Low Noise Micropower 2.5 V and 4.096 V Precision Voltage References

ADR291/ADR292

ANALOG DEVICES

FEATURES

Supply range
  2.8 V to 15 V, ADR291
  4.4 V to 15 V, ADR292
Supply current 12 μA max
Low noise 8 μV and 12 μV p-p (0.1 Hz to 10 Hz)
High output current 5 mA
Temperature range −40°C to +125°C
Pin-compatible with REF02/REF19x

APPLICATIONS

Portable instrumentation
Precision reference for 3 V and 5 V systems
A/D and D/A converter reference
Solar powered applications
Loop current powered instruments

CONNECTION DIAGRAMS

Figure 1. 8-Lead SOIC (R-8)
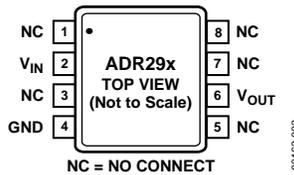
Figure 2. 8-Lead TSSOP (RU-8)

Figure 3. 3-Lead TO-92 (T-3)

GENERAL DESCRIPTION

The ADR291 and ADR292 are low noise, micro-power precision voltage references that use an XFET® reference circuit. The new XFET architecture offers significant performance improvements over traditional band gap and buried Zener based references. Improvements include one quarter the voltage noise output of band gap references operating at the same current, very low and ultralinear temperature drift, low thermal hysteresis, and excellent long-term stability.

The ADR29x family is a series of voltage references providing stable and accurate output voltages from supplies as low as 2.8 V for the ADR291. Output voltage options are 2.5 V and 4.096 V for the ADR291 and ADR292, respectively.
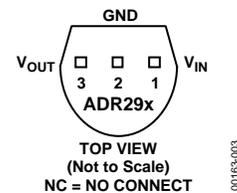
Quiescent current is only 12 μA, making these devices ideal for battery-powered instrumentation. Three electrical grades are available offering initial output accuracies of ±2 mV, ±3 mV, and ±6 mV maximum for the ADR291, and ±3 mV, ±4 mV, and ±6 mV maximum for the ADR292. Temperature coefficients for the three grades are 8 ppm/°C, 15 ppm/°C, and 25 ppm/°C maximum, respectively. Line regulation and load regulation are typically 30 ppm/V and 30 ppm/mA, maintaining the reference's overall high performance. For a device with 5.0 V output, refer to the ADR293 data sheet.

The ADR291 and ADR292 references are specified over the extended industrial temperature range of −40°C to +125°C. Devices are available in the 8-lead SOIC, 8-lead TSSOP, and 3-lead TO-92 packages.

Table 1. ADR29x Product

Part Number	Output Voltage (V)	Initial Accuracy (%)	Temperature Coefficient (ppm/°C) Max
ADR291	2.500	0.08, 0.12, 0.24	8, 15, 25
ADR292	4.096	0.07, 0.10, 0.15	8, 15, 25

ADR291/ADR292

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ADR291 ELECTRICAL SPECIFICATIONS

V_S = 3.0 V to 15 V, T_A = 25°C, unless otherwise noted.

Table 2.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
E GRADE						
Output Voltage	V_O	I_{OUT} = 0 mA	2.498	2.500	2.502	V
Initial Accuracy	V_{OERR}		−2		+2	mV
			−0.08		+0.08	%
F GRADE						
Output Voltage	V_O	I_{OUT} = 0 mA	2.497	2.500	2.503	V
Initial Accuracy	V_{OERR}		−3		+3	mV
			−0.12		+0.12	%
G GRADE						
Output Voltage	V_O	I_{OUT} = 0 mA	2.494	2.500	2.506	V
Initial Accuracy	V_{OERR}		−6		+6	mV
			−0.24		+0.24	
LINE REGULATION						%
E/F Grades	$\Delta V_O/\Delta V_{IN}$	3.0 V to 15 V, I_{OUT} = 0 mA		30	100	ppm/V
G Grade				40	125	ppm/V
LOAD REGULATION						
E/F Grades	$\Delta V_O/\Delta I_{LOAD}$	V_S = 5.0 V, 0 mA to 5 mA		30	100	ppm/mA
G Grade				40	125	ppm/mA
LONG TERM STABILITY	ΔV_O	After 1,000 hours of operation @ 125°C		50		ppm
NOISE VOLTAGE	e_N	0.1 Hz to 10 Hz		8		µV p-p
WIDEBAND NOISE DENSITY	e_N	@ 1 kHz		480		nV/√Hz

V_S = 3.0 V to 15 V, T_A = −25°C ≤ T_A ≤ +85°C, unless otherwise noted.

Table 3.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
TEMPERATURE COEFFICIENT						
E Grade	TCV_O	I_{OUT} = 0 mA		3	8	ppm/°C
F Grade				5	15	ppm/°C
G Grade				10	25	ppm/°C
LINE REGULATION						
E/F Grades	$\Delta V_O/\Delta V_{IN}$	3.0 V to 15 V, I_{OUT} = 0 mA		35	125	ppm/V
G Grade				50	150	ppm/V
LOAD REGULATION						
E/F Grades	$\Delta V_O/\Delta I_{LOAD}$	V_S = 5.0 V, 0 mA to 5 mA		20	125	ppm/mA
G Grade				30	150	ppm/mA

V_S = 3.0 V to 15 V, T_A = −40°C ≤ T_A ≤ +125°C, unless otherwise noted.

Table 4.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
TEMPERATURE COEFFICIENT						
E Grade	TCV$_O$	I_{OUT} = 0 mA		3	10	ppm/°C
F Grade				5	20	ppm/°C
G Grade				10	30	ppm/°C
LINE REGULATION						
E/F Grades	ΔV$_O$/ΔV$_{IN}$	3.0 V to 15 V, I_{OUT} = 0 mA		40	200	ppm/V
G Grade				70	250	ppm/V
LOAD REGULATION						
E/F Grades	ΔV$_O$/ΔI$_{LOAD}$	V_S = 5.0 V, 0 mA to 5 mA		20	200	ppm/mA
G Grade				30	300	ppm/mA
SUPPLY CURRENT	I$_S$	T_A = 25°C		9	12	µA
		−40°C ≤ T_A ≤ +125°C		12	15	µA
THERMAL HYSTERESIS	V$_{O-HYS}$	8-lead SOIC, 8-lead TSSOP		50		ppm

ADR292 ELECTRICAL SPECIFICATIONS

V_S = 5 V to 15 V, T_A = 25°C, unless otherwise noted.

