Precision Programmable Shunt Voltage Reference

Features

- Qualified for Automotive Applications
  - AEC-Q100 Grade 1, TA: −40°C to +125°C
- Reference Voltage Tolerance
  - 2.495 V Typically
  - 0.5% at 25°C
- Adjustable Output Voltage
  - V_{REF} to 36 V
- Low Output Noise
- Typical Output Impedance: 0.2-Ω
- Sink Current Capability: 1 mA to 80 mA
- Package: SOT23G-3

Applications

- Power Module
- LED Lighting
- Current Sensing System
- Instrumentation
- Industrial Control

Description

The TPR433Q and the TPR434Q are 3-terminal adjustable shunt voltage references. The output voltage of both devices can be set to any value within the range from V_{REF} to 36 V with an external feedback resistor network.

The TPR433Q and the TPR434Q have the same electrical performance and the same package but different pin orders. The device provides a 0.2-Ω output impedance and a quick turn-on characteristic, making it an excellent replacement for ordinary Zener diode in many applications.

The TPR433Q and the TPR434Q support a wide output current range from 1 to 80 mA with a SOT23G-3 package. Both devices are qualified with an operating temperature range from −40°C up to +125°C.

Typical Application Circuit

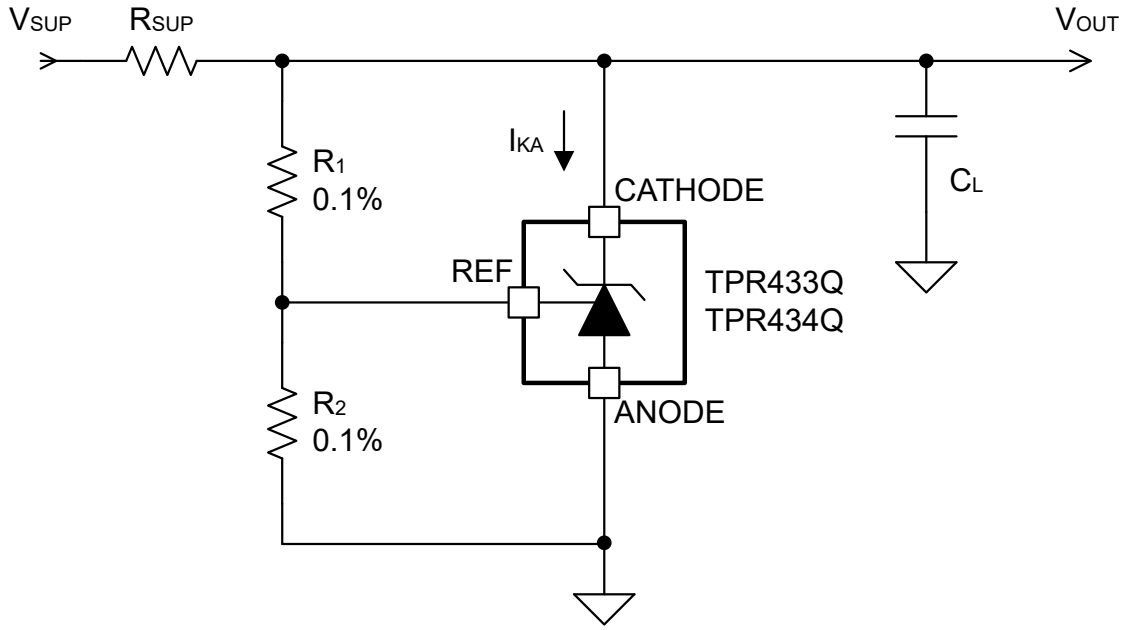


Table of Contents

Product Family Table

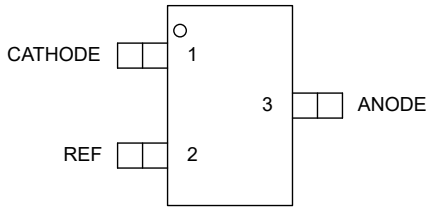
Order Number	Output Voltage	Package
TPR433BQ-3STR-S	0.5%	SOT23G-3
TPR434BQ-3STR-S	0.5%	SOT23G-3

Revision History

Date	Revision	Notes
2024-12-30	Rev.Pre.0	Preliminary revision.
2025-3-25	Rev.A.0	Initial released.

