Burr-Brown Products
from Texas Instruments

REF3012
REF3020
REF3025
REF3033
REF3040

SBVS032 – MARCH 2002

50ppm/°C, 50μA in SOT23-3 CMOS VOLTAGE REFERENCE

FEATURES

- *Micro*SIZE PACKAGE: SOT23-3
- LOW DROPOUT: 1mV
- HIGH OUTPUT CURRENT: 25mA
- LOW TEMPERATURE DRIFT: 50ppm/°C max
- HIGH ACCURACY: 0.2%
- LOW I_Q: 50μA max

APPLICATIONS

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

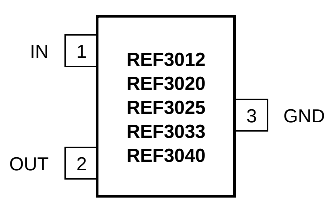
DESCRIPTION

The REF30xx is a precision, low power, low voltage dropout voltage reference family available in a tiny SOT23-3.

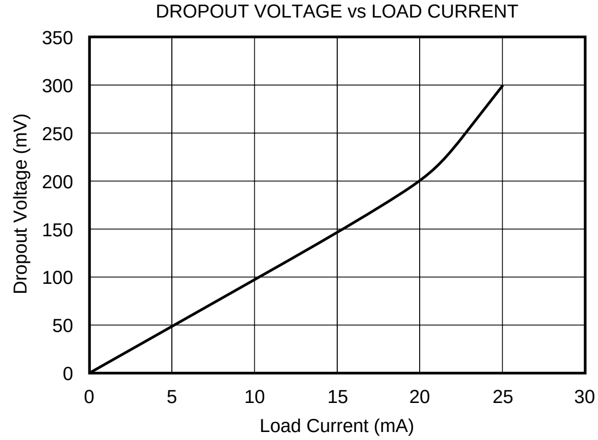
The REF30xx's small size and low power consumption (50μA max) make it ideal for portable and battery-powered applications. The REF30xx does not require a load capacitor, but is stable with any capacitive load.

Unloaded, the REF30xx can be operated with supplies within 1mV of output voltage. All models are specified for the wide temperature range, –40°C to +125°C.

PRODUCT	VOLTAGE (V)
REF3012	1.25
REF3020	2.048
REF3025	2.5
REF3033	3.3
REF3040	4.096



DROPOUT VOLTAGE vs LOAD CURRENT



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ABSOLUTE MAXIMUM RATINGS(1)

Supply Voltage, V+ to V–	5.5V
Output Short-Circuit(2)	Continuous
Operating Temperature	–40°C to +125°C
Storage Temperature	–65°C to +125°C
Junction Temperature	+150°C
Lead Temperature (soldering, 10s)	+300°C

NOTES: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. (2) Short circuit to ground.

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

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR(1)	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
REF3012	SOT23-3	DBZ	–40°C to +125°C	R30A	REF3012AIDBZT	Tape and Reel, 250
"	"	"	"	"	REF3012AIDBZR	Tape and Reel, 3000
REF3020	SOT23-3	DBZ	–40°C to +125°C	R30B	REF3020AIDBZT	Tape and Reel, 250
"	"	"	"	"	REF3020AIDBZR	Tape and Reel, 3000
REF3025	SOT23-3	DBZ	–40°C to +125°C	R30C	REF3025AIDBZT	Tape and Reel, 250
"	"	"	"	"	REF3025AIDBZR	Tape and Reel, 3000
REF3033	SOT23-3	DBZ	–40°C to +125°C	R30D	REF3033AIDBZT	Tape and Reel, 250
"	"	"	"	"	REF3033AIDBZR	Tape and Reel, 3000
REF3040	SOT23-3	DBZ	–40°C to +125°C	R30E	REF3040AIDBZT	Tape and Reel, 250
"	"	"	"	"	REF3040AIDBZR	Tape and Reel, 3000

NOTES: (1) For the most current specifications and package information, refer to our web site at www.ti.com.

ELECTRICAL CHARACTERISTICS

Boldface limits apply over the specified temperature range, $\mathbf{T_A = -40°C \text{ to } +125°C}$.

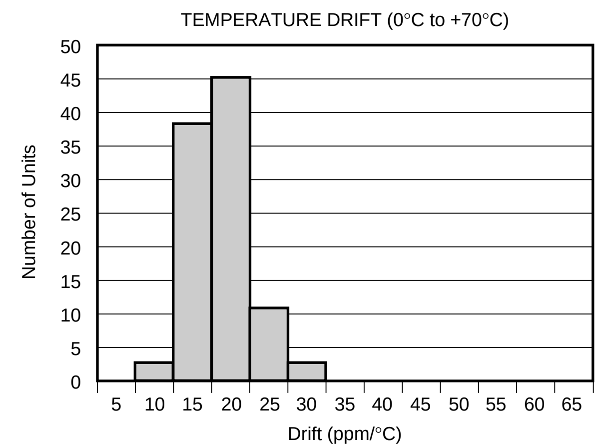
At $T_A = +25°C$, $I_{LOAD} = 0mA$, $V_{IN} = 5V$, unless otherwise noted.

