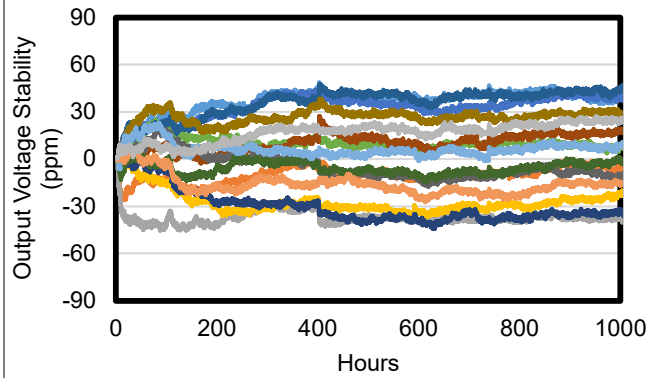


Figure 8. Noise



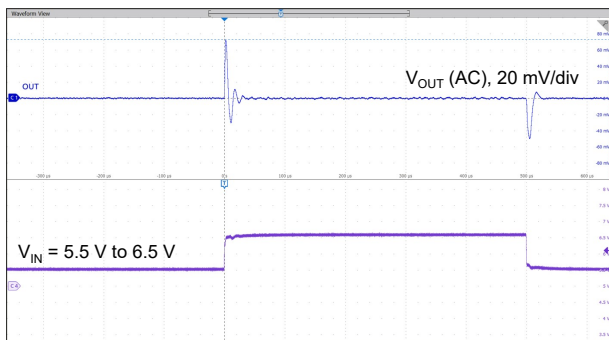
SOP8 Package

Figure 9. Long-Term Stability (First 250 Hours)



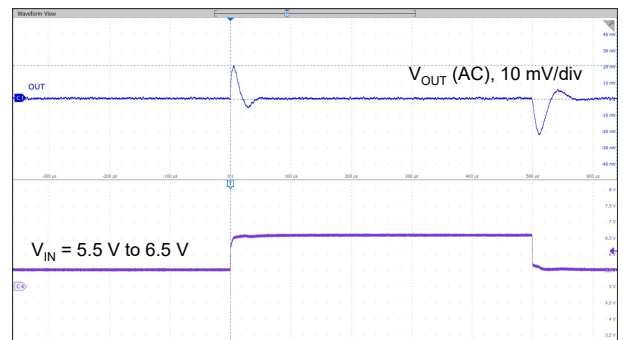
SOP8 Package

Figure 10. Long-Term Stability (First 1000 Hours)