Pin Configuration and Functions

TPR433Q
SOT23G-3 Package
Top View



TPR434Q
SOT23G-3 Package
Top View

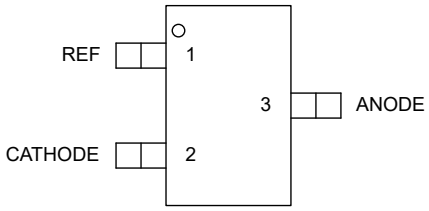


Table 1. Pin Functions: TPR433Q and TPR434Q

Pin No.		Name	I/O	Description
TPR433Q	TPR434Q			
3	3	ANODE	O	Common ANODE pin. Suggest connecting this pin to the ground directly.
1	2	CATHODE	I/O	CATHODE pin. The input of the shunt current/voltage.
2	1	REF	I	REF threshold pin.

Specifications

Absolute Maximum Ratings (1)

Parameter		Min	Max	Unit
CATHODE Voltage (2)			37	V
Continuous CATHODE Current		−100	150	mA
Reference Input Current			10	mA
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) Voltage values are with respect to ANODE, unless other noted.

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	Max	Unit
V_{KA}	CATHODE Voltage	V_{REF}	36	V
I_{KA}	CATHODE Current	1	80	mA
T_J	Junction Temperature Range	−40	125	°C

Thermal Information

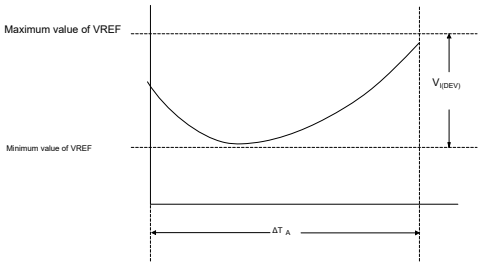
Package Type	θ_{JA}	θ_{JC}	Unit
SOT23G-3	189.9	151.3	°C/W

Electrical Characteristics

All test condition: T_A = +25°C, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{REF}	Reference Voltage	$V_{KA} = V_{REF}$, I_{KA} = 10 mA	2.483	2.495	2.507	V
$V_{I(DEV)}$	Reference Input Voltage Deviation over Temperature Range (1)	$V_{KA} = V_{REF}$, I_{KA} = 10 mA, T_A = −40 to 85°C		5	15	mV
		$V_{KA} = V_{REF}$, I_{KA} = 10 mA, T_A = −40 to 125°C		11	30	mV
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	Ratio of the Change in Reference Voltage to the Change in CATHODE Voltage	I_{KA} = 10 mA, V_{KA} = 10 V to V_{REF}	−1.5	0.3	1.5	mV/V
		I_{KA} = 10 mA, V_{KA} = 36 V to 10 V	−1	0.1	1	mV/V
I_{REF}	Reference Input Current	I_{KA} = 10 mA, R1 = 10 K, R2 Open		1.8	4	μA
$I_{I(DEV)}$	Reference Input Current Deviation over Temperature Range (1)	I_{KA} = 10 mA, R1 = 10 K, R2 Open, T_A = −40 to 125°C		0.1	1	μA
$I_{KA(MIN)}$	Minimum CATHODE Current for Regulation	$V_{KA} = V_{REF}$		0.4	0.6	mA
$I_{KA(OFF)}$	Off-State CATHODE Current	V_{KA} = 36 V, V_{REF} = 0 V		0.2	0.5	μA
		V_{KA} = 36 V, V_{REF} = 0 V, T_A = −40 to 125°C		0.2	1.5	μA
$\lvert Z_{KA} \rvert$	Dynamic Output Impedance (1)	$V_{KA} = V_{REF}$, f <= 1 kHz, I_{KA} = 1 mA to 80 mA		0.2	2.6	Ω

(1) The deviation parameters $V_{I(DEV)}$ and $I_{I(DEV)}$ are defined as the differences between the minimum value and the maximum value obtained over the temperature range. The average full-range temperature coefficient of the reference input voltage α_{VREF} is defined as $\lvert\alpha_{VREF}\rvert\left(\frac{ppm}{°C}\right) = \frac{V_{I(DEV)}/V_{REF,\,25°C}}{\Delta T_A} \times 10^6$. Where, $V_{REF,25°C}$ is the typical value at room temperature of 25°C, ΔT_A is the rated operating ambient temperature range of the device. α_{VREF} is positive or negative, depending on whether the minimum value or maximum value of the V_{REF} occurs at the lower temperature.



(2) The dynamic impedance is defined as $\lvert Z_{KA} \rvert = \frac{\Delta V_{KA}}{\Delta I_{KA}}$. When the device is operating with two external resistors, the total dynamic impedance of the circuit is $\lvert Z' \rvert = \frac{\Delta V}{\Delta I}$, which is approximately equal to $\lvert Z_{KA} \rvert\left(1 + \frac{R1}{R2}\right)$.

