Low-Noise, Low-Drift, Precision Voltage Reference

Features

- Wide Input Voltage Range:
  - 7.5 V to 15 V
- Fixed Output Voltage:
  - 2.048 V, 2.5 V, 3 V, 3.3 V, 4.096 V, 5 V, and 10 V
- Low-Temperature Coefficient:
  - 2.5 ppm/°C Typical from 0°C to 70°C
  - 1 ppm/°C Typical from −40°C to 125°C
- High Initial Accuracy:
  - 0.05% Maximum
- Low Noise:
  - 1 μVpp/V
- Temperature Range: −40°C to 125°C
- Package: SOP8

Applications

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

Description

The TPR70 series is a family of high-precision and low-temperature-drift voltage references with an accuracy of 0.05%, and a temperature coefficient of 1.5 ppm/°C. All products of the TPR70 series can support both sinking and souring currents of ±10 mA and have a low dropout voltage.

The high precision and excellent temperature stability performance make the TPR70 series an ideal reference in a system with high-resolution requirements.

The TPR70 series provides an SOP8 package. All the products are qualified to operate within the temperature range from –40°C to +125°C.

Typical Application Circuit

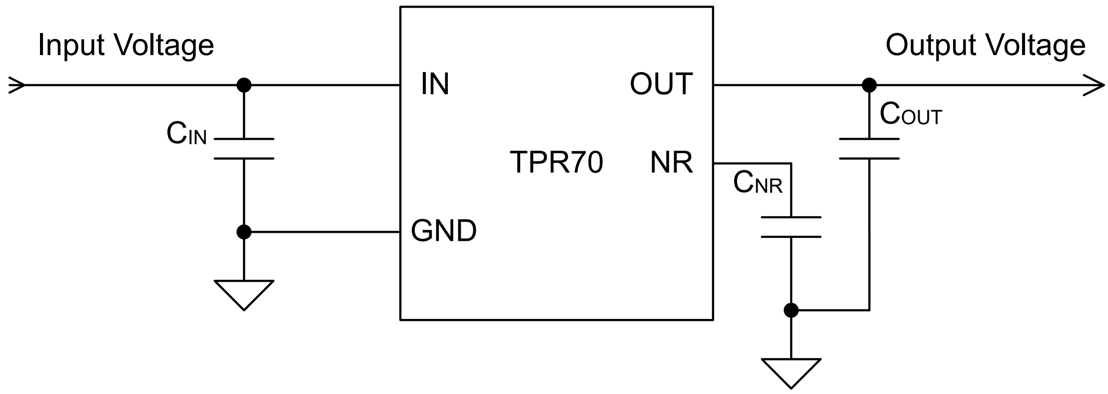


Table of Contents

Product Family Table

Order Number	Output Voltage	Package
TPR7020-SO1R (1)	2.048 V	SOP8
TPR7025-SO1R	2.5 V	SOP8
TPR7030-SO1R (1)	3.0 V	SOP8
TPR7033-SO1R (1)	3.3 V	SOP8
TPR7040-SO1R	4.096 V	SOP8
TPR7050-SO1R	5.0 V	SOP8
TPR70A0-SO1R	10.0 V	SOP8

(1) Preview

Revision History

Date	Revision	Notes
2023-07-15	Rev.Pre.0	Preliminary version.
2023-12-10	Rev.A.0	Initial released.
2024-05-17	Rev.A.1	1. Added a 10-V output voltage option. 2. Corrected the Marking Information in Order Information.
2024-09-30	Rev.A.2	1. Added the test conditions of 10-V output voltage. 2. Corrected the name of Pin 5.

Pin Configuration and Functions

TPR70 Series
SOP8 Package
Top View

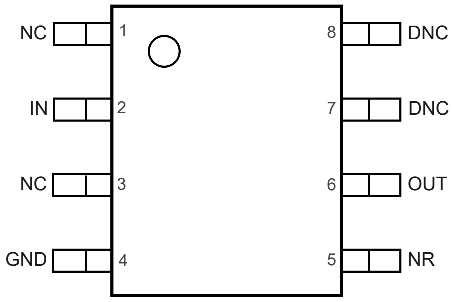


Table 1. Pin Functions: TPR70

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

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)	±1500	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}		7.5		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	61	61	64	°C/W

Electrical Characteristics

All test condition is at T_A = 25°C. V_{IN} = 7.5 V for V_{OUT} ≤ 5 V and V_{IN} = 12 V for V_{OUT} = 10 V, C_{IN} = C_{OUT} = 1 μF, unless otherwise noted.

