REF3112
REF3120
REF3125
REF3130
REF3133
REF3140

SBVS046C – DECEMBER 2003 – REVISED FEBRUARY 2006

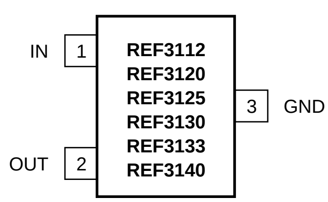
15ppm/°C Max, 100μA, SOT23-3 SERIES VOLTAGE REFERENCE

FEATURES

- *Micro*SIZE PACKAGE: SOT23-3
- LOW DROPOUT: 5mV
- HIGH OUTPUT CURRENT: ±10mA
- HIGH ACCURACY: 0.2% max
- LOW I_Q: 115μA max
- EXCELLENT SPECIFIED DRIFT PERFORMANCE:
  15ppm/°C (max) from 0°C to +70°C
  20ppm/°C (max) from –40°C to +125°C

APPLICATIONS

- PORTABLE, BATTERY-POWERED EQUIPMENT
- DATA ACQUISITION SYSTEMS
- MEDICAL EQUIPMENT
- HAND-HELD TEST EQUIPMENT



SOT23-3

DESCRIPTION

The REF31xx is a family of precision, low power, low dropout, series voltage references available in the tiny SOT23-3 package.

The REF31xx's small size and low power consumption (100μA typ) make it ideal for portable and battery-powered applications. The REF31xx does not require a load capacitor, but is stable with any capacitive load and can sink/source up to 10mA of output current.

Unloaded, the REF31xx can be operated on supplies down to 5mV above the output voltage. All models are specified for the wide temperature range of –40°C to +125°C.

PRODUCT	VOLTAGE (V)
REF3112	1.25
REF3120	2.048
REF3125	2.5
REF3130	3.0
REF3133	3.3
REF3140	4.096

ABSOLUTE MAXIMUM RATINGS[1]

Supply Voltage, V+ to V–	7.0V
Output Short-Circuit	Continuous
Operating Temperature	–55°C to +135°C
Storage Temperature	–65°C to +150°C
Junction Temperature	+150°C

NOTES: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these, or any other conditions beyond those specified, is not implied.

ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

PACKAGE/ORDERING INFORMATION[1]

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
REF3112	SOT23-3	DBZ	–40°C to +125°C	R31A	REF3112AIDBZT	Tape and Reel, 250
"	"	"	"	"	REF3112AIDBZR	Tape and Reel, 3000
REF3120	SOT23-3	DBZ	–40°C to +125°C	R31B	REF3120AIDBZT	Tape and Reel, 250
"	"	"	"	"	REF3120AIDBZR	Tape and Reel, 3000
REF3125	SOT23-3	DBZ	–40°C to +125°C	R31C	REF3125AIDBZT	Tape and Reel, 250
"	"	"	"	"	REF3125AIDBZR	Tape and Reel, 3000
REF3130	SOT23-3	DBZ	–40°C to +125°C	R31E	REF3130AIDBZT	Tape and Reel, 250
"	"	"	"	"	REF3130AIDBZR	Tape and Reel, 3000
REF3133	SOT23-3	DBZ	–40°C to +125°C	R31F	REF3133AIDBZT	Tape and Reel, 250
"	"	"	"	"	REF3133AIDBZR	Tape and Reel, 3000
REF3140	SOT23-3	DBZ	–40°C to +125°C	R31D	REF3140AIDBZT	Tape and Reel, 250
"	"	"	"	"	REF3140AIDBZR	Tape and Reel, 3000

NOTE: (1) (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.

ELECTRICAL CHARACTERISTICS

Boldface limits apply over the specified temperature range, **T_A = –40°C to +125°C.**

At T_A = +25°C, I_{LOAD} = 0mA, V_{IN} = 5V, unless otherwise noted.

PARAMETER		CONDITIONS	REF31xx MIN	TYP	MAX	UNITS
REF3112[1] - 1.25V						
OUTPUT VOLTAGE	V_{OUT}		1.2475	1.25	1.2525	V
Initial Accuracy			–0.2		0.2	%
NOISE						
Output Voltage Noise		f = 0.1Hz to 10Hz		17		μV_{PP}
Voltage Noise		f = 10Hz to 10kHz		24		μVrms
REF3120 – 2.048						
OUTPUT VOLTAGE	V_{OUT}		2.0439	2.048	2.0521	V
Initial Accuracy			–0.2		0.2	%
NOISE						
Output Voltage Noise		f = 0.1Hz to 10Hz		27		μV_{PP}
Voltage Noise		f = 10Hz to 10kHz		39		μVrms
REF3125 – 2.5V						
OUTPUT VOLTAGE	V_{OUT}		2.4950	2.50	2.5050	V
Initial Accuracy			–0.2		0.2	%
NOISE						
Output Voltage Noise		f = 0.1Hz to 10Hz		33		μV_{PP}
Voltage Noise		f = 10Hz to 10kHz		48		μVrms

ELECTRICAL CHARACTERISTICS

Boldface limits apply over the specified temperature range, **T_A = –40°C to +125°C.**

At T_A = +25°C, I_{LOAD} = 0mA, V_{IN} = +5V, unless otherwise noted.

