High-Precision Shunt Voltage Reference

Features

- Fixed Output Voltage:
  - 2.048 V, 2.5 V, 3 V, 3.3 V, 4.096 V, and 5 V
- High Initial Accuracy and Low-Temperature Coefficient
  - Grade A: Max 0.1%, 25 ppm/°C
  - Grade B: Max 0.2%, 50 ppm/°C
- Operation Temperature Range: −40°C to 125°C
- Sink Current Capability: 150 μA to 15 mA
- Stable with Any Capacitive Loads
- Package: SOT23G-3

Applications

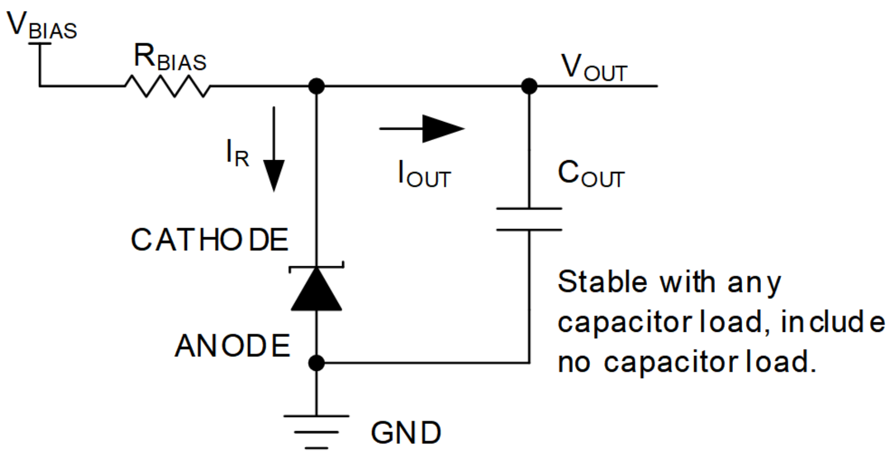
- Power
- Led Lighting
- Current Sensing
- Instrumentation
- Industry

Description

The TPR6040 is a shunt voltage reference with guaranteed temperature stability over the entire operating temperature range. The temperature range is extended from −40 °C to +125 °C.

The TPR6040 operates with a wide current range from 0.15 to 15 mA with a typical dynamic impedance of 0.3 Ω.

Typical Application Circuit



$I_R = (V_{BIAS} - V_{OUT})/R_{BIAS} - I_{OUT}$

$I_{RMIN}(0.15mA) \leqslant I_R \leqslant I_{RMAX}(15mA)$

Table of Contents

Product Family Table

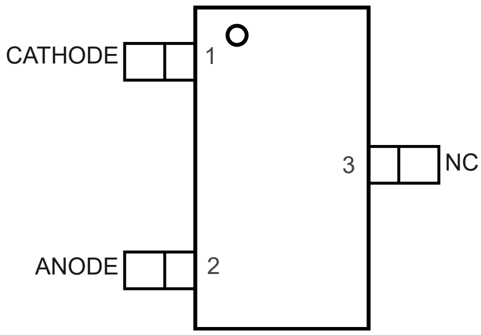
Order Number	Output Voltage (V)	Grade	Accuracy	Package
TPR6040F20-S3TR	2.048	B	0.2%	SOT23G-3
TPR6040F25-S3TR	2.5	B	0.2%	SOT23G-3
TPR6040F30-S3TR	3	B	0.2%	SOT23G-3
TPR6040F33-S3TR	3.3	B	0.2%	SOT23G-3
TPR6040F40-S3TR	4.096	B	0.2%	SOT23G-3
TPR6040F50-S3TR	5	B	0.2%	SOT23G-3

Revision History

Date	Revision	Notes
2019-12-25	Rev.Pre.0	Preliminary version.
2020-07-15	Rev.A.0	Initial release.
2020-07-25	Rev.A.1	1. Added the description of the pin 3 in Pin Configuration. 2. Added Tape and Reel Information.
2022-05-15	Rev.A.2	1. Added the maximum value of ΔV_R / ΔI_R. 2. Added the typical value of Long-Term Stability and Thermal Hysteresis. 3. Removed the Electrical Characteristics table of 8.192 V and 10 V.
2022-12-01	Rev.A.3	1. Removed A Grade Products (refer to TPR6040-S Datasheet for A Grade). 2. Removed the part number of 8.192 V and 10 V.
2024-10-23	Rev.A.4	1. Updated to a new datasheet format. 2. Added Pin function description.

