16-Bit, Ultra-Low Power, Voltage-Output Digital-to-Analog Converter

FEATURES

- **16-Bit Resolution**
- **2.7 V to 5.5 V Single-Supply Operation**
- **Very Low Power: 15 µW for 3 V Power**
- **High Accuracy, INL: 1 LSB**
- **Low Noise: 18n V/$\sqrt{Hz}$**
- **Fast Settling: 1.0 µS**
- **Fast SPI™ Interface, up to 50 MHz**
- **Reset to Mid-Code**
- **Schmitt-Trigger Inputs for Direct Optocoupler Interface**

APPLICATIONS

- **Portable Equipment**
- **Automatic Test Equipment**
- **Industrial Process Control**
- **Data Acquisition Systems**
- **Optical Networking**

DESCRIPTION

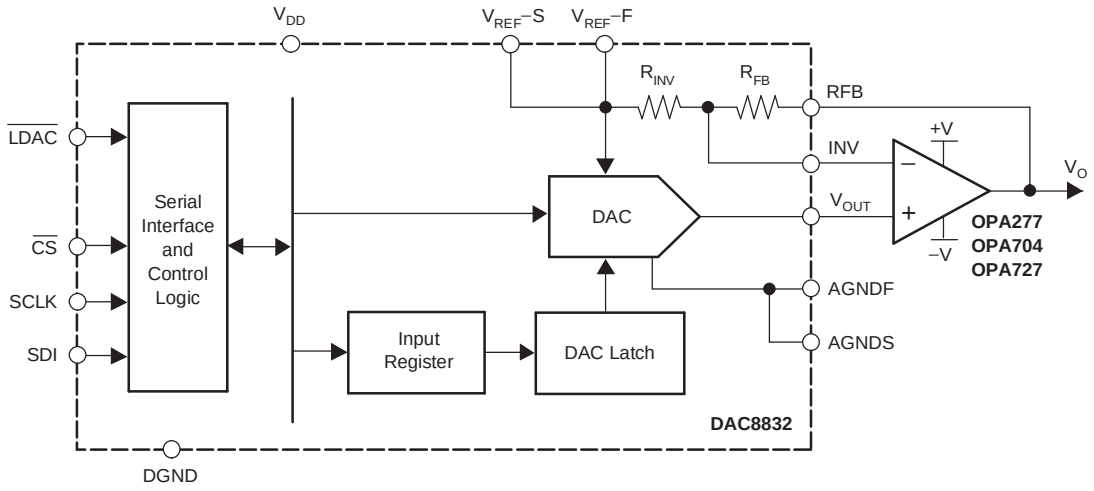
The DAC8832 is a single, 16-bit, serial-input, voltage-output digital-to-analog converter (DAC) operating from a single 3 V to 5 V power supply. The DAC8832 provides excellent linearity (1 LSB INL), low glitch, low noise, and fast settling (1.0 µS to 1/2 LSB of full-scale output) over the specified temperature range of –40°C to +85°C. The output is unbuffered, which reduces the power consumption and the error introduced by the buffer.

This device features a standard high-speed (clock up to 50MHz), 3 V or 5 V SPI serial interface to communicate with a DSP or microprocessor.

The DAC8832 provides unipolar or bipolar output ($\pm V_{REF}$) when working with an external buffer, and is reset to mid-code after power-up. For optimum performance, a set of Kelvin connections to the external reference and the analog ground input are provided.

The DAC8832 is available in a QFN-14 package, and is pin-to-pin compatible with the DAC8831IRGY, which is reset to zero code after power-up.

Functional Block Diagram



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.

ORDERING INFORMATION(1)

PRODUCT	MINIMUM RELATIVE ACCURACY (LSB)	DIFFERENTIAL NONLINEARITY (LSB)	POWER-ON RESET VALUE	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	PACKAGE-LEAD	PACKAGE DESIGNATOR	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
DAC8832IRGY	±4	±1	Mid Code	–40°C to +85°C	8832I	QFN-14	RGY	DAC8832IRGYT	Tape and Reel, 250
								DAC8832IRGYR	Tape and Reel, 1000
DAC8832IBRGY	±2	±1	Mid Code	–40°C to +85°C	8832I	QFN-14	RGY	DAC8832IBRGYT	Tape and Reel, 250
								DAC8832IBRGYR	Tape and Reel, 1000
DAC8832ICRGY	±1	±1	Mid Code	–40°C to +85°C	8832I	QFN-14	RGY	DAC8832ICRGYT	Tape and Reel, 250
								DAC8832ICRGYR	Tape and Reel, 1000

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

ABSOLUTE MAXIMUM RATINGS

Over operating free-air temperature range (unless otherwise noted)(1)

	DAC8832	UNIT
V_{DD} to AGND	–0.3 to +7	V
Digital input voltage to DGND	–0.3 to +V_{DD} + 0.3	V
V_{OUT} to AGND	–0.3 to +V_{DD} + 0.3	V
AGND, AGNDF, AGNDS to DGND	–0.3 to +0.3	V
Operating temperature range	–40 to +85	°C
Storage temperature range	–65 to +150	°C
Junction temperature range (T_J max)	+150	°C
Power dissipation	(T_J max – T_A) / θ_{JA}	W
Thermal impedance, θ_{JA}	54.9	°C/W

(1) Stresses above those listed under absolute maximum ratings may cause permanent damage to the device. Exposure to absolute maximum conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

All specifications at $T_A = T_{MIN}$ to T_{MAX}, V_{DD} = +3 V or V_{DD} = +5 V, V_{REF} = +2.5 V unless otherwise noted.

PARAMETER		CONDITIONS	DAC8832 MIN	DAC8832 TYP	DAC8832 MAX	UNIT
STATIC PERFORMANCE						
Resolution			16			bits
Linearity error	DAC8832ICRGY			±0.5	±1	LSB
	DAC8832IBRGY			±0.5	±2	
	DAC8832IRGY			±0.5	±4	
Differential linearity error		All grades		±0.5	±1	LSB
Gain error		T_A = +25°C		±1	±5	LSB
		T_A = –40°C to +85°C			±7	
Gain drift				±0.1		ppm/°C
Zero code error		T_A = +25°C		±0.25	±1	LSB
		T_A = –40°C to +85°C			±2	
Zero code drift				±0.05		ppm/°C
OUTPUT CHARACTERISTICS						
Voltage output (1)		Unipolar operation	0		$+V_{REF}$	V
		Bipolar operation	$–V_{REF}$		$+V_{REF}$	V
Output impedance				6.25		kΩ
Settling time		To 1/2 LSB of FS, C_L = 10 pF		1		µs
Slew rate (2)		C_L = 10 pF		25		V/µs
Digital-to-analog glitch		1 LSB change around major carry		35		nV-s
Digital feedthrough (3)				0.2		nV-s
Output noise		T_A = +25°C		18		nV/√Hz
Power-supply rejection		V_{DD} varies ±10%			±1	LSB
Bipolar resistor matching		R_{FB} / R_{INV}		1		Ω/Ω
		Ratio error		±0.0015	±0.0076	%
Bipolar zero error		T_A = +25°C		±0.25	±5	LSB
		T_A = –40°C to +85°C			±7	
Bipolar zero drift				±0.2		ppm/°C

(1) See the *Bipolar Output Operation* section for details.
(2) Slew rate is measured from 10% to 90% of transition when the output changes from 0 to full-scale.
(3) Digital feedthrough is defined as the impulse injected into the analog output from the digital input. It is measured when the DAC output does not change; $\overline{CS}$ is held high, while SCLK and DIN signals are toggled.

ELECTRICAL CHARACTERISTICS (continued)

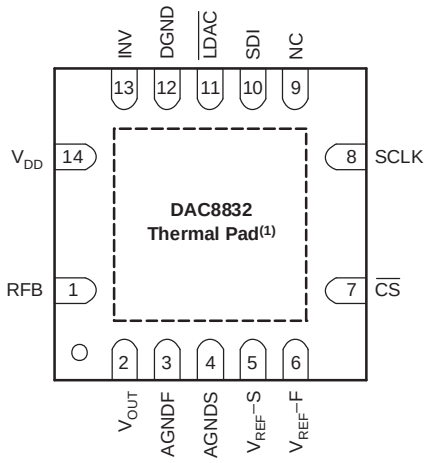
All specifications at $T_A = T_{MIN}$ to T_{MAX}, V_{DD} = +3 V or V_{DD} = +5 V, V_{REF} = +2.5 V unless otherwise noted.

PARAMETER		CONDITIONS	DAC8832			UNIT
			MIN	TYP	MAX	
REFERENCE INPUT						
	Reference input voltage range		1.25		V_{DD}	V
	Reference input impedance(4)	Unipolar mode	9			kΩ
		Bipolar mode	7.5			
	Reference –3 dB bandwidth, BW	Code = FFFFh		1.3		MHz
	Reference feedthrough	Code = 0000h, V_{REF} = 1 V_{PP} at 100 kHz		1		mV
	Signal-to-noise ratio, SNR			92		dB
	Reference input capacitance	Code = 0000h		75		pF
		Code = FFFFh		120		
DIGITAL INPUTS						
V_{IL}	Input low voltage	V_{DD} = 2.7 V			0.6	V
		V_{DD} = 5 V			0.8	
V_{IH}	Input high voltage	V_{DD} = 2.7 V	2.1			V
		V_{DD} = 5 V	2.4			
	Input current				±1	µA
	Input capacitance				10	pF
	Hysteresis voltage			0.4		V
POWER SUPPLY						
V_{DD}	Power-supply voltage		2.7		5.5	V
I_{DD}	Power-supply current	V_{DD} = 3 V		5	20	µA
		V_{DD} = 5 V		5	20	
	Power	V_{DD} = 3 V		15	60	µW
		V_{DD} = 5 V		25	100	
TEMPERATURE RANGE						
	Specified performance		–40		+85	°C

(4) Reference input resistance is code-dependent, minimum at 8555h.

PIN CONFIGURATION (NOT TO SCALE)

RGY PACKAGE
QFN-14
(TOP VIEW)



NOTE: (1) Exposed thermal pad must be connected to analog ground.

TERMINAL FUNCTIONS

TERMINAL		DESCRIPTION
NO.	NAME	
1	RFB	Feedback resistor. Connect to the output of external operational amplifier in bipolar mode.
2	V_{OUT}	Analog output of DAC
3	AGNDF	Analog ground (Force)
4	AGNDS	Analog ground (Sense)
5	V_{REF}-S	Voltage reference input (Sense). Connect to external voltage reference
6	V_{REF}-F	Voltage reference input (Force). Connect to external voltage reference
7	$\overline{CS}$	Chip select input (active low). Data are not clocked into SDI unless $\overline{CS}$ is low.
8	SCLK	Serial clock input.
9	NC	No internal connection
10	SDI	Serial data input. Data are latched into input register on the rising edge of SCLK.
11	$\overline{LDAC}$	Load DAC control input. Active low. When $\overline{LDAC}$ is Low, the DAC latch is simultaneously updated with the content of the input register.
12	DGND	Digital ground
13	INV	Junction point of internal scaling resistors. Connect to external operational amplifier inverting input in bipolar mode.
14	V_{DD}	Analog power supply, +3 V to +5 V.