Table 5.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
E GRADE						
Output Voltage	V$_O$	I_{OUT} = 0 mA	4.093	4.096	4.099	V
Initial Accuracy	V$_{OERR}$		−3		+3	mV
			−0.07		+0.07	%
F GRADE						
Output Voltage	V$_O$	I_{OUT} = 0 mA	4.092	4.096	4.1	V
Initial Accuracy	V$_{OERR}$		−4		+4	mV
			−0.10		+0.10	%
G GRADE						
Output Voltage	V$_O$	I_{OUT} = 0 mA	4.090	4.096	4.102	V
Initial Accuracy	V$_{OERR}$		−6		+6	%
			−0.15		+0.15	mV
LINE REGULATION						
E/F Grades	ΔV$_O$/ΔV$_{IN}$	4.5 V to 15 V, I_{OUT} = 0 mA		30	100	ppm/V
G Grade				40	125	ppm/V
LOAD REGULATION						
E/F Grades	ΔV$_O$/ΔI$_{LOAD}$	V_S = 5.0 V, 0 mA to 5 mA		30	100	ppm/mA
G Grade				40	125	ppm/mA
LONG-TERM STABILITY	ΔV$_O$	After 1,000 hours of operation @ 125°C		50		ppm
NOISE VOLTAGE	e$_N$	0.1 Hz to 10 Hz		12		µV p-p
WIDEBAND NOISE DENSITY	e$_N$	@ 1 kHz		640		nV/√Hz

V_S = 5 V to 15 V, T_A = −25°C ≤ T_A ≤ +85°C, unless otherwise noted.

Table 6.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
TEMPERATURE COEFFICIENT						
E Grade	TCV$_O$	I$_{OUT}$ = 0 mA		3	8	ppm/°C
F Grade				5	15	ppm/°C
G Grade				10	25	ppm/°C
LINE REGULATION						
E/F Grades	ΔV$_O$/ΔV$_{IN}$	4.5 V to 15 V, I$_{OUT}$ = 0 mA		35	125	ppm/V
G Grade				50	150	ppm/V
LOAD REGULATION						
E/F Grades	ΔV$_O$/ΔI$_{LOAD}$	V$_S$ = 5.0 V, 0 mA to 5 mA		20	125	ppm/mA
G Grade				30	150	ppm/mA

V_S = 5 V to 15 V, T_A = −40°C ≤ T_A ≤ +125°C, unless otherwise noted.

Table 7.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
TEMPERATURE COEFFICIENT						
E Grade	TCV$_O$	I$_{OUT}$ = 0 mA		3	10	ppm/°C
F Grade				5	20	ppm/°C
G Grade				10	30	ppm/°C
LINE REGULATION						
E/F Grades	ΔV$_O$/ΔV$_{IN}$	4.5 V to 15 V, I$_{OUT}$ = 0 mA		40	200	ppm/V
G Grade				70	250	ppm/V
LOAD REGULATION						
E/F Grades	ΔV$_O$/ΔI$_{LOAD}$	V$_S$ = 5.0 V, 0 mA to 5 mA		20	200	ppm/mA
G Grade				30	300	ppm/mA
SUPPLY CURRENT	I$_S$	T$_A$ = 25°C		10	15	μA
		−40°C ≤ T$_A$ ≤ +125°C		12	18	μA
THERMAL HYSTERESIS	V$_{O-HYS}$	8-lead SOIC, 8-lead TSSOP		50		ppm

ABSOLUTE MAXIMUM RATINGS

Remove power before inserting or removing units from their sockets.

Table 8.

Parameter	Rating
Supply Voltage	18 V
Output Short-Circuit Duration to GND	Indefinite
Storage Temperature Range	
T, R, RU Package	−65°C to +150°C
Operating Temperature Range	
ADR291/ADR292	−40°C to +125°C
Junction Temperature Range	
T, R, RU Package	−65°C to +125°C
Lead Temperature (Soldering, 60 sec)	300°C

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 indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Table 9. Package Types

Package Type	θ_{JA}[1]	θ_{JC}	Unit
8-Lead SOIC (R)	158	43	°C/W
8-Lead TSSOP (RU)	240	43	°C/W

[1] θ_{JA} is specified for worst-case conditions. For example, θ_{JA} is specified for a device in socket testing. In practice, θ_{JA} is specified for a device soldered in the circuit board.

Table 10. Other XFET Products

Part Number	Nominal Output Voltage (V)	Package Type
ADR420	2.048	8-Lead MSOP/SOIC
ADR421	2.50	8-Lead MSOP/SOIC
ADR423	3.0	8-Lead MSOP/SOIC
ADR425	5.0	8-Lead MSOP/SOIC

ESD 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 this product 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.
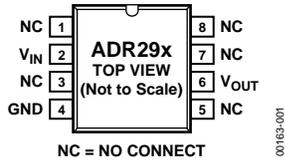
PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS

Figure 4. 8-LeadSOIC (R-8)
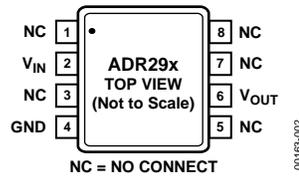
Figure 5. 8-Lead TSSOP (RU-8)
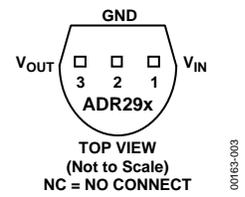
Figure 6. 3-Lead TO-92 (T-3)

Table 11. Pin Function Descriptions

Pin No.				
SOIC	**TSSOP**	**TO-92**	**Mnemonic**	**Description**
1, 3, 5, 7, 8	1, 3, 5, 7, 8	N/A	NC	No Connect
2	2	1	V_{IN}	Input Voltage
4	4	2	GND	Ground
6	6	3	V_{OUT}	Output Voltage

TYPICAL PERFORMANCE CHARACTERISTICS
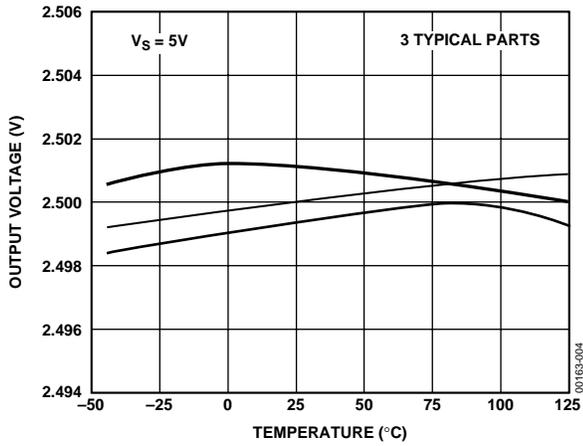
Figure 7. ADR291 V_{OUT} vs. Temperature
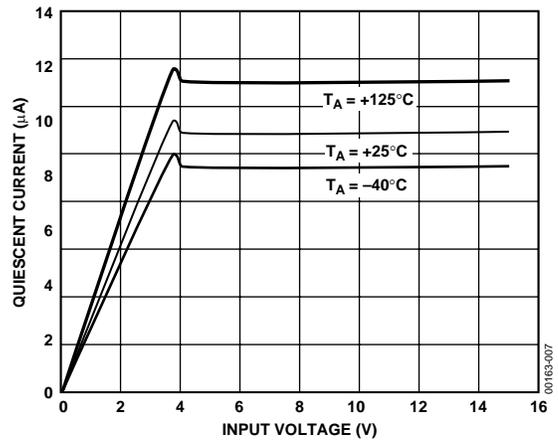
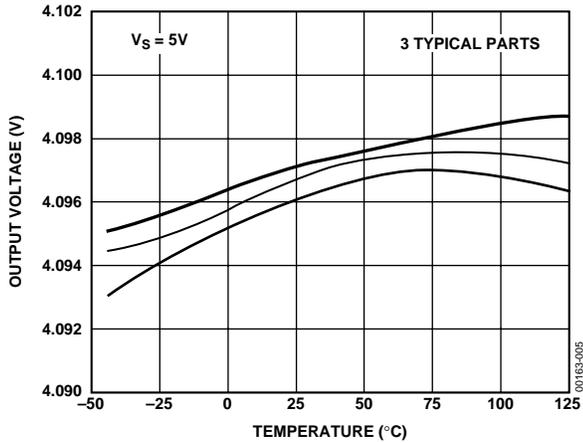Figure 10. ADR292 Quiescent Current vs. Input Voltage

