Precision Low Drift SOT-23 Voltage Reference with Shutdown

ADR318*

FEATURES

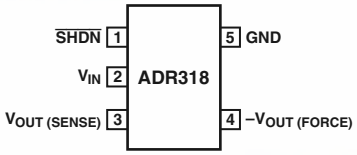
Initial Accuracy: ±5 mV Max, ±0.27% Max
Low Temperature Coefficient: 25 ppm/°C Max
Load Regulation: 100 ppm/mA
Line Regulation: 25 ppm/V
Low Supply Headroom: 0.6 V
Wide Operating Range: (V_{OUT} + 0.6 V) to 15 V
Low Power: 120 μA Max
Shutdown to Less than 3 μA Max
Output Current: 5 mA
Wide Temperature Range: 0°C to 70°C
Tiny 5-Lead SOT-23 Package

APPLICATIONS

Battery Powered Instrumentation
Portable Medical Instruments
Data Acquisition Systems
Industrial Process Control Systems
Fault Protection Critical Systems

PIN CONFIGURATION

5-Lead SOT-23



GENERAL DESCRIPTION

The ADR318 is a precision 1.8 V band gap voltage reference featuring high accuracy, high stability, and low power consumption in a tiny footprint. Patented temperature drift curvature correction techniques minimize nonlinearity of the voltage change with temperature. The wide operating range and low power consumption with additional shutdown capability make the part ideal for battery powered applications. The $V_{OUT\ (SENSE)}$ pin enables greater accuracy by supporting full Kelvin operation in PCBs employing thin or long traces.

The ADR318 is a low dropout voltage (LDV) device that provides a stable output voltage from supplies as low as 600 mV above the output voltage. This device is specified over the industrial operating range of 0°C to 70°C, and is available in the tiny 5-lead SOT-23 package.

The combination of $V_{OUT\ (SENSE)}$ and shutdown functions also enables a number of unique applications, combining precision reference/regulation with fault decision and overcurrent protection. Details are provided in the Applications section.

*Protected by U.S. Patent No. 5,969,657; other patents pending.

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ADR318–SPECIFICATIONS

ELECTRICAL CHARACTERISTICS ($T_A = T_{MIN}$ to T_{MAX},[1] V_{IN} = 5 V, unless otherwise noted.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Initial Accuracy	V_O		1.795	1.8	1.802	V
Initial Accuracy Error	V_{OERR}		–0.27		+0.27	%
Temperature Coefficient	TCV_O	0°C to 70°C		5	25	ppm/°C
Minimum Supply Voltage Headroom	$V_{IN} - V_{OUT}$		600			mV
Line Regulation	$\Delta V_{OUT}/\Delta V_{IN}$	V_{IN} = 2.5 V to 15 V 0°C < T_A < 70°C		10	25	ppm/V
Load Regulation	$\Delta V_{OUT}/\Delta I_{LOAD}$	V_{IN} = 3 V, I_{LOAD} = 0 mA to 5 mA 0°C < T_A < 70°C			100	ppm/mA
Quiescent Current	I_{SY}	No load		100	120	µA
		0°C < T_A < 70°C			140	µA
Voltage Noise	e_N	0.1 Hz to 10 Hz		5		µV p-p
Turn-On Settling Time	t_R			20		µs
Long Term Stability[2]	ΔV_{OUT}			50		ppm/1,000 hrs
Output Voltage Hysteresis	V_{O_HYS}			40		ppm
Ripple Rejection Ratio	RRR	f_{IN} = 60 Hz		85		dB
Short Circuit to Ground	I_{SC}	V_{IN} = 5.0 V		25		mA
		V_{IN} = 15.0 V		30		mA
Shutdown Supply Current	I_{SHDN}				3	µA
Shutdown Logic Input Current	I_{LOGIC}				500	nA
Shutdown Logic Low	V_{INL}				0.8	V
Shutdown Logic High	V_{INH}		2.4			V

NOTES

[1]T_{MIN} = 0°C, T_{MAX} = 70°C

[2]The long-term stability specification is noncumulative. The drift in subsequent 1,000 hour periods is significantly lower than in the first 1,000 hour period.

Specifications subject to change without notice.