Typical Performance Characteristics

All test conditions: T_A = 25°C, V_{OUT} = 2.5 V, I_{KA} = 10 mA, unless otherwise noted.

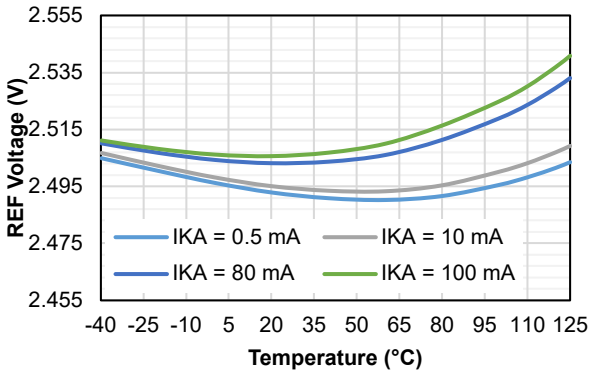


Figure 1. Reference Voltage vs. Temperature

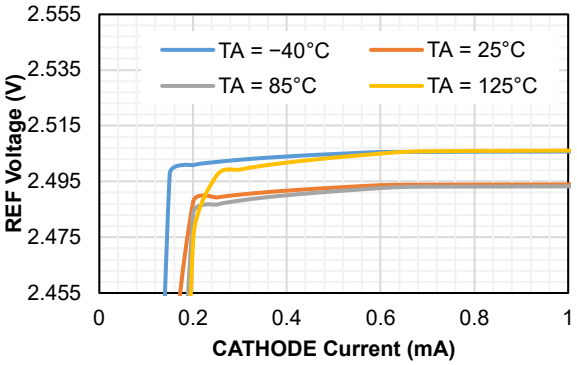


Figure 2. Reference Voltage vs. CATHODE Current

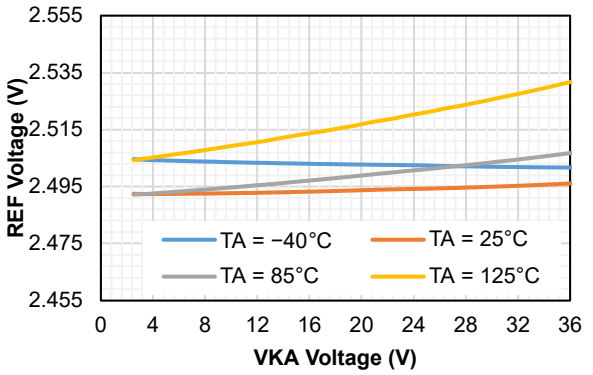


Figure 3. Reference Voltage vs. CATHODE Voltage

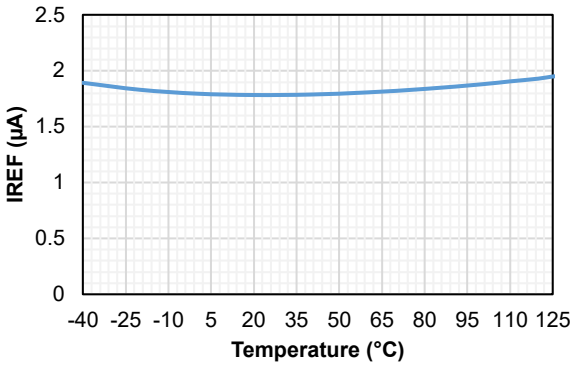


Figure 4. Reference Current vs. Temperature

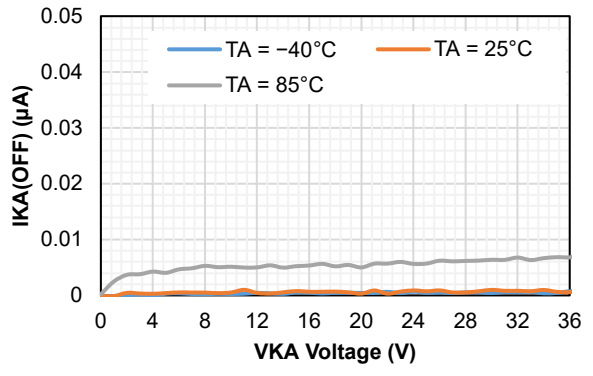


Figure 5. OFF-State CATHODE Current vs. CATHODE Voltage

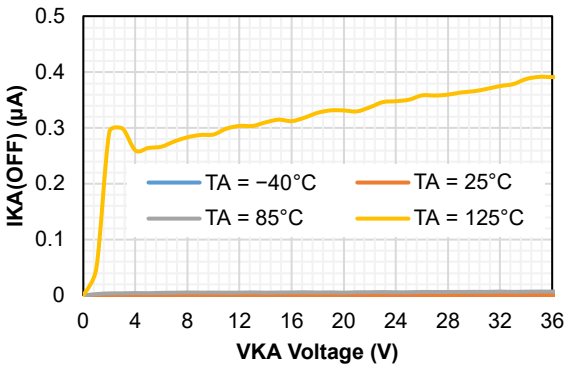


Figure 6. OFF-State CATHODE Current vs. CATHODE Voltage

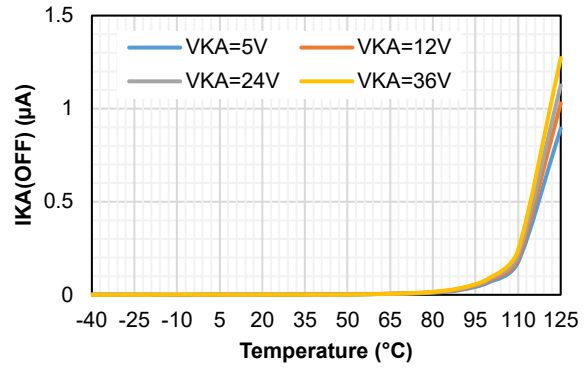


Figure 7. OFF-State CATHODE Current vs. Temperature

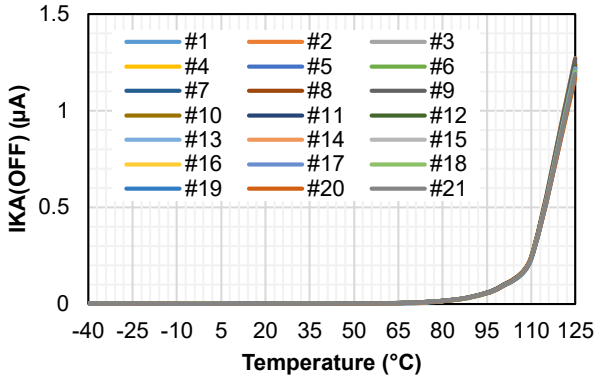


Figure 8. OFF-State CATHODE Current vs. Temperature

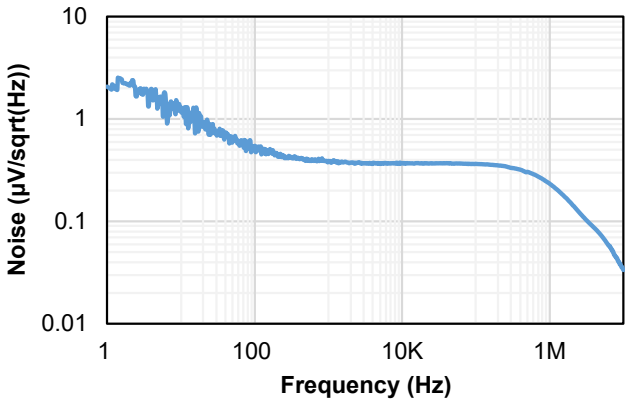