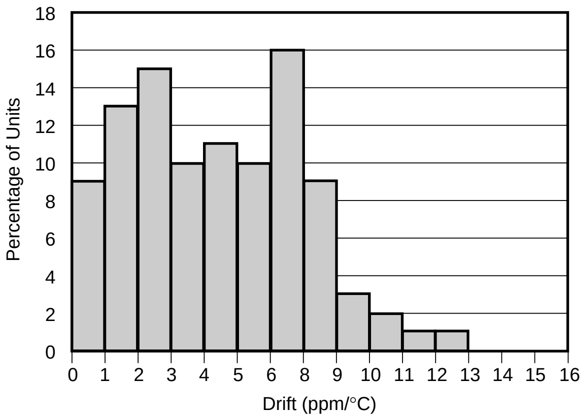
PARAMETER	CONDITIONS	REF31xx MIN	REF31xx TYP	REF31xx MAX	UNITS
REF3130 – 3.0V					
OUTPUT VOLTAGE V_{OUT} Initial Accuracy		2.9940 –0.2	3.0	3.0060 0.2	V %
NOISE Output Voltage Noise Voltage Noise	 f = 0.1Hz to 10Hz f = 10Hz to 10kHz		 39 57		 μV_{PP} µVrms
REF3133 – 3.3V					
OUTPUT VOLTAGE V_{OUT} Initial Accuracy		3.2934 –0.2	3.30	3.3066 0.2	V %
NOISE Output Voltage Noise Voltage Noise	 f = 0.1Hz to 10Hz f = 10Hz to 10kHz		 43 63		 μV_{PP} µVrms
REF3140 – 4.096V					
OUTPUT VOLTAGE V_{OUT} Initial Accuracy		4.0878 –0.2	4.096	4.1042 0.2	V %
NOISE Output Voltage Noise Voltage Noise	 f = 0.1Hz to 10Hz f = 10Hz to 10kHz		 53 78		 μV_{PP} µVrms
REF3112, REF3120, REF3125, REF3130, REF3133, REF3140					
OUTPUT VOLTAGE TEMP DRIFT(2) dV_{OUT}/dT	 **0°C ≤ T_A ≤ +70°C** **–40°C ≤ T_A ≤ +125°C**		 **5** **10**	 **15** **20**	 **ppm/°C** **ppm/°C**
LONG-TERM STABILITY	 0-1000h		 70		 ppm
LINE REGULATION	V_{REF} + 0.05(1) ≤ V_{IN} ≤ 5.5V		20	65	ppm/V
LOAD REGULATION(3) dV_{OUT}/dI_{LOAD} Sourcing Sinking	 0mA < I_{LOAD} < 10mA, V_{IN} = V_{REF} + 250mV(1) –10mA < I_{LOAD} < 0mA, V_{IN} = V_{REF} + 100mV(1)		 10 20	 30 50	 µV/mA µV/mA
THERMAL HYSTERESIS(4) First Cycle Additional Cycles	dT		 100 25		 ppm ppm
DROPOUT VOLTAGE(1) $V_{IN} - V_{OUT}$			**5**	**50**	**mV**
OUTPUT CURRENT I_{LOAD}		–10		10	mA
SHORT-CIRCUIT CURRENT I_{SC} Sourcing Sinking			 50 40		 mA mA
TURN-ON SETTLING TIME	to 0.1% at V_{IN} = +5V with C_L = 0		400		µs
POWER SUPPLY **Voltage** V_S Quiescent Current I_Q **Over Temperature**	I_L = 0	 **V_{REF} + 0.05**(1)	 100 **115**	 **5.5** 115 **135**	 **V** µA **µA**
TEMPERATURE RANGE Specified Range Operating Range Storage Range Thermal Resistance SOT23-3 Surface-Mount θ_{JA}		 –40 –55 –65	 336	 +125 +135 +150	 °C °C °C °C/W

NOTES: (1) Minimum supply voltage for REF3112 is 1.8V.
(2) Box Method used to determine temperature drift.
(3) Typical value of load regulation reflects measurements using force and sense contacts; see the *Load Regulation* section.
(4) Thermal hysteresis is explained in more detail in the *Applications Information* section of this data sheet.
(5) For I_L > 0, see the Typical Characteristic curves.

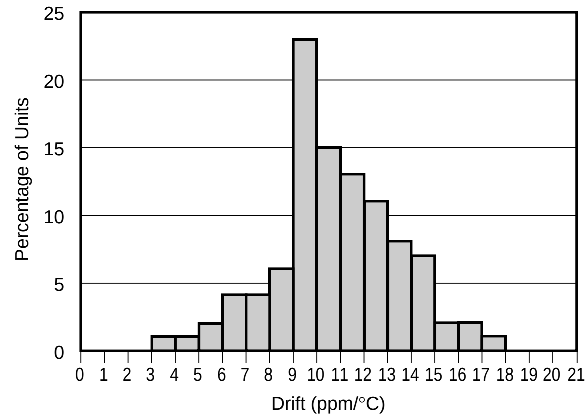
TYPICAL CHARACTERISTICS

At T_A = +25°C, V_{IN} = +5V power supply, REF3125 is used for typical characteristics, unless otherwise noted.

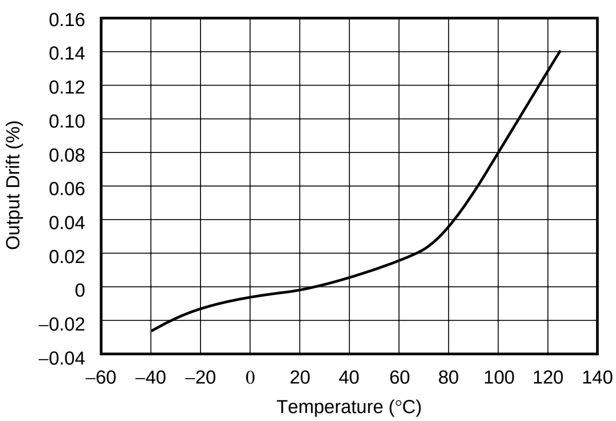
TEMPERATURE DRIFT (0°C to +70°C)



