

### FEATURES

- Precision 1.200 V voltage reference**
- Ultracompact 3-lead SOT-23 package**
- No external capacitor required**
- Low output noise: 4  $\mu\text{V}$  p-p (0.1 Hz to 10 Hz)**
- Initial accuracy:  $\pm 0.67\%$  maximum**
- Temperature coefficient: 60 ppm/ $^{\circ}\text{C}$  maximum**
- Operating current range: 100  $\mu\text{A}$  to 10 mA**
- Output impedance: 0.3  $\Omega$  maximum**
- Temperature range:  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$**
- Qualified for automotive applications**

### APPLICATIONS

- Automotive systems**
- Precision data acquisition systems**
- Microcontroller reference voltage**

### GENERAL DESCRIPTION

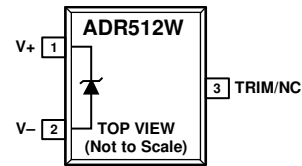
Designed for space critical applications, the ADR512W is a low voltage (1.200 V), precision shunt-mode voltage reference in the ultracompact SOT-23 package. The ADR512W features low temperature drift (60 ppm/ $^{\circ}\text{C}$ ), high accuracy ( $\pm 0.67\%$ ), and ultralow noise (4  $\mu\text{V}$  p-p) performance.

The ADR512W's advanced design eliminates the need for an external capacitor, yet it is stable with any capacitive load. The

minimum operating current increases from a scant 100  $\mu\text{A}$  to a maximum of 10 mA.

A TRIM terminal is available on the ADR512W to provide adjustment of the output voltage over  $\pm 0.5\%$  without affecting the temperature coefficient of the device. This feature provides users with the flexibility to trim out any system errors.

### PIN CONFIGURATION



NC = NO CONNECT. DO NOT CONNECT TO THIS PIN.

Figure 1. 3-Lead SOT-23

09838-001

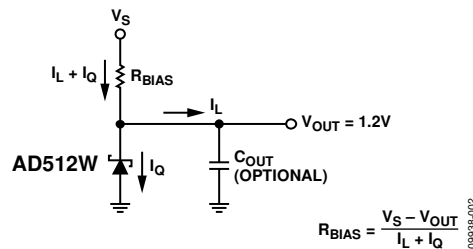


Figure 2. Typical Operating Circuit

#### Rev. 0

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## REVISION HISTORY

5/11—Revision 0: Initial Version

## SPECIFICATIONS

### ELECTRICAL CHARACTERISTICS

$I_{IN} = 100 \mu\text{A}$  to  $10 \text{ mA}$  at  $T_A = 25^\circ\text{C}$ , unless otherwise noted.

Table 1.

Parameter	Symbol	Test Conditions/Comments	Min	Typ	Max	Unit
Output Voltage <sup>1</sup>	$V_O$		1.192	1.2	1.208	V
Initial Accuracy	$V_{OERR}$		-8.0		+8.0	mV
Temperature Coefficient A Grade	$TCV_O$	$-40^\circ\text{C} < T_A < +85^\circ\text{C}$			60	ppm/ $^\circ\text{C}$
Output Voltage Change vs. $I_{IN}$	$\Delta V_R$	$I_{IN} = 0.1 \text{ mA to } 10 \text{ mA}$			3	mV
Dynamic Output Impedance	$(\Delta V_R / \Delta I_R)$	$I_{IN} = 1 \text{ mA} \pm 100 \mu\text{A}$			0.3	$\Omega$
Minimum Operating Current	$I_{IN}$	$-40^\circ\text{C} < T_A < +85^\circ\text{C}$	100			$\mu\text{A}$
Voltage Noise	$e_N$ p-p	$f = 0.1 \text{ Hz to } 10 \text{ Hz}$		4		$\mu\text{V p-p}$
Turn-On Settling Time <sup>2</sup>	$t_R$	To within 0.1% of output		10		$\mu\text{s}$
Output Voltage Hysteresis	$V_{O\_HYS}$			50		ppm

<sup>1</sup> The forward diode voltage characteristic at  $-1 \text{ mA}$  is typically  $0.65 \text{ V}$ .