$V_{IN} = 5.5\text{ V to }6.5\text{ V}$, $C_{OUT} = 1\ \mu\text{F}$

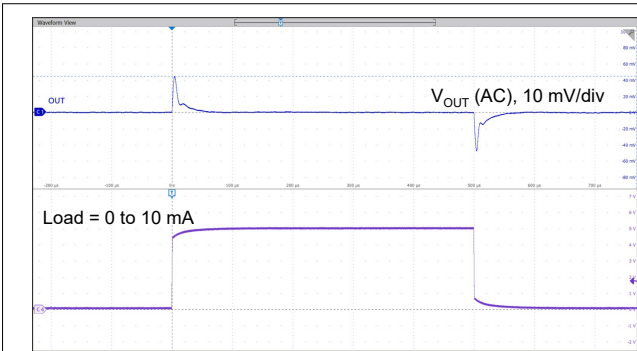
Figure 11. Line Transient



$V_{IN} = 5.5\text{ V to }6.5\text{ V}$, $C_{OUT} = 10\ \mu\text{F}$

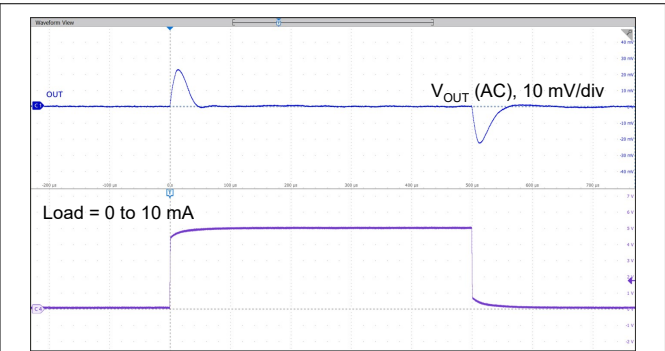
Figure 12. Line Transient

Low-Noise, Low-Drift, Precision Voltage Reference



Load = 0 to 10 mA, $C_{OUT} = 1 \mu F$

Figure 13. Load Transient



Load = 0 to 10 mA, $C_{OUT} = 10 \mu F$

Figure 14. Load Transient

Detailed Description

Overview

The TPR50 series is a family of high-precision and low-temperature-drift voltage references with 0.05% initial accuracy and 2.5 ppm/°C temperature coefficient. All products of the TPR50 series are able to support both sinking and sourcing current of ±10 mA and have a low dropout voltage.

The high precision and excellent temperature stability performance make the TPR50 series an ideal reference in the system with high resolution requirement.

Functional Block Diagram

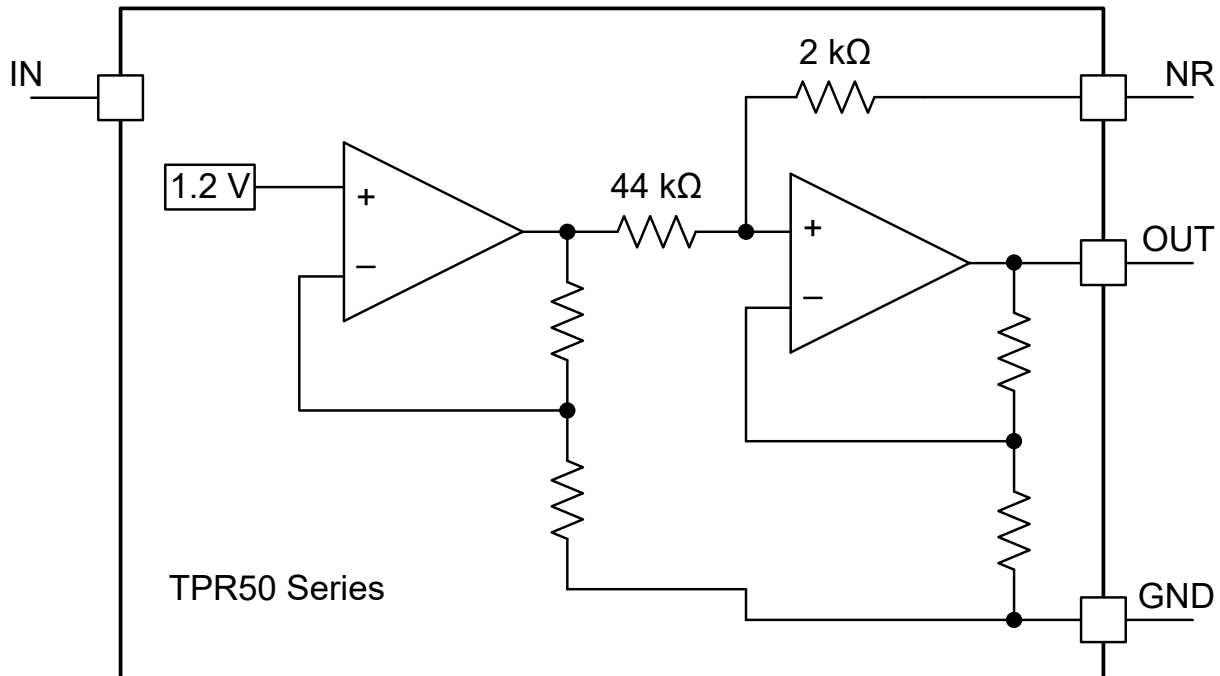


Figure 15. Functional Block Diagram

Feature Description

Temperature Drift

The TPR50 is one of the low-temperature-drift voltage references. Temperature drift is defined as the voltage variation over the operating temperature change, which can be calculated as [Equation 1](#).