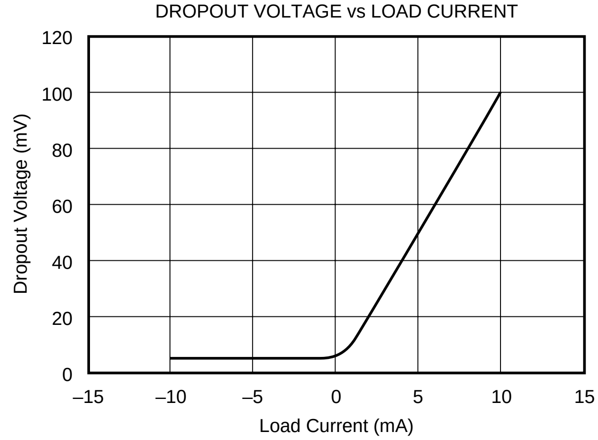
TEMPERATURE DRIFT (–40°C to +125°C)



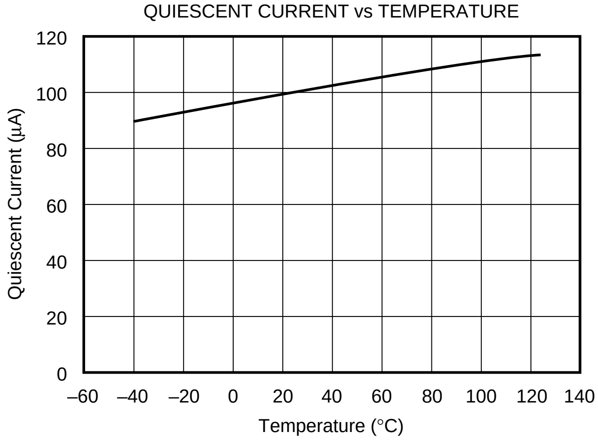
OUTPUT VOLTAGE vs TEMPERATURE



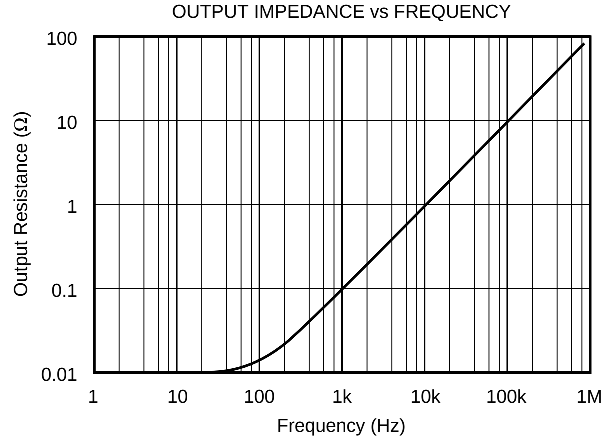
DROPOUT VOLTAGE vs LOAD CURRENT



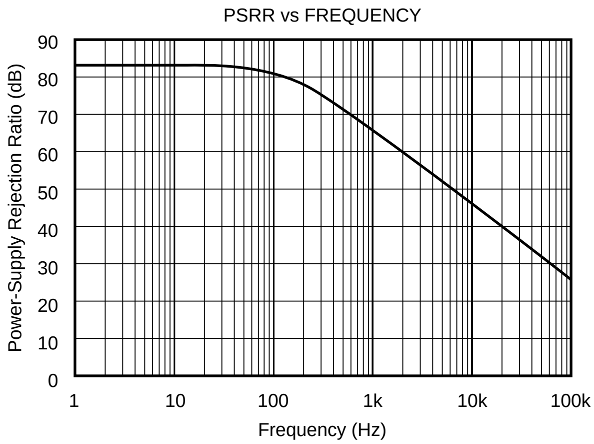
QUIESCENT CURRENT vs TEMPERATURE

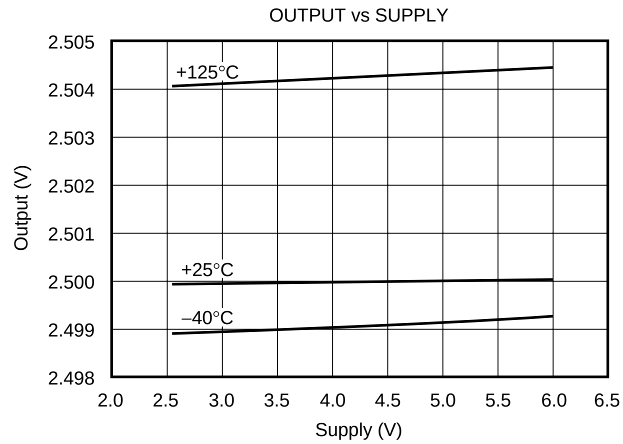


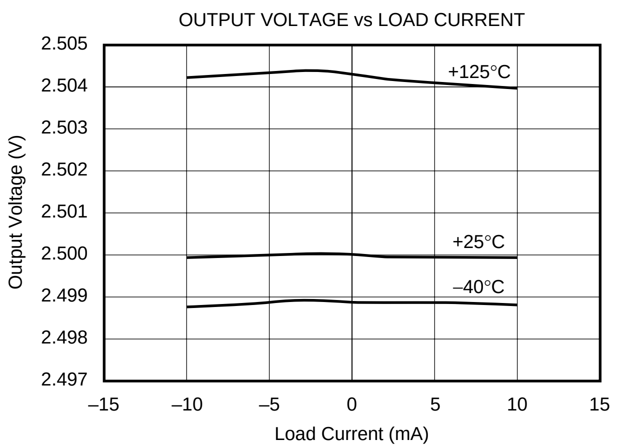
OUTPUT IMPEDANCE vs FREQUENCY

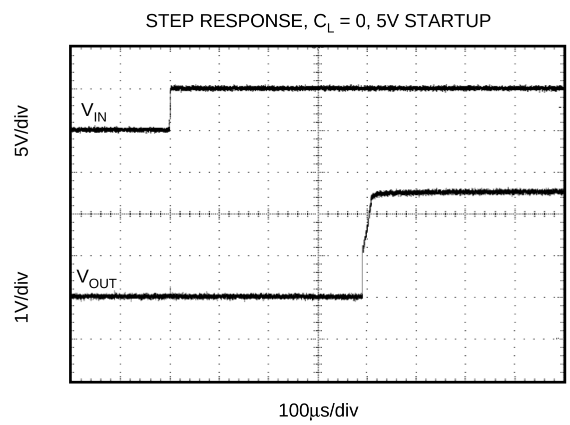


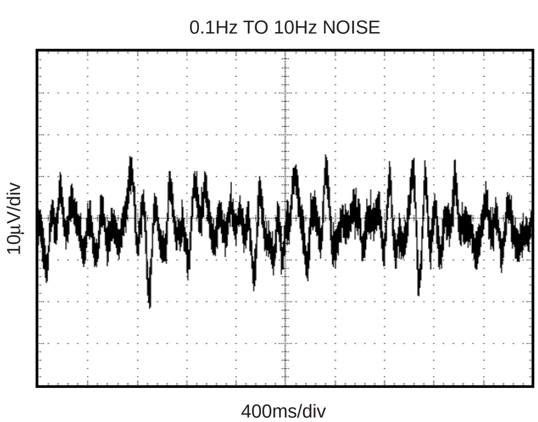
At T_A = +25°C, V_{IN} = +5V power supply, REF3125 is used for typical characteristics, unless otherwise noted.