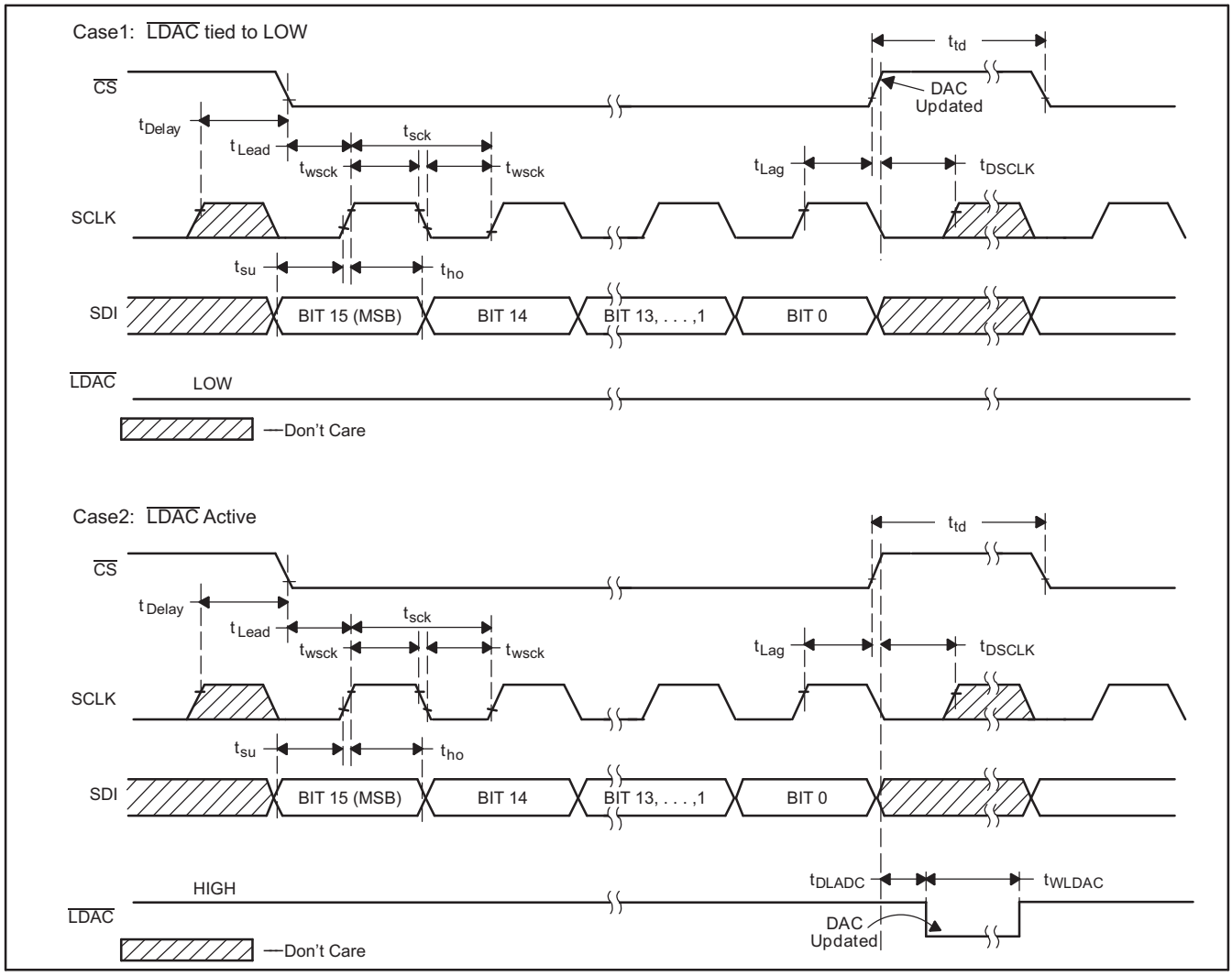


Figure 1. DAC8832 Timing Diagram

TIMING CHARACTERISTICS: V_{DD} = +5 V(1)(2)

At –40°C to +85°C, unless otherwise noted.

PARAMETER		MIN	MAX	UNIT
t_{sck}	SCLK period	20		ns
t_{wsck}	SCLK high or low time	10		ns
t_{Delay}	Delay from SCLK high to $\overline{CS}$ low	10		ns
t_{Lead}	$\overline{CS}$ enable lead time	10		ns
t_{Lag}	$\overline{CS}$ enable lag time	10		ns
t_{DSCLK}	Delay from $\overline{CS}$ high to SCLK high	10		ns
t_{td}	$\overline{CS}$ high between active period	30		ns
t_{su}	Data setup time (input)	10		ns
t_{ho}	Data hold time (input)	0		ns
t_{WLDAC}	$\overline{LDAC}$ width	30		ns
t_{DLDAC}	Delay from $\overline{CS}$ high to $\overline{LDAC}$ low	30		ns
	V_{DD} high to $\overline{CS}$ low (power-up delay)	10		µs

(1) Assured by design. Not production tested.
(2) Sample tested during the initial release and after any redesign or process changes that may affect this parameter.

TIMING CHARACTERISTICS: V_{DD} = +3 V(1)(2)

At –40°C to +85°C, unless otherwise noted.

PARAMETER		MIN	MAX	UNIT
t_{sck}	SCLK period	20		ns
t_{wsck}	SCLK high or low time	10		ns
t_{Delay}	Delay from SCLK high to $\overline{CS}$ low	10		ns
t_{Lead}	$\overline{CS}$ enable lead time	10		ns
t_{Lag}	$\overline{CS}$ enable lag time	10		ns
t_{DSCLK}	Delay from $\overline{CS}$ high to SCLK high	10		ns
t_{td}	$\overline{CS}$ high between active period	30		ns
t_{su}	Data setup time (input)	10		ns
t_{ho}	Data hold time (input)	0		ns
t_{WLDAC}	$\overline{LDAC}$ width	30		ns
t_{DLDAC}	Delay from $\overline{CS}$ high to $\overline{LDAC}$ low	30		ns
	V_{DD} high to $\overline{CS}$ low (power-up delay)	10		µs

(1) Assured by design. Not production tested.
(2) Sample tested during the initial release and after any redesign or process changes that may affect this parameter.

TYPICAL CHARACTERISTICS: V_{DD} = +5 V

At T_A = +25°C, V_{REF} = +2.5 V unless otherwise noted.

LINEARITY ERROR vs DIGITAL INPUT CODE

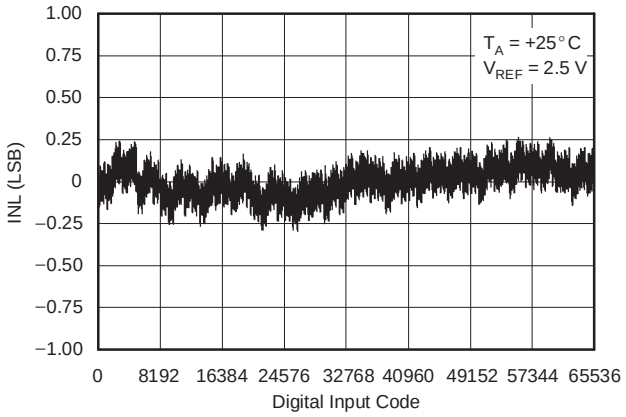


Figure 2.

DIFFERENTIAL LINEARITY ERROR vs DIGITAL INPUT CODE

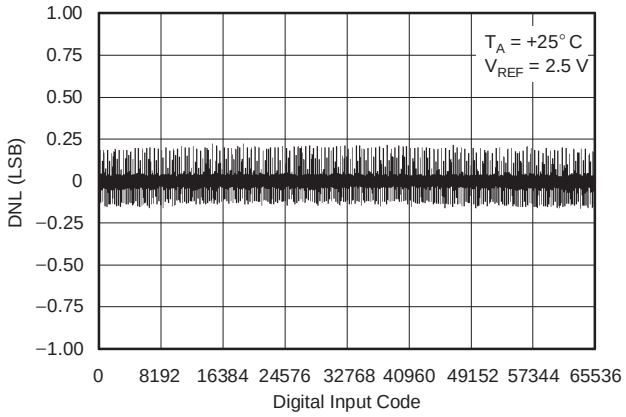


Figure 3.

LINEARITY ERROR vs DIGITAL INPUT CODE

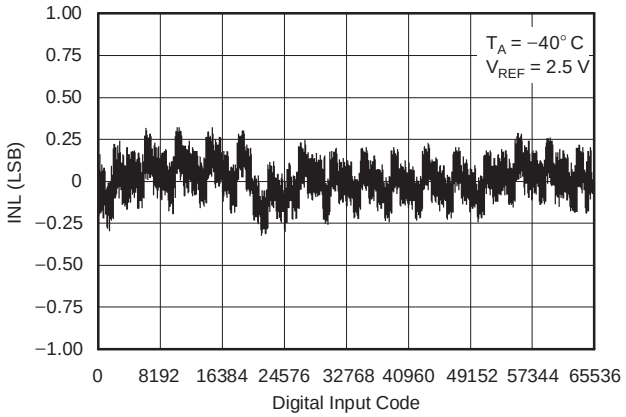


Figure 4.

DIFFERENTIAL LINEARITY ERROR vs DIGITAL INPUT CODE

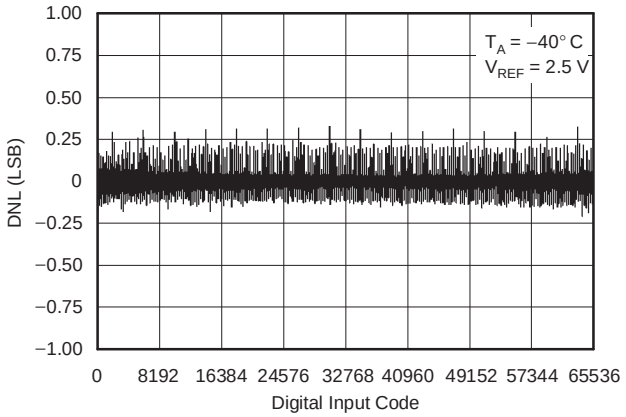


Figure 5.

LINEARITY ERROR vs DIGITAL INPUT CODE

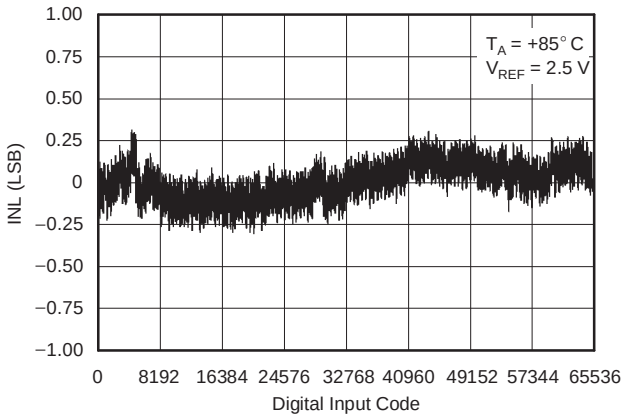


Figure 6.