$$\text{Temperature Drift} = \left(\frac{V_{\text{OUT,max}} - V_{\text{OUT,min}}}{V_{\text{OUT}}} \right) / (T_{\text{max}} - T_{\text{min}}) \times 10^6 \text{ (ppm/}^\circ\text{C)} \quad (1)$$

Where, $V_{\text{OUT,max}}$ and $V_{\text{OUT,min}}$ are the maximum and minimum voltage values during the temperature change, T_{max} and T_{min} are the temperature range, V_{OUT} is the nominal output voltage.

The maximum temperature drift of TPR50 is 6 ppm/°C from -40°C to 125°C.

Thermal Hysteresis

Thermal hysteresis is defined as the voltage change after the operating temperature cycling, which can be calculated as Equation 2.

$$\text{Thermal Hysteresis} = \frac{(V_{PRE} - V_{POST})}{V_{OUT}} \times 10^6 \text{ (ppm)} \tag{2}$$

Where, V_{PRE} is the output voltage before the temperature cycling and V_{POST} is the output voltage after the temperature cycling, V_{OUT} is the nominal output voltage.

Noise Reduction

The TPR50 features a low output noise voltage with a typically value of 8 μV_{PP} at $V_{NOM} = 2.5 \text{ V}$ under room temperature. The noise voltage is proportional to the output voltage and the operating temperature. The noise reduction (NR) pin provides additional filtering to reduce the output noise further, and it is recommended to connect a 10-nF or greater capacitor from the NR pin to ground.

Output Voltage Adjustment

The TPR50 provides a series of fixed output voltage with very high accuracy. Also, the TPR50 provides an NR/TR pin to trim the output voltage with external resistor dividers. Figure 16 shows a typical application circuit to adjust the output voltage.

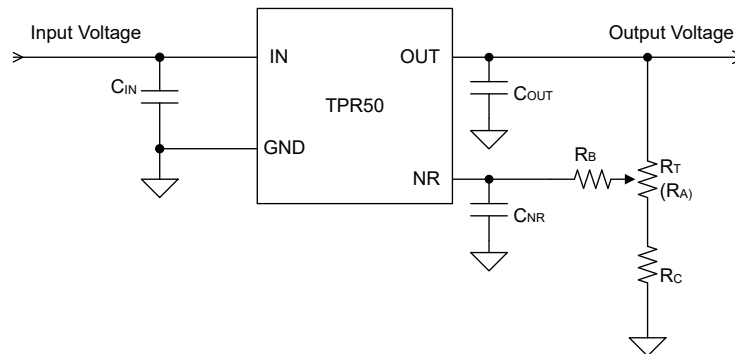


Figure 16. Output Voltage Trim with NR/TR Pin

Table 2 shows an example of 2.5-V output voltage adjustment.

Table 2. Output Voltage Trim Example of 2.5 V

| R_T (k Ω) | R_A (k Ω) | R_B (k Ω) | R_C (k Ω) | $V_{OUT,TROM}$ (V) |
|---------------------|---------------------|---------------------|---------------------|--------------------|
| 10 | 0 | 470 | 1 | 2.3249 |
| | 1 | | | 2.3619 |
| | 4.5 | | | 2.5000 |
| | 5.08 | | | 2.5244 |
| | 9 | | | 2.7036 |
| | 10 | | | 2.7540 |

(1) R_T is the total value of the rheostat, and R_A is the low-side value of the rheostat.