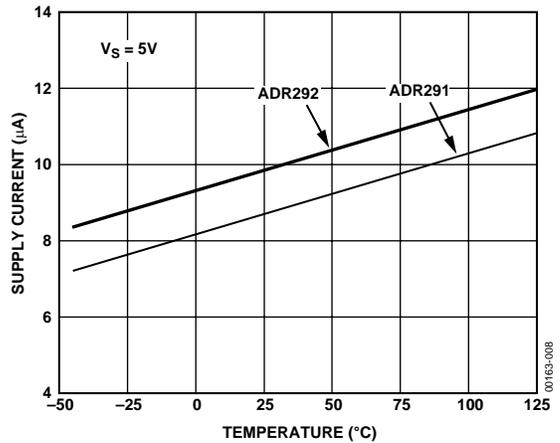Figure 8. ADR292 V_{OUT} vs. Temperature

Figure 11. ADR291/ADR292 Supply Current vs. Temperature
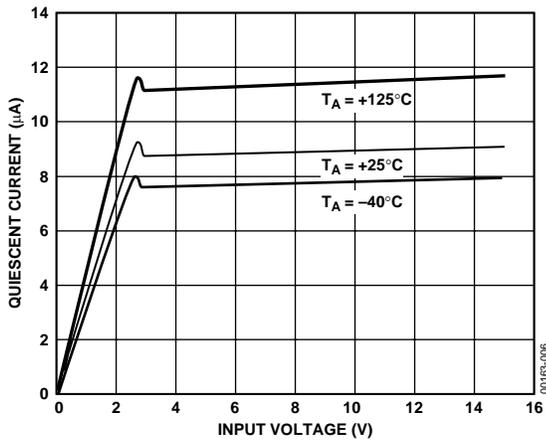

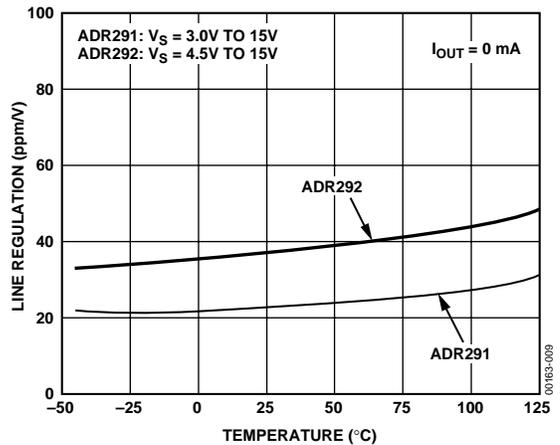Figure 9. ADR291 Quiescent Current vs. Input Voltage

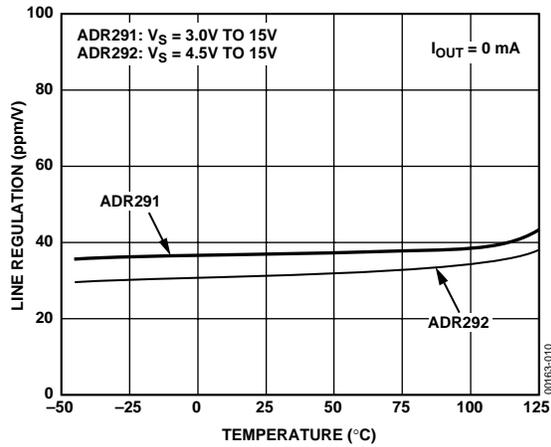Figure 12. ADR291/ADR292 Line Regulation vs. Temperature

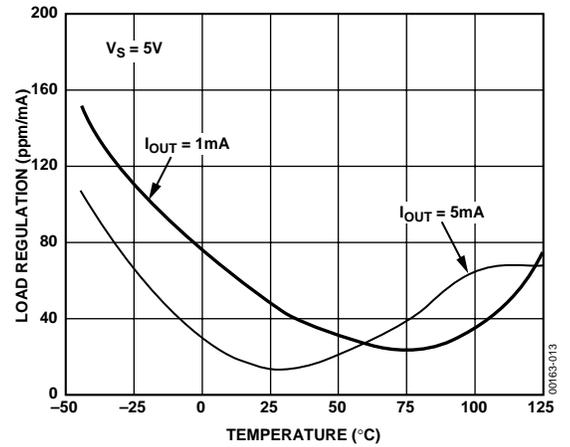Figure 13. ADR291/ADR292 Line Regulation vs. Temperature

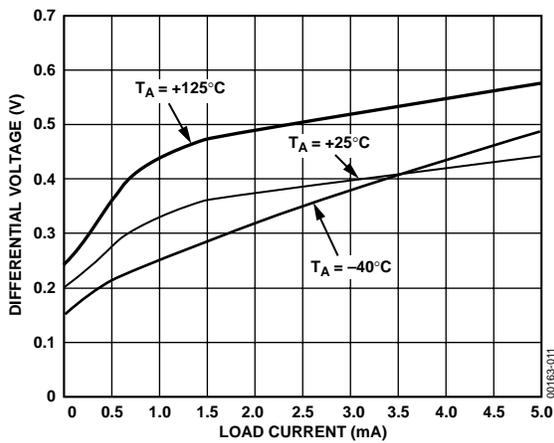Figure 16. ADR291 Load Regulation vs. Temperature

Figure 14. ADR291 Minimum Input-Output
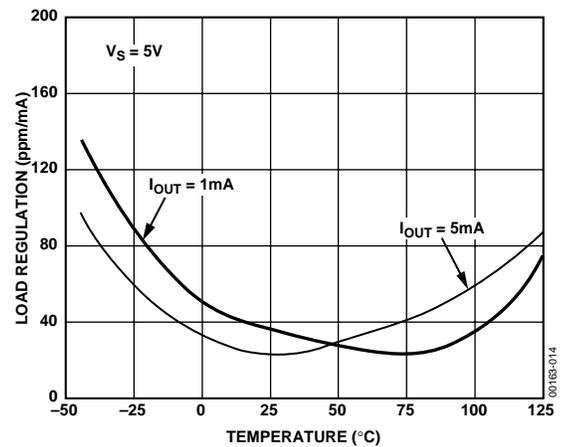Voltage Differential vs. Load Current