DIFFERENTIAL LINEARY ERROR vs DIGITAL INPUT CODE

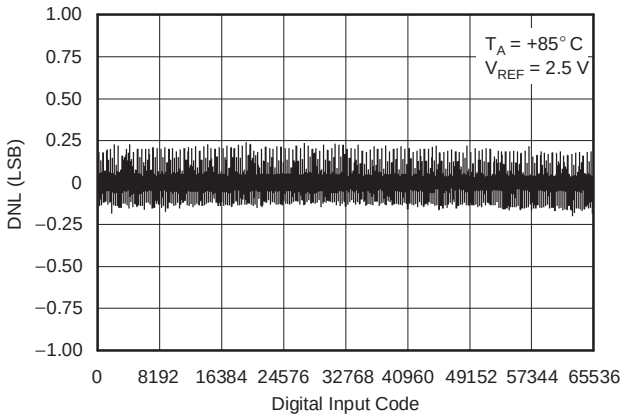


Figure 7.

TYPICAL CHARACTERISTICS: V_{DD} = +5 V (continued)

At T_A = +25°C, V_{REF} = +2.5 V unless otherwise noted.

LINEARITY ERROR vs DIGITAL INPUT CODE

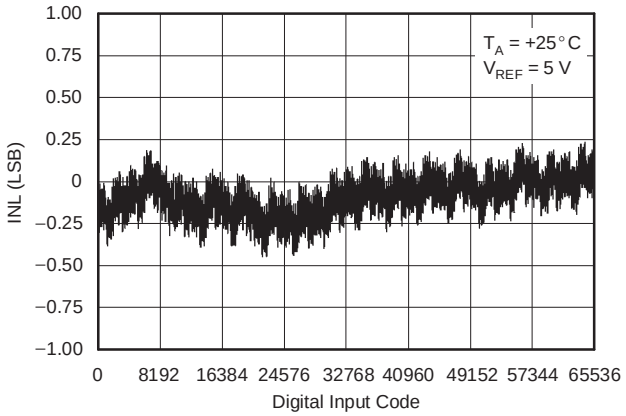


Figure 8.

DIFFERENTIAL LINEARITY ERROR vs DIGITAL INPUT CODE

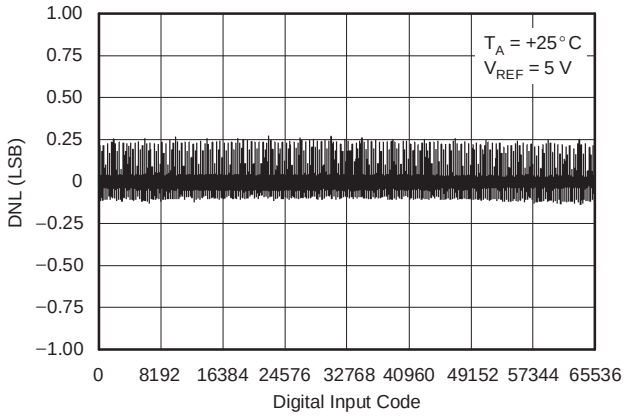


Figure 9.

LINEARITY ERROR vs REFERENCE VOLTAGE

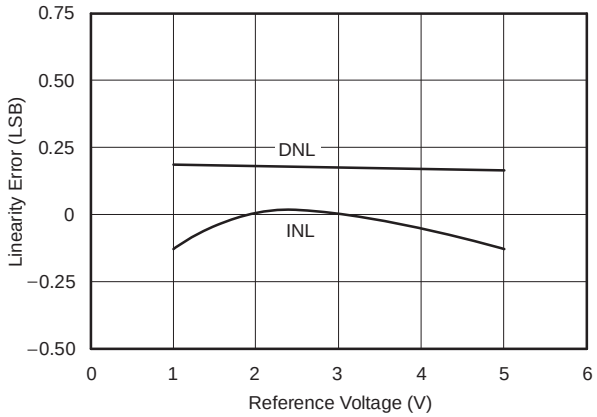


Figure 10.

LINEARITY ERROR vs SUPPLY VOLTAGE

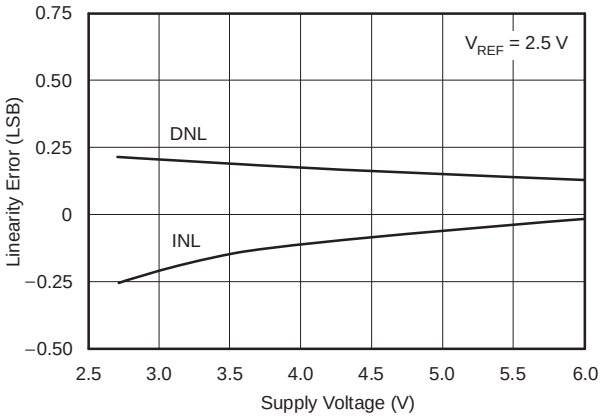


Figure 11.

GAIN ERROR vs TEMPERATURE

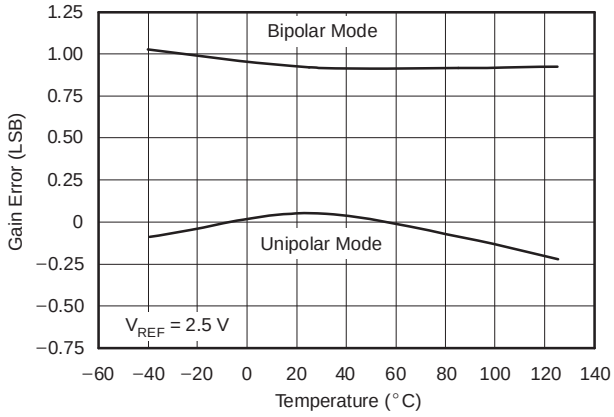


Figure 12.

ZERO-CODE ERROR vs TEMPERATURE

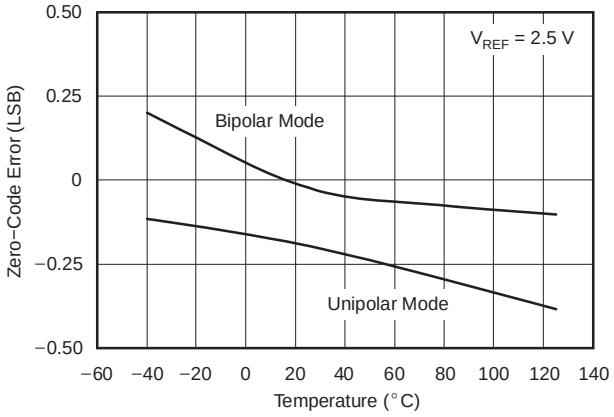


Figure 13.

TYPICAL CHARACTERISTICS: V_{DD} = +5 V (continued)

At T_A = +25°C, V_{REF} = +2.5 V unless otherwise noted.

REFERENCE CURRENT vs CODE (UNIPOLAR MODE)

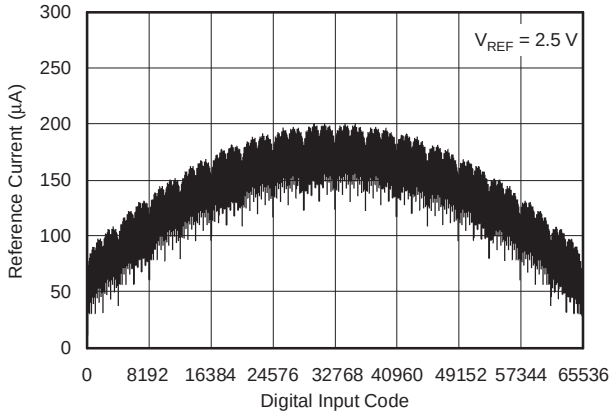


Figure 14.

REFERENCE CURRENT vs CODE (BIPOLAR MODE)

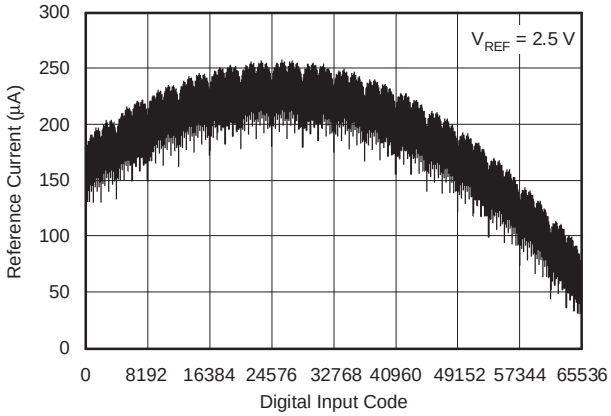


Figure 15.

SUPPLY CURRENT vs DIGITAL INPUT VOLTAGE

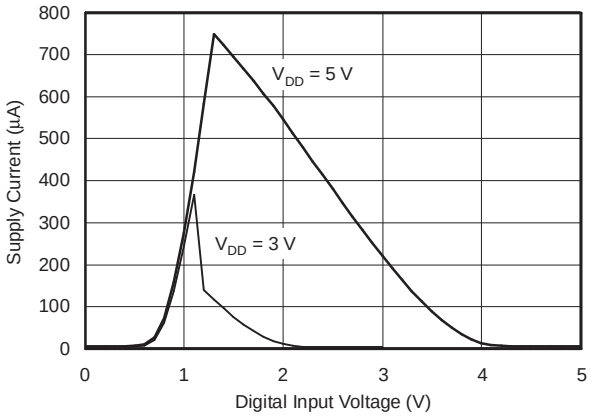


Figure 16.

SUPPLY CURRENT vs TEMPERATURE

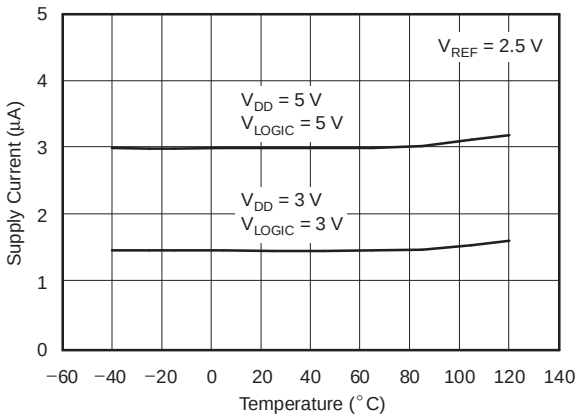


Figure 17.

SUPPLY CURRENT vs SUPPLY VOLTAGE

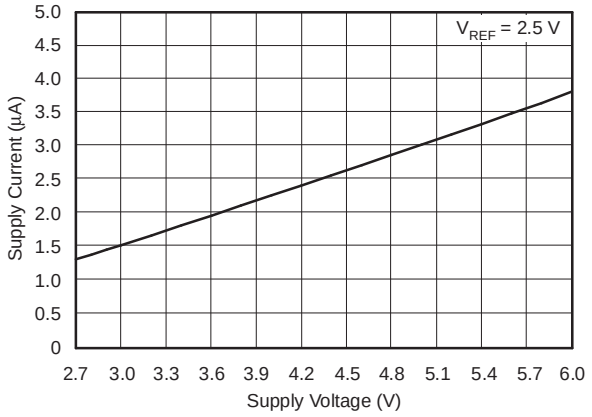


Figure 18.