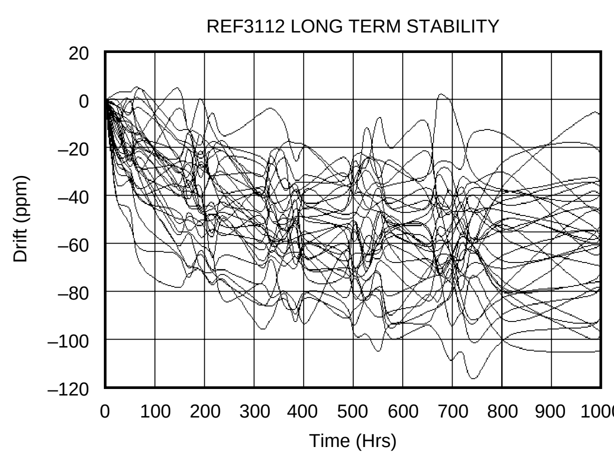








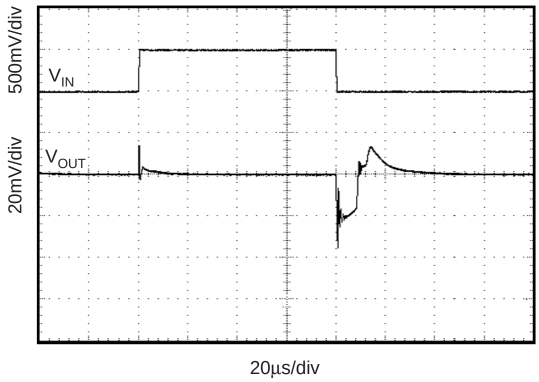




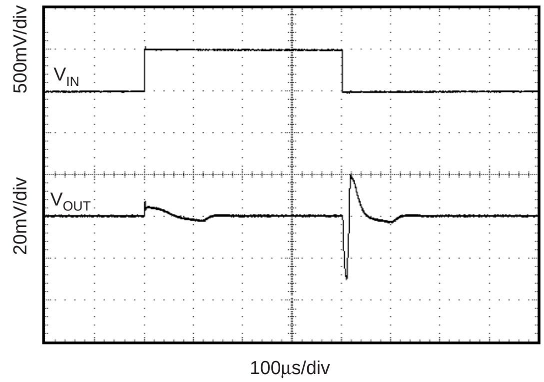
TYPICAL CHARACTERISTICS (Cont.)

At T_A = +25°C, V_{IN} = +5V power supply, REF3125 is used for typical characteristics, unless otherwise noted.

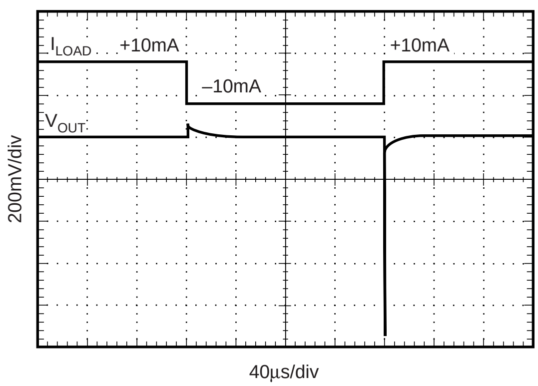
LINE TRANSIENT
C_L = 0pF



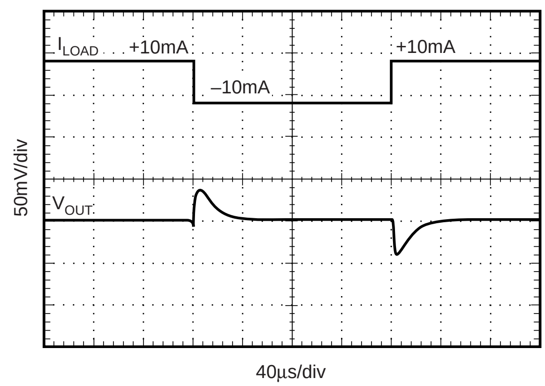
LINE TRANSIENT
C_L = 10µF



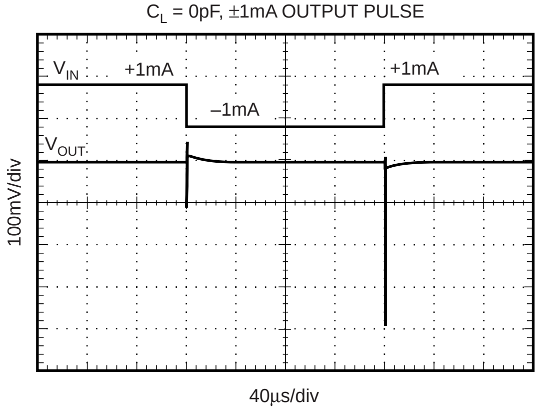
LOAD TRANSIENT
C_L = 0pF, ±10mA OUTPUT PULSE