ABSOLUTE MAXIMUM RATINGS[1, 2]

Supply Voltage . . . . . 18 V
Output Short-Circuit Duration
to GND . . . . . Observe Derating Curves
Storage Temperature Range
RJ Package . . . . . –65°C to +125°C
Operating Temperature Range . . . . . 0°C to 70°C
Junction Temperature Range
RJ Package . . . . . –65°C to +150°C
Lead Temperature Range
Soldering, 60 sec . . . . . 300°C

NOTES
[1]Absolute maximum ratings apply at 25°C, unless otherwise noted.
[2]Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Package Type	θ_{JA}	θ_{JC}	Unit
5-Lead SOT-23 (RJ)	230	146	°C/W

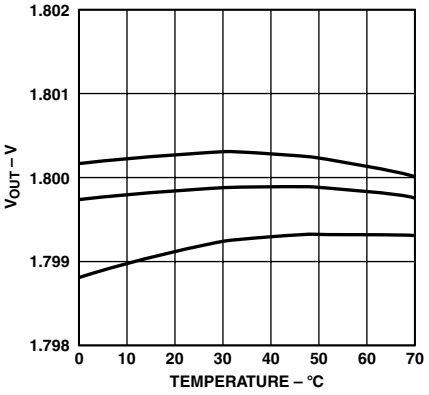
ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option	Branding Information	Output Voltage	Devices per Reel
ADR318ARJ-REEL7	0°C to 70°C	5-Lead SOT-23	RJ-5	R0A	1.800 V	3,000

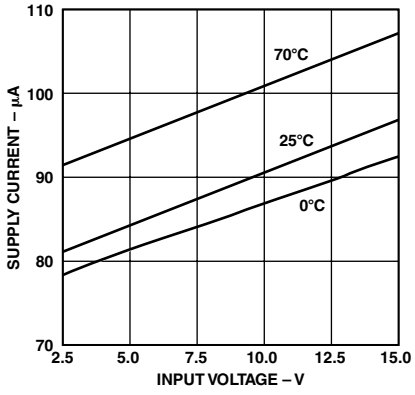
CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the ADR318 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

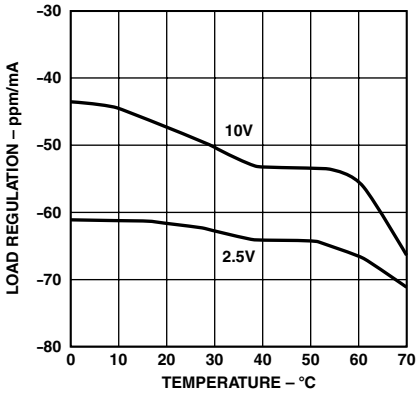
ADR318–Typical Performance Characteristics



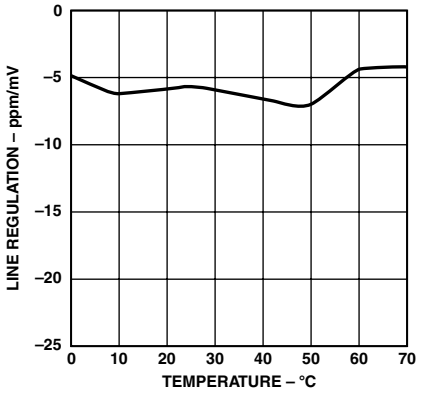
TPC 1. Typical Output Voltage vs. Temperature