SUPPLY CURRENT vs REFERENCE VOLTAGE

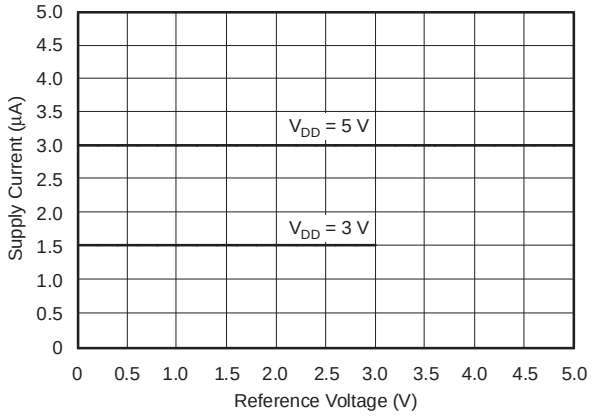


Figure 19.

TYPICAL CHARACTERISTICS: V_{DD} = +5 V (continued)

At T_A = +25°C, V_{REF} = +2.5 V unless otherwise noted.

MAJOR-CARRY GLITCH (FALLING)

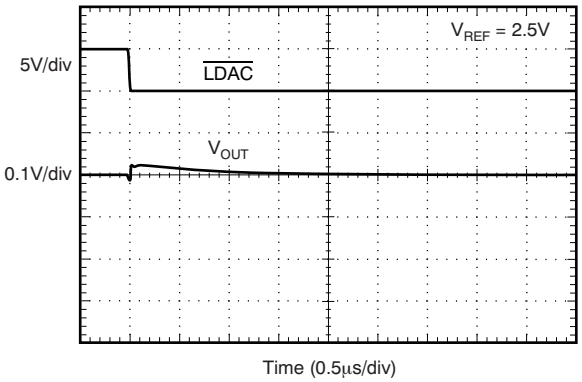


Figure 20.

MAJOR-CARRY GLITCH (RISING)

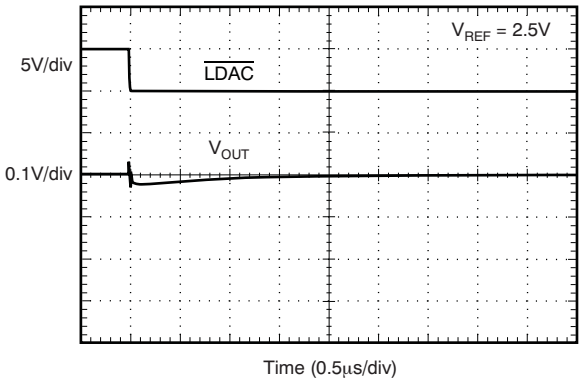


Figure 21.

DAC SETTLING TIME (FALLING)

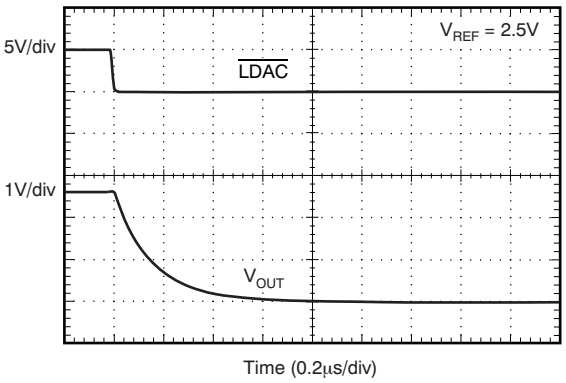


Figure 22.

DAC SETTLING TIME (RISING)

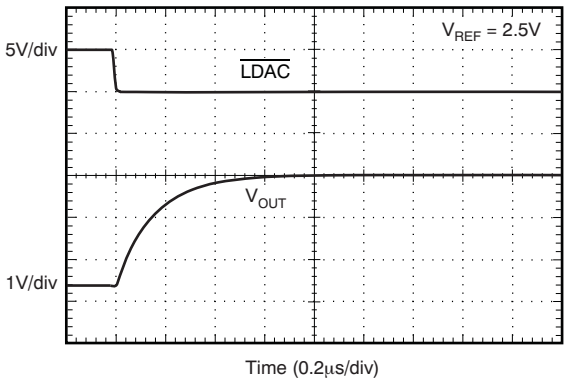


Figure 23.

DIGITAL FEEDTHROUGH

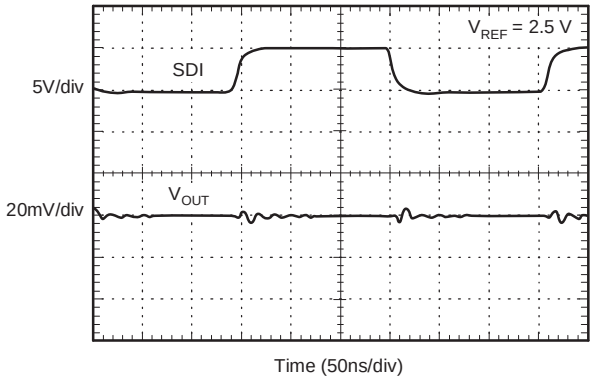


Figure 24.

TYPICAL CHARACTERISTICS: V_{DD} = +3 V

At T_A = +25°C, V_{REF} = +2.5 V unless otherwise noted.

LINEARITY ERROR vs DIGITAL INPUT CODE

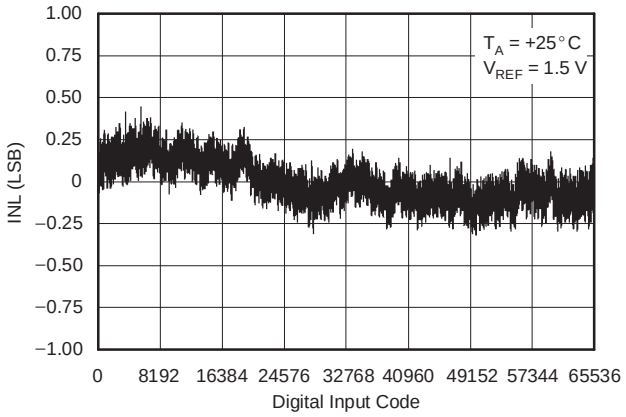


Figure 25.

DIFFERENTIAL LINEARITY ERROR vs DIGITAL INPUT CODE

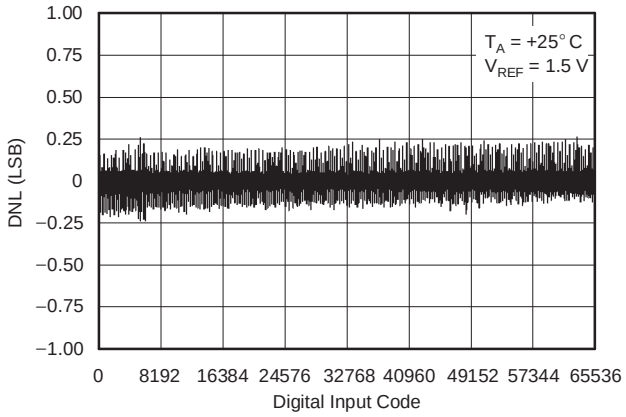


Figure 26.

LINEARITY ERROR vs DIGITAL INPUT CODE

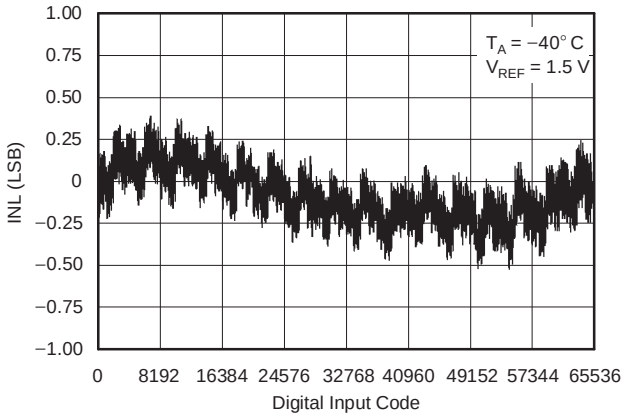


Figure 27.

DIFFERENTIAL LINEARITY ERROR vs DIGITAL INPUT CODE

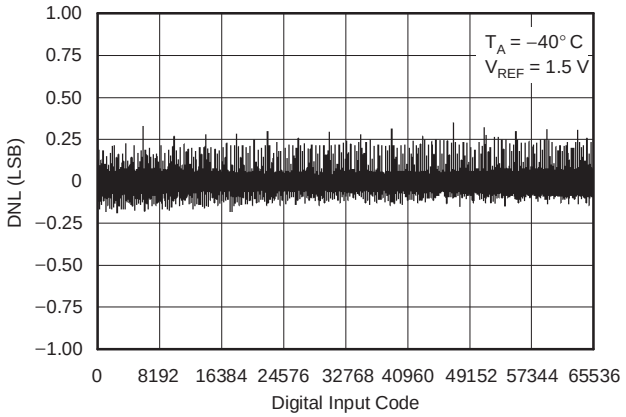


Figure 28.

LINEARITY ERROR vs DIGITAL INPUT CODE

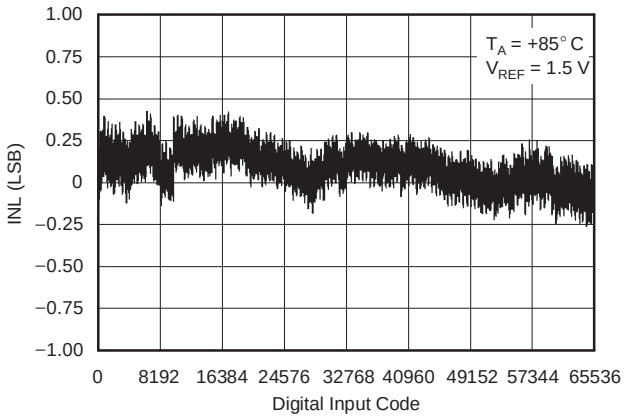


Figure 29.

DIFFERENTIAL LINEARY ERROR vs DIGITAL INPUT CODE

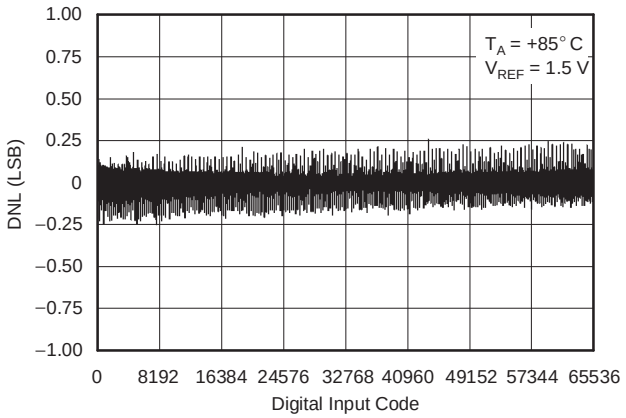


Figure 30.