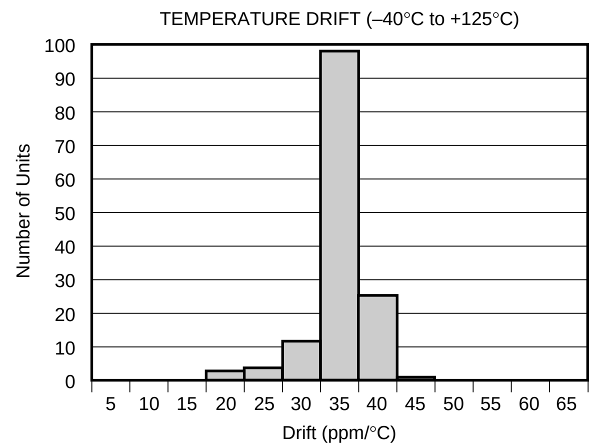
PARAMETER	CONDITIONS	REF30xx MIN	REF30xx TYP	REF30xx MAX	UNITS
OUTPUT VOLTAGE V_{OUT} Initial Accuracy		1.2475	1.25	1.2525 0.2	V %
NOISE Output Voltage Noise Voltage Noise	 f = 0.1Hz to 10Hz f = 10Hz to 10kHz		 20 42		 µVp-p µVrms
LINE REGULATION	$1.8V \le V_{IN} \le 5.5V$		60	190	µV/V
OUTPUT VOLTAGE V_{OUT} Initial Accuracy		2.044	2.048	2.052 0.2	V %
NOISE Output Voltage Noise Voltage Noise	 f = 0.1Hz to 10Hz f = 10Hz to 10kHz		 28 65		 µVp-p µVrms
LINE REGULATION	$V_{REF} + 50mV \le V_{IN} \le 5.5V$		110	290	µV/V
OUTPUT VOLTAGE V_{OUT} Initial Accuracy		2.495	2.50	2.505 0.2	V %
NOISE Output Voltage Noise Voltage Noise	 f = 0.1Hz to 10Hz f = 10Hz to 10kHz		 35 80		 µVp-p µVrms
LINE REGULATION	$V_{REF} + 50mV \le V_{IN} \le 5.5V$		120	325	µV/V
OUTPUT VOLTAGE V_{OUT} Initial Accuracy		3.294	3.30	3.306 0.2	V %
NOISE Output Voltage Noise Voltage Noise	 f = 0.1Hz to 10Hz f = 10Hz to 10kHz		 41 105		 µVp-p µVrms
LINE REGULATION	$V_{REF} + 50mV \le V_{IN} \le 5.5V$		130	400	µV/V
OUTPUT VOLTAGE V_{OUT} Initial Accuracy		4.088	4.096	4.104 0.2	V %
NOISE Output Voltage Noise Voltage Noise	 f = 0.1Hz to 10Hz f = 10Hz to 10kHz		 45 128		 µVp-p µVrms
LINE REGULATION	$V_{REF} + 50mV \le V_{IN} \le 5.5V$		160	410	µV/V
OUTPUT VOLTAGE TEMP DRIFT(2) dV_{OUT}/dT	 **$0°C \le T_A \le +70°C$** **$-40°C \le T_A \le +85°C$** **$-40°C \le T_A \le +125°C$**		 **20** **30** **35**	 **50** **65** **75**	 **ppm/°C** **ppm/°C** **ppm/°C**
LONG-TERM STABILITY	 0-1000h 1000-2000h		 24 15		 ppm ppm
LOAD REGULATION(3) dV_{OUT}/dI_{LOAD}	$0mA < I_{LOAD} < 25mA$, $V_{IN} = V_{REF} + 500mV$(1)		3	100	µV/mA
THERMAL HYSTERESIS(4) dT			25	100	ppm
DROPOUT VOLTAGE $V_{IN} - V_{OUT}$			1	50	mV
SHORT-CIRCUIT CURRENT I_{SC}			45		mA
TURN ON SETTLING TIME	to 0.1% at $V_{IN} = 5V$ with $C_L = 0$		120		µs
POWER SUPPLY Voltage V_S **Over Temperature** Quiescent Current I_Q **Over Temperature**	 $I_L = 0$ **$-40°C \le T_A \le +125°C$** **$-40°C \le T_A \le +125°C$**	 $V_{REF} + 0.001$(5) **V_{REF} + 0.05**	 42	 5.5 **5.5** 50 **59**	 V **V** µA **µA**
TEMPERATURE RANGE Specified Range Operating Range Storage Range Thermal Resistance SOT23-3 Surface-Mount θ_{JC} θ_{JA}		 –40 –40 –65	 110 336	 +125 +125 +150	 °C °C °C °C/W °C/W

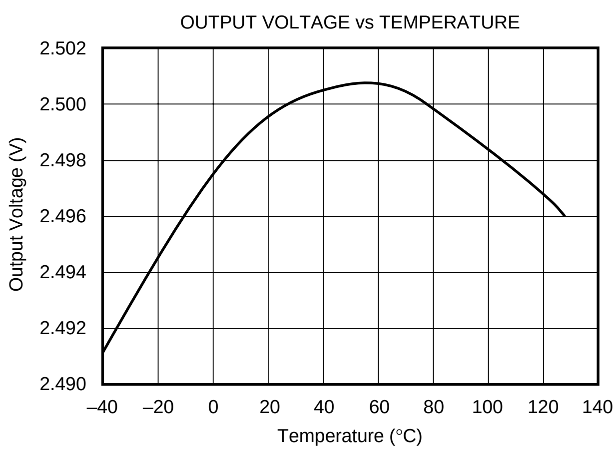
NOTES: (1) Minimum supply voltage for REF3012 is 1.8V. (2) Box Method used to determine over temperature drift. (3) Typical value of load regulation reflects measurements using a force and sense contacts, see text "Load Regulation". (4) Thermal hysteresis procedure is explained in more detail in Applications Information section of data sheet. (5) For $I_L > 0$, see Typical Characteristic curves.