Application and Implementation

Note

Information in the following application sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

Application Information

The TPR50 series is a family of high-precision and low-temperature-drift voltage references with 0.05% initial accuracy and 2.5 ppm/°C temperature coefficient. All products of the TPR50 series are able to support both sinking and sourcing current of ±10 mA and have a low dropout voltage.

Typical Application

Figure 17 shows the typical application schematic.

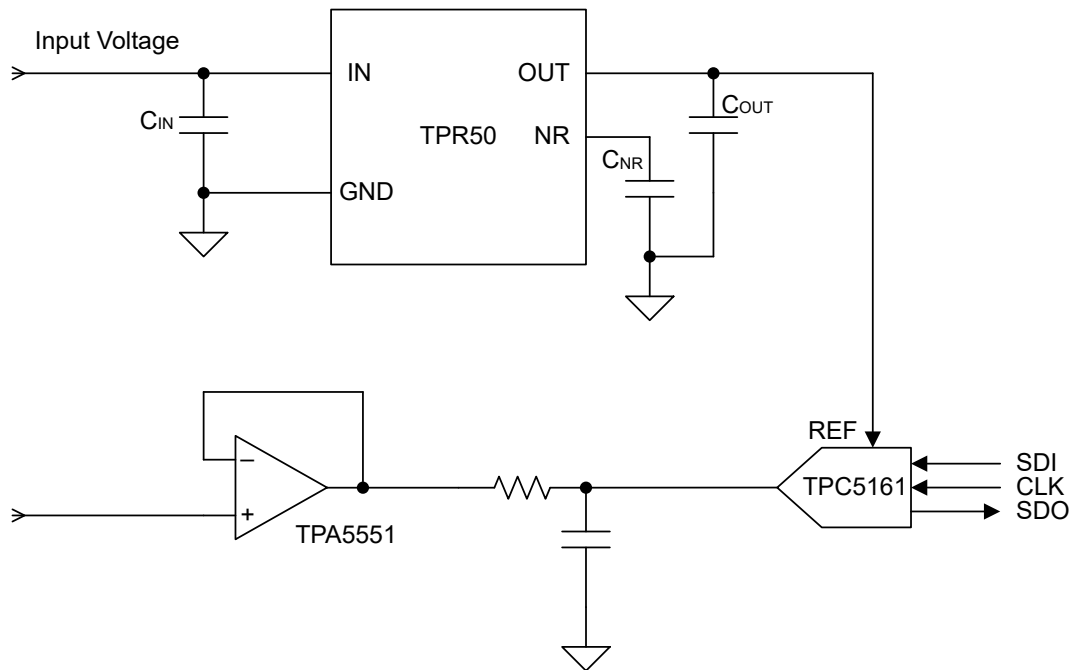


Figure 17. Typical Application Circuit

Power Dissipation and Thermal Consideration

During normal operation, the device junction temperature should meet the requirement in the [Recommended Operating Conditions](#) table. Use below equations to calculate the power dissipation and estimate the junction temperature.

The power dissipation can be calculated using [Equation 3](#).

Low-Noise, Low-Drift, Precision Voltage Reference

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} + V_{IN} \times I_Q \quad (3)$$

The junction temperature can be estimated using [Equation 4](#). θ_{JA} is the junction-to-ambient thermal resistance.

$$T_J = T_A + P_D \times \theta_{JA} \quad (4)$$

Layout

Layout Guideline

- Both input capacitors and output capacitors must be placed as close to the device pins as possible.
- It is recommended to bypass the IN pin to ground with a 1- μ F to 10- μ F capacitor in parallel with a 0.1- μ F small ceramic capacitor. The loop area formed by the bypass capacitor connection, the IN pin, and the GND pin of the system must be as small as possible.
- It is required to place a decoupling 1- μ F to 50- μ F capacitor at the output. A small 1- μ F ceramic capacitor in parallel is recommended to filter the noise and improve the output transient performance.