Figure 9. Equivalent Noise Voltage vs. Frequency

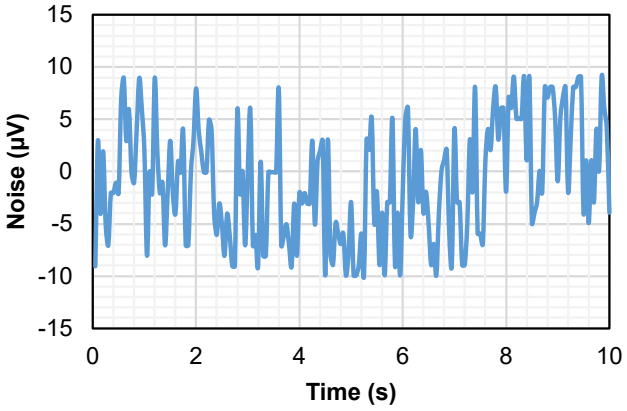


Figure 10. 0.1 to 10-Hz Noise Voltage

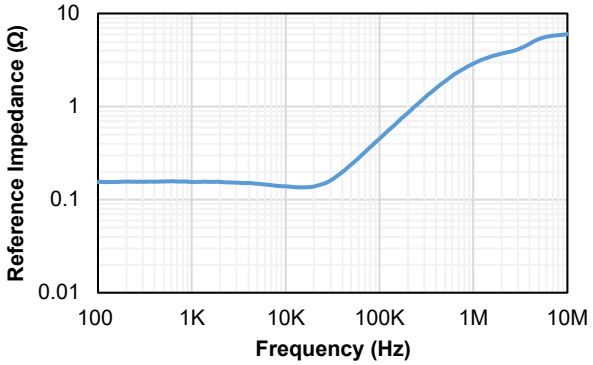
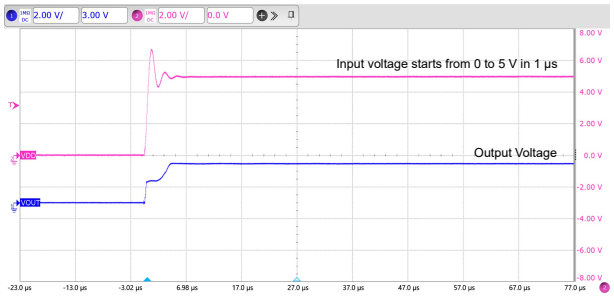
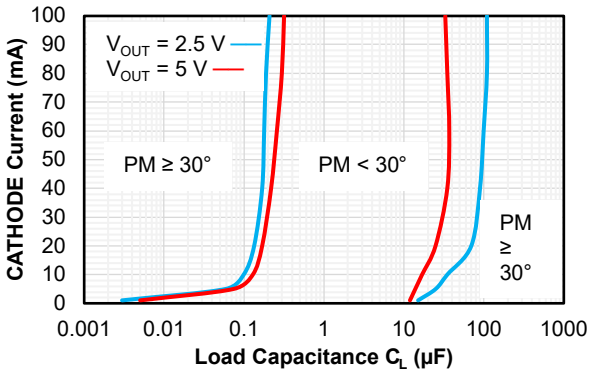


Figure 11. Reference Impedance vs. Frequency



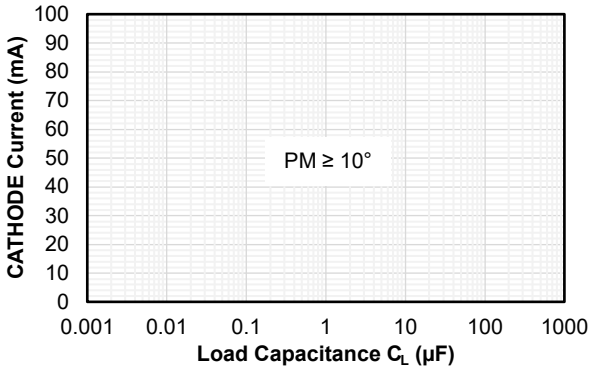
Input voltage starts from 0 to 5 V in 1 µs. No C_L.

Figure 12. Power Up



The areas within the boundary represent application conditions that may cause the phase margin (PM) ≤ 30°. V_{OUT} ≥ 10 V, all current and all capacitance conditions have ≥ 30° phase margin.

Figure 13. Stability Boundary Conditions



V_{OUT} ≥ 2.5 V, all current and all capacitance conditions have ≥ 10° phase margin.

Figure 14. Stability Boundary Conditions

Detailed Description

Overview

The TPR433Q and the TPR434Q are 3-terminal adjustable shunt voltage references. The output voltage of both devices can be set to any value within the range from V_{REF} to 36 V with an external feedback resistor network.