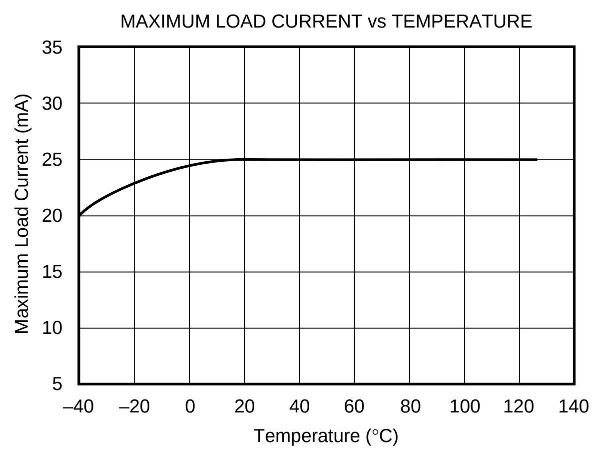
TYPICAL CHARACTERISTICS

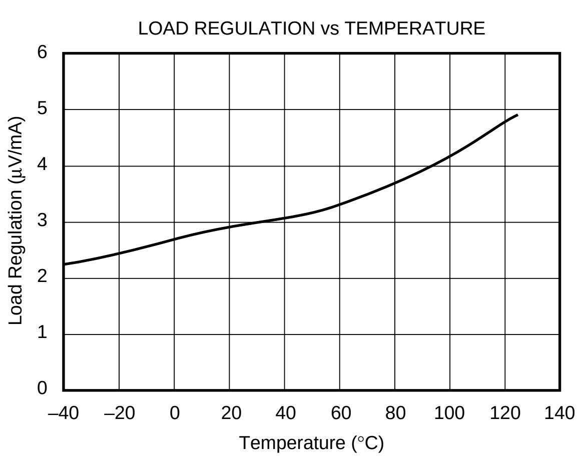
At T_A = +25°C, V_{IN} = +5V power supply, REF3025 is used for typical characteristics, unless otherwise noted.

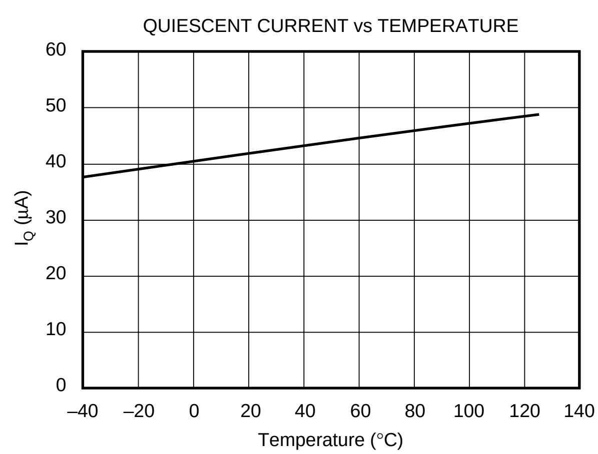






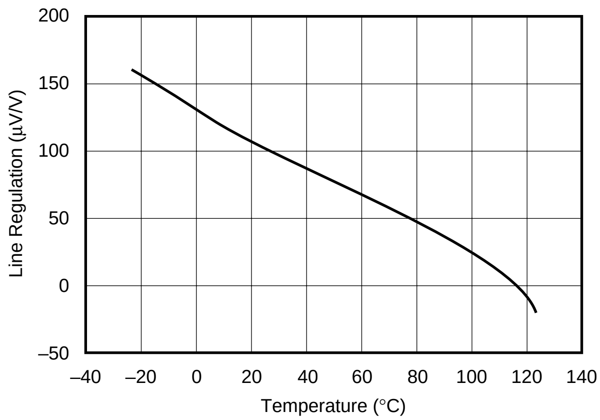




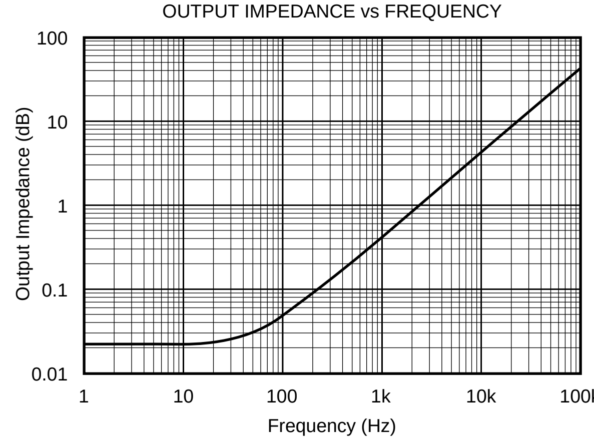


TYPICAL CHARACTERISTICS (Cont.)

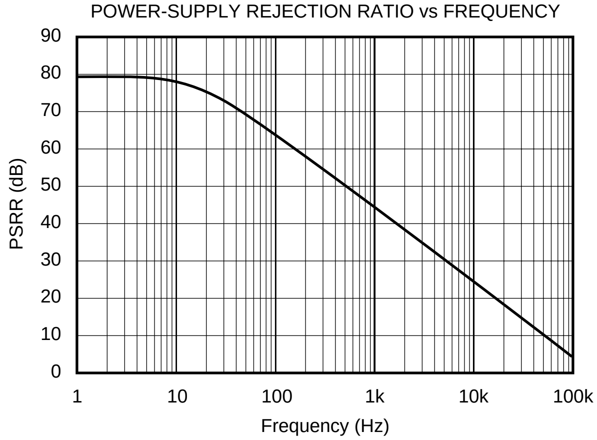
At T_A = +25°C, V_{IN} = +5V power supply, REF3025 is used for typical characteristics, unless otherwise noted.