TYPICAL CHARACTERISTICS: V_{DD} = +3 V (continued)

At T_A = +25°C, V_{REF} = +2.5 V unless otherwise noted.

LINEARITY ERROR vs DIGITAL INPUT CODE

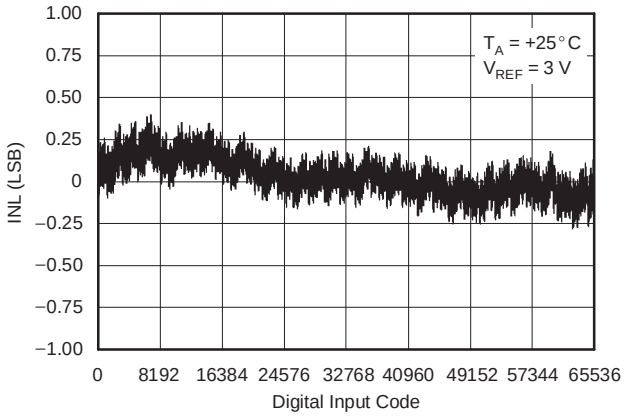


Figure 31.

DIFFERENTIAL LINEARITY ERROR vs DIGITAL INPUT CODE

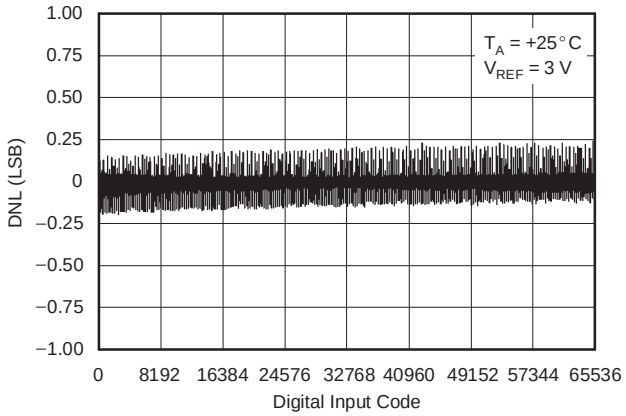


Figure 32.

LINEARITY ERROR vs REFERENCE VOLTAGE

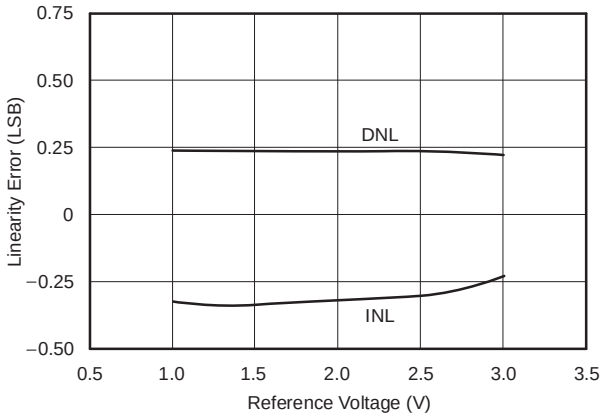


Figure 33.

GAIN ERROR vs TEMPERATURE

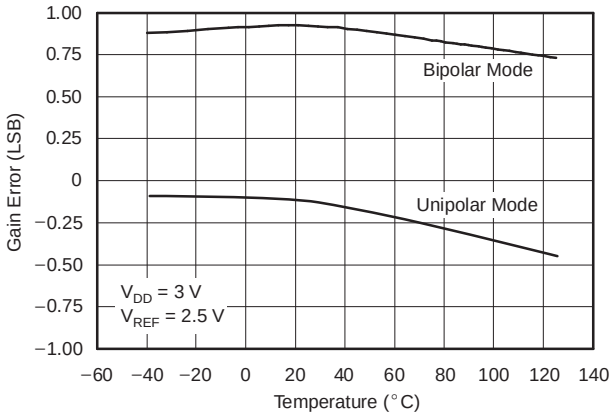


Figure 34.

ZERO-CODE ERROR vs TEMPERATURE

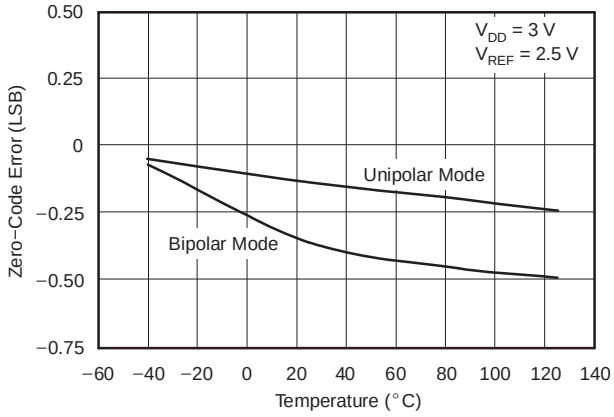


Figure 35.

REFERENCE CURRENT vs CODE (UNIPOLAR MODE)

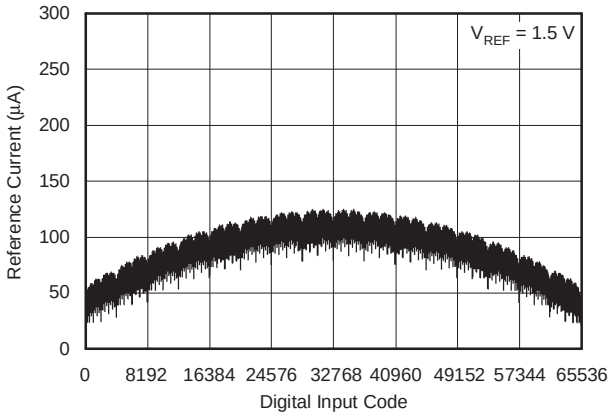


Figure 36.

TYPICAL CHARACTERISTICS: V_{DD} = +3 V (continued)

At T_A = +25°C, V_{REF} = +2.5 V unless otherwise noted.

REFERENCE CURRENT vs CODE (BIPOLAR MODE)

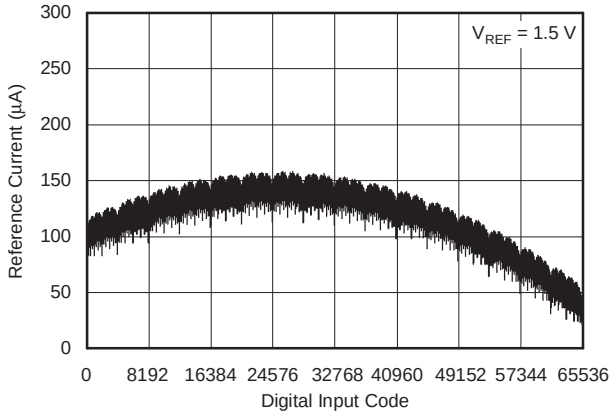


Figure 37.

DIGITAL FEEDTHROUGH

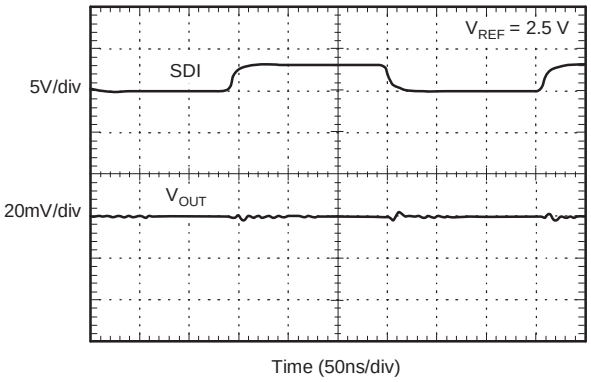


Figure 38.

MAJOR-CARRY GLITCH (FALLING)

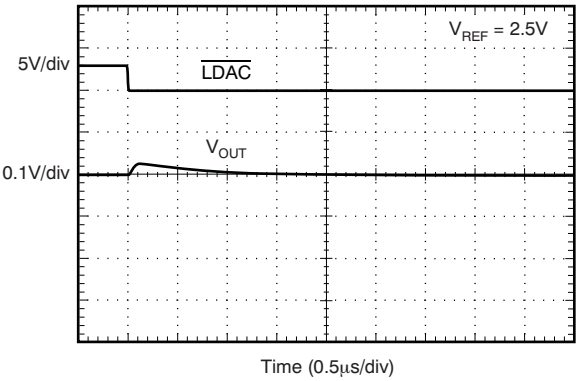


Figure 39.

MAJOR-CARRY GLITCH (RISING)

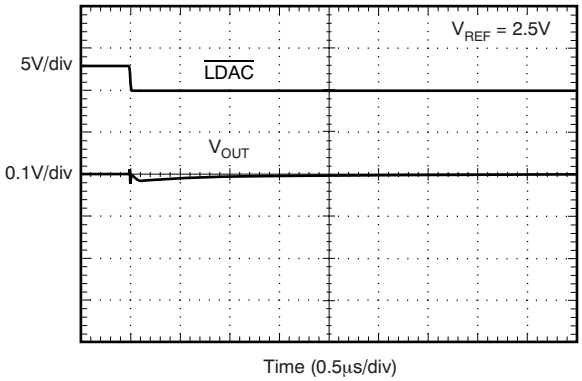


Figure 40.

DAC SETTLING TIME (FALLING)

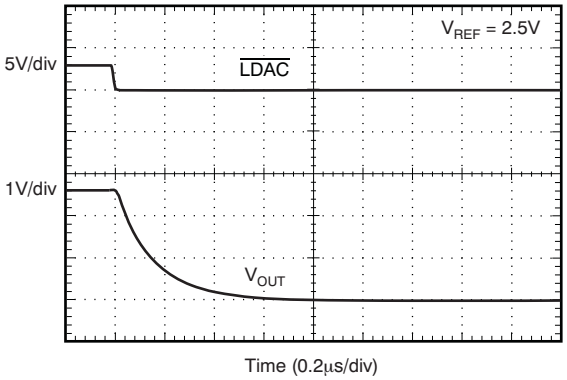


Figure 41.

DAC SETTLING TIME (RISING)

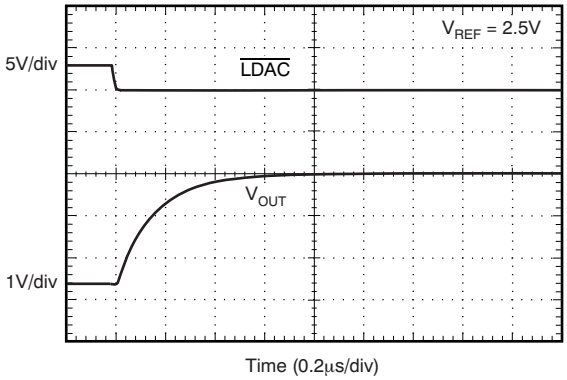


Figure 42.