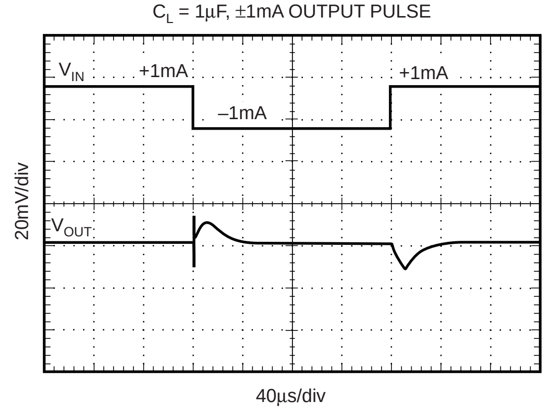
LOAD TRANSIENT
C_L = 1µF, ±10mA OUTPUT PULSE



LOAD TRANSIENT
C_L = 0pF, ±1mA OUTPUT PULSE



LOAD TRANSIENT
C_L = 1µF, ±1mA OUTPUT PULSE



THEORY OF OPERATION

The REF31xx is a family of series, CMOS, precision bandgap voltage references. The basic bandgap topology is shown in Figure 1. Transistors Q_1 and Q_2 are biased such that the current density of Q_1 is greater than that of Q_2. The difference of the two base-emitter voltages, $Vbe_1 - Vbe_2$, has a positive temperature coefficient and is forced across resistor R_1. This voltage is gained up and added to the base-emitter voltage of Q_2, which has a negative temperature coefficient. The resulting output voltage is virtually independent of temperature.

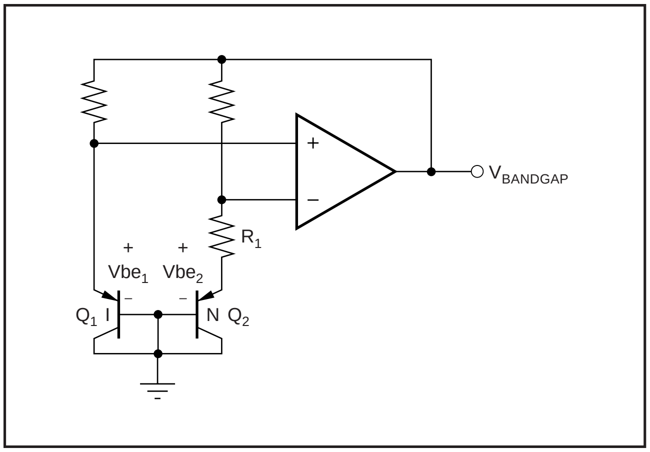


FIGURE 1. Simplified Schematic of Bandgap Reference.

APPLICATION INFORMATION

The REF31xx does not require a load capacitor and is stable with any capacitive load. Figure 2 shows typical connections required for operation of the REF31xx. A supply bypass capacitor of 0.47µF is recommended.

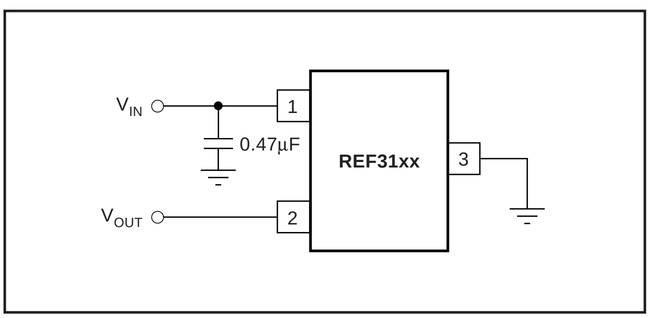


FIGURE 2. Typical Connections for Operating REF31xx.

SUPPLY VOLTAGE

The REF31xx family of references features an extremely low dropout voltage. With the exception of the REF3112, which has a minimum supply requirement of 1.8V, these references can be operated with a supply of only 5mV above the output voltage in an unloaded condition. For loaded conditions, a typical dropout voltage versus load is shown in the typical curves.

The REF31xx features a low quiescent current, which is extremely stable over changes in both temperature and supply. The typical room temperature quiescent current is 100µA, and the maximum quiescent current over temperature is just 135µA. The quiescent current typically changes less than 2µA over the entire supply range, as shown in Figure 3.

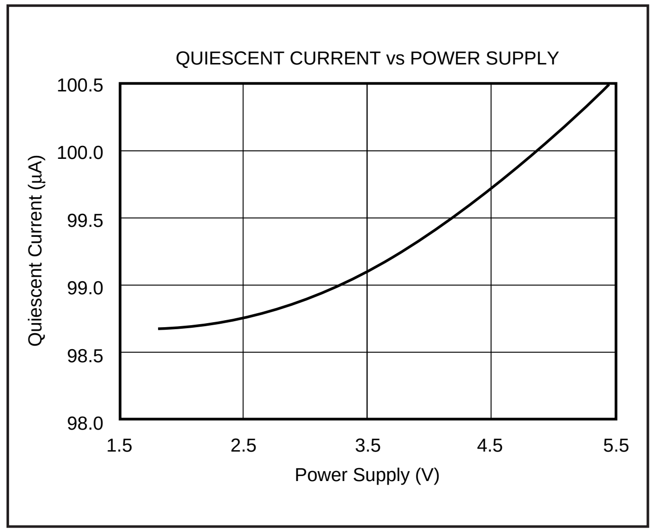


FIGURE 3. Supply Current vs Supply Voltage.

Supply voltages below the specified levels can cause the REF31xx to momentarily draw currents greater than the typical quiescent current. This can be prevented by using a power supply with a fast rising edge and low output impedance.