Parameter		Conditions	Min	Typ	Max	Unit
Output Voltage						
V_{OUT}	Output Voltage	TPR7020		2.048		V
		TPR7025		2.5		V
		TPR7030		3		V
		TPR7033		3.3		V
		TPR7040		4.096		V
		TPR7050		5		V
		TPR70A0		10		V
	Initial Accuracy		−0.05%		+0.05%	
	Output Noise	f = 0.1 Hz to 10 Hz		1		$\mu V_{PP}/V$
Input Voltage and Current						
V_{IN}	Input Voltage		7.5		15	V
I_Q	Quiescent Current	T_A= –40°C to 125°C		0.6	1.7	mA
Output Voltage Temperature Drift						
TC	Temperature Coefficient	T_A = 0 to 70°C		2.5	5	ppm/°C
		T_A = −40°C to 125°C		1.5	3	ppm/°C
Output Regulation						
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation for V_{OUT} ≤ 5 V	V_{IN} = 7.5 V to 10 V		0.1		ppm/V
		V_{IN} = 7.5 V to 10 V, T_A = −40°C to 125°C	−5		5	ppm/V
	Line Regulation for V_{OUT} = 10 V	V_{IN} = 12 V to 15 V		1.9		ppm/V
		V_{IN} = 12 V to 15 V, T_A = −40°C to 125°C	−5		5	ppm/V
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation for V_{OUT} ≤ 5 V	V_{IN} = 7.5 V, −10 mA < I_{OUT} < 10 mA		2.5		ppm/mA
		V_{IN} = 7.5 V, −10 mA < I_{OUT} < 10 mA, T_A = −40°C to 125°C	−20		20	ppm/mA
	Load Regulation for V_{OUT} = 10 V	V_{IN} = 12 V, −10 mA < I_{OUT} < 10 mA		2.5		ppm/mA
		V_{IN} = 12 V, −10 mA < I_{OUT} < 10 mA, T_A = −40°C to 125°C	−20		20	ppm/mA
Thermal Hysteresis						
THYS	Thermal Hysteresis	Cycle 1 (+25°C to +125°C to −40°C to 25 °C)		24.4		ppm
		Cycle 2 (+25°C to +125°C to −40°C to 25 °C)		2.3		ppm

Parameter		Conditions	Min	Typ	Max	Unit
		Cycle 1 (+25°C to +70°C to 0°C to 25 °C)		10.4		ppm
		Cycle 2 (+25°C to +70°C to 0°C to 25 °C)		2.0		ppm
Long-Term Stability						
LTS	Long-Term Stability	1000 hours		10		ppm
		2000 hours				ppm
Turn-On Settling Time						
t_{ON}	Turn-on Settling Time	C_{OUT} = 1 μF		100		μs
Capacitive Load						
C_{OUT}			0.1		100	μF

Typical Performance Characteristics

All test conditions: V_{IN} = 7.5 V, V_{OUT} = 2.5 V, I_{OUT} = 0 mA, C_{IN} = C_{OUT} = 1 µF, T_J = 25°C, unless otherwise noted.