Pin Configuration and Functions

TPR6040
SOT23G-3
Top View



Pin 3 must be left floating or connected to Pin 2.

Table 1. Pin Functions: TPR6040

Pin No.	Pin Name	I/O	Description
2	ANODE	O	ANODE pin. Connect this pin to ground.
1	CATHODE	I/O	CATHODE pin. Shunt current and input voltage.
3	NC	–	Do not connect. This pin must be left floating or connected to Pin 2.

Specifications

Absolute Maximum Ratings (1)

Parameter		Min	Max	Unit
	Reverse Current		20	mA
	Forward 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.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001 (1)	4000	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
I_R	Cathode Reverse Current	0.15	15	mA

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
SOT23G-3	250	81	°C/W

Electrical Characteristics – TPR6040F20, 2.048-V Output

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_R	Reverse Breakdown Voltage Tolerance	I_R = 1 mA, A Grade, "−S" suffix	−0.1		0.1	%
		I_R = 1 mA, B Grade	−0.2		0.2	%
ΔV_R / ΔV_T	Average Reverse Breakdown Voltage Temperature Coefficient	I_R = 1 mA, A Grade, "−S" suffix T_A = −40 to 125°C	−25		25	ppm
		I_R = 1 mA, B Grade T_A = −40 to 125°C	−50		50	ppm
I_{RMIN}	Minimum Operating Current			100	150	µA
		T_A = −40 to 125°C			150	µA
ΔV_R / ΔI_R	Reverse Breakdown Voltage Change with Operating Current Change (1)	$I_{RMIN} \le I_R$ < 1 mA			0.8	mV
		$I_{RMIN} \le I_R$ < 1 mA T_A = −40 to 125°C			1	mV
		$I_{RMIN} \le I_R$ < 15 mA			2	mV
		$I_{RMIN} \le I_R$ < 15 mA T_A = −40 to 125°C			3	mV
Noise	Wideband Noise	I_R = 100 µA, 10 Hz ≤ f ≤ 10 kHz		72		μV_{RMS}
	Output Voltage Noise	f = 0.1 Hz to 10 Hz		40		μV_{PP}
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz		0.3	0.8	Ω
LTD	Long-Term Stability	0 to 1000 hours		200		ppm
		1000 to 2000 hours		200		ppm
TH	Thermal Hysteresis			80		ppm

(1) The changing output due to die temperature change must be considered separately.

Electrical Characteristics – TPR6040F25, 2.5-V Output

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_R	Reverse Breakdown Voltage Tolerance	I_R = 1 mA, A Grade, "−S" suffix	−0.1		0.1	%
		I_R = 1 mA, B Grade	−0.2		0.2	%
ΔV_R / ΔV_T	Average Reverse Breakdown Voltage Temperature Coefficient	I_R = 1 mA, A Grade, "−S" suffix T_A = −40 to 125°C	−25		25	ppm
		I_R = 1 mA, B Grade T_A = −40 to 125°C	−50		50	ppm
I_{RMIN}	Minimum Operating Current			100	150	μA
		T_A = −40 to 125°C			150	μA
ΔV_R / ΔI_R	Reverse Breakdown Voltage Change with Operating Current Change (1)	$I_{RMIN} \le I_R$ < 1 mA			0.8	mV
		$I_{RMIN} \le I_R$ < 1 mA T_A = −40 to 125°C			1	mV
		$I_{RMIN} \le I_R$ < 15 mA			2	mV
		$I_{RMIN} \le I_R$ < 15 mA T_A = −40 to 125°C			3	mV
Noise	Wideband Noise	I_R = 100 μA, 10 Hz ≤ f ≤ 10 kHz		90		μV_{RMS}
	Output Voltage Noise	f = 0.1 Hz to 10 Hz		50		μV_{PP}
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz		0.3	0.8	Ω
LTD	Long-Term Stability	0 to 1000 hours		200		ppm
		1000 to 2000 hours		200		ppm
TH	Thermal Hysteresis			80		ppm

(1) The changing output due to die temperature change must be considered separately.