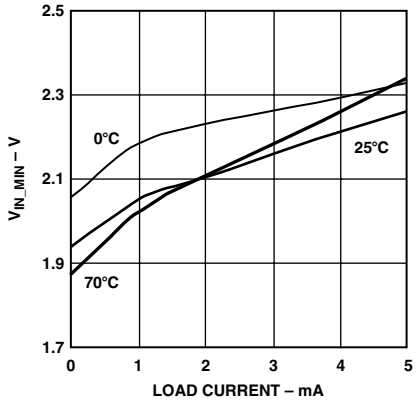
TPC 2. Supply Current vs. Input Voltage



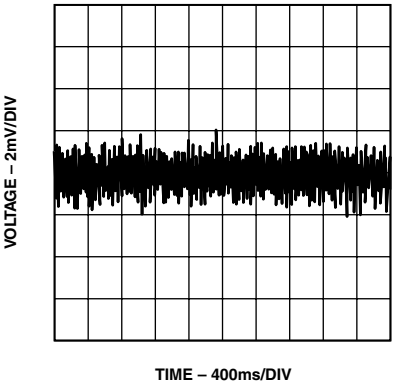
TPC 3. Load Regulation vs. Temperature



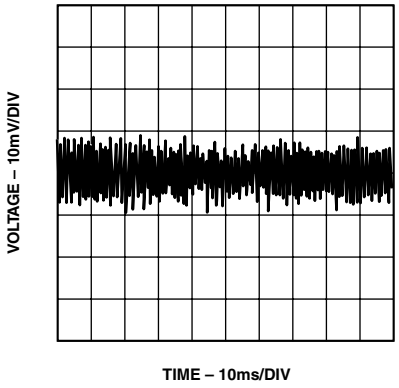
TPC 4. Line Regulation vs. Temperature



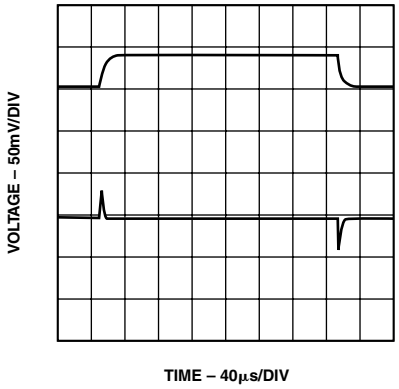
TPC 5. Minimum Input Voltage vs. Load Current



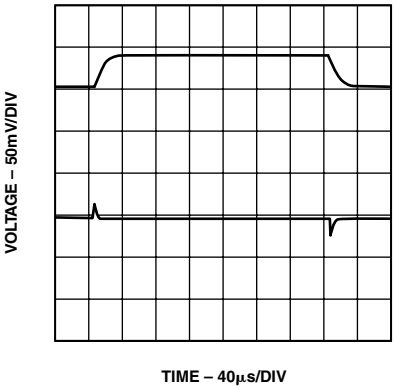
TPC 6. Typical Output Voltage Noise 0.1 Hz to 10 Hz



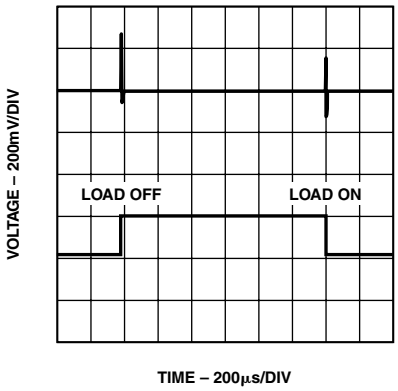
TPC 7. Typical Output Voltage Noise 10 Hz to 10 kHz



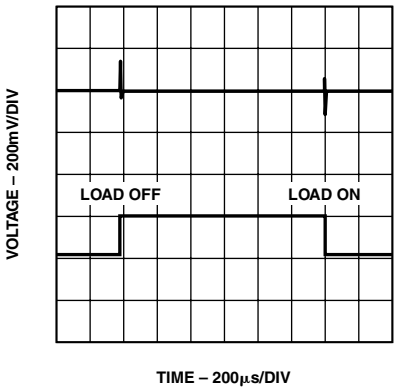
TPC 8. Line Transient Response, C_{BYPASS} = 0 µF



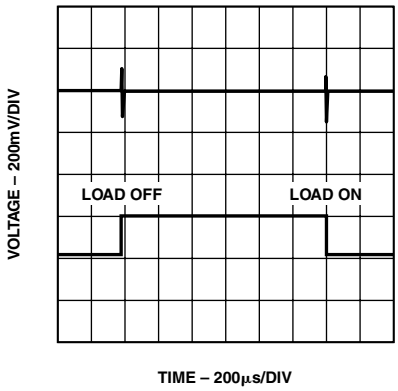
TPC 9. Line Transient Response, C_{BYPASS} = 0.1 µF



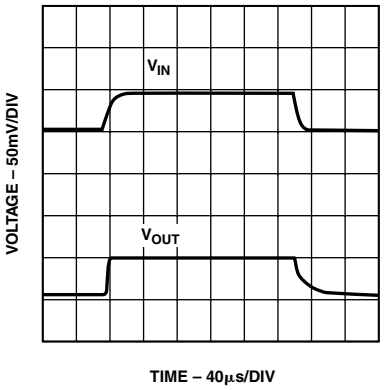
TPC 10. Load Transient Response, C_L = 0 nF