THEORY OF OPERATION

GENERAL DESCRIPTION

The DAC8832 is a single, 16-bit, serial-input, voltage-output DAC. It operates from a single supply ranging from 2.7 V to 5 V, and typically consumes 5 µA. Data are written to this device in a 16-bit word format, via an SPI serial interface. To ensure a known power-up state, the DAC8832 is designed with a power-on reset function. The DAC8832 is reset to mid-scale code. In unipolar mode, the DAC8832 is reset to 1/2 × V_{REF}, and in bipolar mode, is reset to 0 V. Kelvin sense connections for the reference and analog ground are also included.

DIGITAL-TO-ANALOG SECTIONS

The DAC architecture consists of two matched DAC sections and is segmented. A simplified circuit diagram is shown in Figure 43. The four MSBs of the 16-bit data word are decoded to drive 15 switches, E1 to E15. Each of these switches connects one of 15 matched resistors to either AGND or V_{REF}. The remaining 12 bits of the data word drive switches S0 to S11 of a 12-bit voltage mode R-2R ladder network.

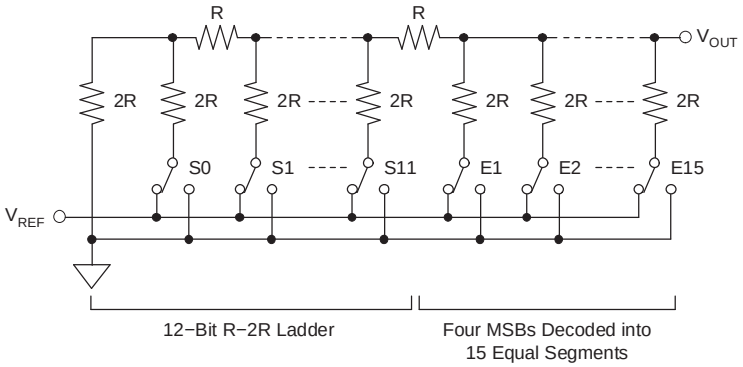


Figure 43. DAC Architecture

OUTPUT RANGE

The output of the DAC is:

$V_{OUT} = (V_{REF} \times Code)/65536$

Where *Code* is the decimal data word loaded to the DAC latch.

POWER-ON RESET

The DAC8832 has a power-on reset function to ensure the output is at a known state upon power-up. Upon power-up, the DAC latch and input register contain mid-scale code until new data are loaded from the input serial shift register. Therefore, after power-up, the output from pin V_{OUT} is $0.5 \times V_{REF}$ in unipolar mode, and 0 V in bipolar mode.

However, the serial register is not cleared on power-up, so its contents are undefined. When loading data initially to the device, 16 bits or more should be loaded to prevent erroneous data appearing on the output. If more than 16 bits are loaded, the last 16 are kept; if less than 16 are loaded, bits will remain from the previous word. If the device must be interfaced with data shorter than 16 bits, the data should be padded with 0s at the LSBs.

SERIAL INTERFACE

The digital interface is standard 3-wire connection compatible with SPI, QSPI™, Microwire™, and TI DSP interfaces, which can operate at speeds up to 50 M-bits/sec. The data transfer is framed by $\overline{CS}$, the chip select signal. The DAC works as a bus slave. The bus master generates the synchronize clock, SCLK, and initiates the transmission. When $\overline{CS}$ is high, the DAC is not accessed, and the clock SCLK and serial input data SDI are ignored. The bus master accesses the DAC by driving pin $\overline{CS}$ low. Immediately following the high-to-low transition of $\overline{CS}$, the serial input data on pin SDI is shifted out from the bus master synchronously on the falling edge of SCLK, and latched on the rising edge of SCLK into the input shift register, MSB first. The low-to-high transition of $\overline{CS}$ transfers the contents of the input shift register to the input register. All data registers are 16-bit. It takes 16 clocks of SCLK to transfer one data word to the parts. To complete a whole data word, $\overline{CS}$ must go high immediately after 16 SCLKs are clocked in. If more than 16 SCLKs are applied during the low state of $\overline{CS}$, the last 16 bits are transferred to the input register on the rising edge of $\overline{CS}$. However, if $\overline{CS}$ is not kept low during the entire 16 SCLK cycles, the data are corrupted. In this case, reload the DAC with a new 16-bit word.

The DAC8832 has an $\overline{LDAC}$ pin allowing the DAC latch to be updated asynchronously by bringing $\overline{LDAC}$ low after $\overline{CS}$ goes high. In this case, $\overline{LDAC}$ must be maintained high while $\overline{CS}$ is low. If $\overline{LDAC}$ is tied permanently low, the DAC latch is updated immediately after the input register is loaded (caused by the low-to-high transition of $\overline{CS}$).

APPLICATION INFORMATION

UNIPOLAR OUTPUT OPERATION

The DAC8832 is capable of driving unbuffered loads of 60 kΩ. Unbuffered operation results in low supply current (typically 5 µA) and a low offset error. The DAC8832 can be configured to output both unipolar and bipolar voltages. Figure 44 shows a typical unipolar output voltage circuit. The code table for this mode of operation is shown in Table 1.

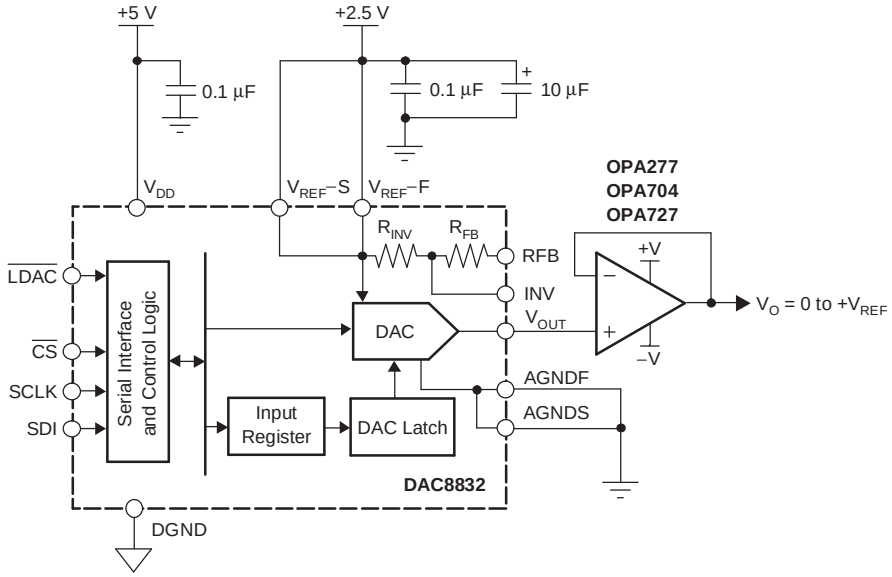


Figure 44. Unipolar Output Mode

Table 1. Unipolar Code

DAC LATCH CONTENTS MSB LSB	ANALOG OUTPUT
1111 1111 1111 1111	$V_{REF} \times (65{,}535/65{,}536)$
1000 0000 0000 0000	$V_{REF} \times (32{,}768/65{,}536) = 1/2\ V_{REF}$
0000 0000 0000 0001	$V_{REF} \times (1/65{,}536)$
0000 0000 0000 0000	0 V

Assuming a perfect reference, the worst-case output voltage may be calculated in the following equation:

Unipolar Mode Worst-Case Output:

$$V_{OUT\_UNI} = \frac{D}{2^{16}} \times \left(V_{REF} + V_{GE}\right) + V_{ZSE} + INL$$

Where:

V_{OUT_UNI} = Unipolar mode worst-case output
D = Code loaded to DAC
V_{REF} = Reference voltage applied to part
V_{GE} = Gain error in volts
V_{ZSE} = Zero scale error in volts
INL = Integral nonlinearity in volts

BIPOLAR OUTPUT OPERATION

With the aid of an external operational amplifier, the DAC8832 may be configured to provide a bipolar voltage output. A typical circuit of such an operation is shown in Figure 45. The matched bipolar offset resistors R_{FB} and R_{INV} are connected to an external operational amplifier to achieve this bipolar output swing; typically, $R_{FB} = R_{INV} = 28\ k\Omega$.

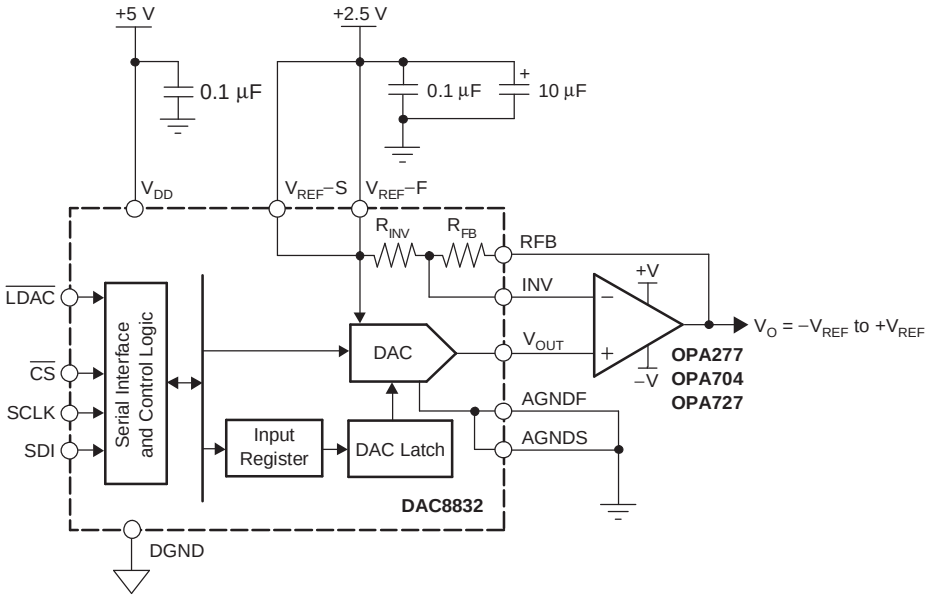


Figure 45. Bipolar Output Mode

Table 2 shows the transfer function for this output operating mode. The DAC8832 also provides a set of Kelvin connections to the analog ground and external reference inputs.

Table 2. Bipolar Code

DAC LATCH CONTENTS	
MSB LSB	ANALOG OUTPUT
1111 1111 1111 1111	$+V_{REF} \times (32{,}767/32{,}768)$
1000 0000 0000 0001	$+V_{REF} \times (1/32{,}768)$
1000 0000 0000 0000	0 V
0111 1111 1111 1111	$-V_{REF} \times (1/32{,}768)$
0000 0000 0000 0000	$-V_{REF} \times (32{,}768/32{,}768) = -V_{REF}$

Assuming a perfect reference, the worst-case output voltage may be calculated from the following equation:

Bipolar Mode Worst-Case Output:

$$V_{OUT\_BIP} = \frac{\left[\left(V_{OUT\_UNI} + V_{OS}\right)(2 + RD) - V_{REF}(1 + RD)\right]}{1 + \left(\frac{2 + RD}{A}\right)}$$

Where:

V_{OS} = External operational amplifier input offset voltage
RD = R_{FB} and R_{IN} resistor matching error
A = Operational amplifier open-loop gain

OUTPUT AMPLIFIER SELECTION

For bipolar mode, a precision amplifier should be used, supplied from a dual power supply. This provides the $\pm V_{REF}$ output.