Electrical Characteristics – TPR6040F30, 3-V Output

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_R	Reverse Breakdown Voltage Tolerance	I_R = 1 mA, A Grade, "−S" suffix	−0.1		0.1	%
		I_R = 1 mA, B Grade	−0.2		0.2	%
ΔV_R / ΔV_T	Average Reverse Breakdown Voltage Temperature Coefficient	I_R = 1 mA, A Grade, "−S" suffix T_A = −40 to 125°C	−25		25	ppm
		I_R = 1 mA, B Grade T_A = −40 to 125°C	−50		50	ppm
I_{RMIN}	Minimum Operating Current			100	150	μA
		T_A = −40 to 125°C			150	μA
ΔV_R / ΔI_R	Reverse Breakdown Voltage Change with Operating Current Change (1)	$I_{RMIN} \le I_R$ < 1 mA			1	mV
		$I_{RMIN} \le I_R$ < 1 mA T_A = −40 to 125°C			1.2	mV
		$I_{RMIN} \le I_R$ < 15 mA			2.4	mV
		$I_{RMIN} \le I_R$ < 15 mA T_A = −40 to 125°C			3.6	mV
Noise	Wideband Noise	I_R = 100 μA, 10 Hz ≤ f ≤ 10 kHz		108		μV_{RMS}
	Output Voltage Noise	f = 0.1 Hz to 10 Hz		60		μV_{PP}
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz		0.3	0.8	Ω
LTD	Long-Term Stability	0 to 1000 hours		200		ppm
		1000 to 2000 hours		200		ppm
TH	Thermal Hysteresis			80		ppm

(1) The changing output due to die temperature change must be considered separately.

Electrical Characteristics – TPR6040F33, 3.3-V Output

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_R	Reverse Breakdown Voltage Tolerance	I_R = 1 mA, A Grade, "−S" suffix	−0.1		0.1	%
		I_R = 1 mA, B Grade	−0.2		0.2	%
ΔV_R / ΔV_T	Average Reverse Breakdown Voltage Temperature Coefficient	I_R = 1 mA, A Grade, "−S" suffix T_A = −40 to 125°C	−25		25	ppm
		I_R = 1 mA, B Grade T_A = −40 to 125°C	−50		50	ppm
I_{RMIN}	Minimum Operating Current			100	150	μA
		T_A = −40 to 125°C			150	μA
ΔV_R / ΔI_R	Reverse Breakdown Voltage Change with Operating Current Change (1)	I_{RMIN} ≤ I_R < 1 mA			1.1	mV
		I_{RMIN} ≤ I_R < 1 mA T_A = −40 to 125°C			1.4	mV
		I_{RMIN} ≤ I_R < 15 mA			2.7	mV
		I_{RMIN} ≤ I_R< 15 mA T_A = −40 to 125°C			4	mV
Noise	Wideband Noise	I_R = 100 μA, 10 Hz ≤ f ≤ 10 kHz		119		μV_{RMS}
	Output Voltage Noise	f = 0.1 Hz to 10 Hz		66		μV_{PP}
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz		0.3	0.8	Ω
LTD	Long-Term Stability	0 to 1000 hours		200		ppm
		1000 to 2000 hours		200		ppm
TH	Thermal Hysteresis			80		ppm

(1) The changing output due to die temperature change must be considered separately.

Electrical Characteristics – TPR6040F40, 4.096-V Output

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_R	Reverse Breakdown Voltage Tolerance	I_R = 1 mA, A Grade, "−S" suffix	−0.1		0.1	%
		I_R = 1 mA, B Grade	−0.2		0.2	%
ΔV_R / ΔV_T	Average Reverse Breakdown Voltage Temperature Coefficient	I_R = 1 mA, A Grade, "−S" suffix T_A = −40 to 125°C	−25		25	ppm
		I_R = 1 mA, B Grade T_A = −40 to 125°C	−50		50	ppm
I_{RMIN}	Minimum Operating Current			100	150	μA
		T_A = −40 to 125°C			150	μA
ΔV_R / ΔI_R	Reverse Breakdown Voltage Change with Operating Current Change (1)	$I_{RMIN} \le I_R$ < 1 mA			1.4	mV
		$I_{RMIN} \le I_R$ < 1 mA T_A = −40 to 125°C			1.7	mV
		$I_{RMIN} \le I_R$ < 15 mA			3.3	mV
		$I_{RMIN} \le I_R$ < 15 mA T_A = −40 to 125°C			5	mV
Noise	Wideband Noise	I_R = 100 μA, 10 Hz ≤ f ≤ 10 kHz		148		μV_{RMS}
	Output Voltage Noise	f = 0.1 Hz to 10 Hz		82		μV_{PP}
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz		0.3	0.8	Ω
LTD	Long-Term Stability	0 to 1000 hours		200		ppm
		1000 to 2000 hours		200		ppm
TH	Thermal Hysteresis			80		ppm

(1) The changing output due to die temperature change must be considered separately.