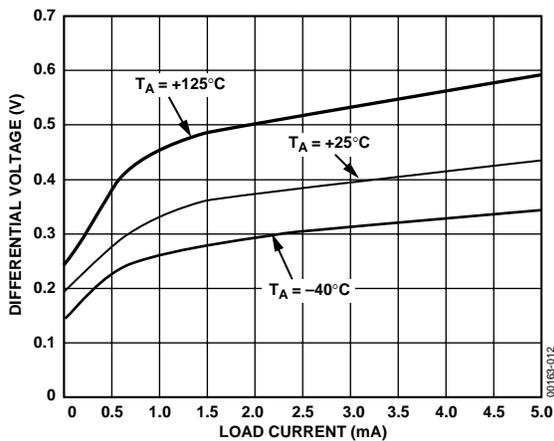Figure 17. ADR292 Load Regulation vs. Temperature

Figure 15. ADR292 Minimum Input-Output
Voltage Differential vs. Load Current
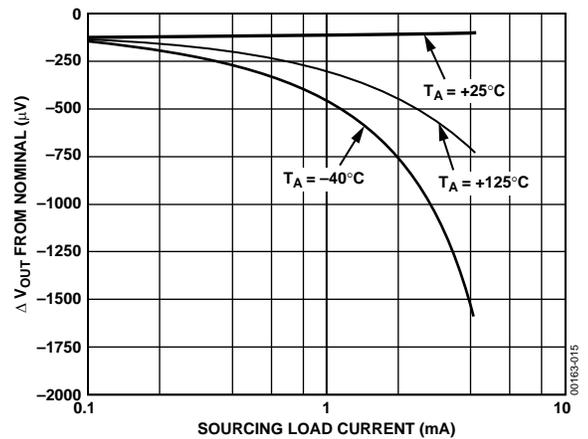

Figure 18. ADR291 ΔV_{OUT} from Nominal vs. Load Current
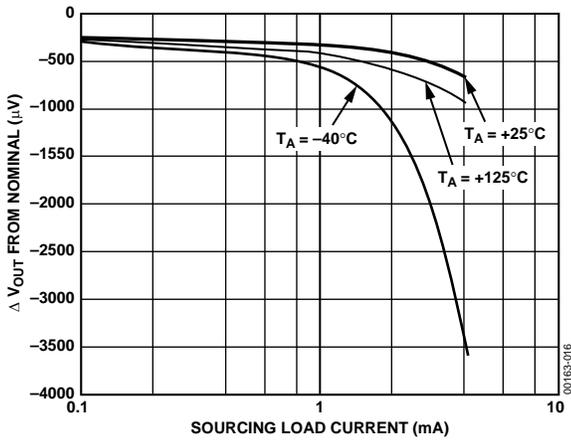
Figure 19. ADR292 ΔV_OUT from Nominal vs. Load Current
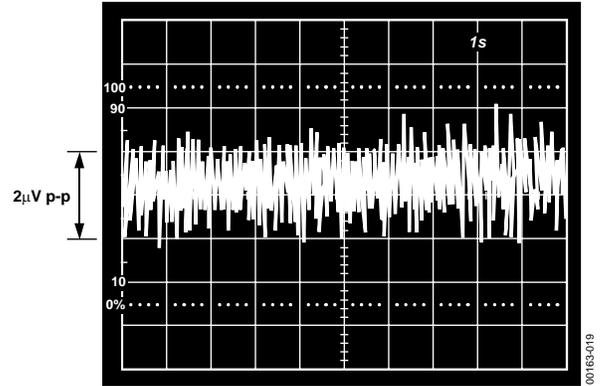
Figure 22. ADR291 0.1 Hz to 10 Hz Noise
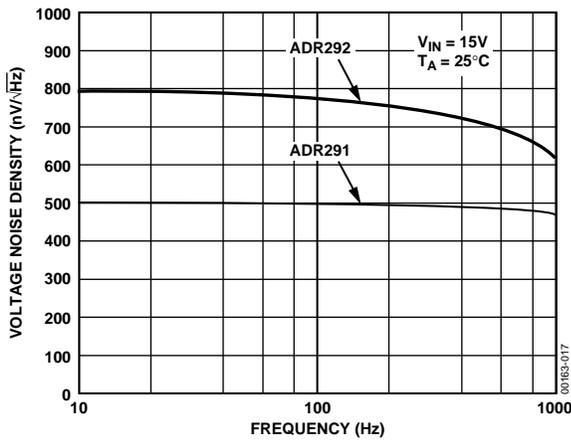
Figure 20. Voltage Noise Density vs. Frequency