<sup>2</sup> Measured without a load capacitor.

## ABSOLUTE MAXIMUM RATINGS

Table 2.

Parameter	Rating
Reverse Current	25 mA
Forward Current	20 mA
Storage Temperature Range	
RT Package	−65°C to +150°C
Operating Temperature Range	−40°C to +85°C
Junction Temperature Range	
RT Package	−65°C to +150°C
Lead Temperature Range (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.

## THERMAL RESISTANCE

$\theta_{JA}$  is specified for the worst-case conditions, that is, a device soldered in a circuit board for surface-mount packages.

Table 3. Thermal Resistance

Package Type <sup>1</sup>	$\theta_{JA}$ <sup>2</sup>	$\theta_{JC}$	Unit
3-SOT-23 (RT)	230	146	°C/W

<sup>1</sup>Package power dissipation =  $(T_{JMAX} - T_A)/\theta_{JA}$ .

<sup>2</sup> $\theta_{JA}$  is specified for worst-case conditions; that is.,  $\theta_{JA}$  is specified for the device soldered.

## ESD CAUTION



**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

# TYPICAL PERFORMANCE CHARACTERISTICS

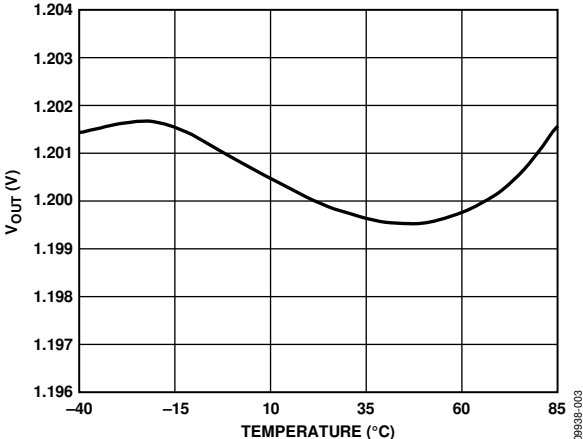


Figure 3. Typical  $V_{OUT}$  vs. Temperature

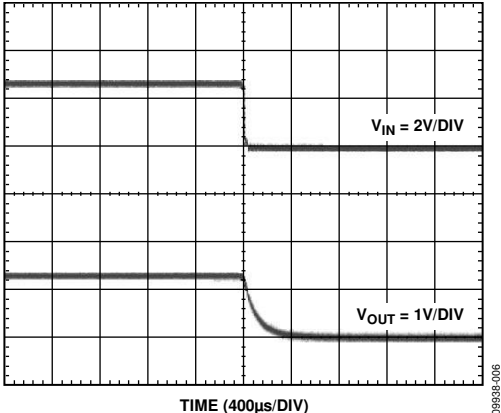


Figure 6. Turn-Off Time