Layout Example

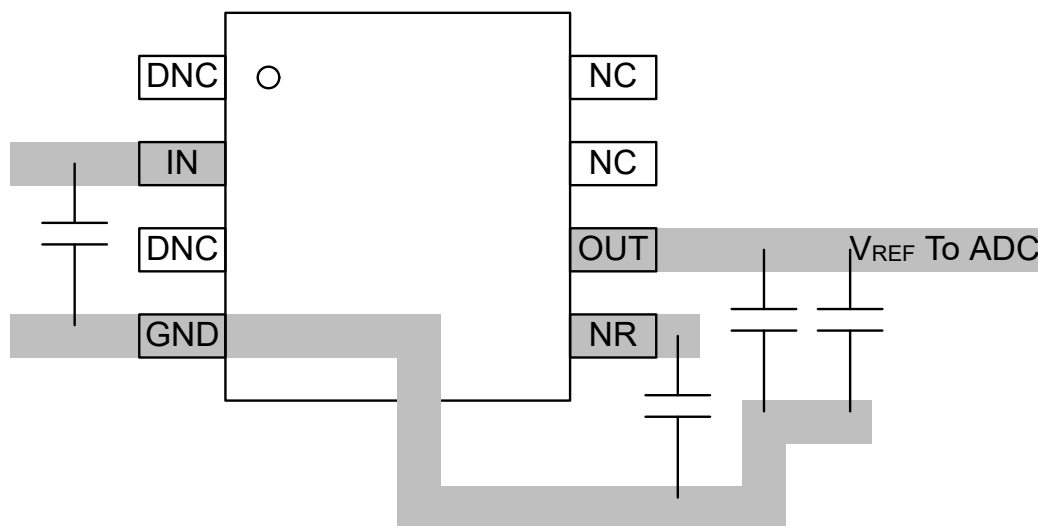
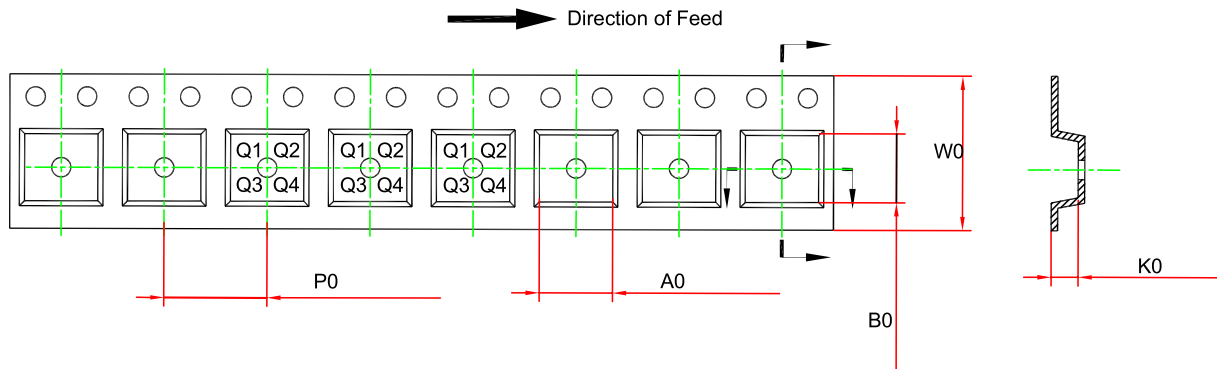
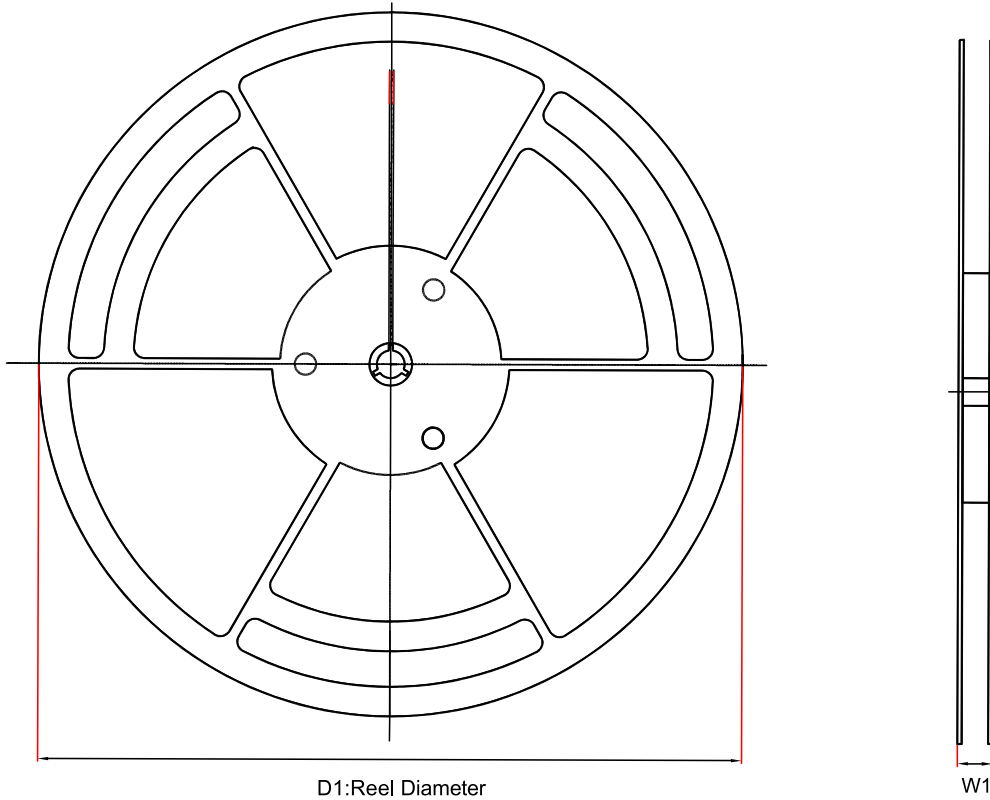