Figure 23. ADR291 Output Impedance vs. Frequency

Figure 21. ADR291/ADR292 Ripple Rejection vs. Frequency

Figure 24. ADR292 Output Impedance vs. Frequency

Figure 25. ADR291 Load Transient

Figure 26. ADR291 Load Transient

Figure 27. ADR291 Load Transient

Figure 28. ADR291 Turn-On Time

Figure 29. ADR291 Turn-Off Time

Figure 30. Typical Hysteresis for the ADR291 Product

TERMINOLOGY

Line Regulation
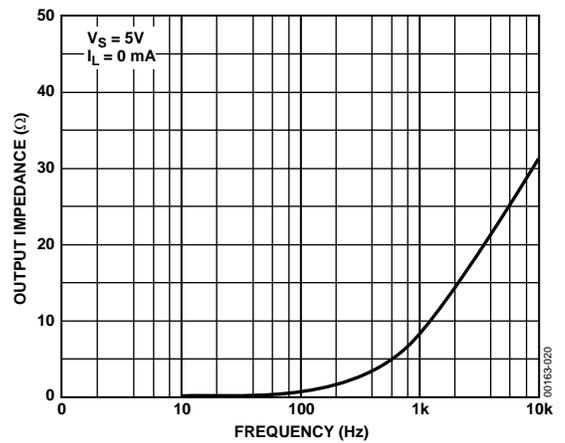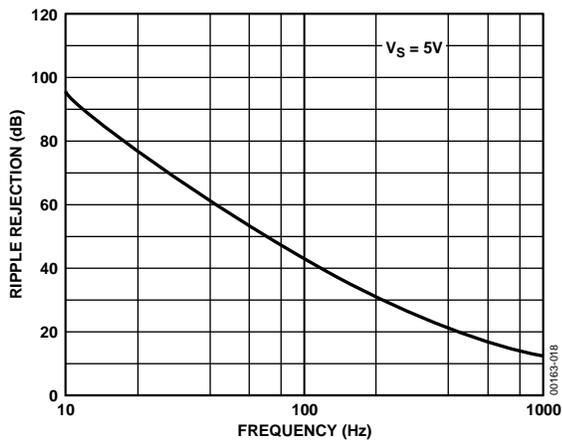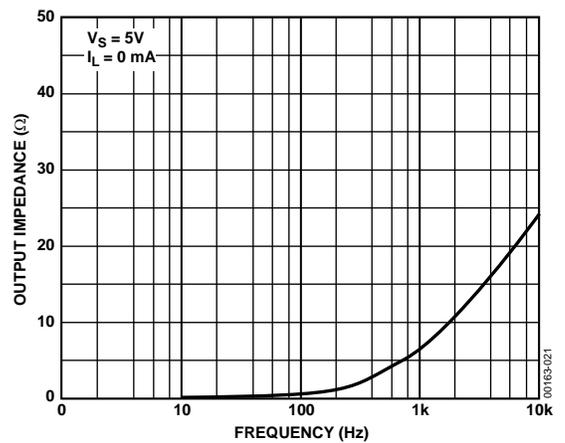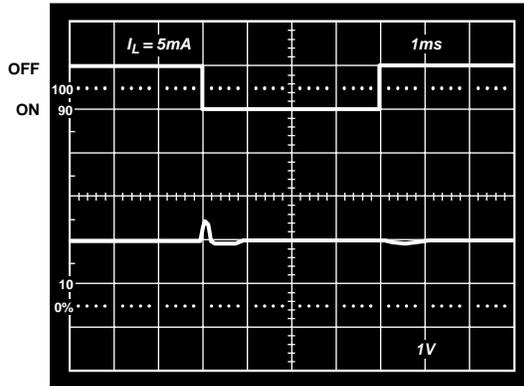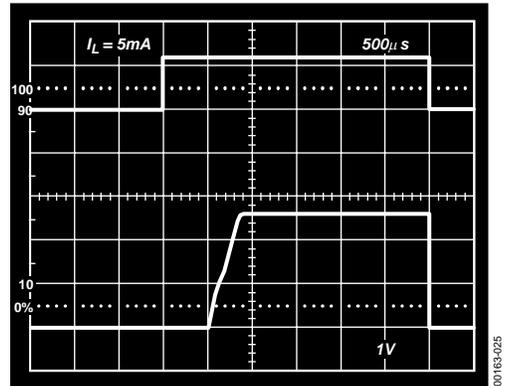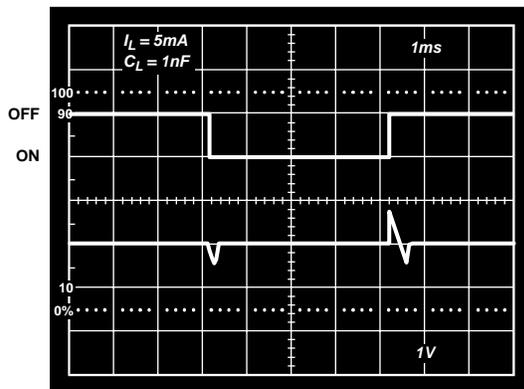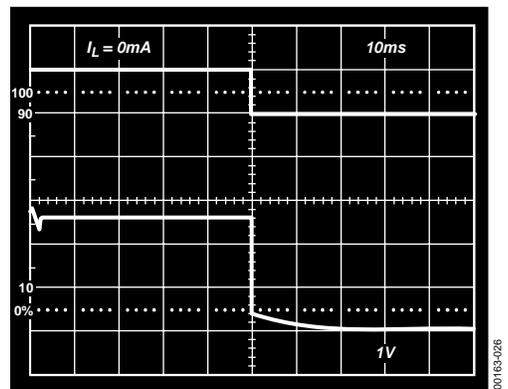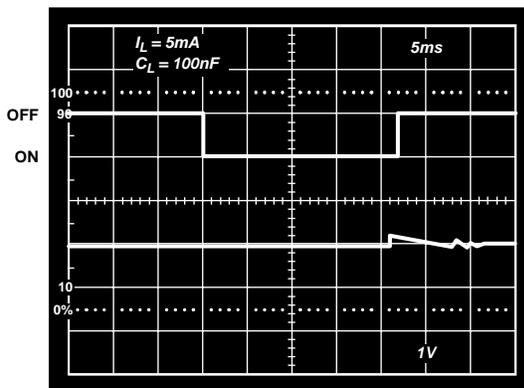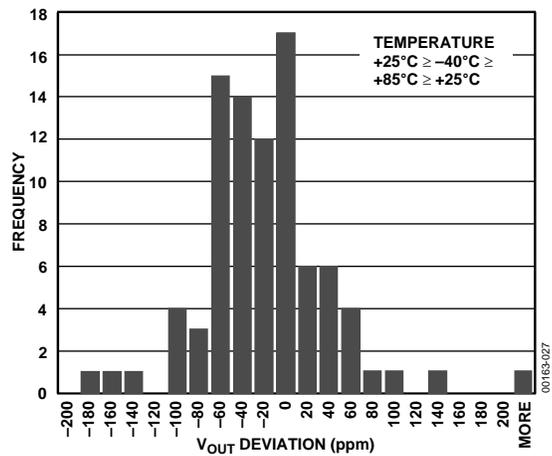Line Regulation refers to the change in output voltage due to a specified change in input voltage. It includes the effects of self-heating. Line regulation is expressed as percent-per-volt, parts-per-million-per-volt, or microvolts-per-volt change in input voltage.

Load Regulation

The change in output voltage is due to a specified change in load current and includes the effects of self-heating. Load regulation is expressed in microvolts-per-milliampere, parts-per-million-per-milliampere, or ohms of dc output resistance.

Long-Term Stability
Long term stability refers to the typical shift of output voltage at 25°C on a sample of parts subjected to a test of 1,000 hours at 125°C.

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

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 125°C.

Temperature Coefficient
Temperature coefficient is the change of output voltage over the operating temperature change normalized by the output voltage at 25°C, expressed in ppm/°C. The equation follows:

$$TCV_O[\text{ppm}/°C] = \frac{V_O(T_2) - V_O(T_1)}{V_O(25°C) \times (T_2 - T_1)} \times 10^6$$

where:

V_O (25°C) = V_O at 25°C.

$V_O(T_1)$ = V_O at Temperature 1.

$V_O(T_2)$ = V_O at Temperature 2.

NC = no connect.

There are internal connections at NC pins that are reserved for manufacturing purposes. Users should not connect anything at the NC pins.

Thermal Hysteresis
Thermal hysteresis is defined as the change of output voltage after the device is cycled through temperatures from +25°C to −40°C to +85°C and back to +25°C. This is a typical value from a sample of parts put through such a cycle.

$$V_{O-HYS} = V_O(25°C) - V_{O\_TC}$$

$$V_{O-HYS}[\text{ppm}] = \frac{V_O(25°C) - V_{O\_TC}}{V_O(25°C)} \times 10^6$$

where:

V_O (25°C) = V_O at 25°C.

V_{O_TC} = V_O at 25°C after temperature cycle at +25°C to −40°C to +85°C and back to +25°C.

THEORY OF OPERATION

The ADR29x series of references uses a reference generation technique known as XFET (eXtra implanted junction FET). This technique yields a reference with low noise, low supply current, and very low thermal hysteresis.