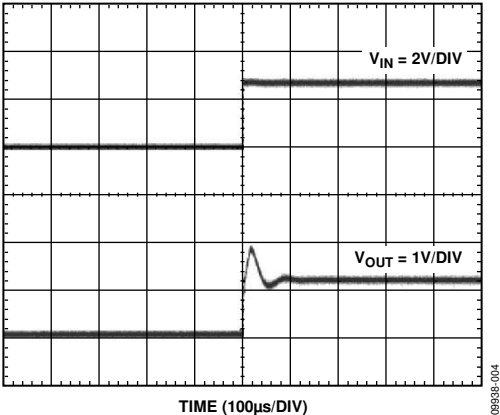


Figure 4. Turn-On Time

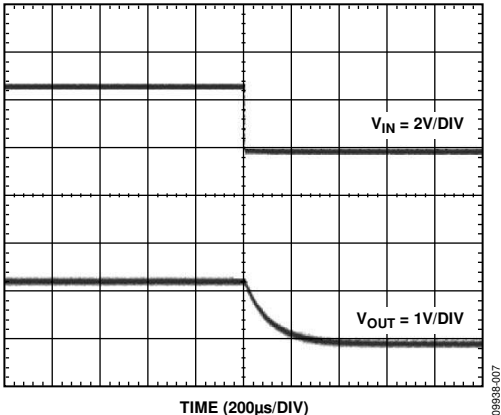


Figure 7. Turn-Off Time with a 1  $\mu$ F Input Capacitor

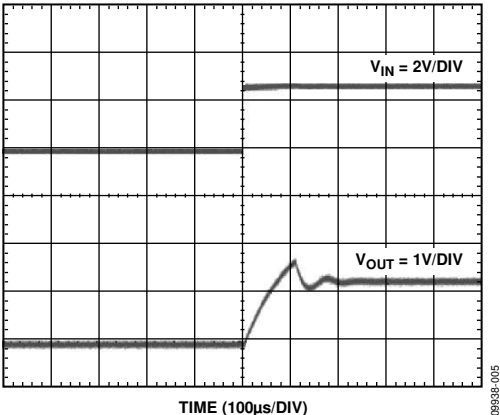


Figure 5. Turn-On Time with a 1  $\mu$ F Input Capacitor

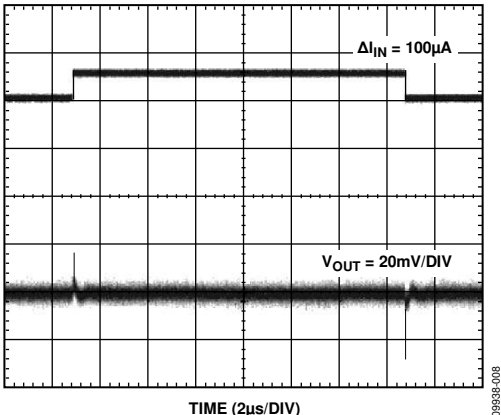


Figure 8. Output Response to a 100  $\mu$ A Input Current Change

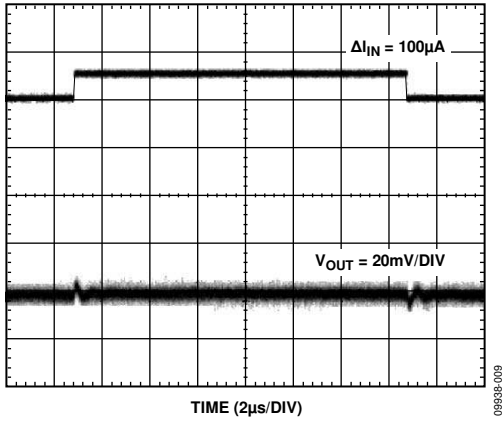


Figure 9. Output Response to a 100  $\mu\text{A}$  Input Current Change with a 1  $\mu\text{F}$  Capacitor

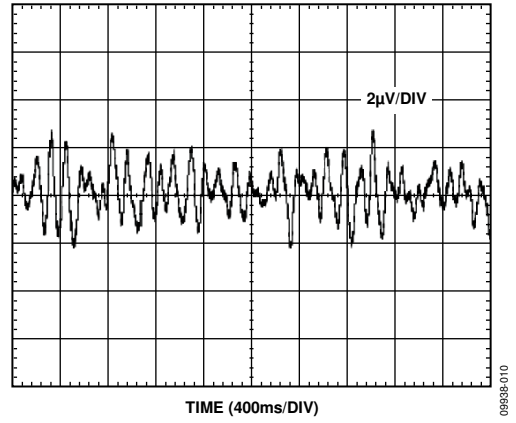


Figure 10. 0.1 Hz to 10 Hz Noise

## TERMINOLOGY

### Temperature Coefficient

Temperature coefficient is the change in 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.

### Thermal Hysteresis

Thermal hysteresis is defined as the change in output voltage after the device is cycled through temperature 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.

$$V_{o\_HYS} = V_o(25^\circ C) - V_{o\_TC} \quad (2)$$

$$V_{o\_HYS} [ppm] = \frac{V_o(25^\circ C) - V_{o\_TC}}{V_o(25^\circ C)} \times 10^6$$

where:

$V_o(25^\circ C) = V_o$  at 25°C.