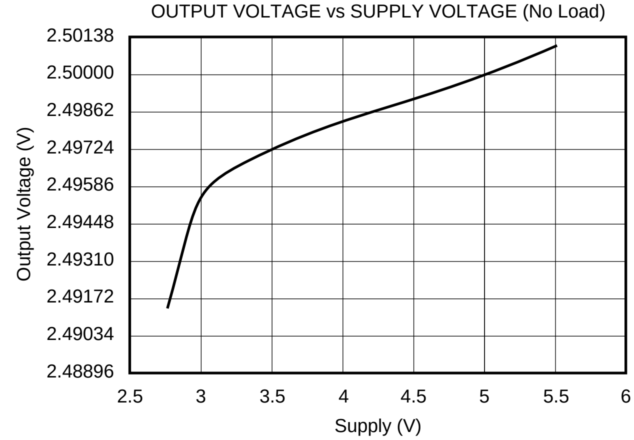
LINE REGULATION vs TEMPERATURE



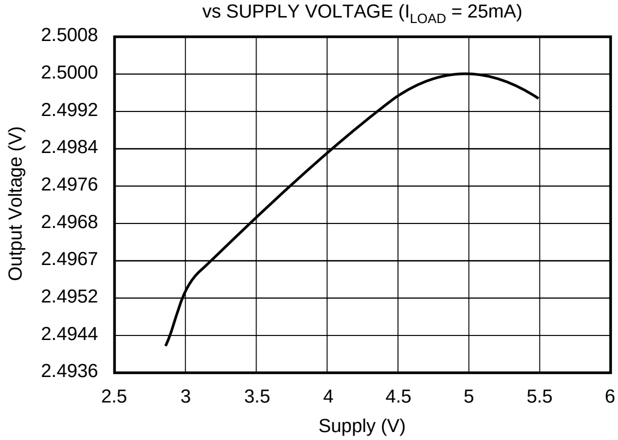
OUTPUT IMPEDANCE vs FREQUENCY



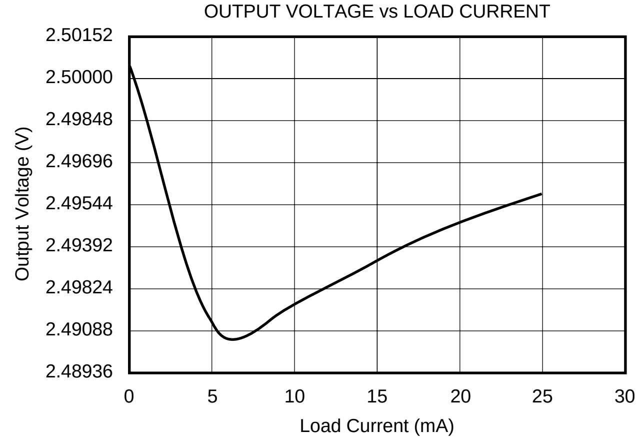
POWER-SUPPLY REJECTION RATIO vs FREQUENCY



OUTPUT VOLTAGE vs SUPPLY VOLTAGE (No Load)



OUTPUT VOLTAGE vs SUPPLY VOLTAGE (I_{LOAD} = 25mA)

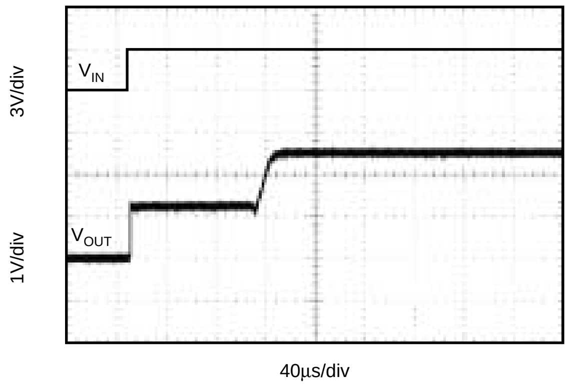


OUTPUT VOLTAGE vs LOAD CURRENT

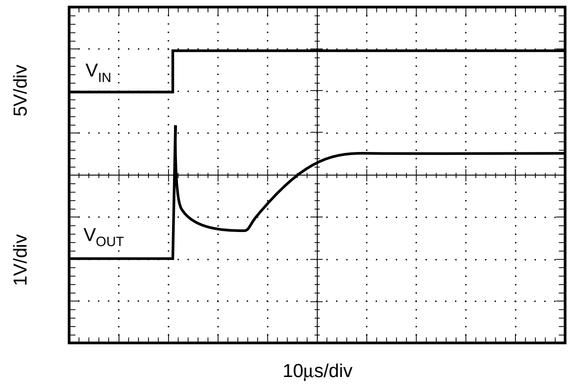
TYPICAL CHARACTERISTICS (Cont.)

At T_A = +25°C, V_{IN} = +5V power supply, REF3025 is used for typical characteristics, unless otherwise noted.