The core of the XFET reference consists of two junction field effect transistors, one having an extra channel implant to raise its pinch-off voltage. By running the two JFETs at the same drain current, the difference in pinch-off voltage can be amplified and used to form a highly stable voltage reference. The intrinsic reference voltage is around 0.5 V with a negative temperature coefficient of about −120 ppm/K. This slope is essentially locked to the dielectric constant of silicon and can be closely compensated by adding a correction term generated in the same fashion as the proportional-to-temperature (PTAT) term used to compensate band gap references. Because most of the noise of a band gap reference comes from the compensation circuitry, the intrinsic temperature coefficient offers a significant advantage (being some 30 times lower), and therefore, requiring less correction resulting in much lower noise.

The simplified schematic in Figure 31 shows the basic topology of the ADR29x series. The temperature correction term is provided by a current source with a value designed to be proportional to absolute temperature. The general equation is

$$V_{OUT} = \Delta V_P \left(\frac{R1 + R2 + R3}{R1} \right) + (I_{PTAT})(R3)$$

where ΔV_P is the difference in pinch-off voltage between the two FETs, and I_{PTAT} is the positive temperature coefficient correction current. The various versions of the ADR29x family are created by on-chip adjustment of R1 and R3 to achieve 2.500 V or 4.096 V at the reference output.

The process used for the XFET reference also features vertical NPN and PNP transistors, the latter of which are used as output devices to provide a very low drop-out voltage.
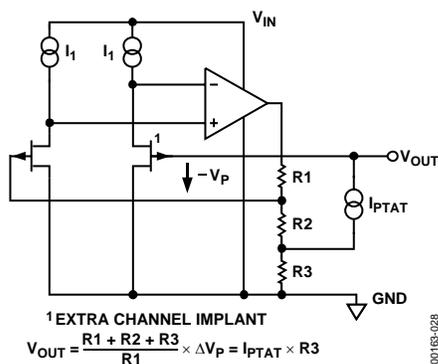

Figure 31. ADR291/ADR292 Simplified Schematic

DEVICE POWER DISSIPATION CONSIDERATIONS

The ADR29x family of references is guaranteed to deliver load currents to 5 mA with an input voltage that ranges from 2.7 V to 15 V (minimum supply voltage depends on the output voltage chosen). When these devices are used in applications with large input voltages, care should be exercised to avoid exceeding the published specifications for maximum power dissipation or junction temperature that could result in premature device failure. Use the following formula to calculate maximum junction temperature or dissipation of a device:

$$P_D = \frac{T_J - T_A}{\theta_{JA}}$$

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

BASIC VOLTAGE REFERENCE CONNECTIONS

References, in general, require a bypass capacitor connected from the V_{OUT} pin to the GND pin. The circuit in Figure 32 illustrates the basic configuration for the ADR29x family of references. Note that the decoupling capacitors are not required for circuit stability.
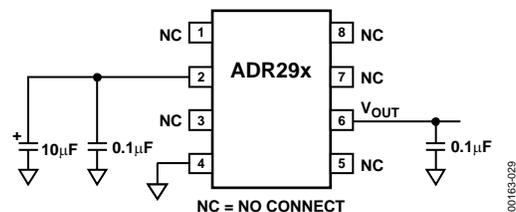
Figure 32. Basic Voltage Reference Configuration

NOISE PERFORMANCE

The noise generated by the ADR29x family of references is typically less than 12 μV p-p over the 0.1 Hz to 10 Hz band. The noise measurement is made with a band-pass filter made of a 2-pole high-pass filter with a corner frequency at 0.1 Hz and a 2-pole low-pass filter with a corner frequency at 10 Hz.

TURN-ON TIME

Upon application of power (cold start), the time required for the output voltage to reach its final value within a specified error band is defined as the turn-on settling time. Two components normally associated with this are the time it takes for the active circuits to settle and for the thermal gradients on the chip to stabilize. Figure 28 shows the turn-on settling time for the ADR291.

APPLICATIONS SECTION

NEGATIVE PRECISION REFERENCE WITHOUT PRECISION RESISTORS

In many current-output CMOS DAC applications, where the output signal voltage must be of the same polarity as the reference voltage, it is often necessary to reconfigure a current-switching DAC into a voltage-switching DAC through the use of a 1.25 V reference, an op amp, and a pair of resistors. Directly using a current-switching DAC requires an additional operational amplifier at the output to reinvert the signal. A negative voltage reference is then desirable from the point that an additional operational amplifier is not required for either reinversion (current-switching mode) or amplification (voltage-switching mode) of the DAC output voltage. In general, any positive voltage reference can be converted into a negative voltage reference through the use of an operational amplifier and a pair of matched resistors in an inverting configuration. The disadvantage to that approach is that the largest single source of error in the circuit is the relative matching of the resistors used.

The circuit illustrated in Figure 33 avoids the need for tightly matched resistors with the use of an active integrator circuit. In this circuit, the output of the voltage reference provides the input drive for the integrator. To maintain circuit equilibrium, the integrator adjusts its output to establish the proper relationship between the reference's V_{OUT} and GND. Thus, any negative output voltage desired can be chosen by simply substituting for the appropriate reference IC. There is one caveat with this approach: although rail-to-rail output amplifiers work best in the application, these operational amplifiers require a finite amount (mV) of headroom when required to provide any load current. The choice for the circuit's negative supply should take this issue into account.
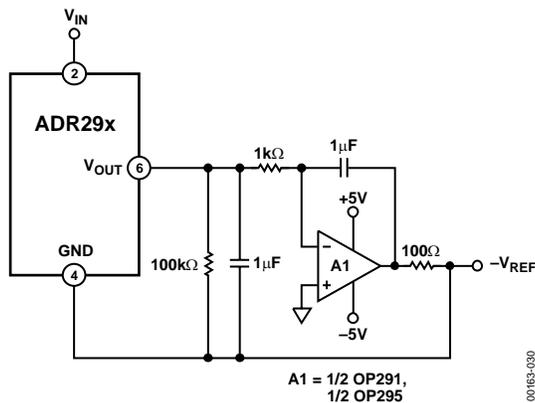

Figure 33. A Negative Precision Voltage Reference Uses No Precision Resistors

PRECISION CURRENT SOURCE

In low power applications, there is often a need for a precision current source that can operate on low supply voltages. As shown in Figure 34, any one of the devices in the ADR29x family of references 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 R_{SET}, 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 12 μA to approximately 5 mA.
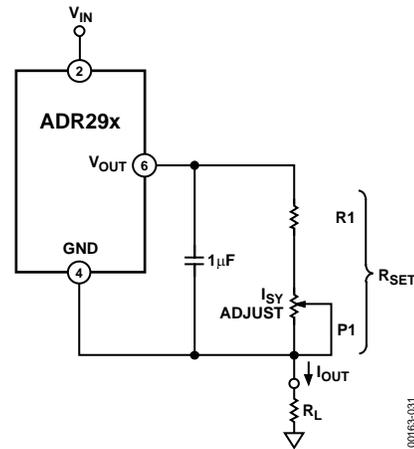