THERMAL HYSTERESIS

Thermal hysteresis for the REF31xx is defined as the change in output voltage after operating the device at 25°C, cycling the device through the specified temperature range, and returning to 25°C. It can be expressed as:

$$V_{HYST} = \left(\frac{abs\left|V_{PRE} - V_{POST}\right|}{V_{NOM}} \right) \bullet 10^6 (ppm)$$

Where: V_{HYST} = Thermal hysteresis

V_{PRE} = Output voltage measured at 25°C pre-temperature cycling

V_{POST} = Output voltage measured after the device has been cycled through the specified temperature range of –40°C to +125°C and returned to 25°C.

TEMPERATURE DRIFT

The REF31xx is designed to exhibit minimal drift error, defined as the change in output voltage over varying temperature. The drift is calculated using the “box” method which is described by the following equation:

$$\left(\frac{V_{OUTMAX} - V_{OUTMIN}}{V_{OUT} \bullet \text{Temperature Range}} \right) \bullet 10^6 \text{ ppm}$$

The REF31xx features a typical drift coefficient of 5ppm from 0°C to 70°C—the primary temperature range for many applications. For the industrial temperature range of –40°C to 125°C, the REF31xx family drift increases to a typical value of 10ppm.

NOISE PERFORMANCE

Typical 0.1Hz to 10Hz voltage noise can be seen in the Typical Characteristic Curve, *0.1 to 10Hz Voltage Noise*. The noise voltage of the REF31xx increases with output voltage and operating temperature. Additional filtering may be used to improve output noise levels, although care should be taken to ensure the output impedance does not degrade the AC performance.

LONG-TERM STABILITY

Long-term stability refers to the change of the output voltage of a reference over a period of months or years. This effect lessens as time progresses, as is shown by the long-term stability curves. The typical drift value for the REF31xx is 70ppm from 0-1000 hours. This parameter is characterized by measuring 30 units at regular intervals for a period of 1000 hours.

LOAD REGULATION

Load regulation is defined as the change in output voltage due to changes in load current. The load regulation of the REF31xx is measured using force and sense contacts as pictured in Figure 4. The force and sense lines reduce the impact of contact and trace resistance, resulting in accurate measurement of the load regulation contributed solely by the REF31xx. For applications requiring improved load regulation, force and sense lines should be used.

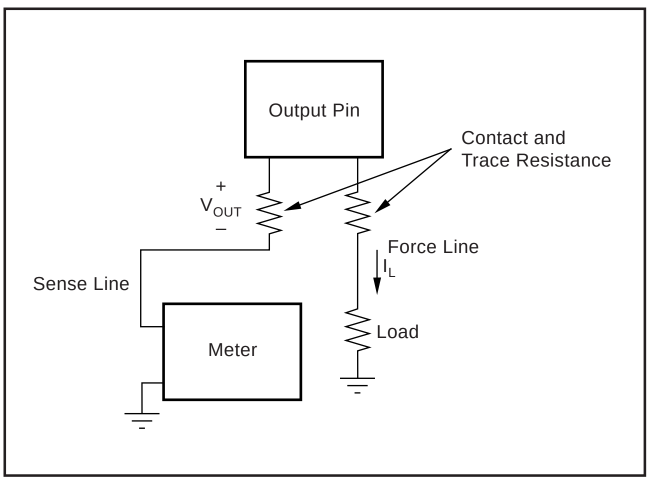


FIGURE 4. Accurate Load Regulation of REF31xx.

APPLICATION CIRCUITS

Negative Reference Voltage

For applications requiring a negative and positive reference voltage, the REF31xx and OPA703 can be used to provide a dual supply reference from a ±5V supply. Figure 5 shows the REF3125 used to provide a ±2.5V supply reference voltage. The low drift performance of the REF31xx complement the low offset voltage and low drift of the OPA703 to provide an accurate solution for split-supply applications.

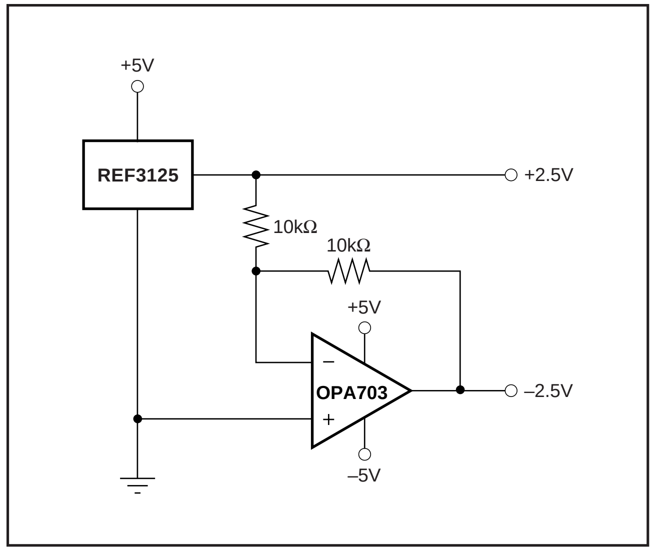


FIGURE 5. REF3125 Combined with OPA703 to Create Positive and Negative Reference Voltages.

DATA ACQUISITION

Data acquisition systems often require stable voltage references to maintain accuracy. The REF31xx family features stability and a wide range of voltages suitable for most micro-controllers and data converters. Figure 6, Figure 7, and Figure 8 show basic data acquisition systems.