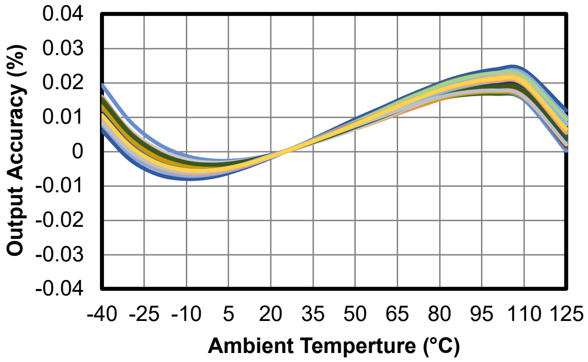


Figure 1. V_{OUT} vs. Temperature

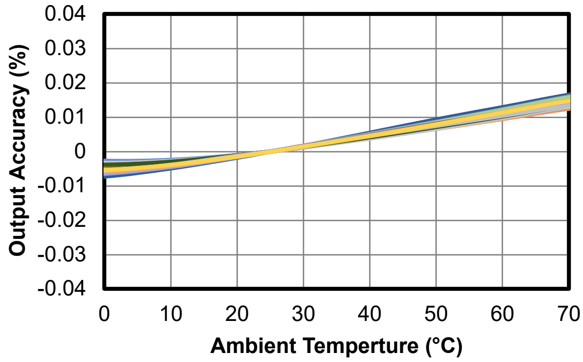


Figure 2. V_{OUT} vs. Temperature

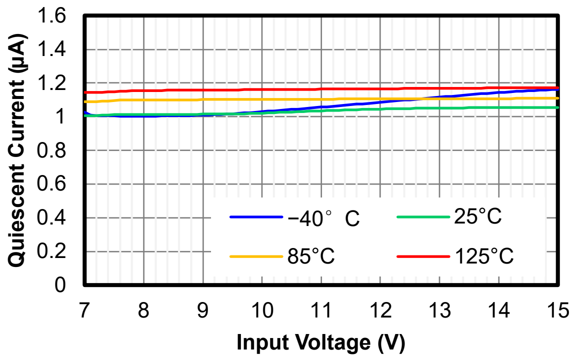


Figure 3. Quiescent Current vs. V_{IN}

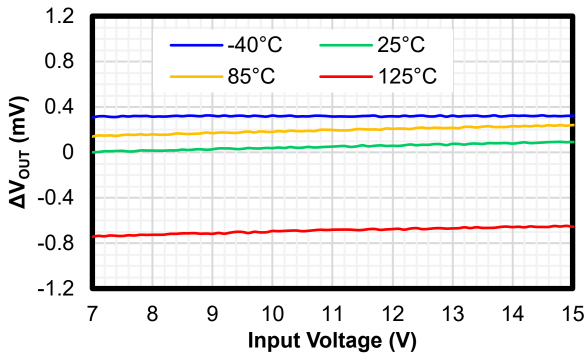


Figure 4. Line Regulation

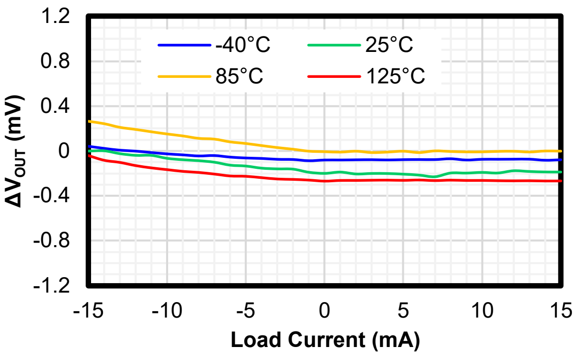


Figure 5. Load Regulation

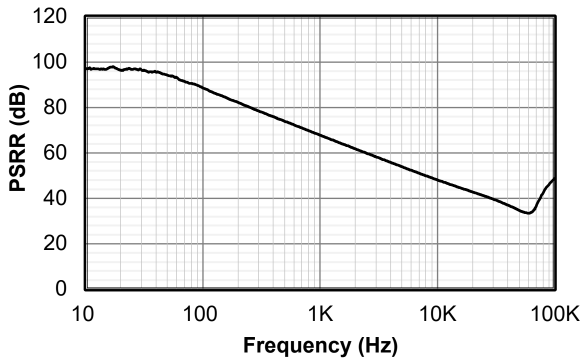


Figure 6. PSRR

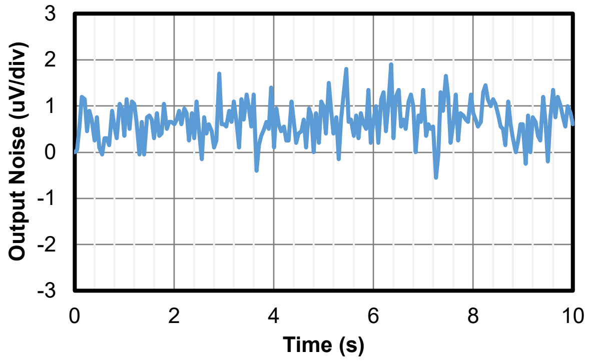


Figure 7. Noise

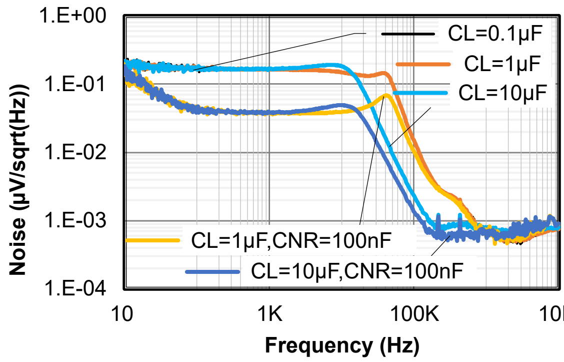
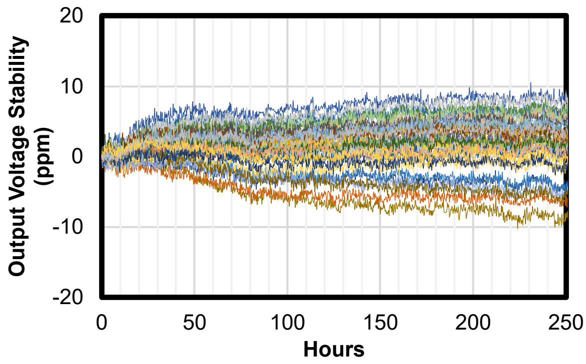
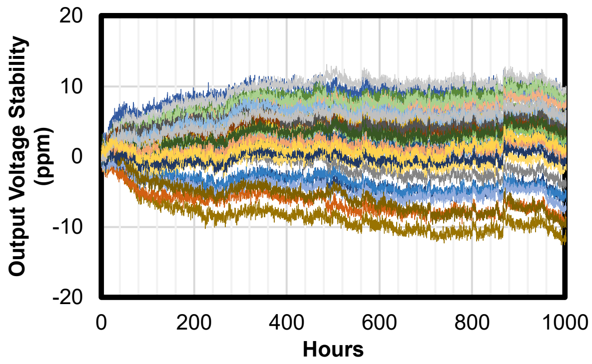


Figure 8. Noise



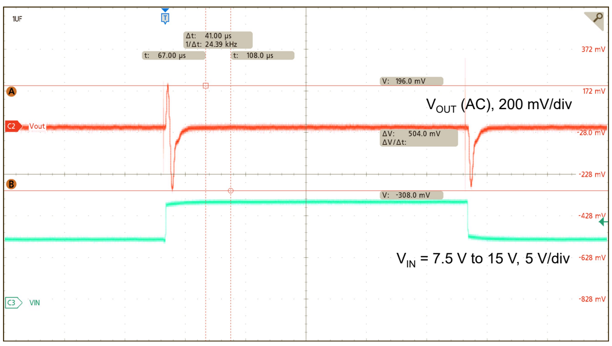
Sample Number: 40

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



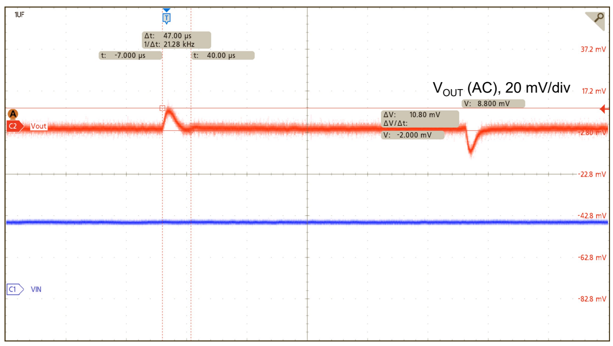
Sample Number: 40

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



V_{IN} = 7.5 V to 15 V, C_{OUT} = 1 µF

Figure 11. Line Transient



Load = 0 to 10 mA, C_{OUT} = 1 µF

Figure 12. Load Transient

Detailed Description

Overview

The TPR70 series is a family of high-precision and low-temperature-drift voltage references with an initial accuracy of 0.05% and a temperature coefficient of 1.5 ppm/°C. All products of the TPR70 series can support both sinking and souring currents of ±10 mA and have a low dropout voltage.