In a single-supply application, selection of a suitable operational amplifier may be more difficult because the output swing of the amplifier does not usually include the negative rail; in this case, AGND. This output swing can result in some degradation of the specified performance unless the application does not use codes near 0.

The selected operational amplifier needs to have low-offset voltage (the DAC LSB is 38 µV with a 2.5 V reference), eliminating the need for output offset trims. Input bias current should also be low because the bias current multiplied by the DAC output impedance (approximately 6.25 kΩ) adds to the zero-code error.

Rail-to-rail input and output performance are required. For fast settling, the slew rate of the operational amplifier should not impede the settling time of the DAC. Output impedance of the DAC is constant and code-independent, but in order to minimize gain errors the input impedance of the output amplifier should be as high as possible. The amplifier should also have a 3 dB bandwidth of 1 MHz or greater. The amplifier adds another time constant to the system, thus increasing the settling time of the output. A higher 3 dB amplifier bandwidth results in a shorter effective settling time of the combined DAC and amplifier.

REFERENCE AND GROUND

Since the input impedance is code-dependent, the reference pin should be driven from a low impedance source. The DAC8832 operates with a voltage reference ranging from 1.25 V to V_{DD}. References below 1.25 V result in reduced accuracy.

The DAC full-scale output voltage is determined by the reference. Table 1 and Table 2 outline the analog output voltage for particular digital codes.

For optimum performance, Kelvin sense connections are provided. If the application does not require separate force and sense lines, they should be tied together close to the package to minimize voltage drops between the package leads and the internal die.

POWER SUPPLY AND REFERENCE BYPASSING

For accurate high-resolution performance, it is recommended that the reference and supply pins be bypassed with a 10 µF tantalum capacitor in parallel with a 0.1 µF ceramic capacitor.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/ Ball Finish	MSL Peak Temp (3)	Samples (Requires Login)
DAC8832IBRGYR	ACTIVE	VQFN	RGY	14	3000	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	
DAC8832IBRGYRG4	ACTIVE	VQFN	RGY	14	3000	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	
DAC8832IBRGYT	ACTIVE	VQFN	RGY	14	250	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	
DAC8832IBRGYTG4	ACTIVE	VQFN	RGY	14	250	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	
DAC8832ICRGYR	ACTIVE	VQFN	RGY	14	3000	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	
DAC8832ICRGYRG4	ACTIVE	VQFN	RGY	14	3000	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	
DAC8832ICRGYT	ACTIVE	VQFN	RGY	14	250	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	
DAC8832ICRGYTG4	ACTIVE	VQFN	RGY	14	250	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	
DAC8832IRGYR	ACTIVE	VQFN	RGY	14	3000	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	
DAC8832IRGYRG4	ACTIVE	VQFN	RGY	14	3000	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	
DAC8832IRGYT	ACTIVE	VQFN	RGY	14	250	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	
DAC8832IRGYTG4	ACTIVE	VQFN	RGY	14	250	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	

(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.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
DAC8832IBRGYT	Active	Production	VQFN (RGY) | 14	250 | SMALL T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	BQW
DAC8832IBRGYT.A	Active	Production	VQFN (RGY) | 14	250 | SMALL T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	BQW
DAC8832ICRGYR	Active	Production	VQFN (RGY) | 14	3000 | LARGE T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	BQW
DAC8832ICRGYR.A	Active	Production	VQFN (RGY) | 14	3000 | LARGE T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	BQW
DAC8832ICRGYT	Active	Production	VQFN (RGY) | 14	250 | SMALL T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	BQW
DAC8832ICRGYT.A	Active	Production	VQFN (RGY) | 14	250 | SMALL T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	BQW
DAC8832IRGYR	Active	Production	VQFN (RGY) | 14	3000 | LARGE T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	BQW
DAC8832IRGYR.A	Active	Production	VQFN (RGY) | 14	3000 | LARGE T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	BQW
DAC8832IRGYRG4	Active	Production	VQFN (RGY) | 14	3000 | LARGE T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	BQW
DAC8832IRGYT	Active	Production	VQFN (RGY) | 14	250 | SMALL T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	BQW
DAC8832IRGYT.A	Active	Production	VQFN (RGY) | 14	250 | SMALL T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	BQW

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

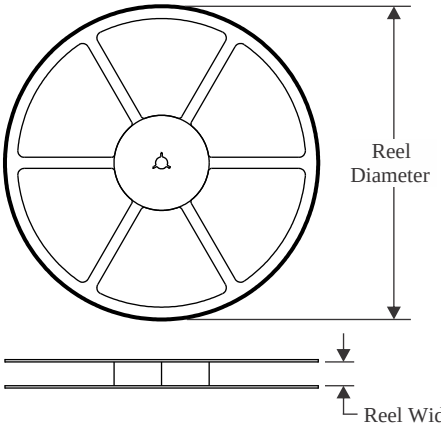
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

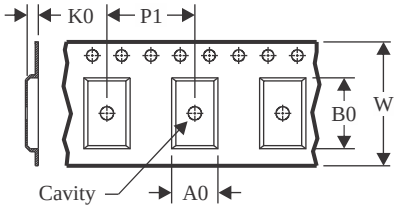
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

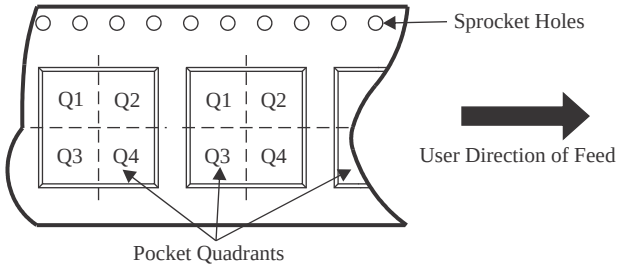


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

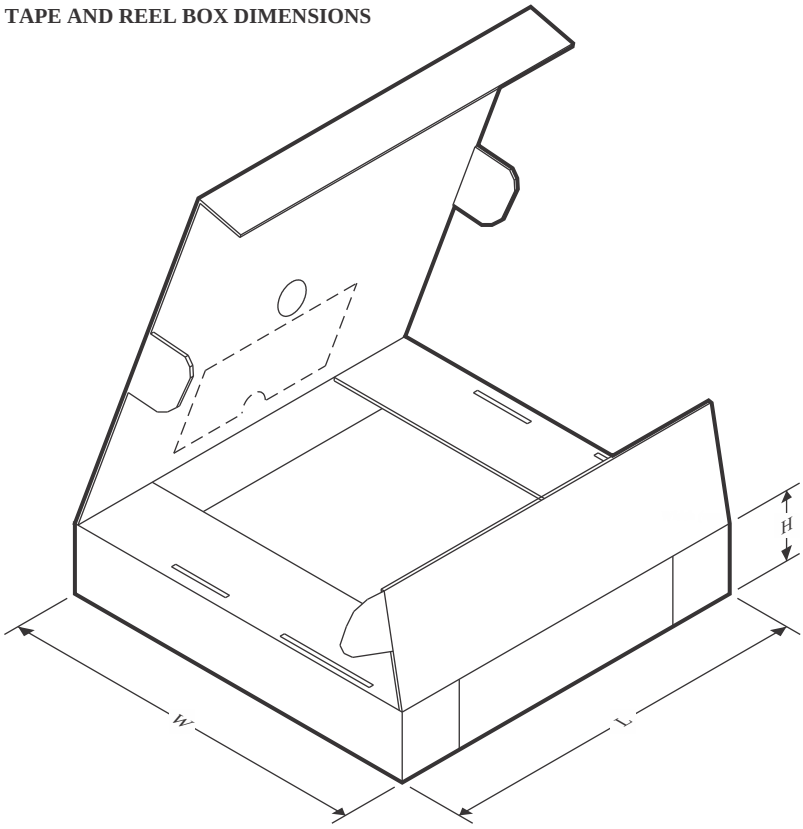
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
DAC8832IBRGYT	VQFN	RGY	14	250	180.0	12.4	3.85	3.85	1.35	8.0	12.0	Q1
DAC8832ICRGYR	VQFN	RGY	14	3000	330.0	12.4	3.85	3.85	1.35	8.0	12.0	Q1
DAC8832ICRGYT	VQFN	RGY	14	250	180.0	12.4	3.85	3.85	1.35	8.0	12.0	Q1
DAC8832IRGYR	VQFN	RGY	14	3000	330.0	12.4	3.85	3.85	1.35	8.0	12.0	Q1
DAC8832IRGYT	VQFN	RGY	14	250	180.0	12.4	3.85	3.85	1.35	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DAC8832IBRGYT	VQFN	RGY	14	250	210.0	185.0	35.0
DAC8832ICRGYR	VQFN	RGY	14	3000	350.0	350.0	43.0
DAC8832ICRGYT	VQFN	RGY	14	250	210.0	185.0	35.0
DAC8832IRGYR	VQFN	RGY	14	3000	350.0	350.0	43.0
DAC8832IRGYT	VQFN	RGY	14	250	210.0	185.0	35.0