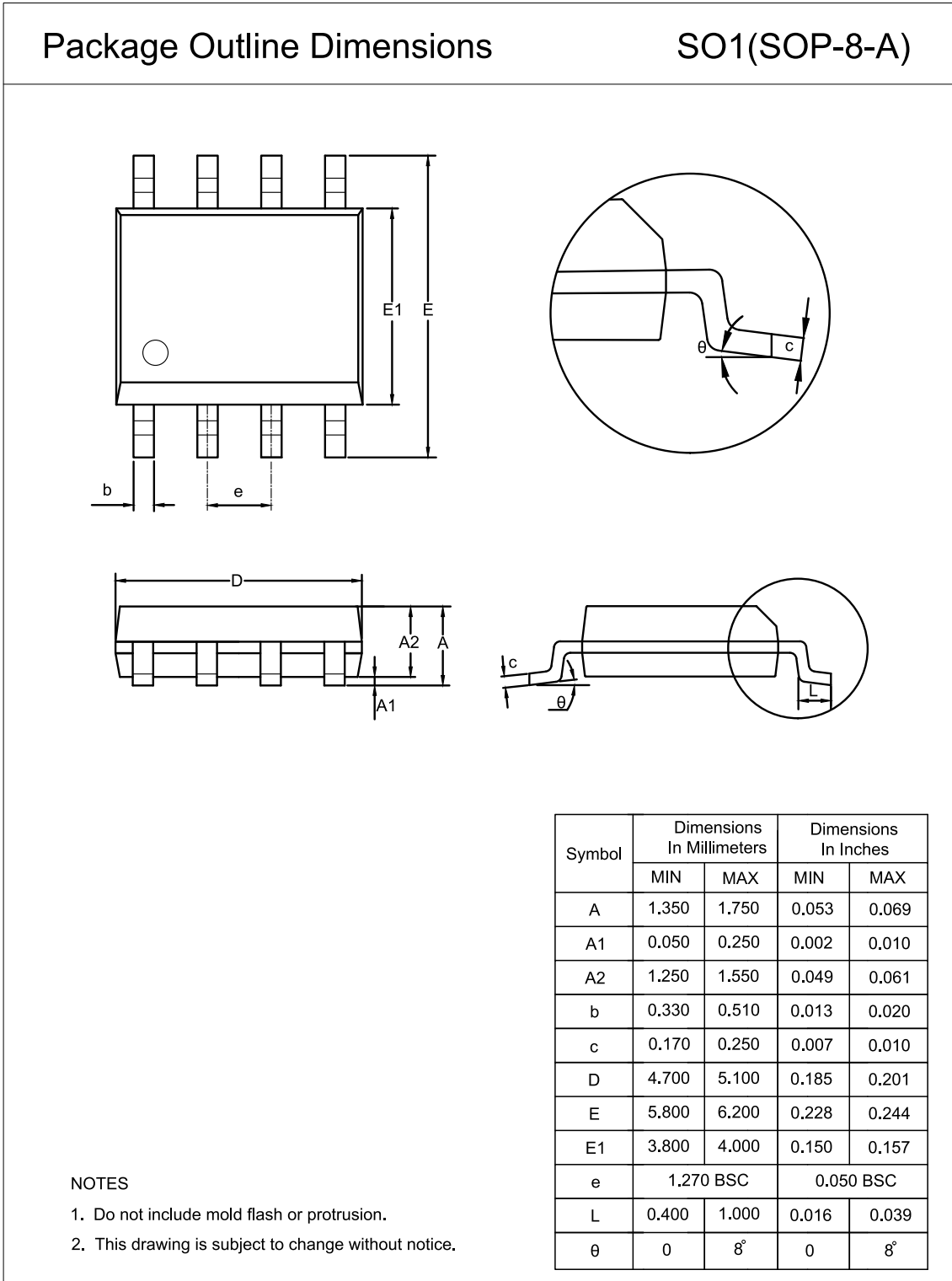
Figure 18. Layout Example

Tape and Reel Information



| Order Number | Package | D1 (mm) | W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P0 (mm) | W0 (mm) | Pin1 Quadrant |
|-------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------------|
| TPR50xx-SO1R ⁽¹⁾ | SOP8 | 330 | 17.6 | 6.4 | 5.4 | 2.1 | 8 | 12 | Q1 |
