

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
- Qualified for Automotive Applications with AEC-Q100 Reliability Test
- Package: SOT23G-3

Applications

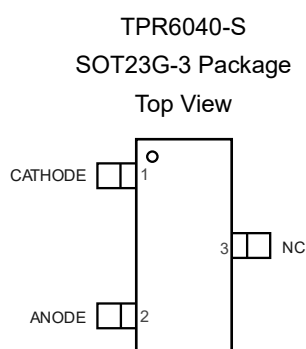
- Power
- Led Lighting
- Current Sensing
- Instrumentation
- Industry

Description

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

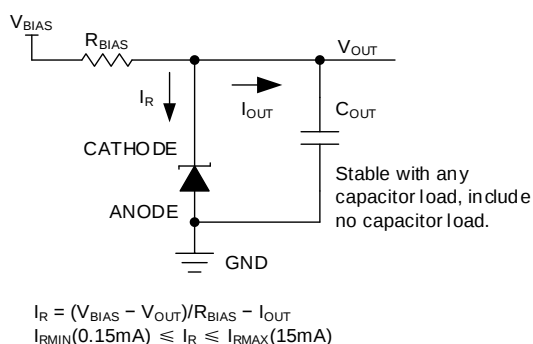
The TPR6040-S operates with a wide current range from 0.15 to 15 mA with a typical dynamic impedance of 0.3 Ω.

Pin Configuration



Pin 3 must be left floating or connected to Pin 2

Typical Connection



Product Family Table

Order Number	Output Voltage (V)	Grade	AEC-Q100 Reliability Test	Accuracy	Package
TPR6040F20-S3TR-S	2.048	A	Pass	0.1%	SOT23G-3
TPR6040F25-S3TR-S	2.5	A	Pass	0.1%	SOT23G-3
TPR6040F30-S3TR-S	3	A	Pass	0.1%	SOT23G-3
TPR6040F33-S3TR-S	3.3	A	Pass	0.1%	SOT23G-3
TPR6040F40-S3TR-S	4.096	A	Pass	0.1%	SOT23G-3
TPR6040F50-S3TR-S	5	A	Pass	0.1%	SOT23G-3

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Revision History

Date	Revision	Notes
2019-12-25	Rev.Pre.0	Pre-Release Version
2020-07-15	Rev.A.0	Initial Release Version
2020-07-25	Rev.A.1	1. Added pin3 description in pin configuration. 2. Added Tape and Reel Information.
2022-05-15	Rev.A.2	1. Added maximum value of $\Delta V_R / \Delta I_R$ 2. Added typical value of Long-Term Stability and Thermal Hysteresis 3. Removed Electrical Characteristics table of 8.192 V and 10 V
2022-12-01	Rev.A.3	Added "Qualified for Automotive Applications with AEC-Q100 Reliability Test"