$V_{o\_TC} = V_o$  at 25°C after temperature cycles from +25°C to -40°C to +85°C and back to +25°C.

# ADR512W

## APPLICATIONS INFORMATION

The ADR512W is a 1.2 V precision shunt voltage reference. It is designed to operate without an external output capacitor between the positive and negative terminals for stability. An external capacitor can be used for additional filtering of the supply.

As with all shunt voltage references, an external bias resistor ( $R_{BIAS}$ ) is required between the supply voltage and the ADR512W (see Figure 2).  $R_{BIAS}$  sets the current that is required to pass through the load ( $I_L$ ) and the ADR512W ( $I_Q$ ). The load and the supply voltage can vary, thus  $R_{BIAS}$  is chosen as follows:

- $R_{BIAS}$  must be small enough to supply the minimum  $I_Q$  current to the ADR512W even when the supply voltage is at its minimum and the load current is at its maximum value.
- $R_{BIAS}$  also must be large enough so that  $I_Q$  does not exceed 10 mA when the supply voltage is at its maximum and the load current is at its minimum.

Given these conditions,  $R_{BIAS}$  is determined by the supply voltage ( $V_S$ ), the load and operating current ( $I_L$  and  $I_Q$ ) of the ADR512W, and the ADR512W's output voltage.

$$R_{BIAS} = (V_S - V_{OUT}) / (I_L + I_Q) \quad (3)$$

### ADJUSTABLE PRECISION VOLTAGE SOURCE

The ADR512W, combined with a precision low input bias op amp such as the AD8610, can be used to output a precise adjustable voltage. Figure 11 illustrates the implementation of this application using the ADR512W.

The output of the op amp,  $V_{OUT}$ , is determined by the gain of the circuit, which is completely dependent on resistors  $R_2$  and  $R_1$ .

$$V_{OUT} = 1 + \frac{R_2}{R_1} \quad (4)$$

An additional capacitor in parallel with  $R_2$  can be added to filter out high frequency noise. The value of  $C_2$  is dependent on the value of  $R_2$ .

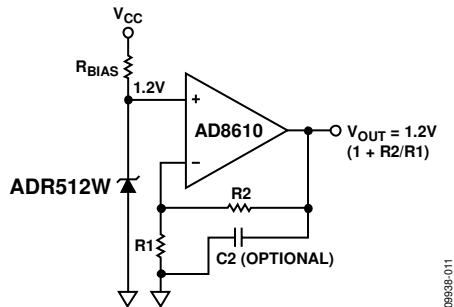


Figure 11. Adjustable Precision Voltage Source

### OUTPUT VOLTAGE TRIM

Using a mechanical or digital potentiometer, the output voltage of the ADR512W can be trimmed  $\pm 0.5\%$ . The circuit in Figure 12 illustrates how the output voltage can be trimmed using a 10 k  $\Omega$  potentiometer.

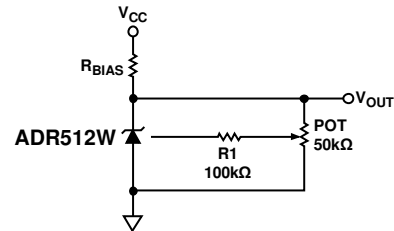


Figure 12. Output Voltage Trim

### USING THE ADR512W WITH PRECISION DATA CONVERTERS

The compact ADR512W package and the device's low minimum operating current requirement make it ideal for use in battery powered portable instruments, such as the AD7533 CMOS multiplying DAC, that use precision data converters.

Figure 13 shows the ADR512W serving as an external reference to the AD7533, a CMOS multiplying DAC. Such a DAC requires a negative voltage input to provide a positive output range. In this application, the ADR512W supplies a  $-1.2$  V reference to the REF input of the AD7533.