The high precision and excellent temperature stability performance make the TPR70 series an ideal reference in a system with high-resolution requirements.

Functional Block Diagram

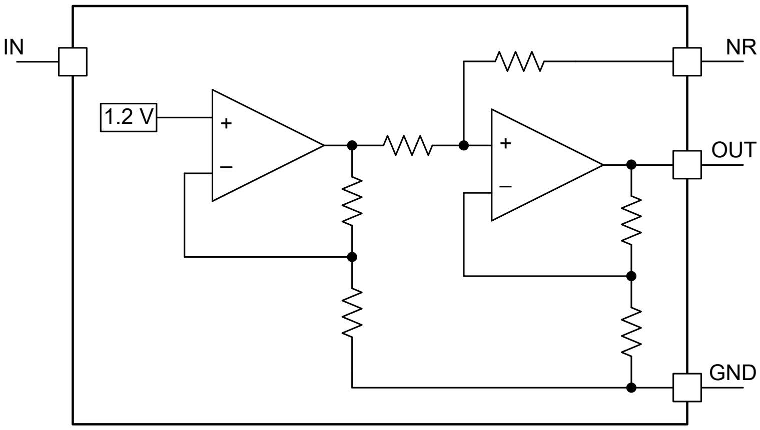


Figure 13. Functional Block Diagram

Feature Description

Temperature Drift

The TPR70 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.

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

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

The maximum temperature drift of the TPR70 is 3 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, V_{POST} is the output voltage after the temperature cycling, and V_{OUT} is the nominal output voltage.

Noise Reduction

The TPR70 features a low output noise voltage with a typical value of 2.5 μV_{PP} at V_{NOM} = 2.5 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 further reduce the output noise. It is recommended to connect a 10-nF or greater capacitor from the NR pin to ground.

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 TPR70 series is a family of high-precision and low-temperature-drift voltage references with an initial accuracy of 0.05% and a temperature coefficient of 1.5 ppm/°C. All products of the TPR70 series can support both sinking and souring currents of ±10 mA and have a low dropout voltage.

Typical Application

Figure 14 shows the typical application schematic.

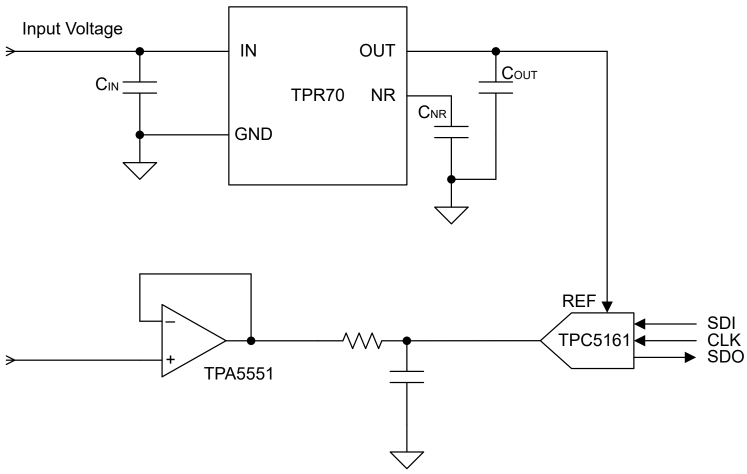


Figure 14. Typical Application Circuit

Power Dissipation and Thermal Consideration

During normal operation, the device junction temperature should meet the requirements in the Recommended Operating Conditions table. Use the equations below to calculate the power dissipation and estimate the junction temperature.

The power dissipation can be calculated using Equation 3.

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

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 and output capacitors must be placed as close to the pins of the device as possible.
- It is recommended to bypass the IN pin to ground with a 1-µF to 10-µF capacitor in parallel with a 0.1-µF 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-µF to 50-µF capacitor at the output. A small 1-µF ceramic capacitor in parallel is recommended to filter the noise and improve the output transient performance.