Electrical Characteristics – TPR6040F50, 5-V Output

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_R	Reverse Breakdown Voltage Tolerance	I_R = 1 mA, A Grade, "−S" suffix	−0.1		0.1	%
		I_R = 1 mA, B Grade	−0.2		0.2	%
ΔV_R / ΔV_T	Average Reverse Breakdown Voltage Temperature Coefficient	I_R = 1 mA, A Grade, "−S" suffix T_A = −40 to 125°C	−25		25	ppm
		I_R = 1 mA, B Grade T_A = −40 to 125°C	−50		50	ppm
I_{RMIN}	Minimum Operating Current			100	150	μA
		T_A = −40 to 125°C			150	μA
ΔV_R / ΔI_R	Reverse Breakdown Voltage Change with Operating Current Change (1)	$I_{RMIN} \le I_R < 1$ mA			1.6	mV
		$I_{RMIN} \le I_R < 1$ mA T_A = −40 to 125°C			2	mV
		$I_{RMIN} \le I_R < 15$ mA			4	mV
		$I_{RMIN} \le I_R < 15$ mA T_A = −40 to 125°C			6	mV
Noise	Wideband Noise	I_R = 100 μA, 10 Hz ≤ f ≤ 10 kHz		180		μV_{RMS}
	Output Voltage Noise	f = 0.1 Hz to 10 Hz		100		μV_{PP}
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz		0.3	0.8	Ω
LTD	Long-Term Stability	0 to 1000 hours		200		ppm
		1000 to 2000 hours		200		ppm
TH	Thermal Hysteresis			80		ppm

(1) The changing output due to die temperature change must be considered separately.

Typical Performance Characteristics

All test conditions: V_{OUT} = 2.5 V, T_A = +25℃, unless otherwise noted.