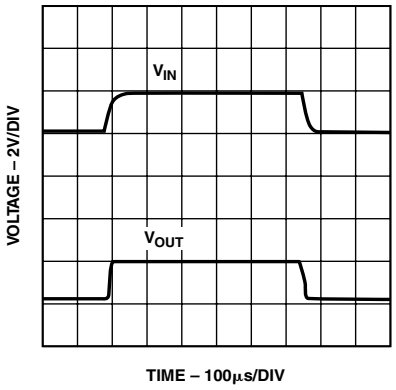
TPC 11. Load Transient Response, C_L = 1 nF



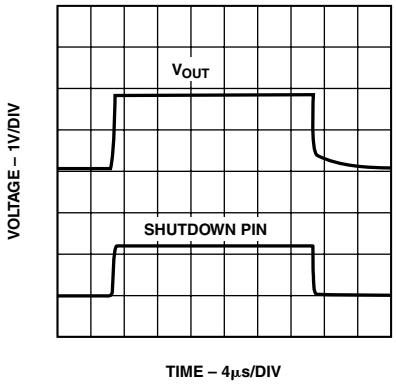
TPC 12. Load Transient Response, C_L = 100 nF



TPC 13. Turn On/Turn Off Response at 5 V, R_{LOAD} = 1.8 kΩ



TPC 14. Turn On/Turn Off Response at 5 V, R_{LOAD} = 1.8 kΩ, C_{BYPASS} = 0.1 μF



TPC 15. Shutdown Pin Response

PARAMETER DEFINITIONS

Temperature Coefficient

Temperature coefficient is the change of output voltage with respect to operating temperature changes, normalized by the output voltage at 25°C. This parameter is expressed in ppm/°C, and can be determined with the following equation:

$$TCV_O\left[\frac{ppm}{^\circ C}\right] = \frac{V_O(T_2) - V_O(T_1)}{V_O(25^\circ C) \times (T_2 - T_1)} \times 10^6 \quad (1)$$

where:

$V_O(25^\circ C) = V_O$ at 25°C

$V_O(T_1) = V_O$ at temperature 1

$V_O(T_2) = V_O$ at temperature 2

Long Term Stability

Long term stability is the typical shift of output voltage at 25°C on a sample of parts subjected to a test of 1,000 hours at 25°C:

$$\Delta V_O = V_O(t_0) - V_O(t_1)$$

$$\Delta V_O[ppm] = \frac{V_O(t_0) - V_O(t_1)}{V_O(t_0)} \times 10^6 \quad (2)$$

where:

$V_O(t_0) = V_O$ at 25°C at time 0

$V_O(t_1) = V_O$ at 25°C after 1,000 hours operation at 25°C

Thermal Hysteresis

Thermal hystereses is defined as the change of output voltage after the device is cycled through temperature from +25°C to –40°C to +125°C and back to +25°C. This is a typical value from a sample of parts put through such a cycle.

$$V_{O\_HYS} = V_O(25^\circ C) - V_{O\_TC}$$

$$V_{O\_HYS}[ppm] = \frac{V_O(25^\circ C) - V_{O\_TC}}{V_O(25^\circ C)} \times 10^6 \quad (3)$$

where:

$V_O(25^\circ C) = V_O$ at 25°C

$V_{O\_TC} = V_O$ at 25°C after temperature cycle at +25°C to –40°C to +125°C and back to +25°C

THEORY OF OPERATION

Band gap references are the high performance solution for low supply voltage and low power voltage reference applications, and the ADR318 is no exception. The uniqueness of this product lies in its architecture. By observing Figure 1, the ideal zero TC band gap voltage is referenced to the output, not to ground. Therefore, if noise exists on the ground line, it will be greatly attenuated on V_{OUT}. The band gap cell consists of the PNP pair Q51 and Q52, running at unequal current densities. The difference in V_{BE} results in a voltage with a positive TC that is amplified by the ratio of 2 × R58/R54. This PTAT voltage, combined with the V_{BE}s of Q51 and Q52, produces the stable band gap voltage.

Reduction in band gap curvature is performed by the ratio of the resistors R44 and R59, one of which is linearly temperature dependent. Precision laser trimming and other patented circuit techniques are used to further enhance the drift performance.