Specifications

Absolute Maximum Ratings

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

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: $T_A = +25^{\circ}\text{C}$, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_R	Reverse Breakdown Voltage Tolerance	$I_R = 1\text{ mA}$, A Grade, “-S” suffix	-0.1		0.1	%
		$I_R = 1\text{ mA}$, B Grade	-0.2		0.2	%
$\Delta V_R/\Delta V_T$	Average Reverse Breakdown Voltage Temperature Coefficient	$I_R = 1\text{ mA}$, A Grade, “-S” suffix $T_A = -40\text{ to }125^{\circ}\text{C}$	-25		25	ppm
		$I_R = 1\text{ mA}$, B Grade $T_A = -40\text{ to }125^{\circ}\text{C}$	-50		50	ppm
I_{RMIN}	Minimum Operating Current			100	150	μA
		$T_A = -40\text{ to }125^{\circ}\text{C}$			150	μA
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change ⁽¹⁾	$I_{RMIN} \leq I_R < 1\text{ mA}$			0.8	mV
		$I_{RMIN} \leq I_R < 1\text{ mA}$, $T_A = -40\text{ to }125^{\circ}\text{C}$			1	mV
		$I_{RMIN} \leq I_R < 15\text{ mA}$			2	mV
		$I_{RMIN} \leq I_R < 15\text{ mA}$, $T_A = -40\text{ to }125^{\circ}\text{C}$			3	mV
Noise	Wideband Noise	$I_R = 100\text{ }\mu\text{A}$, $10\text{ Hz} \leq f \leq 10\text{ kHz}$		72		μV_{RMS}
	Output Voltage Noise	$f = 0.1\text{ Hz to }10\text{ Hz}$		40		μV_{PP}
Z_R	Reverse Dynamic Impedance	$I_R = 1\text{ mA}$, $f = 120\text{ Hz}$		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: $T_A = +25^{\circ}\text{C}$, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_R	Reverse Breakdown Voltage Tolerance	$I_R = 1\text{ mA}$, A Grade, “-S” suffix	-0.1		0.1	%
		$I_R = 1\text{ mA}$, B Grade	-0.2		0.2	%
$\Delta V_R/\Delta V_T$	Average Reverse Breakdown Voltage Temperature Coefficient	$I_R = 1\text{ mA}$, A Grade, “-S” suffix $T_A = -40\text{ to }125^{\circ}\text{C}$	-25		25	ppm
		$I_R = 1\text{ mA}$, B Grade, $T_A = -40\text{ to }125^{\circ}\text{C}$	-50		50	ppm
I_{RMIN}	Minimum Operating Current			100	150	μA
		$T_A = -40\text{ to }125^{\circ}\text{C}$			150	μA
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change ⁽¹⁾	$I_{RMIN} \leq I_R < 1\text{ mA}$			0.8	mV
		$I_{RMIN} \leq I_R < 1\text{ mA}$, $T_A = -40\text{ to }125^{\circ}\text{C}$			1	mV
		$I_{RMIN} \leq I_R < 15\text{ mA}$			2	mV
		$I_{RMIN} \leq I_R < 15\text{ mA}$, $T_A = -40\text{ to }125^{\circ}\text{C}$			3	mV
Noise	Wideband Noise	$I_R = 100\text{ }\mu\text{A}$, $10\text{ Hz} \leq f \leq 10\text{ kHz}$		90		μV_{RMS}
	Output Voltage Noise	$f = 0.1\text{ Hz to }10\text{ Hz}$		50		μV_{PP}
Z_R	Reverse Dynamic Impedance	$I_R = 1\text{ mA}$, $f = 120\text{ Hz}$		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: $T_A = +25^{\circ}\text{C}$, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_R	Reverse Breakdown Voltage Tolerance	$I_R = 1\text{ mA}$, A Grade, “-S” suffix	-0.1		0.1	%
		$I_R = 1\text{ mA}$, B Grade	-0.2		0.2	%
$\Delta V_R/\Delta V_T$	Average Reverse Breakdown Voltage Temperature Coefficient	$I_R = 1\text{ mA}$, A Grade, “-S” suffix $T_A = -40\text{ to }125^{\circ}\text{C}$	-25		25	ppm
		$I_R = 1\text{ mA}$, B Grade, $T_A = -40\text{ to }125^{\circ}\text{C}$	-50		50	ppm
I_{RMIN}	Minimum Operating Current			100	150	μA
		$T_A = -40\text{ to }125^{\circ}\text{C}$			150	μA
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change ⁽¹⁾	$I_{RMIN} \leq I_R < 1\text{ mA}$			1	mV
		$I_{RMIN} \leq I_R < 1\text{ mA}$, $T_A = -40\text{ to }125^{\circ}\text{C}$			1.2	mV
		$I_{RMIN} \leq I_R < 15\text{ mA}$			2.4	mV
		$I_{RMIN} \leq I_R < 15\text{ mA}$, $T_A = -40\text{ to }125^{\circ}\text{C}$			3.6	mV
Noise	Wideband Noise	$I_R = 100\text{ }\mu\text{A}$, $10\text{ Hz} \leq f \leq 10\text{ kHz}$		108		μV_{RMS}
	Output Voltage Noise	$f = 0.1\text{ Hz to }10\text{ Hz}$		60		μV_{PP}