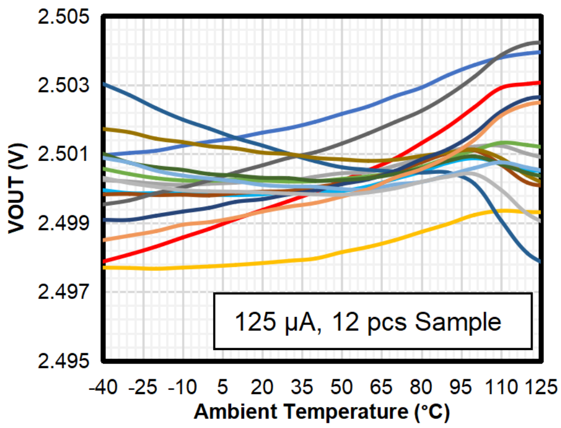


Figure 1. V_{OUT} vs. Temperature

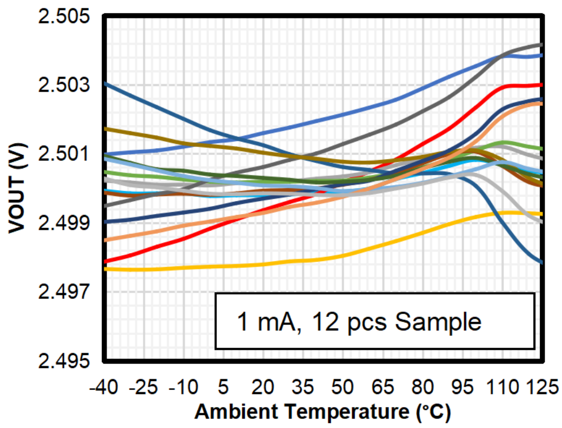


Figure 2. V_{OUT} vs. Temperature

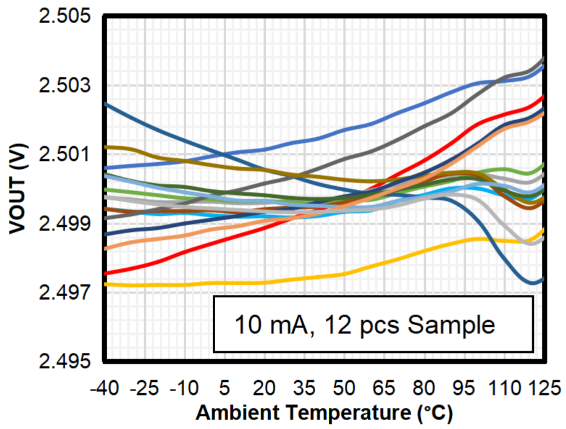


Figure 3. V_{OUT} vs. Temperature

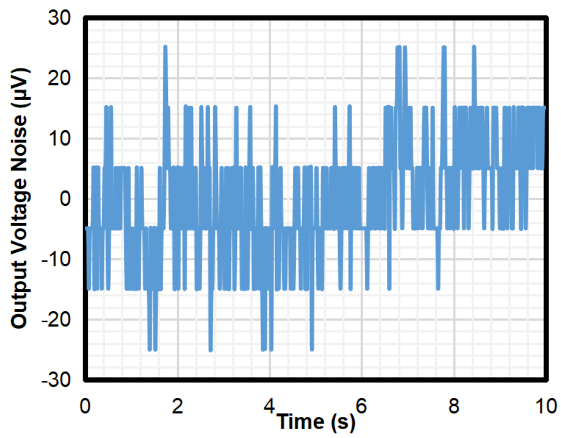


Figure 4. 0.1-Hz to 10-Hz Noise

Figure 5. Power up, 100 µs, V_{BIAS} = 6.5 V, R_{BIAS} = 0.5 kΩ

Figure 6. Power up, 15 ms, V_{BIAS} = 6.5 V, R_{BIAS} = 0.5 kΩ

Typical Performance Characteristics (Continued)

All test conditions: V_{IN} = 5 V, T_A = +25°C, unless otherwise noted.

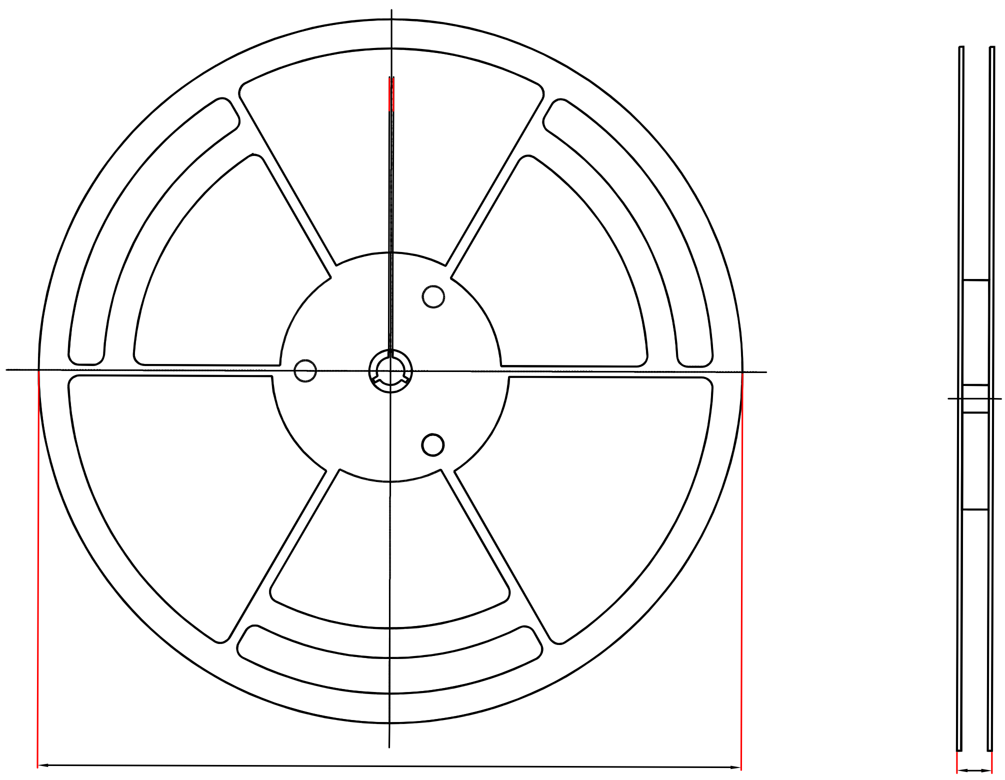
Figure 7. Power up, 100 µs, V_{BIAS} = 6.5 V, R_{BIAS} = 2.5 kΩ