The TPR433Q and the TPR434Q have the same electrical performance and the same package but different pin orders. The device provides a 0.2-Ω output impedance and a quick turn-on characteristic, making it an excellent replacement for ordinary Zener diode in many applications.

The TPR433Q and the TPR434Q support a wide output current range from 1 to 80 mA with a SOT23G-3 package. Both devices are qualified with an operating temperature range from −40°C up to +125°C.

Functional Block Diagram

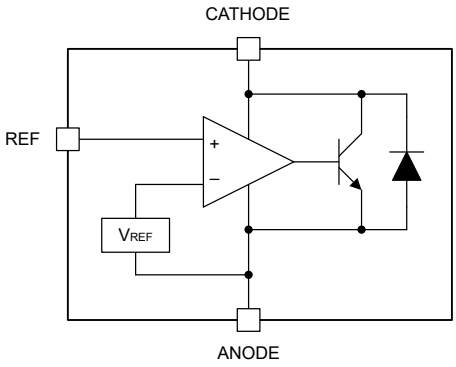


Figure 15. Functional Block Diagram

Feature Description

The TPR433Q and the TPR434Q products are 3-terminal adjustable shunt voltage references. They consist of an internal reference and amplifier that outputs a sink current based on the difference between the REF pin and the internal reference (shown in the Functional Block Diagram).