Z_R	Reverse Dynamic Impedance	$I_R = 1\text{ mA}$, $f = 120\text{ Hz}$		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: $T_A = +25^{\circ}\text{C}$, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_R	Reverse Breakdown Voltage Tolerance	$I_R = 1\text{ mA}$, A Grade, “-S” suffix	-0.1		0.1	%
		$I_R = 1\text{ mA}$, B Grade	-0.2		0.2	%
$\Delta V_R/\Delta V_T$	Average Reverse Breakdown Voltage Temperature Coefficient	$I_R = 1\text{ mA}$, A Grade, “-S” suffix $T_A = -40\text{ to }125^{\circ}\text{C}$	-25		25	ppm
		$I_R = 1\text{ mA}$, B Grade, $T_A = -40\text{ to }125^{\circ}\text{C}$	-50		50	ppm
I_{RMIN}	Minimum Operating Current			100	150	μA
		$T_A = -40\text{ to }125^{\circ}\text{C}$			150	μA
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change ⁽¹⁾	$I_{RMIN} \leq I_R < 1\text{ mA}$			1.1	mV
		$I_{RMIN} \leq I_R < 1\text{ mA}$, $T_A = -40\text{ to }125^{\circ}\text{C}$			1.4	mV
		$I_{RMIN} \leq I_R < 15\text{ mA}$			2.7	mV
		$I_{RMIN} \leq I_R < 15\text{ mA}$, $T_A = -40\text{ to }125^{\circ}\text{C}$			4	mV
Noise	Wideband Noise	$I_R = 100\text{ }\mu\text{A}$, $10\text{ Hz} \leq f \leq 10\text{ kHz}$		119		μV_{RMS}
	Output Voltage Noise	$f = 0.1\text{ Hz to }10\text{ Hz}$		66		μV_{PP}
Z_R	Reverse Dynamic Impedance	$I_R = 1\text{ mA}$, $f = 120\text{ Hz}$		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: $T_A = +25^{\circ}\text{C}$, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_R	Reverse Breakdown Voltage Tolerance	$I_R = 1\text{ mA}$, A Grade, “-S” suffix	-0.1		0.1	%
		$I_R = 1\text{ mA}$, B Grade	-0.2		0.2	%
$\Delta V_R/\Delta V_T$	Average Reverse Breakdown Voltage Temperature Coefficient	$I_R = 1\text{ mA}$, A Grade, “-S” suffix $T_A = -40\text{ to }125^{\circ}\text{C}$	-25		25	ppm
		$I_R = 1\text{ mA}$, B Grade, $T_A = -40\text{ to }125^{\circ}\text{C}$	-50		50	ppm
I_{RMIN}	Minimum Operating Current			100	150	μA
		$T_A = -40\text{ to }125^{\circ}\text{C}$			150	μA
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change ⁽¹⁾	$I_{RMIN} \leq I_R < 1\text{ mA}$			1.4	mV
		$I_{RMIN} \leq I_R < 1\text{ mA}$, $T_A = -40\text{ to }125^{\circ}\text{C}$			1.7	mV
		$I_{RMIN} \leq I_R < 15\text{ mA}$			3.3	mV
		$I_{RMIN} \leq I_R < 15\text{ mA}$, $T_A = -40\text{ to }125^{\circ}\text{C}$			5	mV
Noise	Wideband Noise	$I_R = 100\text{ }\mu\text{A}$, $10\text{ Hz} \leq f \leq 10\text{ kHz}$		148		μV_{RMS}
	Output Voltage Noise	$f = 0.1\text{ Hz to }10\text{ Hz}$		82		μV_{PP}
Z_R	Reverse Dynamic Impedance	$I_R = 1\text{ mA}$, $f = 120\text{ Hz}$		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: $T_A = +25^{\circ}\text{C}$, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_R	Reverse Breakdown Voltage Tolerance	$I_R = 1\text{ mA}$, A Grade, “-S” suffix	-0.1		0.1	%
		$I_R = 1\text{ mA}$, B Grade	-0.2		0.2	%
$\Delta V_R/\Delta V_T$	Average Reverse Breakdown Voltage Temperature Coefficient	$I_R = 1\text{ mA}$, A Grade, “-S” suffix $T_A = -40\text{ to }125^{\circ}\text{C}$	-25		25	ppm
		$I_R = 1\text{ mA}$, B Grade, $T_A = -40\text{ to }125^{\circ}\text{C}$	-50		50	ppm
I_{RMIN}	Minimum Operating Current			100	150	μA
		$T_A = -40\text{ to }125^{\circ}\text{C}$			150	μA
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change ⁽¹⁾	$I_{RMIN} \leq I_R < 1\text{ mA}$			1.6	mV
		$I_{RMIN} \leq I_R < 1\text{ mA}$, $T_A = -40\text{ to }125^{\circ}\text{C}$			2	mV
		$I_{RMIN} \leq I_R < 15\text{ mA}$			4	mV
		$I_{RMIN} \leq I_R < 15\text{ mA}$, $T_A = -40\text{ to }125^{\circ}\text{C}$			6	mV
Noise	Wideband Noise	$I_R = 100\text{ }\mu\text{A}$, $10\text{ Hz} \leq f \leq 10\text{ kHz}$		180		μV_{RMS}
	Output Voltage Noise	$f = 0.1\text{ Hz to }10\text{ Hz}$		100		μV_{PP}
Z_R	Reverse Dynamic Impedance	$I_R = 1\text{ mA}$, $f = 120\text{ Hz}$		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: $V_{OUT} = 2.5\text{ V}$, $T_A = +25^\circ\text{C}$, unless otherwise noted.