| TPR50xx-VS1R-S ⁽¹⁾ | MSOP8 | 330 | 17.6 | 5.2 | 3.3 | 1.5 | 8 | 12 | Q1 |

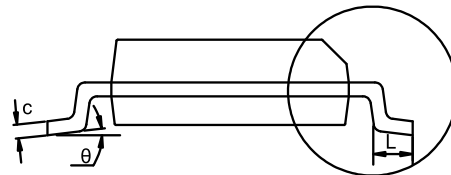
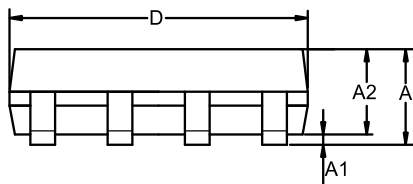
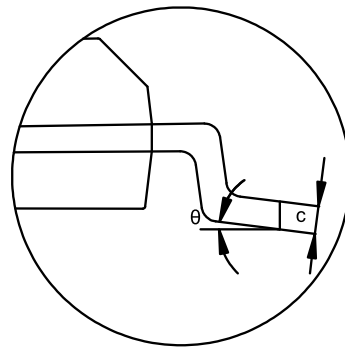
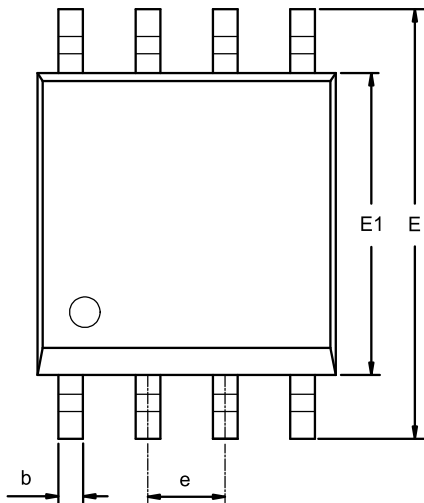
(1) Output voltage value, xx = 12 to 50. For example, 25 means output voltage of 2.5 V.