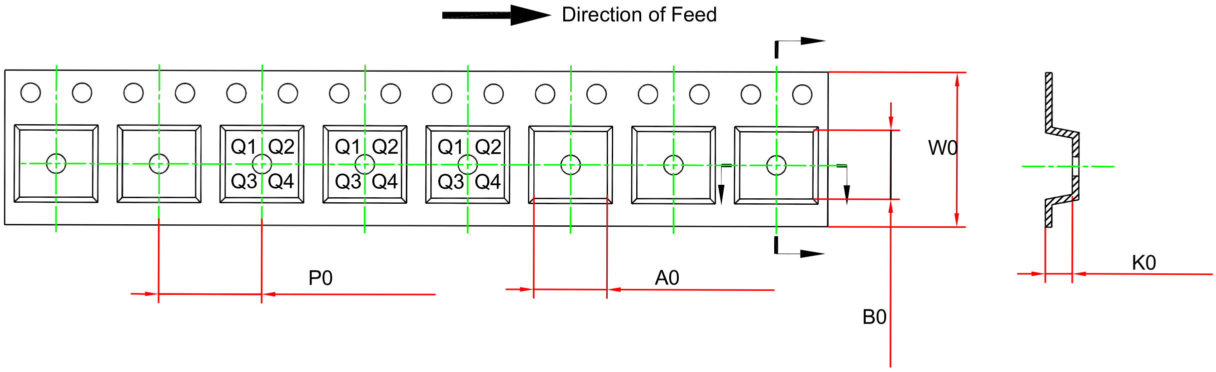
Figure 8. Power up, 15 ms, V_{BIAS} = 6.5 V, R_{BIAS} = 2.5 kΩ

Figure 9. Power up, 100 µs, V_{BIAS} = 6.5 V, R_{BIAS} = 20 kΩ

Figure 10. Power up, 15 ms, V_{BIAS} = 6.5 V, R_{BIAS} = 20 kΩ

Tape and Reel Information





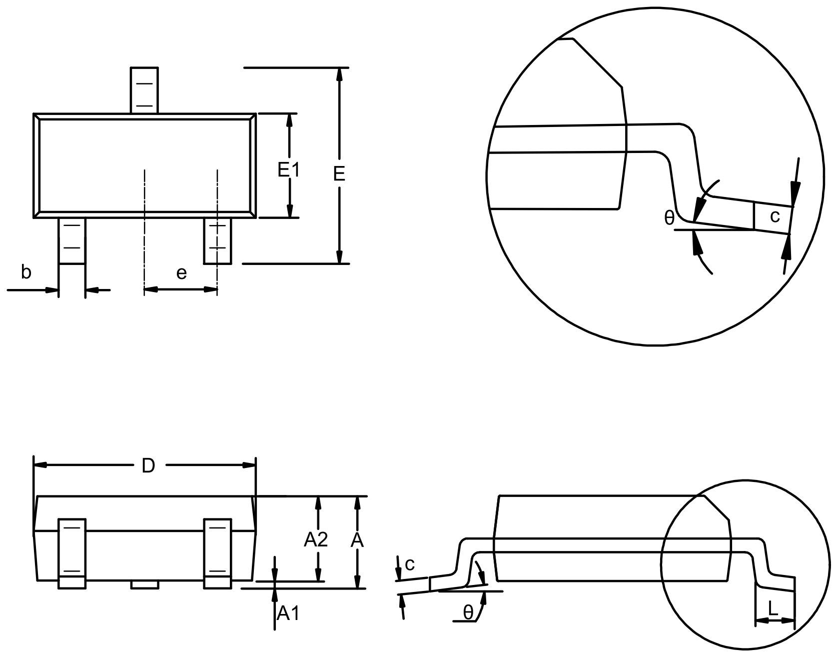
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPR6040Fxx-S3TR	SOT23G-3	178	12.1	3.15	2.77	1.22	4.0	8.0	Q3

(1) Output voltage, xx = 20 to 50.

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
TPR6040F20-S3TR	−40 to 125°C	SOT23G-3	R6B	3	Tape and Reel, 3000	Green
TPR6040F25-S3TR	−40 to 125°C	SOT23G-3	R6C	3	Tape and Reel, 3000	Green
TPR6040F30-S3TR	−40 to 125°C	SOT23G-3	R6D	3	Tape and Reel, 3000	Green
TPR6040F33-S3TR	−40 to 125°C	SOT23G-3	R6E	3	Tape and Reel, 3000	Green
TPR6040F40-S3TR	−40 to 125°C	SOT23G-3	R6F	3	Tape and Reel, 3000	Green
TPR6040F50-S3TR	−40 to 125°C	SOT23G-3	R6G	3	Tape and Reel, 3000	Green

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

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