Closed Loop Operation

The TPR433Q and the TPR434Q products operate in a closed loop when the voltage or current of the CATHODE pin is fed back to the REF pin. In this manner, the device regulates a fixed voltage or current. The feedback allows the device to function as an error amplifier, adjusting a portion of the output voltage to maintain the desired regulation. This is achieved by relating the output voltage back to the reference pin in order to make it equal to the internal reference voltage, which can be done through resistive or direct feedback.

Open Loop Operation

The TPR433Q and the TPR434Q products operate in the open loop when the voltage or current of the CATHODE pin is not being fed to the REF pin in any way. When proper CATHODE current (I_{KA}) is applied, the device exhibits the characteristics shown in Figure 15. With such high gain in this setup, the device is typically used as a comparator. The integrated reference makes it the preferred choice for users to monitor a specific signal level.

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 TPR433Q and the TPR434Q products are 3-terminal adjustable shunt voltage references. The output voltage of both devices can be set to any value within the range from V_{REF} to 36 V with an external feedback resistor network. The following section shows the typical usage of the device.

Typical Application

Shunt Regulator/Reference

Figure 16 shows the typical application schematic in the shunt regulator/reference (closed loop) mode.

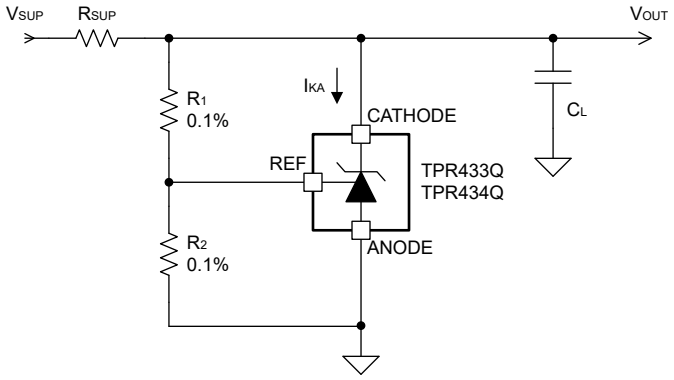


Figure 16. Typical Application Circuit in Shunt Regulator/Reference Mode

As discussed in the Feature Description, a feedback resistors network is required at the device CATHODE pin and REF pin to get regulated output voltage. The CATHODE voltage can be set to the value between V_{REF} to 36 V with the below Equation 1.

$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) \times V_{REF} \quad (1)$$

Where, R1 and R2 are the feedback resistors, V_{REF} is 2.495 V typically.

Comparator with Integrated Reference

Figure 17 shows the typical application schematic in the comparator (open loop) mode.

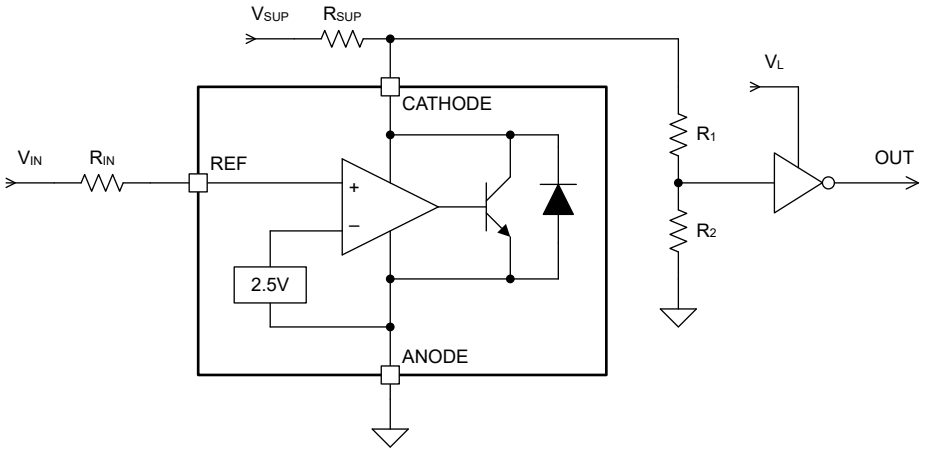


Figure 17. Typical Application Circuit in Comparator Mode

As discussed in the Feature Description, the device operates as a comparator with the configuration in the above figure. By comparing the V_{REF} pin voltage to the internal reference voltage, the device outputs a logic signal accordingly. With a proper CATHODE current (≥ $I_{KA(MIN)}$), the device has enough open loop gain to provide a quick response.