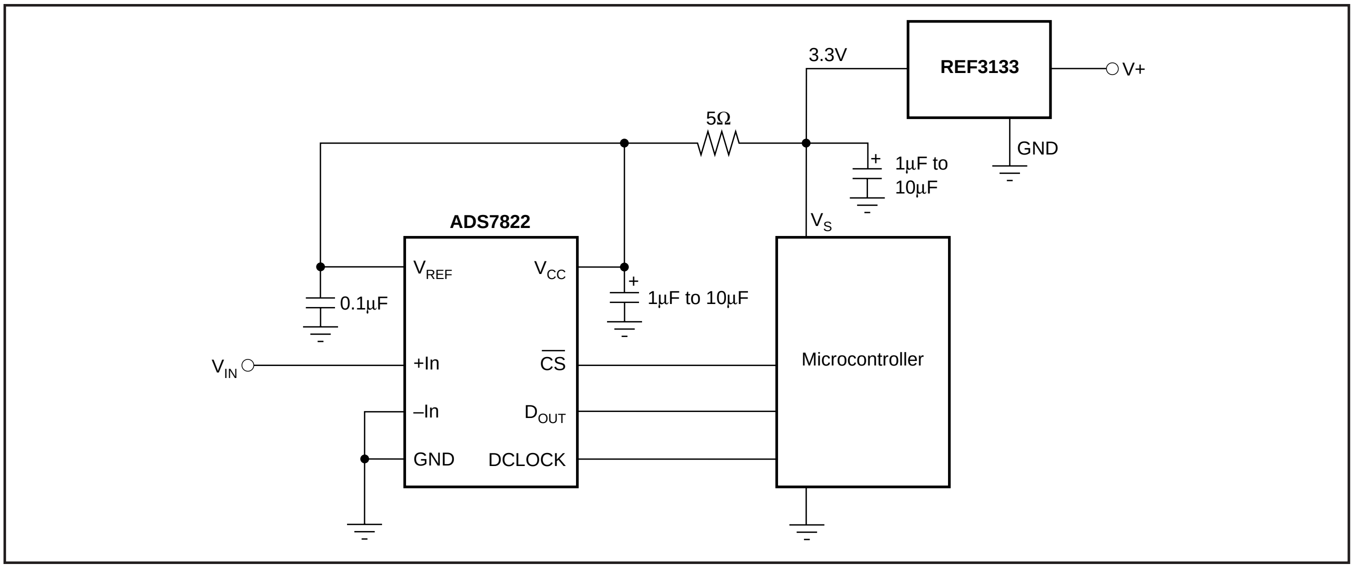


FIGURE 6. Basic Data Acquisition System 1.

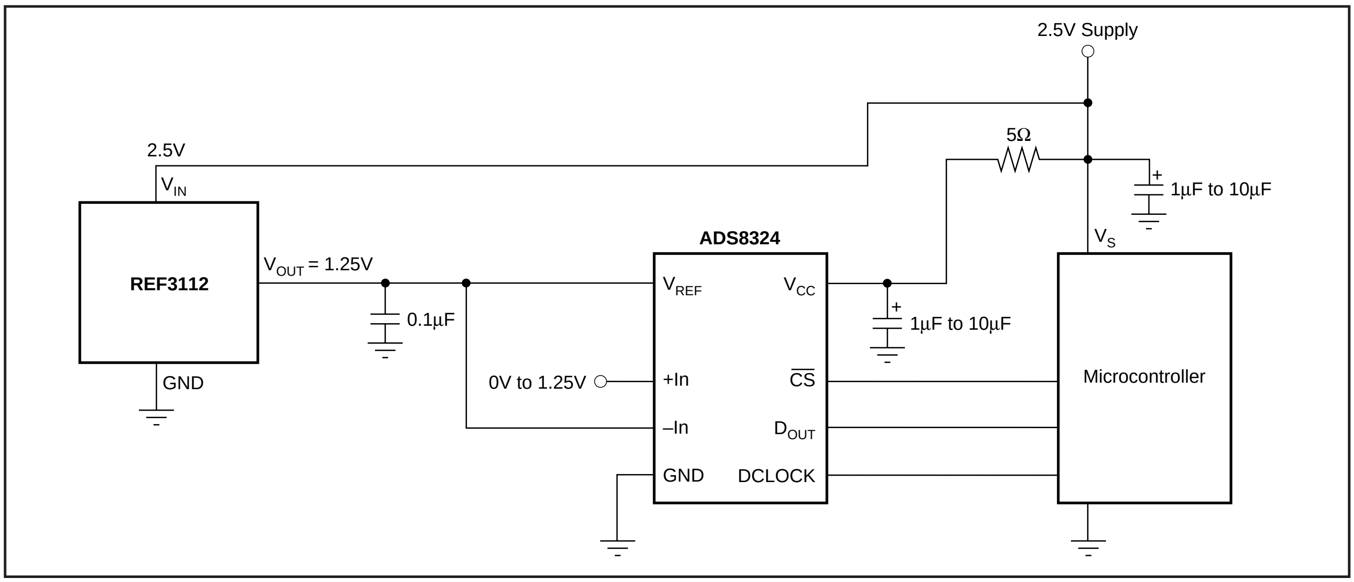


FIGURE 7. Basic Data Acquisition System 2.