Figure 34. A Precision Current Source

HIGH VOLTAGE FLOATING CURRENT SOURCE

The circuit shown in Figure 35 can be used to generate a floating current source with minimal self-heating. This particular configuration operates on high supply voltages determined by the breakdown voltage of the N-channel JFET.
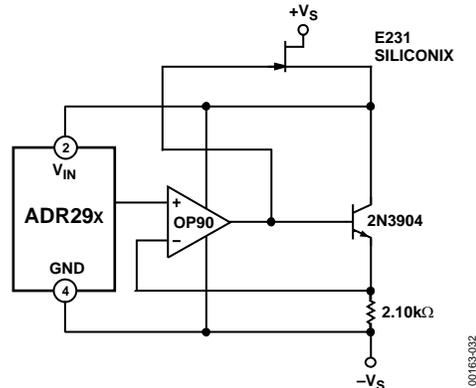

Figure 35. High Voltage Floating Current Source

KELVIN CONNECTIONS

In many portable instrumentation applications, the PC board area is directly related to cost; therefore, circuit interconnects are reduced to a minimal width. These narrow lines can cause large voltage drops if the voltage reference is required to provide load currents to various functions. In fact, circuit interconnects can exhibit a typical line resistance of 0.45 mΩ/square (1 oz. Cu, for example). Force and sense connections, also referred to as Kelvin connections, offer a convenient method of eliminating the effects of voltage drops in circuit wires. Load currents flowing through wiring resistance produce an error ($V_{ERROR} = R \times I_L$) at the load. However, the Kelvin connection shown in Figure 36 overcomes the problem by including the wiring resistance within the forcing loop of the op amp. Since the op amp senses the load voltage, the op amp loop control forces the output to compensate for the wiring error producing the correct voltage at the load.
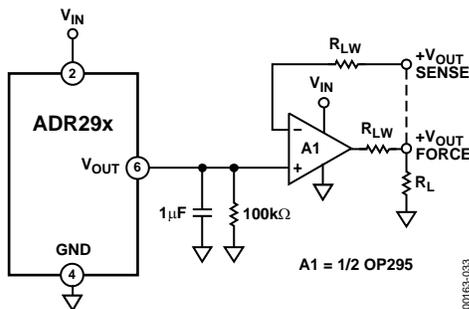

Figure 36. Advantage of Kelvin Connection

LOW POWER, LOW VOLTAGE REFERENCE FOR DATA CONVERTERS

The ADR29x family has a number of features that makes it ideally suited for use with A/D and D/A converters. Because of its low supply voltage, the ADR291 can be used with today's converters that run on 3 V supplies without having to add a higher supply voltage for the reference. The low quiescent current (12 µA maximum) and low noise, tight temperature coefficient, combined with the high accuracy of the ADR29x, make it ideal for low power applications such as hand-held, battery-operated equipment.

One such ADC for which the ADR291 is well suited is the AD7701. Figure 37 shows the ADR291 used as the reference for this converter. The AD7701 is a 16-bit A/D converter with on-chip digital filtering intended for the measurement of wide dynamic range, low frequency signals such as those representing chemical, physical, or biological processes. It contains a charge balancing (Σ-Δ) ADC, calibration microcontroller with on-chip static RAM, a clock oscillator, and a serial communications port.

This entire circuit runs on ±5 V supplies. The power dissipation of the AD7701 is typically 25 mW and, when combined with the power dissipation of the ADR291 (60 µW), the entire circuit still consumes about 25 mW.
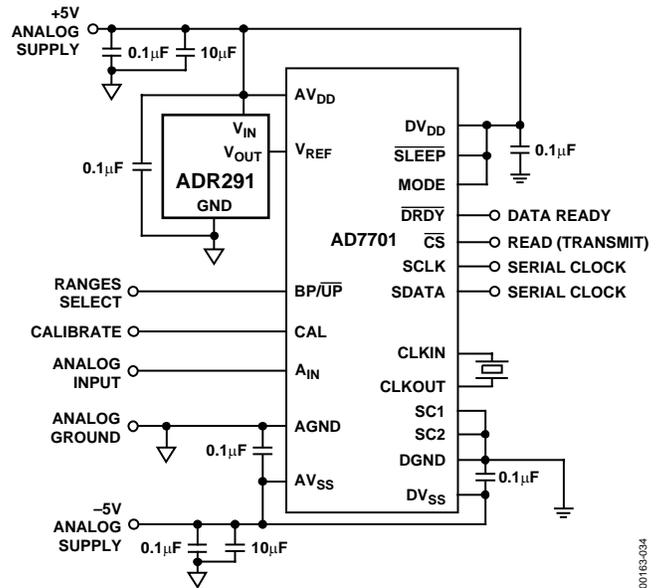

Figure 37. Low Power, Low Voltage Supply Reference for the AD7701

VOLTAGE REGULATOR FOR PORTABLE EQUIPMENT

The ADR29x family of references is ideal for providing a stable, low cost, and low power reference voltage in portable equipment power supplies. Figure 38 shows how the ADR291 and ADR292 can be used in a voltage regulator that not only has low output noise (as compared to switch mode design) and low power, but also a very fast recovery after current surges. Some precautions should be taken in the selection of the output capacitors. Too high an ESR (effective series resistance) could endanger the stability of the circuit. A solid tantalum capacitor, 16 V or higher, and an aluminum electrolytic capacitor, 10 V or higher, are recommended for C1 and C2, respectively. Also, the path from the ground side of C1 and C2 to the ground side of R1 should be kept as short as possible.
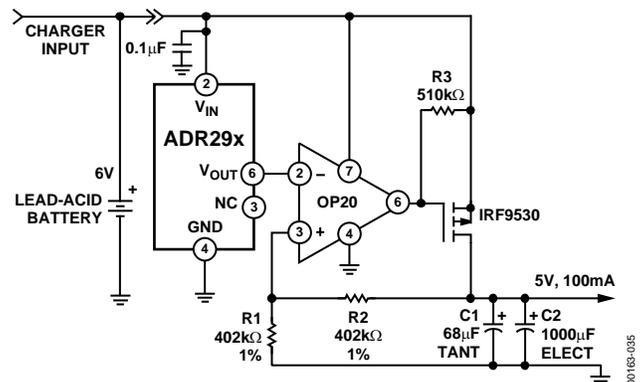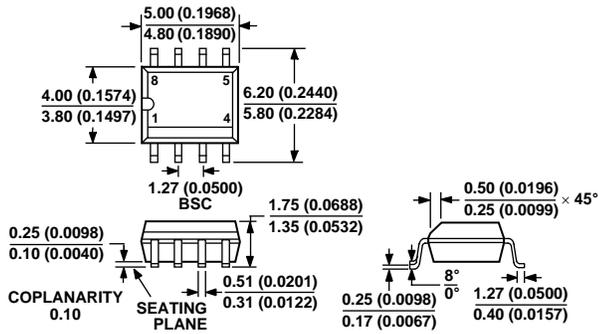