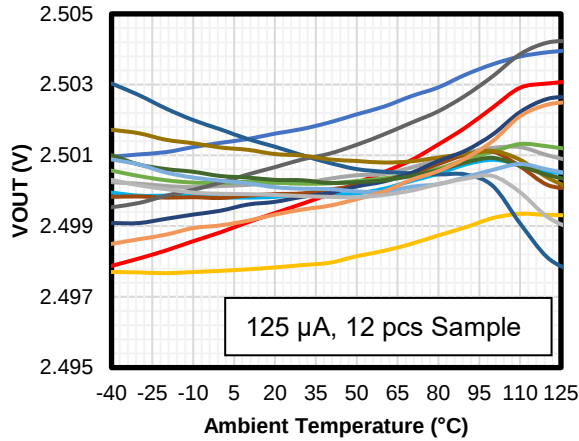


Figure 1. V_{OUT} vs. Temperature

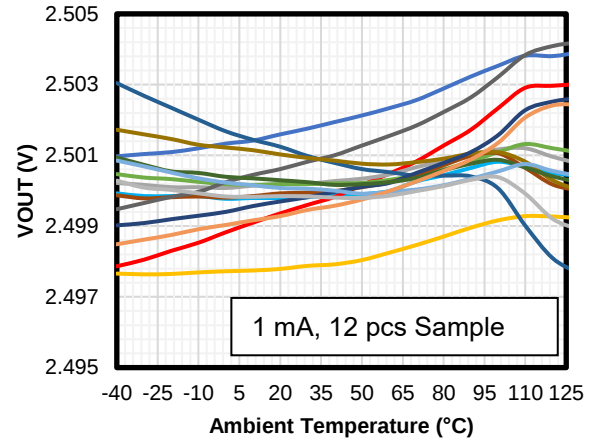


Figure 2. V_{OUT} vs. Temperature

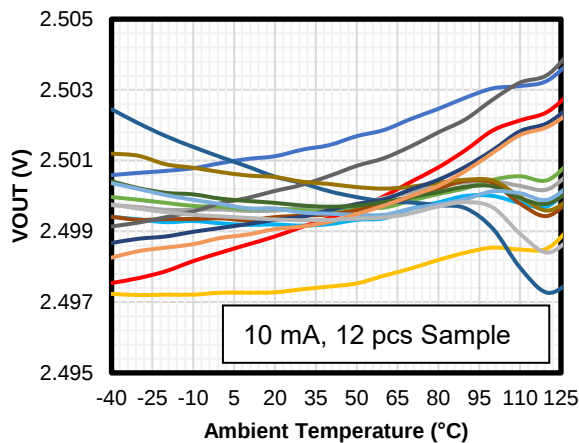


Figure 3. V_{OUT} vs. Temperature

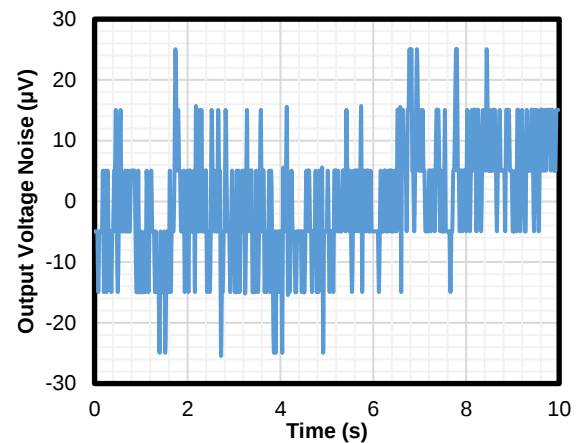


Figure 4. 0.1 to 10-Hz Noise



**Figure 5. Power Up, 100 μs , $V_{BIAS} = 6.5\text{ V}$,
 $R_{BIAS} = 0.5\text{ k}\Omega$**



**Figure 6. Power Up, 15 ms, $V_{BIAS} = 6.5\text{ V}$,
 $R_{BIAS} = 0.5\text{ k}\Omega$**

Typical Performance Characteristics (Continued)

All test conditions: $V_{IN} = 5\text{ V}$, $T_A = +25^\circ\text{C}$, unless otherwise noted.