Package Outline Dimensions
SOP8


MSOP8

Package Outline Dimensions

VS1(MSOP-8-A)



| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|----------|------------------------------|-------|-------------------------|-------|
| | MIN | MAX | MIN | MAX |
| A | 0.800 | 1.100 | 0.031 | 0.043 |
| A1 | 0.020 | 0.150 | 0.001 | 0.006 |
| A2 | 0.750 | 0.950 | 0.030 | 0.037 |
| b | 0.250 | 0.380 | 0.010 | 0.015 |
| c | 0.090 | 0.230 | 0.004 | 0.009 |
| D | 2.900 | 3.100 | 0.114 | 0.122 |
| E | 4.700 | 5.100 | 0.185 | 0.201 |
| E1 | 2.900 | 3.100 | 0.114 | 0.122 |
| e | 0.650 BSC | | 0.026 BSC | |
| L | 0.400 | 0.800 | 0.016 | 0.031 |
| θ | 0 | 8° | 0 | 8° |

NOTES

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

Order Information

| Order Number | Operating Temperature Range | Package | Marking Information | MSL | Transport Media, Quantity | Eco Plan |
|----------------|-----------------------------|---------|---------------------|------|---------------------------|----------|
| TPR5012-SO1R | -40°C to +125°C | SOP8 | R5A | MSL3 | 4,000 | Green |
| TPR5020-SO1R | -40°C to +125°C | SOP8 | R5B | MSL3 | 4,000 | Green |
| TPR5025-SO1R | -40°C to +125°C | SOP8 | R5C | MSL3 | 4,000 | Green |
| TPR5030-SO1R | -40°C to +125°C | SOP8 | R5D | MSL3 | 4,000 | Green |
| TPR5033-SO1R | -40°C to +125°C | SOP8 | R5E | MSL3 | 4,000 | Green |
| TPR5040-SO1R | -40°C to +125°C | SOP8 | R5F | MSL3 | 4,000 | Green |
| TPR5045-SO1R | -40°C to +125°C | SOP8 | R5H | MSL3 | 4,000 | Green |
| TPR5050-SO1R | -40°C to +125°C | SOP8 | R5G | MSL3 | 4,000 | Green |
| TPR5012-VS1R-S | -40°C to +125°C | MSOP8 | R5A | MSL3 | 3,000 | Green |
| TPR5020-VS1R-S | -40°C to +125°C | MSOP8 | R5B | MSL3 | 3,000 | Green |
| TPR5025-VS1R-S | -40°C to +125°C | MSOP8 | R5C | MSL3 | 3,000 | Green |
| TPR5030-VS1R-S | -40°C to +125°C | MSOP8 | R5D | MSL3 | 3,000 | Green |
| TPR5033-VS1R-S | -40°C to +125°C | MSOP8 | R5E | MSL3 | 3,000 | Green |
| TPR5040-VS1R-S | -40°C to +125°C | MSOP8 | R5F | MSL3 | 3,000 | Green |
| TPR5045-VS1R-S | -40°C to +125°C | MSOP8 | R5H | MSL3 | 3,000 | Green |
| TPR5050-VS1R-S | -40°C to +125°C | MSOP8 | R5G | MSL3 | 3,000 | Green |

(1) **Green:** 3PEAK defines "Green" to mean RoHS compatible and free of halogen substances.

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