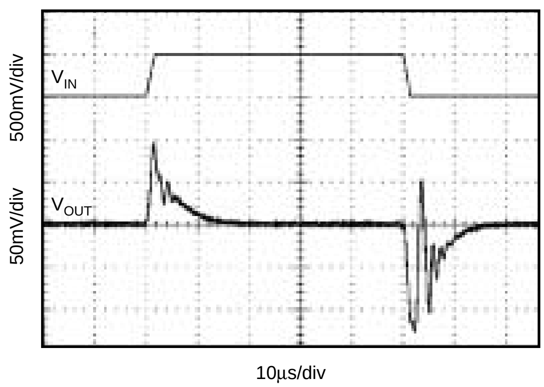
STEP RESPONSE, C_L = 0, 3V STARTUP



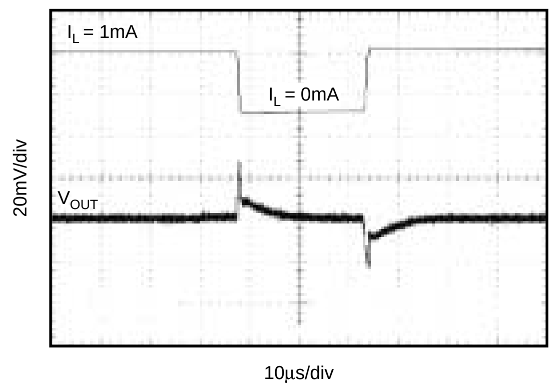
STEP RESPONSE, C_L = 0, 5V STARTUP



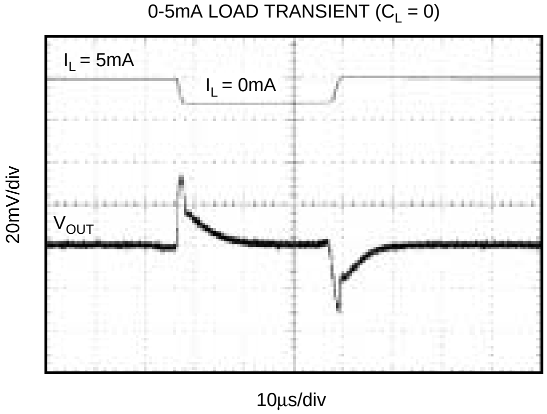
LINE TRANSIENT RESPONSE



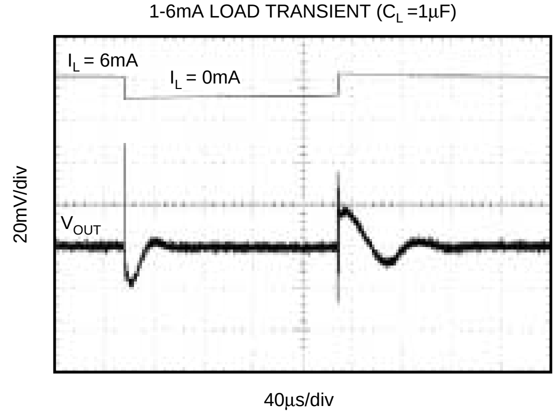
0-1mA LOAD TRANSIENT (C_L = 0)



0-5mA LOAD TRANSIENT (C_L = 0)



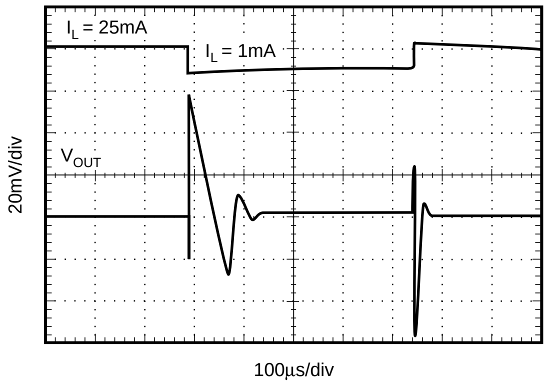
1-6mA LOAD TRANSIENT (C_L =1μF)



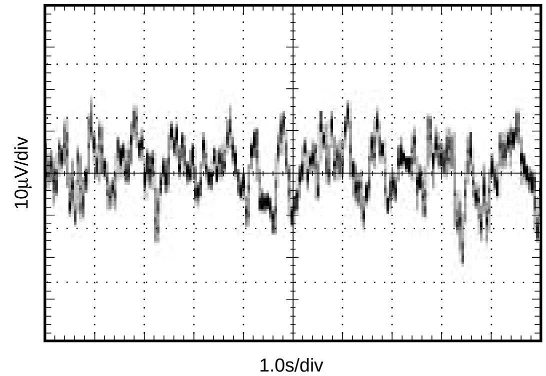
TYPICAL CHARACTERISTICS (Cont.)

At T_A = +25°C, V_{IN} = +5V power supply, REF3025 is used for typical characteristics, unless otherwise noted.

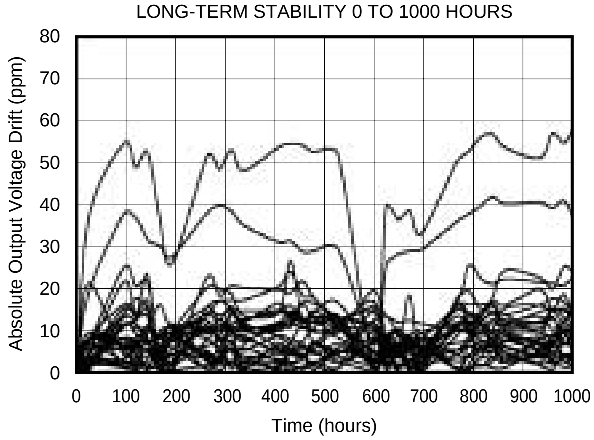
1-25mA LOAD TRANSIENT (C_L = 1µF)



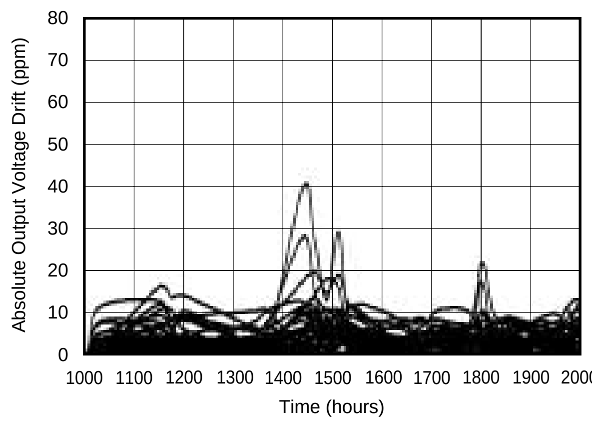
0.1Hz TO 10Hz NOISE



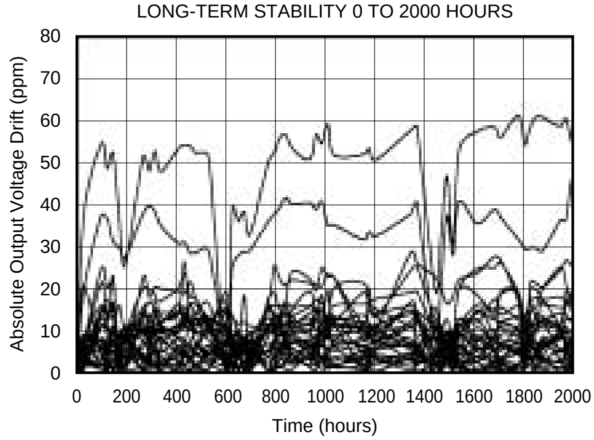
LONG-TERM STABILITY 0 TO 1000 HOURS



LONG-TERM STABILITY 1000 TO 2000 HOURS



LONG-TERM STABILITY 0 TO 2000 HOURS



THEORY OF OPERATION

The REF30xx is a series, CMOS, precision bandgap voltage reference. It's basic topology is shown in Figure 1. The 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-emiter 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 coefficient. The resulting output voltage is virtually independent of temperature. The curvature of the bandgap voltage, as seen in the typical curve, "Output Voltage vs Temperature", is due to the slightly nonlinear temperature coefficient of the base-emitter voltage of Q_2.