GENERIC PACKAGE VIEW

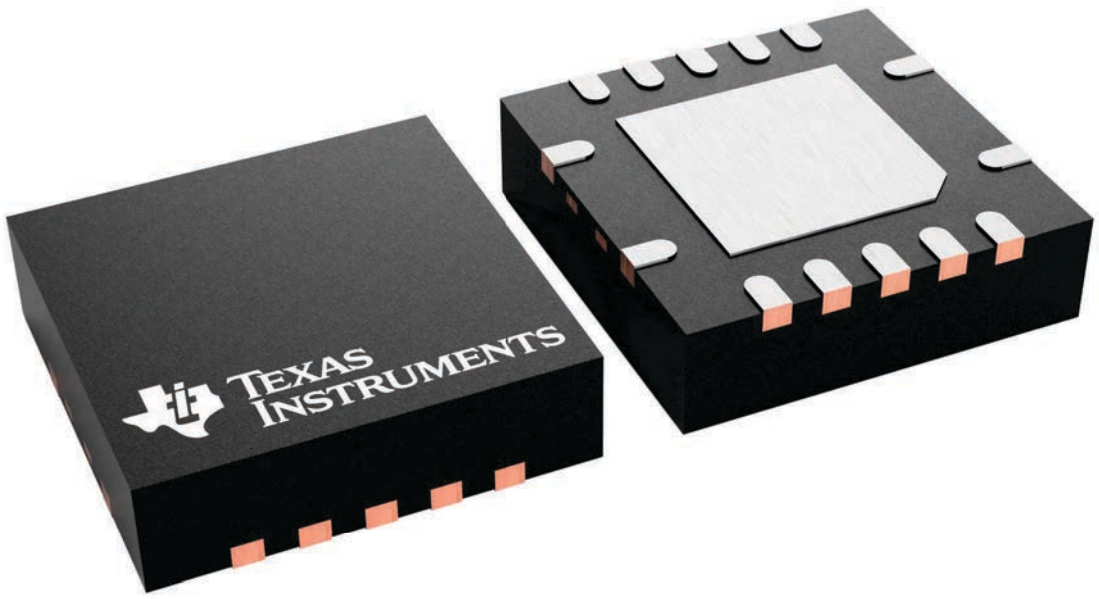
RGY 14

VQFN - 1 mm max height

3.5 x 3.5, 0.5 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



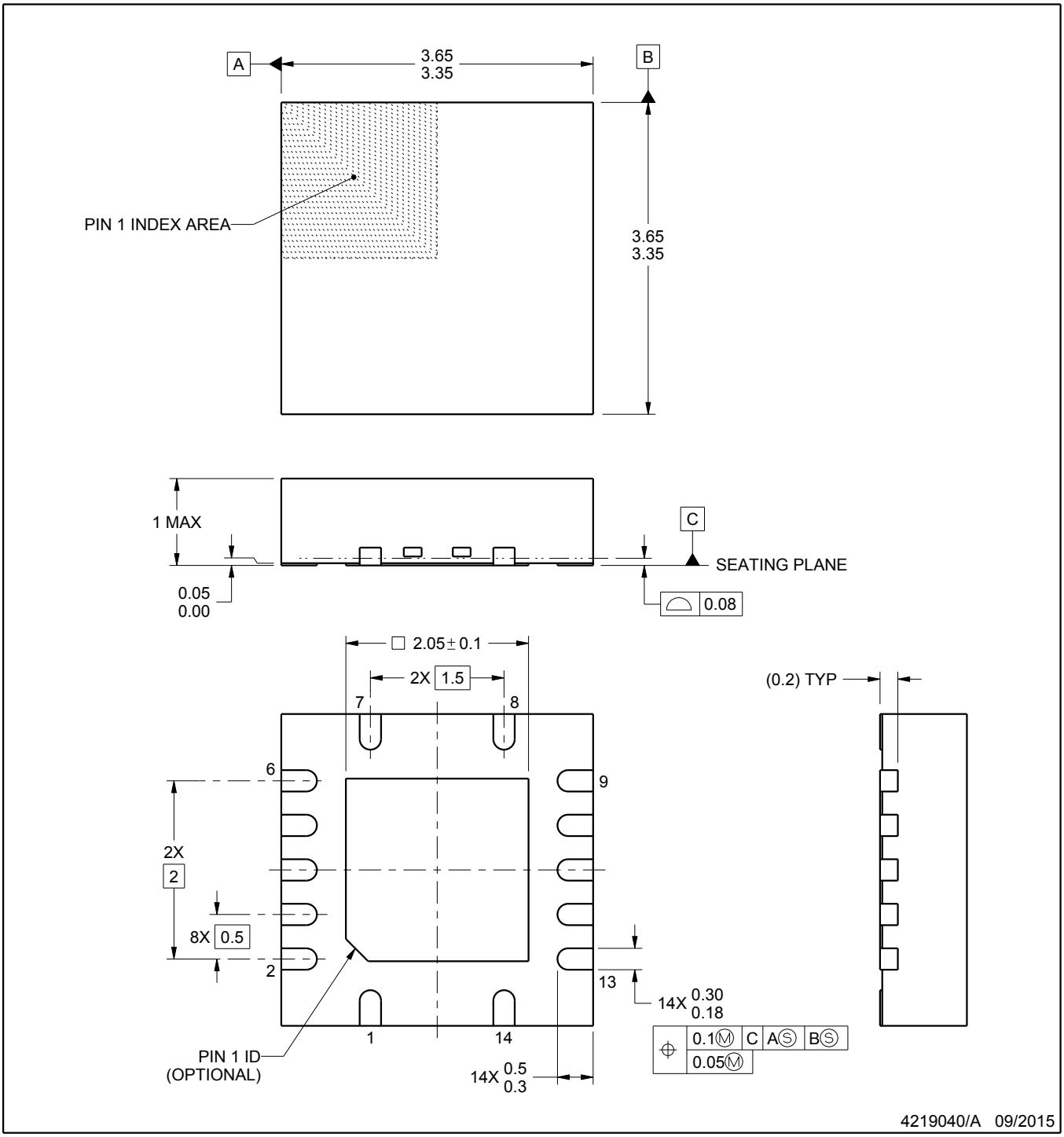
4231541/A

PACKAGE OUTLINE

RGY0014A

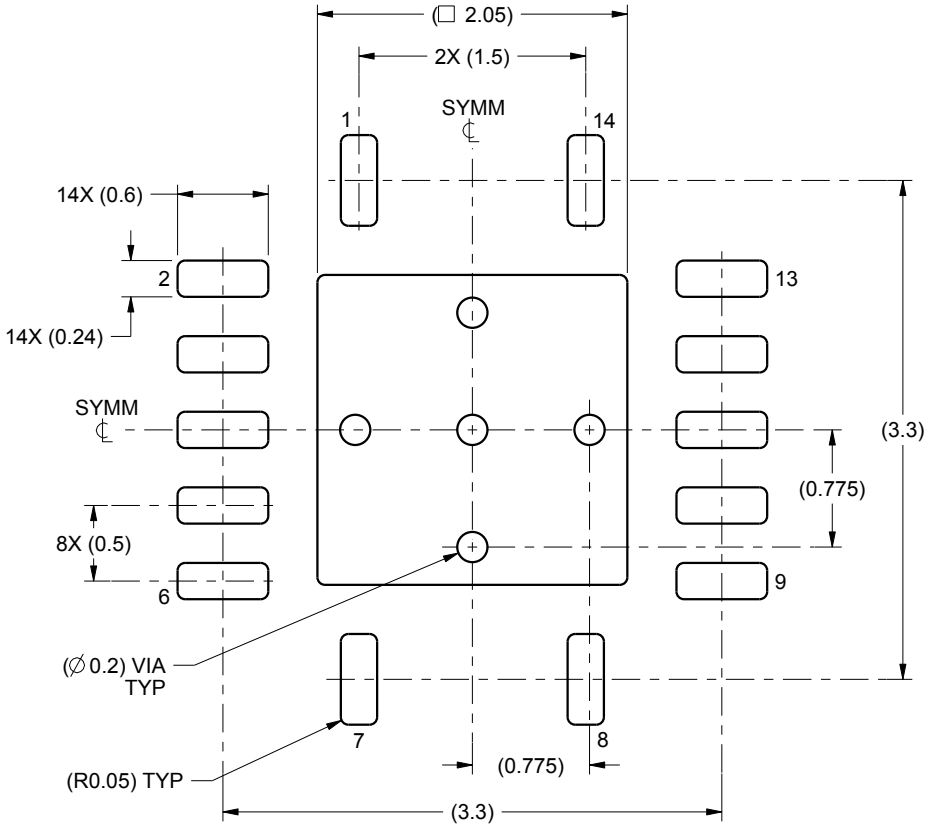
VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

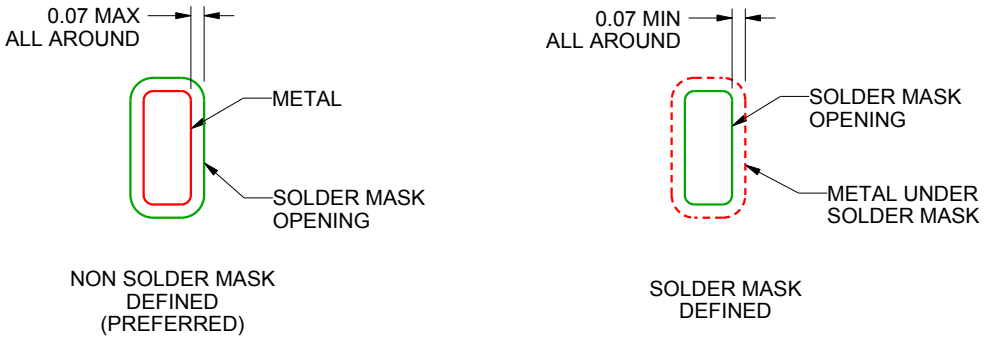


NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.



LAND PATTERN EXAMPLE
SCALE:20X

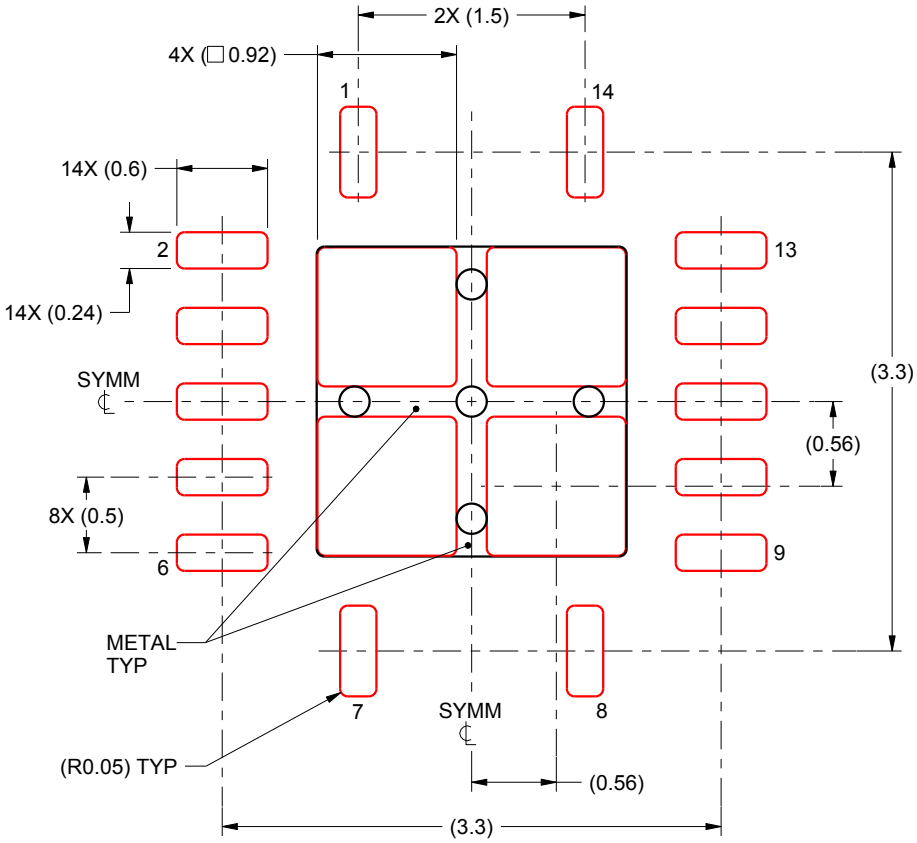


SOLDER MASK DETAILS

4219040/A 09/2015

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD
80% PRINTED SOLDER COVERAGE BY AREA
SCALE:20X

4219040/A 09/2015

NOTES: (continued)

5. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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