**Figure 7. Power Up, 100 μs , $V_{BIAS} = 6.5\text{ V}$,
 $R_{BIAS} = 2.5\text{ k}\Omega$**



**Figure 8. Power Up, 15 ms, $V_{BIAS} = 6.5\text{ V}$,
 $R_{BIAS} = 2.5\text{ k}\Omega$**

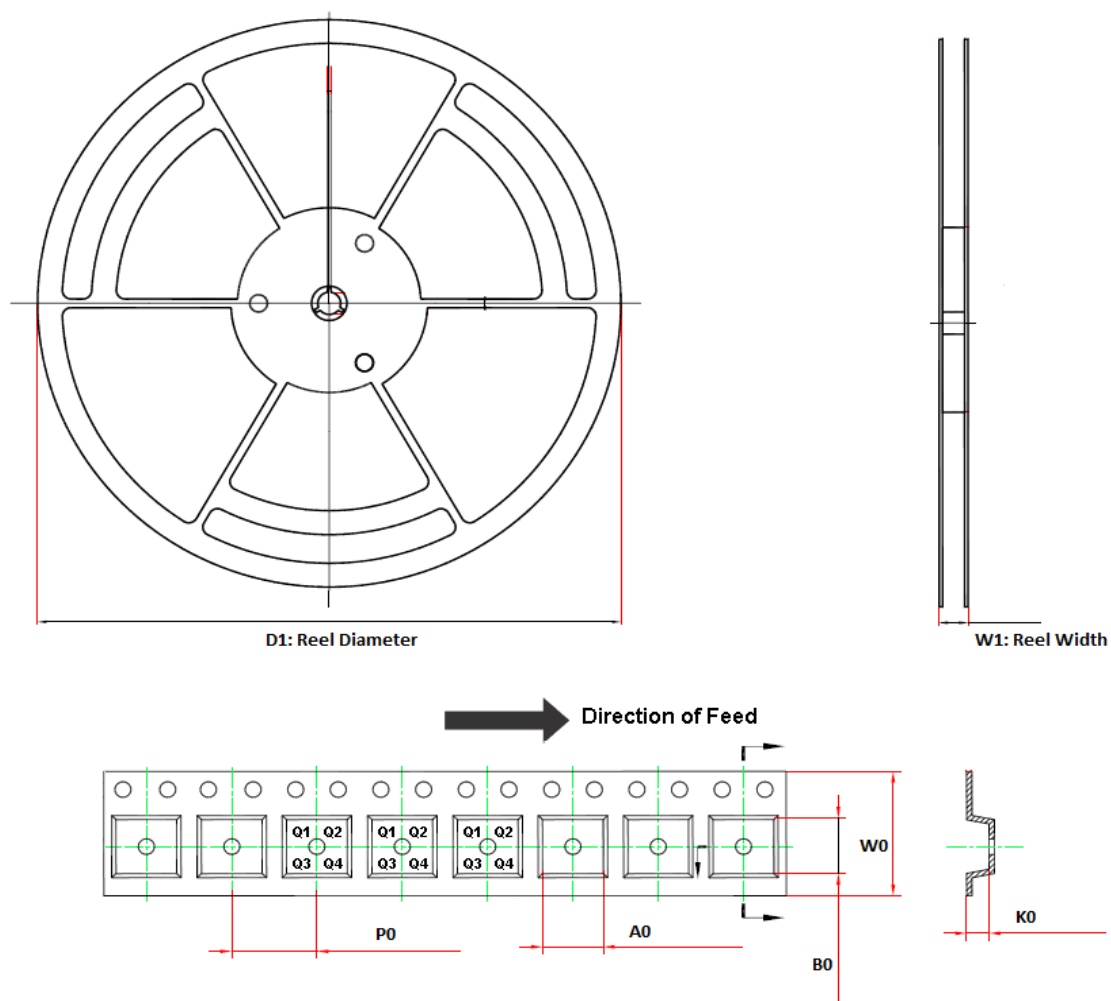


**Figure 9. Power Up, 100 μs , $V_{BIAS} = 6.5\text{ V}$,
 $R_{BIAS} = 20\text{ k}\Omega$**



**Figure 10. Power Up, 15 ms, $V_{BIAS} = 6.5\text{ V}$,
 $R_{BIAS} = 20\text{ k}\Omega$**

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-S	SOT23G-3	178	12.1	3.15	2.77	1.22	4.0	8.0	Q3

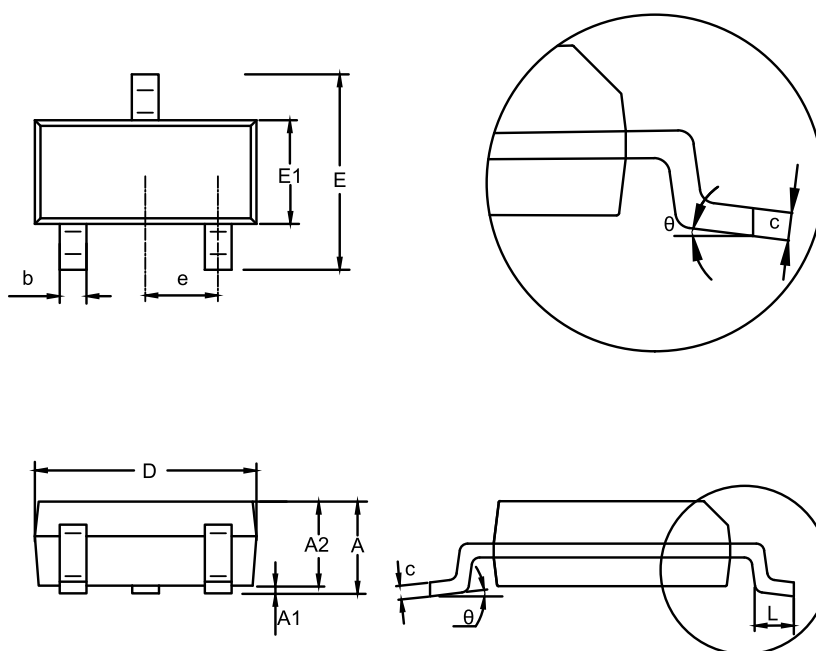
(1) Output voltage, xx = 20 to 50.

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	0.280	0.500	0.011	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-S	-40 to 125°C	SOT23G-3	R6B	MSL3	3,000	Green
TPR6040F25-S3TR-S	-40 to 125°C	SOT23G-3	R6C	MSL3	3,000	Green
TPR6040F30-S3TR-S	-40 to 125°C	SOT23G-3	R6D	MSL3	3,000	Green
TPR6040F33-S3TR-S	-40 to 125°C	SOT23G-3	R6E	MSL3	3,000	Green
TPR6040F40-S3TR-S	-40 to 125°C	SOT23G-3	R6F	MSL3	3,000	Green
TPR6040F50-S3TR-S	-40 to 125°C	SOT23G-3	R6G	MSL3	3,000	Green

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

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