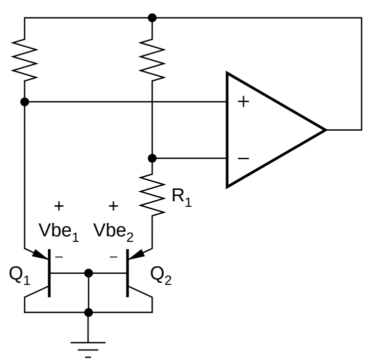


FIGURE 1. Simplified Schematic of Bandgap Reference.

APPLICATION INFORMATION

The REF30xx does not require a load capacitor, and is stable with any capacitive load. Figure 2 shows typical connections required for operation of the REF30xx. A supply bypass capacitor of 0.47µF is recommended.

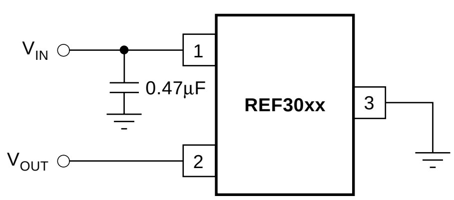


FIGURE 2. Typical Connections for Operating REF30xx.

SUPPLY VOLTAGE

The REF30xx family of references features an extremely low dropout voltage. With the exception of the REF3012, which has a minimum supply requirement of 1.8V, the REF30xx can be operated with a supply of only 1mV above the output voltage in an unloaded condition. For loaded conditions, a typical dropout voltage versus load is shown on the cover page.

The REF30xx features a low quiescent current, which is extremely stable over changes in both temperature and supply. The typical room temperature quiescent current is 42µA, and the maximum quiescent current over temperature is just 59µA. Additionally, the quiescent current typically changes less than 2.5µA over the entire supply range, as shown in Figure 3.

Supply voltages below the specified levels can cause the REF30xx to momentarily draw currents greater than the typical quiescent current. Using a power supply with a fast rising edge and low output impedance easily prevents this.

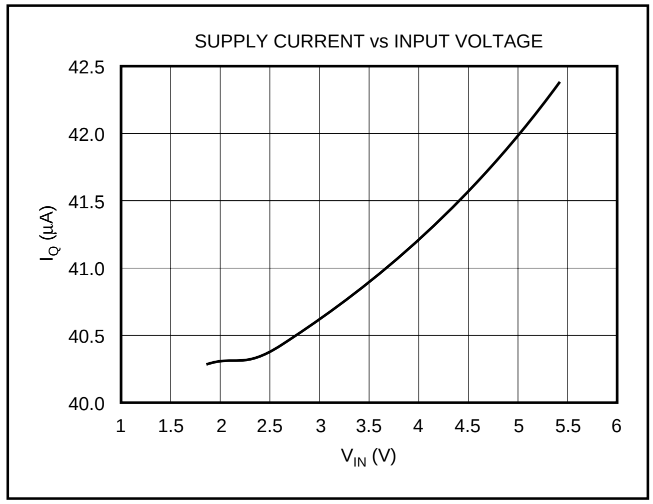


FIGURE 3. Supply Current vs Supply Voltage.

THERMAL HYSTERESIS

Thermal hysteresis for the REF30xx 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, and 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} = Calculated hysteresis

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

V_{POST} = Output voltage measured when device has been operated at 25°C, cycled through specified range –40°C to +125°C and returned to operation at 25°C.

TEMPERATURE DRIFT

The REF30xx is designed to exhibit minimal drift error, defined as the change in output voltage over varying temperature. Using the 'box' method of drift measurement, the REF30xx features a typical drift coefficient of 20ppm from 0°C to 70°C—the primary temperature range of use for many applications. For industrial temperature ranges of –40°C to 125°C, the REF30xx family drift increases to a typical value of 50ppm.

NOISE PERFORMANCE

The REF30xx generates noise less than 50µVp-p between frequencies of 0.1Hz to 10Hz, and can be seen in the Typical Characteristic Curve “0.1 to 10Hz Voltage Noise”. The noise voltage of the REF30xx 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 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 apparent by the long term stability curves. The typical drift value for the REF30xx is 24ppm from 0-1000 hours, and 15ppm from 1000-2000 hours. This parameter is characterized by measuring 30 units at regular intervals for a period of 2000 hours.

LOAD REGULATION

Load regulation is defined as the change in output voltage due to changes in load current. Load regulation for the REF30xx is measured using force and sense contacts as pictured in Figure 4. The force and sense lines tied to the contact area of the output pin reduce the impact of contact and trace resistance, resulting in accurate measurement of the load regulation contributed solely by the REF30xx. For applications requiring improved load regulation, force and sense lines should be used.

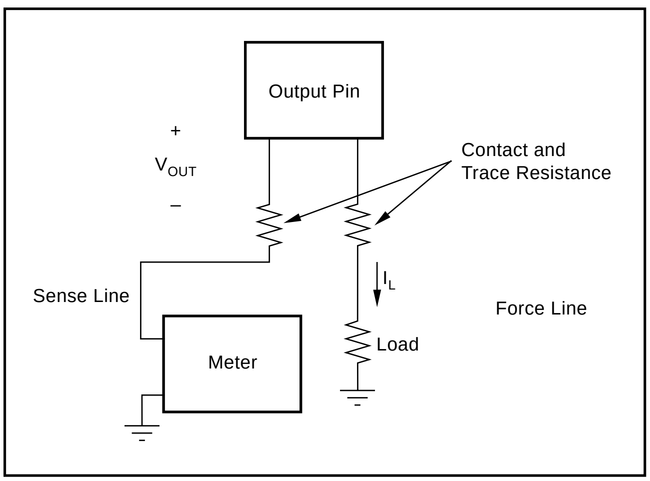


FIGURE 4. Accurate Load Regulation of REF30xx.