Layout Example

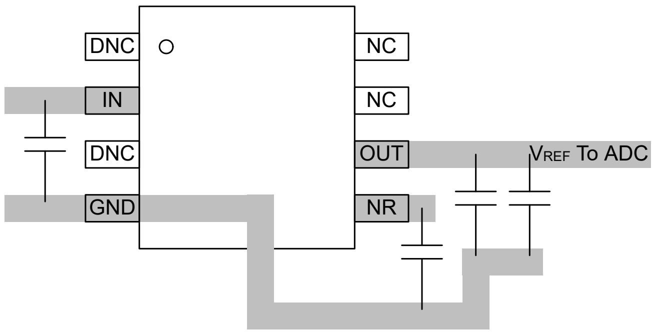
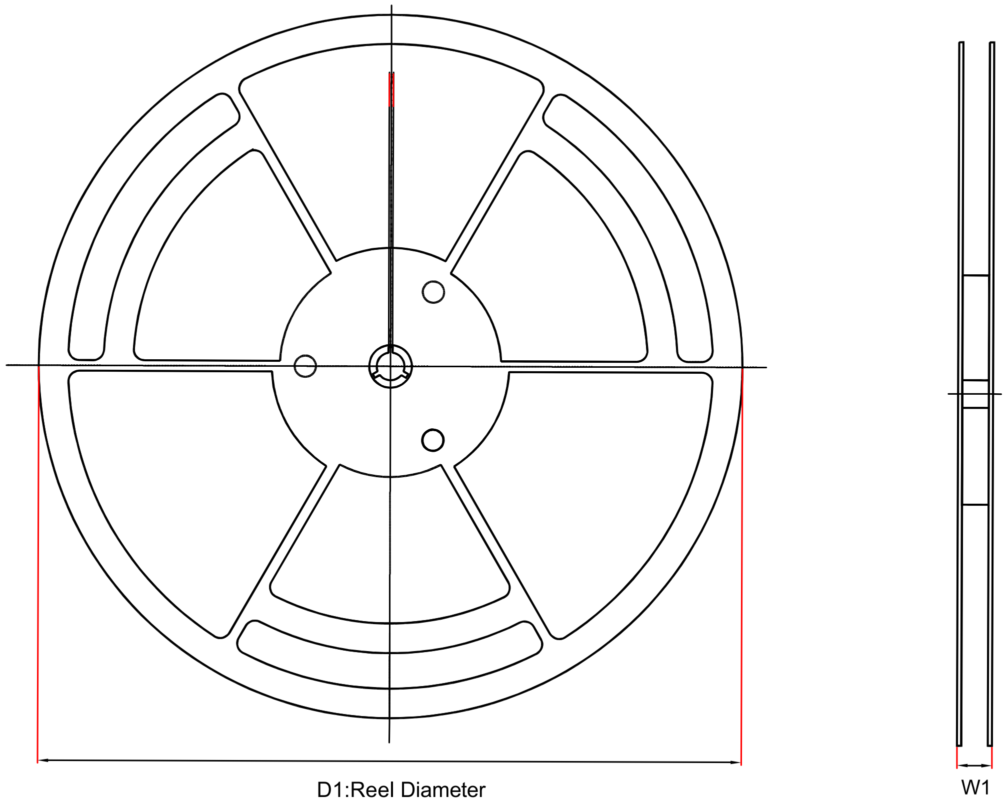
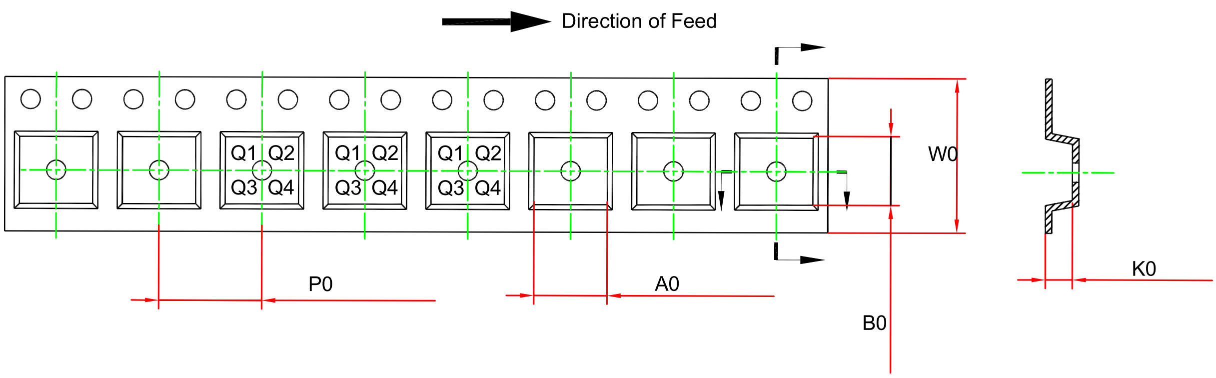