Figure 38. Voltage Regulator for Portable Equipment

OUTLINE DIMENSIONS

COMPLIANT TO JEDEC STANDARDS MS-012AA
CONTROLLING DIMENSIONS ARE IN MILLIMETERS; INCH DIMENSIONS
(IN PARENTHESES) ARE ROUNDED-OFF MILLIMETER EQUIVALENTS FOR
REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN

Figure 39. 8-Lead Standard Small Outline Package [SOIC]
Narrow Body
(R-8)
Dimensions shown in millimeters and (inches)
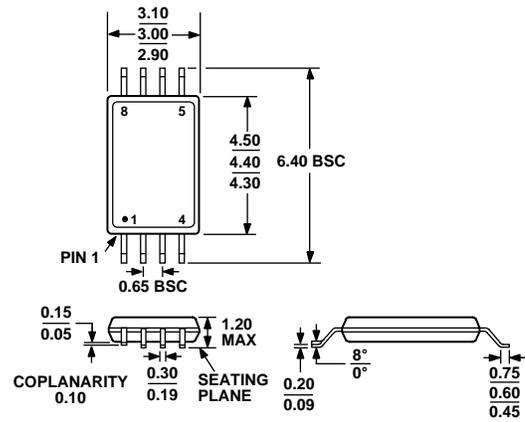
COMPLIANT TO JEDEC STANDARDS MO-153AA

Figure 40. 8-Lead Thin Shrink Small Outline Package [TSSOP]
(RU-8)
Dimensions shown in millimeters

COMPLIANT TO JEDEC STANDARDS TO-226-AA
CONTROLLING DIMENSIONS ARE IN INCHES; MILLIMETER DIMENSIONS
(IN PARENTHESES) ARE ROUNDED-OFF EQUIVALENTS FOR
REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.

Figure 41. 3-Lead Plastic Header-Style Package [TO-92]
(T-3)
Dimensions shown in inches and (millimeters)

ORDERING GUIDE

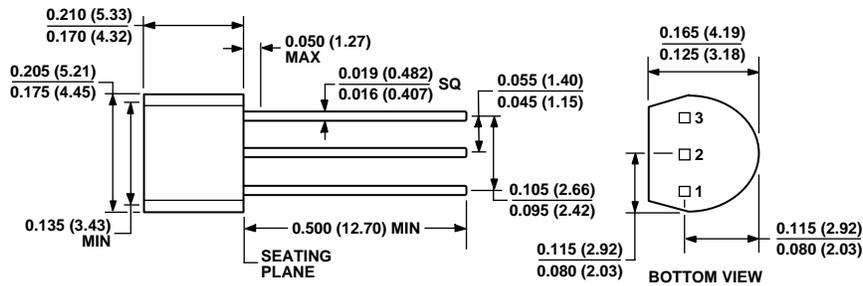| Model	Output Voltage	Initial Accuracy (%)	Temperature Coefficient Max (ppm/°C)	Package Description	Package Option	Ordering Quantity
ADR291ER	2.50	0.08	8	8-Lead SOIC	R-8	98
ADR291ER-REEL7	2.50	0.08	8	8-Lead SOIC	R-8	1,000
ADR291ERZ[1]	2.50	0.08	8	8-Lead SOIC	R-8	98
ADR291ERZ-REEL7[1]	2.50	0.08	8	8-Lead SOIC	R-8	1,000
ADR291FR	2.50	0.12	15	8-Lead SOIC	R-8	98
ADR291FR-REEL	2.50	0.12	15	8-Lead SOIC	R-8	2,500
ADR291FR-REEL7	2.50	0.12	15	8-Lead SOIC	R-8	1,000
ADR291FRZ[1]	2.50	0.12	15	8-Lead SOIC	R-8	98
ADR291FRZ-REEL[1]	2.50	0.12	15	8-Lead SOIC	R-8	2,500
ADR291FRZ-REEL7[1]	2.50	0.12	15	8-Lead SOIC	R-8	1,000
ADR291GR	2.50	0.24	25	8-Lead SOIC	R-8	98
ADR291GR-REEL	2.50	0.24	25	8-Lead SOIC	R-8	2,500
ADR291GR-REEL7	2.50	0.24	25	8-Lead SOIC	R-8	1,000
ADR291GRZ[1]	2.50	0.24	25	8-Lead SOIC	R-8	98
ADR291GRZ-REEL[1]	2.50	0.24	25	8-Lead SOIC	R-8	2,500
ADR291GRZ-REEL7[1]	2.50	0.24	25	8-Lead SOIC	R-8	1,000
ADR291GRU	2.50	0.24	25	8-Lead TSSOP	RU-8	98
ADR291GRU-REEL7	2.50	0.24	25	8-Lead TSSOP	RU-8	1,000
ADR291GRUZ[1]	2.50	0.24	25	8-Lead TSSOP	RU-8	98
ADR291GRUZ-REEL[1]	2.50	0.24	25	8-Lead TSSOP	RU-8	1,000
ADR291GRUZ-REEL7[1]	2.50	0.24	25	8-Lead TSSOP	RU-8	1,000
ADR291GT9	2.50	0.24	25	3-Lead TO-92	T-3	98
ADR291GT9-REEL	2.50	0.24	25	3-Lead TO-92	T-3	2,000
ADR291GT9Z[1]	2.50	0.24	25	3-Lead TO-92	T-3	98
ADR292ER	4.096	0.07	8	8-Lead SOIC	R-8	98
ADR292ER-REEL	4.096	0.07	8	8-Lead SOIC	R-8	2,500
ADR292ERZ[1]	4.096	0.07	8	8-Lead SOIC	R-8	98
ADR292ERZ-REEL[1]	4.096	0.07	8	8-Lead SOIC	R-8	2,500
ADR292FR	4.096	0.10	15	8-Lead SOIC	R-8	98
ADR292FR-REEL	4.096	0.10	15	8-Lead SOIC	R-8	2,500
ADR292FR-REEL7	4.096	0.10	15	8-Lead SOIC	R-8	1,000
ADR292FRZ[1]	4.096	0.10	15	8-Lead SOIC	R-8	98
ADR292FRZ-REEL[1]	4.096	0.10	15	8-Lead SOIC	R-8	2,500
ADR292FRZ-REEL7[1]	4.096	0.10	15	8-Lead SOIC	R-8	1,000
ADR292GR	4.096	0.15	25	8-Lead SOIC	R-8	98
ADR292GR-REEL7	4.096	0.15	25	8-Lead SOIC	R-8	1,000
ADR292GRZ[1]	4.096	0.15	25	8-Lead SOIC	R-8	98
ADR292GRZ-REEL7[1]	4.096	0.15	25	8-Lead SOIC	R-8	1,000
ADR292GRU	4.096	0.24	25	8-Lead TSSOP	RU-8	98
ADR292GRU-REEL7	4.096	0.15	25	8-Lead TSSOP	RU-8	1,000
ADR292GRUZ[1]	4.096	0.24	25	8-Lead TSSOP	RU-8	98
ADR292GRUZ-REEL7[1]	4.096	0.15	25	8-Lead TSSOP	RU-8	1,000

[1] Z = Pb-free part.

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