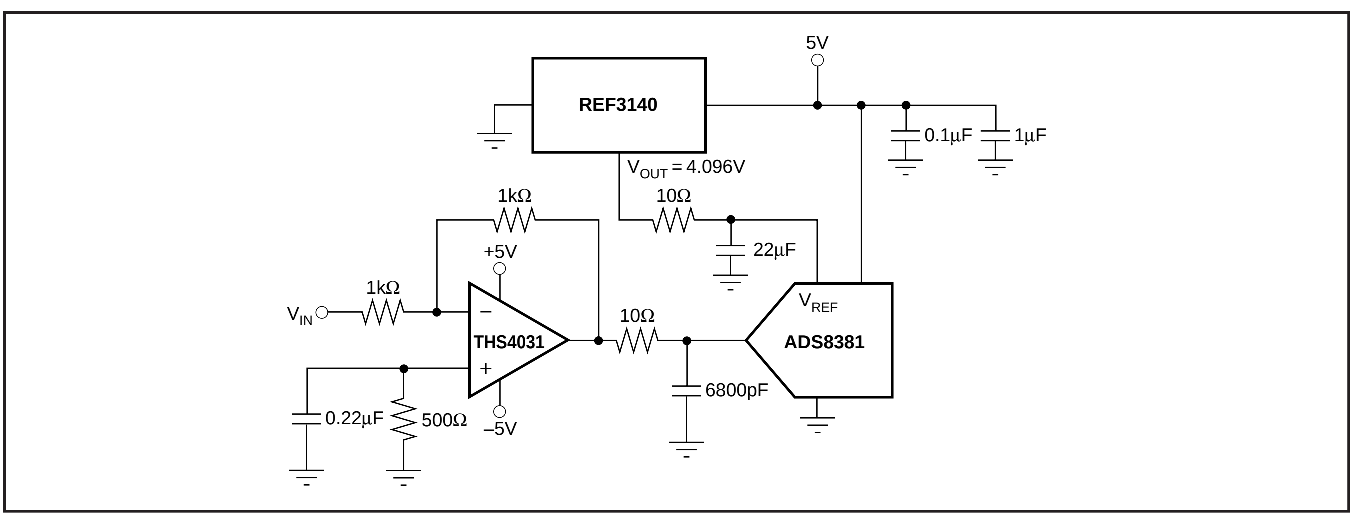


FIGURE 8. REF3140 Provides an Accurate Reference for Driving the ADS8381.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
REF3112AIDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3112AIDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3112AIDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3112AIDBZTG4	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3120AIDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3120AIDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3120AIDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3120AIDBZTG4	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3125AIDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3125AIDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3125AIDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3125AIDBZTG4	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3130AIDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3130AIDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3130AIDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3130AIDBZTG4	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3133AIDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3133AIDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3133AIDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3133AIDBZTG4	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3140AIDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3140AIDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3140AIDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
REF3140AIDBZTG4	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

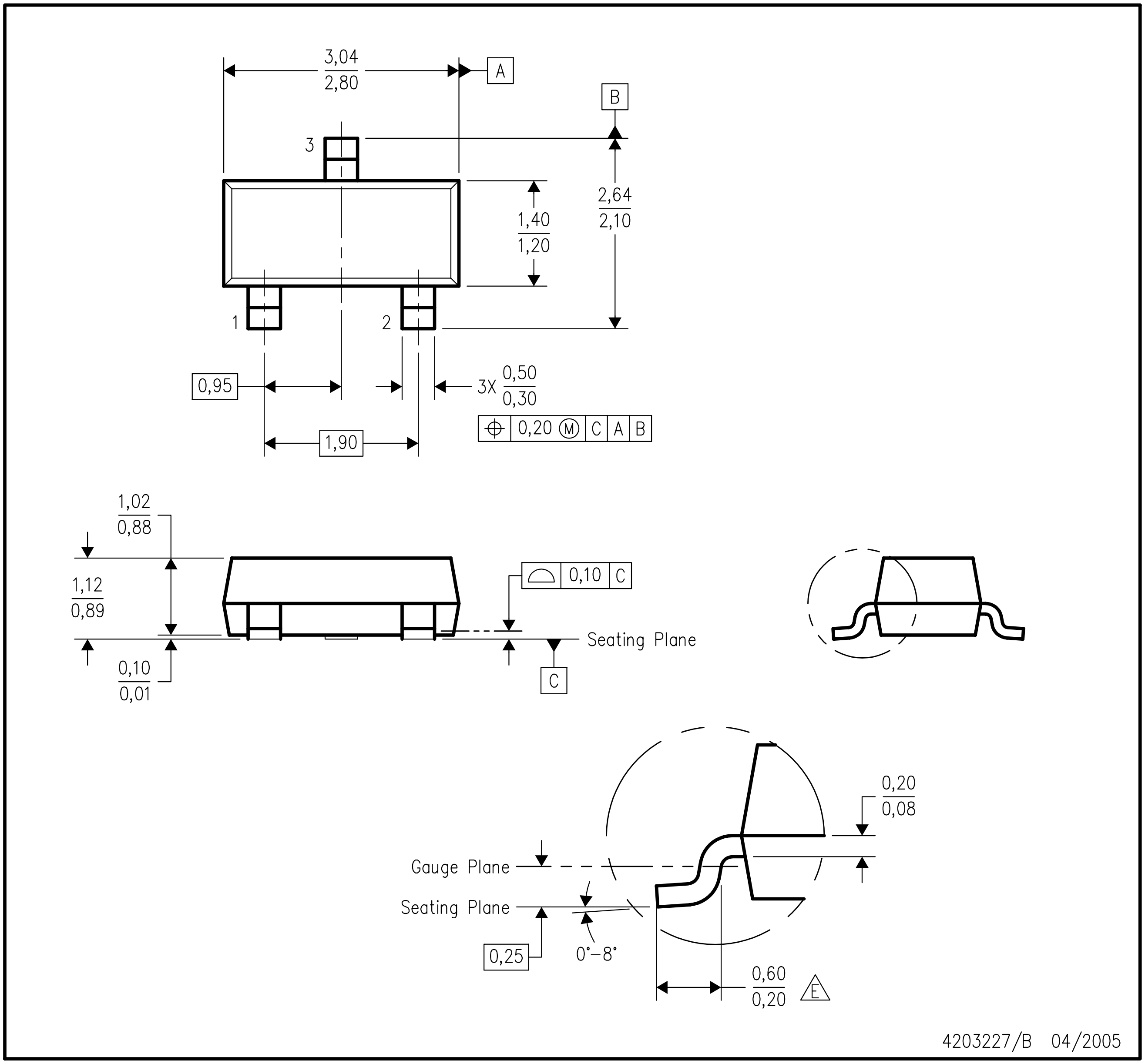
[2] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

[3] MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

DBZ (R-PDSO-G3) PLASTIC SMALL-OUTLINE



NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M—1994.
B. This drawing is subject to change without notice.
C. Lead dimensions are inclusive of plating.
D. Body dimensions are exclusive of mold flash and protrusion. Mold flash and protrusion not to exceed 0.25 per side.
E. Falls within JEDEC TO—236 variation AB, except minimum foot length.

IMPORTANT NOTICE

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
Low Power Wireless	www.ti.com/lpw	Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265