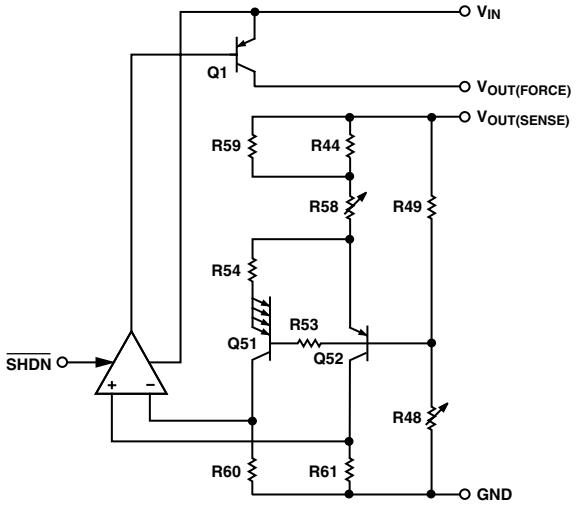


Figure 1. Simplified Schematic

Device Power Dissipation Considerations

The ADR318 is capable of delivering load currents up to 5 mA with an input voltage that ranges from 2.4 V to 15 V. When this device is used in applications with high input voltages, care should be taken to avoid exceeding the specified maximum power dissipation or junction temperature that could result in premature device failure. The following formula should be used to calculate the device's maximum junction temperature or dissipation:

$$P_D = \frac{T_J - T_A}{\theta_{JA}} \quad (4)$$

In Equation 4, T_J and T_A are, respectively, the junction and ambient temperatures, P_D is the device power dissipation, and θ_{JA} is the device package thermal resistance.

Shutdown Mode Operation

The ADR318 includes a shutdown feature that is TTL/CMOS compatible. A logic LOW or a 0 V condition on the $\overline{SHDN}$ pin is required to turn the device off. During shutdown, the output of the reference becomes a high impedance state where its potential would then be determined by external circuitry. If the shutdown feature is not used, the $\overline{SHDN}$ pin should be connected to V_{IN} (Pin 2).

APPLICATIONS

Basic Voltage Reference Connection

The circuit in Figure 2 illustrates the basic configuration for the ADR318. Decoupling capacitors are not required for circuit stability. The ADR318 is capable of driving capacitative loads from 0 μF to 10 μF. However, a 0.1 μF ceramic output capacitor is recommended to absorb and deliver the charge as is required by a dynamic load.

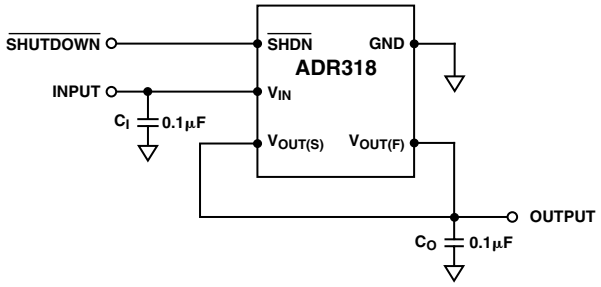


Figure 2. Voltage Reference Connection

Precision Negative Voltage Reference without Precision Resistors

A negative reference can be easily generated by combining the ADR318 with an op amp. Figure 3 shows this simple negative reference configuration. $V_{OUT(F)}$ and $V_{OUT(S)}$ are at virtual ground and therefore the negative reference can be taken directly from the output of the op amp. The op amp should be a dual-supply, low offset, rail-to-rail amplifier, such as the OP1177.

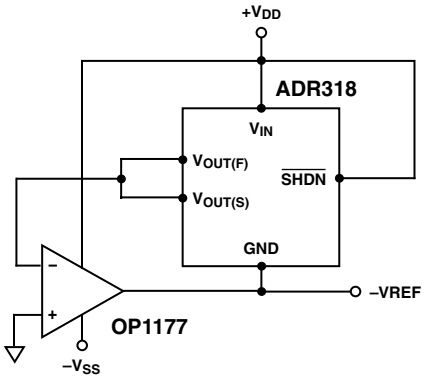


Figure 3. Negative Reference

General-Purpose Current Source

Many times in low power applications, the need arises for a precision current source that can operate on low supply voltages. As shown in Figure 4, the ADR318 can be configured as a precision current source. The circuit configuration illustrated is a floating current source with a grounded load. The reference's output voltage is bootstrapped across R1, which sets the output current into the load. With this configuration, circuit precision is maintained for load currents in the range from the reference's supply current, typically 90 mA to approximately 5 mA. The supply current is a function of I_{SET} and will increase slightly at a given I_{SET}.