APPLICATION CIRCUITS

Negative Reference Voltage

For applications requiring a negative and positive reference voltage, the OPA703 and REF30xx can be used to provide a dual supply reference from a ±5V supply. Figure 5 shows the REF3025 used to provide a ±2.5V supply reference voltage. The low offset voltage and low drift of the OPA703 complement the low drift performance of the REF30xx to provide an accurate solution for split-supply applications.

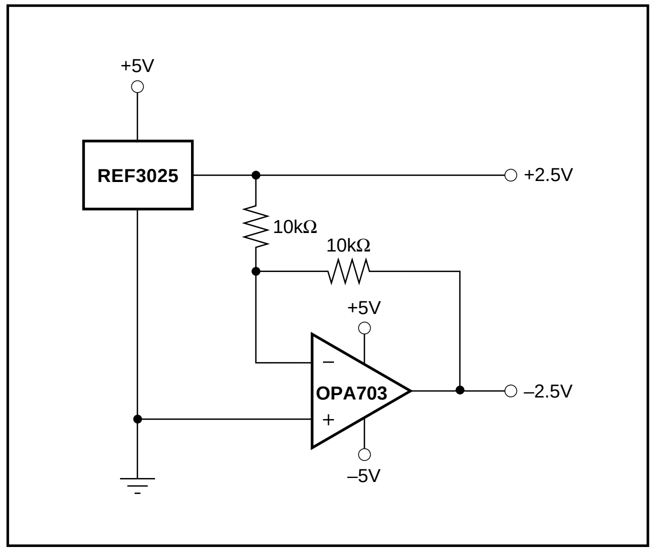


FIGURE 5. REF3025 Combined with OPA703 to Create Positive and Negative Reference Voltages.

DATA ACQUISITION

Often data acquisition systems require stable voltage references to maintain necessary accuracy. The REF30xx family features stability and a wide range of voltages suitable for most micro-controllers and data converters. Figure 6 and Figure 7 show two basic data acquisition systems.

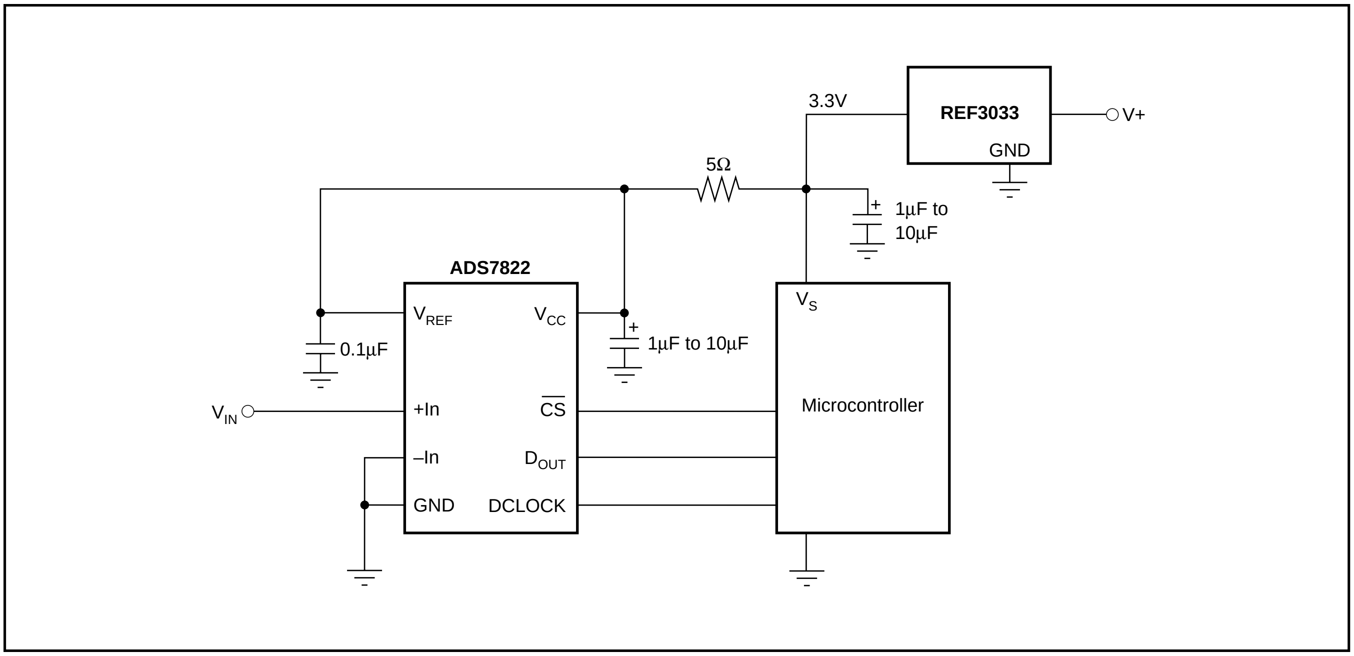


FIGURE 6. Basic Data Acquisition System 1.