Figure 15. Layout Example

Tape and Reel Information





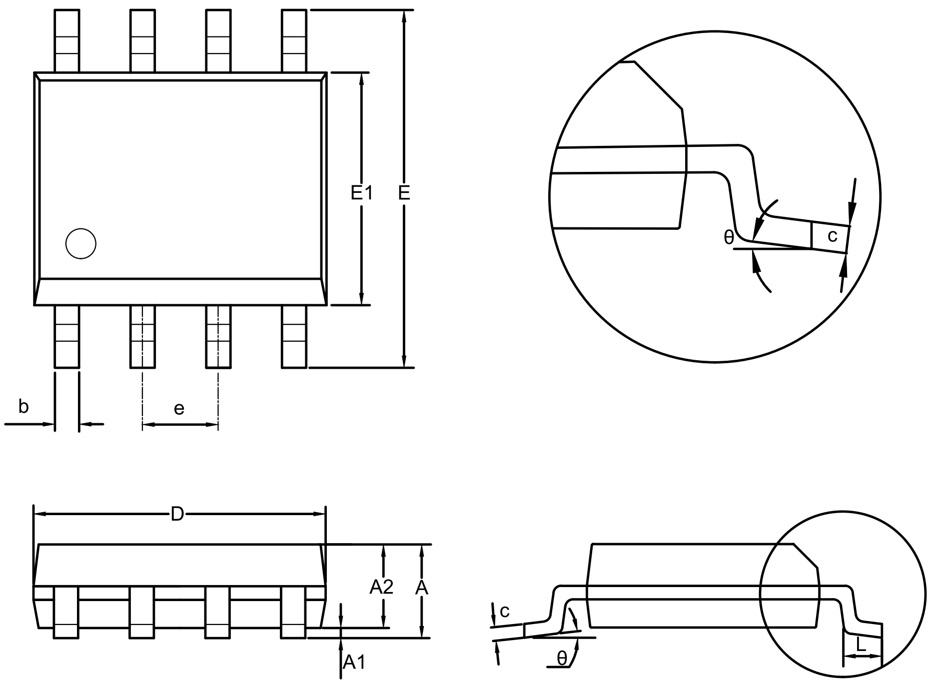
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPR7020-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
TPR7025-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
TPR7030-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
TPR7033-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
TPR7040-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
TPR7050-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1

Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPR70A0-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1

Package Outline Dimensions

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.

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPR7020-SO1R (1)	−40°C to +125°C	SOP8	R70B	MSL3	Tape and Reel, 4000	Green
TPR7025-SO1R	−40°C to +125°C	SOP8	R70C	MSL3	Tape and Reel, 4000	Green
TPR7030-SO1R (1)	−40°C to +125°C	SOP8	R70D	MSL3	Tape and Reel, 4000	Green
TPR7033-SO1R (1)	−40°C to +125°C	SOP8	R70E	MSL3	Tape and Reel, 4000	Green
TPR7040-SO1R	−40°C to +125°C	SOP8	R70F	MSL3	Tape and Reel, 4000	Green
TPR7050-SO1R	−40°C to +125°C	SOP8	R70G	MSL3	Tape and Reel, 4000	Green
TPR70A0-SO1R	−40°C to +125°C	SOP8	R70H	MSL3	Tape and Reel, 4000	Green

(1) For future products, contact the 3PEAK factory for more information and samples.

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

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