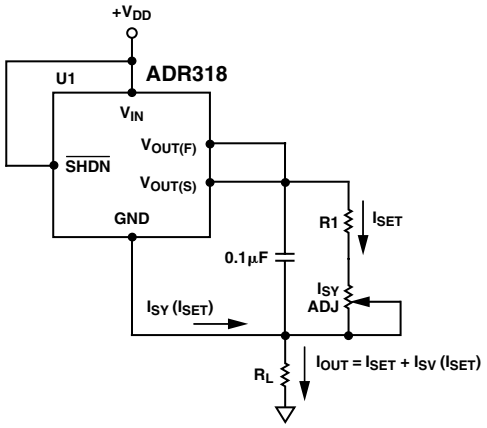


Figure 4. General-Purpose Current Source

High Power Performance with Current Limit

In some cases, the user may want higher output current delivered to a load and still achieve better than 0.5% accuracy out of the ADR318. The accuracy for a reference is normally specified on the data sheet with no load. However, the output voltage changes with load current.

The circuit in Figure 5 provides high current without compromising the accuracy of the ADR318. The power BJT Q1 provides the required current, up to a 1 A. The ADR318 delivers the base drive to Q1 through the force pin. The sense pin of the ADR318 is a regulated output and is connected to the load.

The transistor Q2 protects Q1 during short circuit limit faults by robbing its base drive. The maximum current is $I_{L, MAX} = 0.6\ V/R_S$.

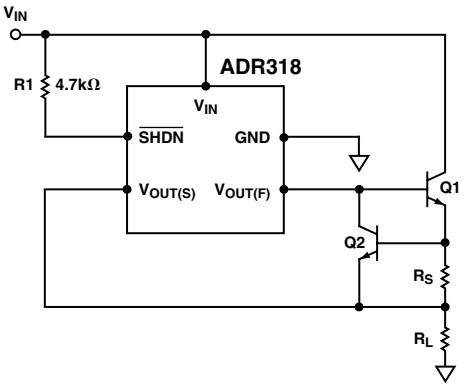


Figure 5. High Power Performance with Current Limit

A similar circuit function can also be achieved using the Darlington transistor configuration, as shown in Figure 6.

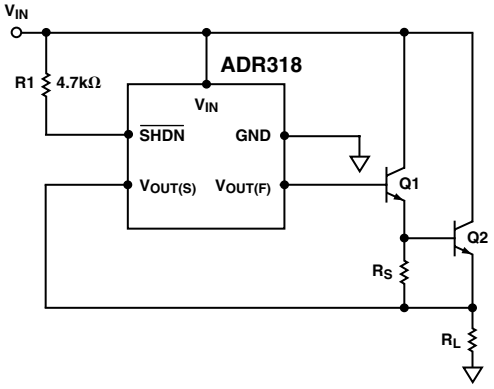


Figure 6. High Output Current with Darlington Drive Configuration

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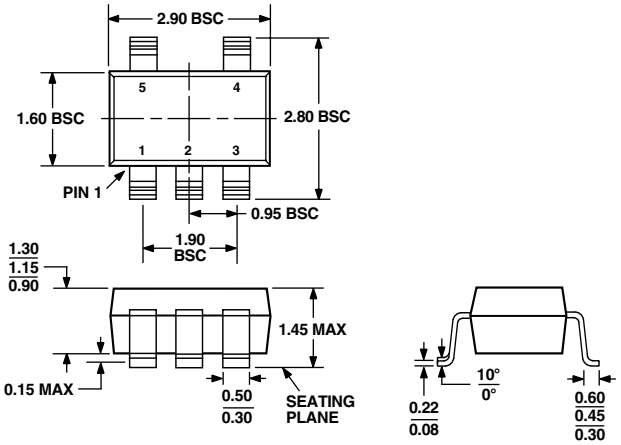
OUTLINE DIMENSIONS

5-Lead Plastic Surface-Mount Package [SOT-23]
(RJ-5)

Dimensions shown in millimeters



COMPLIANT TO JEDEC STANDARDS MO-178AA

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