Layout

Layout Guideline

- Both input bypass capacitors and output bypass capacitors must be placed as close to the device pins as possible.
- It is recommended to use wide trace and thick copper to minimize I×R drop for the high current path.

Layout Example

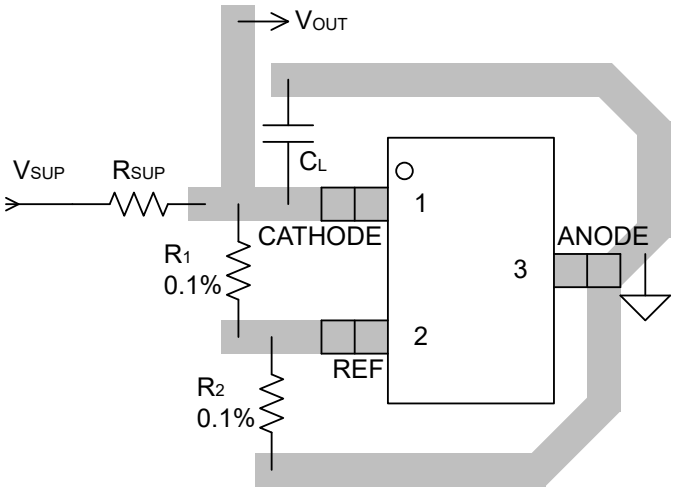


Figure 18. Layout Example of the TPR433Q in Shunt Regulator/Reference Mode

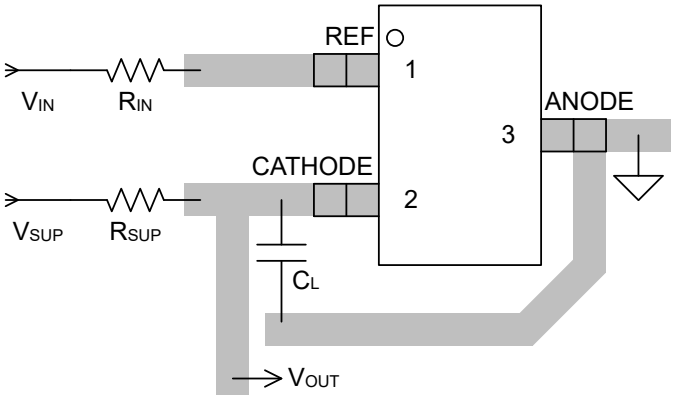
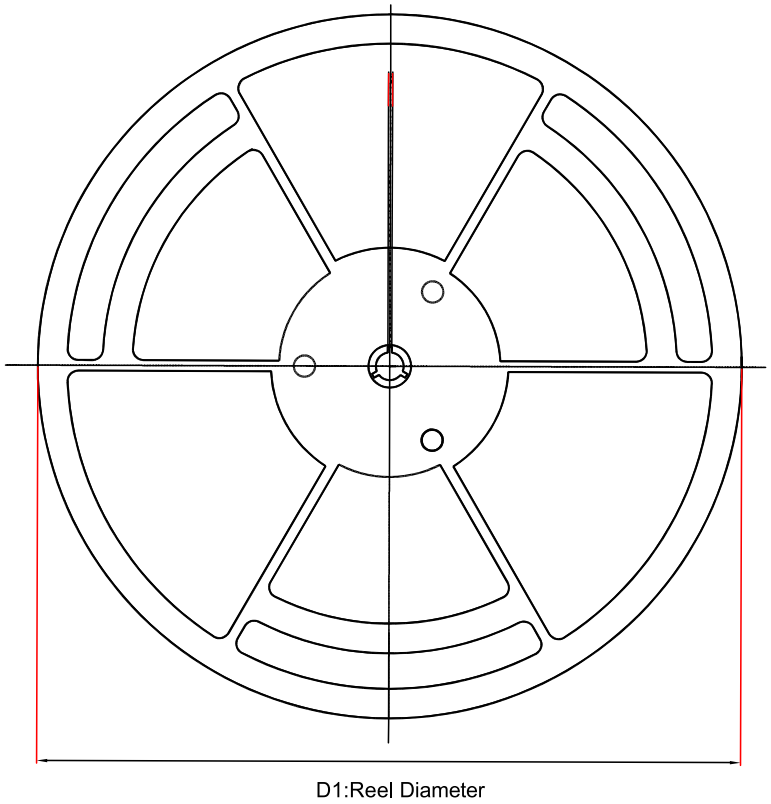
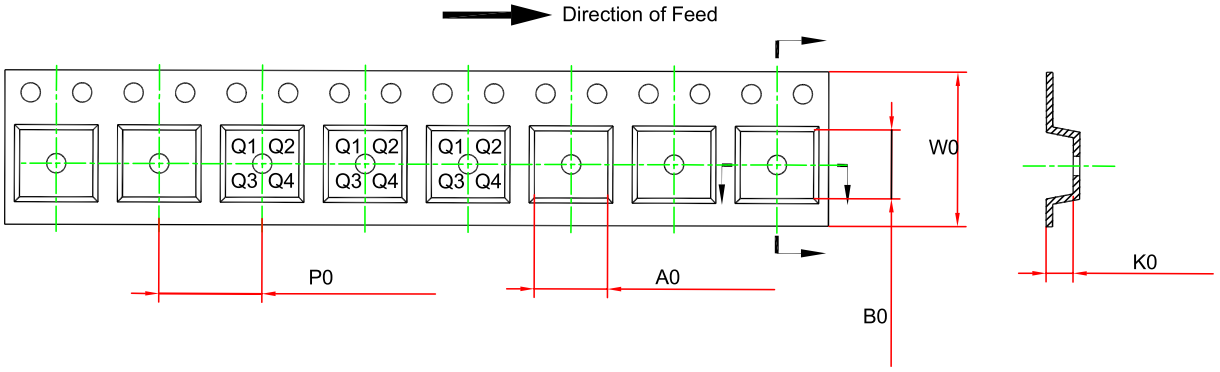