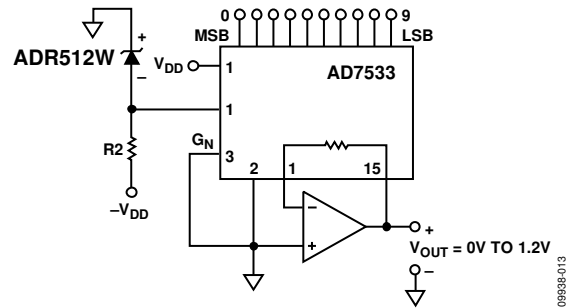


Figure 13. The ADR512W as a Reference for a 10-Bit CMOS DAC (AD7533)

### PRECISE NEGATIVE VOLTAGE REFERENCE

The ADR512W is suitable for use in applications where a precise negative voltage reference is desired, including the application detailed in Figure 13.

Figure 14 shows the ADR512W configured to provide a  $-1.2$  V output.



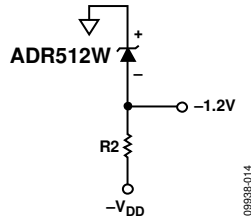


Figure 14. Precise -1.2 V Reference Configuration

Because the ADR512W characteristics resemble those of a Zener diode, the cathode shown in Figure 14 is 1.2 V higher with respect to the anode (V+ with respect to V- on the ADR512W package). Because the cathode of the ADR512W is tied to ground, the anode must be -1.2 V.

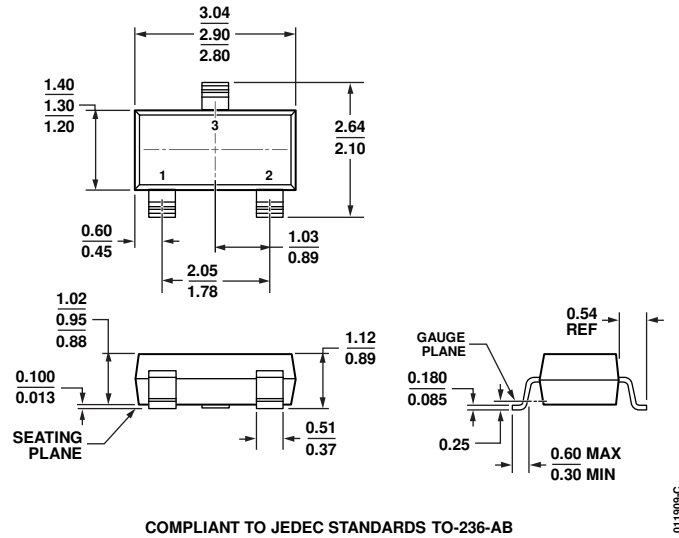
R1 in Figure 14 should be chosen so that 100 μA to 10 mA is provided to properly bias the ADR512W.

$$R1 = \frac{V_{DD}}{I} \tag{5}$$

The resistor, R1, should be chosen so that power dissipation is at a minimum. An ideal resistor value can be determined through manipulation of Equation 5.

# ADR512W

## OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS TO-236-AB

Figure 15. 3-Lead Small Outline Transistor Package [SOT-23-3] (RT-3)

Dimensions shown in millimeters

## ORDERING GUIDE

Model <sup>1,2</sup>	Output Voltage (V <sub>O</sub> )	Initial Accuracy		Temperature Coefficient (ppm/°C)	Package Description	Package Option	Branding	Number of Parts per Reel	Temperature Range
		(mV)	(%)						
ADR512WARTZ-R7	1.2	±8.0	±0.7	60	3-Lead SOT-23-3	RT-3	R1R	3,000	-40°C to +85°C

<sup>1</sup> Z = RoHS Compliant Part.

<sup>2</sup> W = Qualified for Automotive Applications.

## AUTOMOTIVE PRODUCTS

The ADR512W model is available with controlled manufacturing to support the quality and reliability requirements of automotive applications. Note that this automotive model may have specifications that differ from the commercial models; therefore, designers should review the Specifications section of this data sheet carefully. Only the automotive grade product shown is available for use in automotive applications. Contact your local Analog Devices account representative for specific product ordering information and to obtain the specific Automotive Reliability reports for this model.

**NOTES**

**ADR512W**

**NOTES**