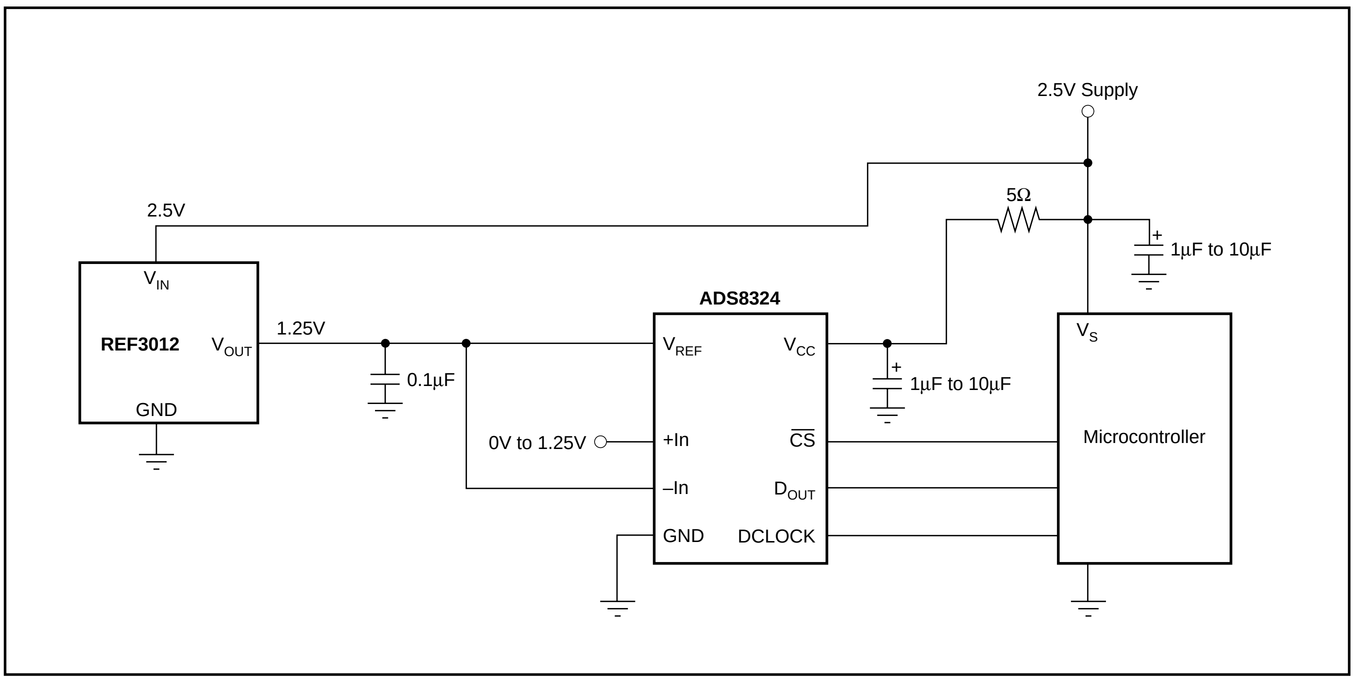
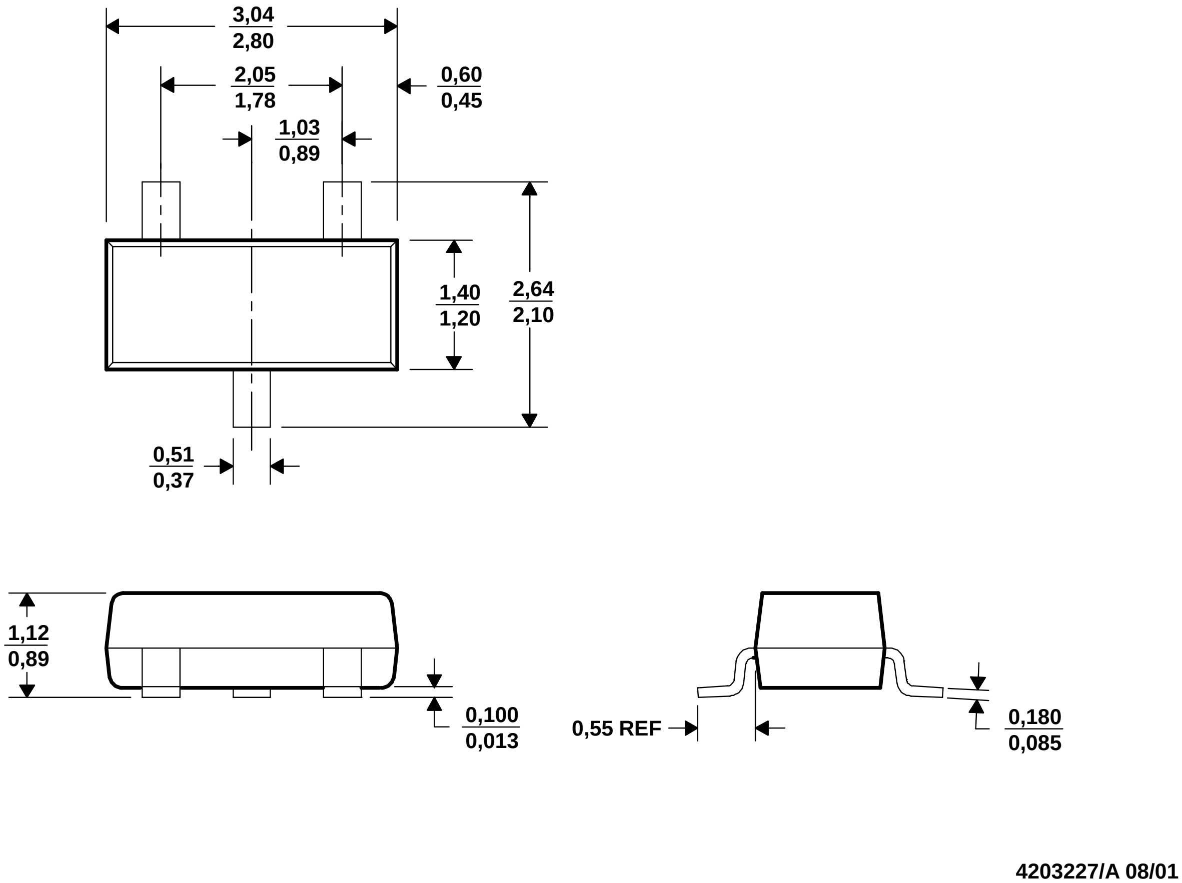


FIGURE 7. Basic Data Acquisition System 2.

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



NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Dimensions are inclusive of plating.
D. Dimensions are exclusive of mold flash and metal burr.

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