Figure 19. Layout Example of the TPR434Q in Comparator Mode

Tape and Reel Information



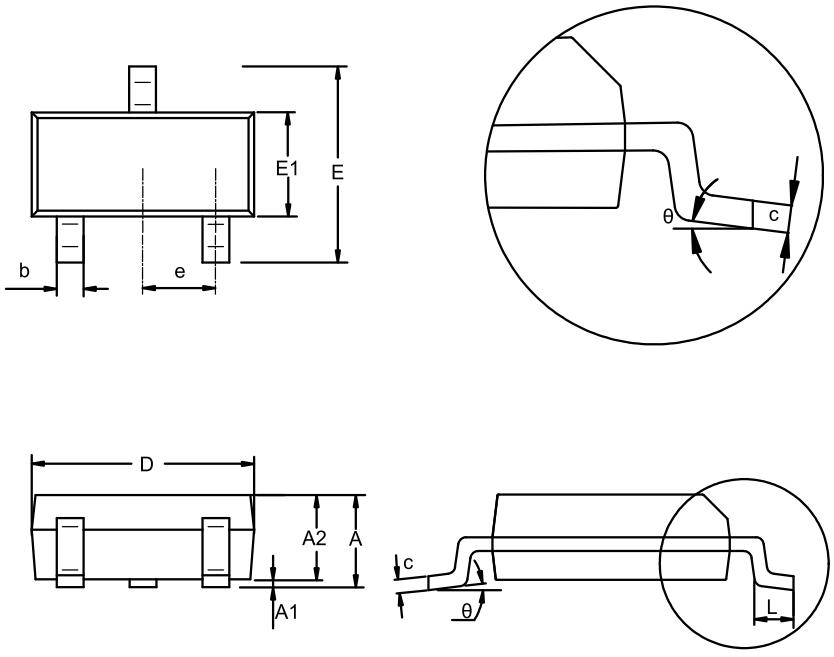


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPR433BQ-3STR-S	SOT23G-3	178	13.1	3.15	2.77	1.22	4.0	8.0	Q3
TPR434BQ-3STR-S	SOT23G-3	178	13.1	3.15	2.77	1.22	4.0	8.0	Q3

Package Outline Dimensions

SOT23G-3

Package Outline Dimensions 3ST(SOT23G-3-A)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.890	1.120	0.035	0.044
A1	0.000	0.100	0.000	0.004
A2	0.890	1.100	0.035	0.043
b	0.300	0.500	0.012	0.020
c	0.132	0.230	0.005	0.009
D	2.800	3.000	0.110	0.118
E	2.250	2.640	0.089	0.104
E1	1.200	1.400	0.047	0.055
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.

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPR433BQ-3STR-S	−40°C to +125°C	SOT23G-3	R33	MSL1	3,000	Green
TPR434BQ-3STR-S	−40°C to +125°C	SOT23G-3	R34	MSL1	3,000	Green

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

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