BURR - BROWN®

DAC7644

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16-Bit, Quad Voltage Output DIGITAL-TO-ANALOG CONVERTER

FEATURES

- LOW POWER: 10mW
- UNIPOLAR OR BIPOLAR OPERATION
- SETTLING TIME: 10μs to 0.003%
- 15-BIT LINEARITY AND MONOTONICITY: –40°C to +85°C
- PROGRAMMABLE RESET TO MID-SCALE OR ZERO-SCALE
- DATA READBACK
- DOUBLE-BUFFERED DATA INPUTS

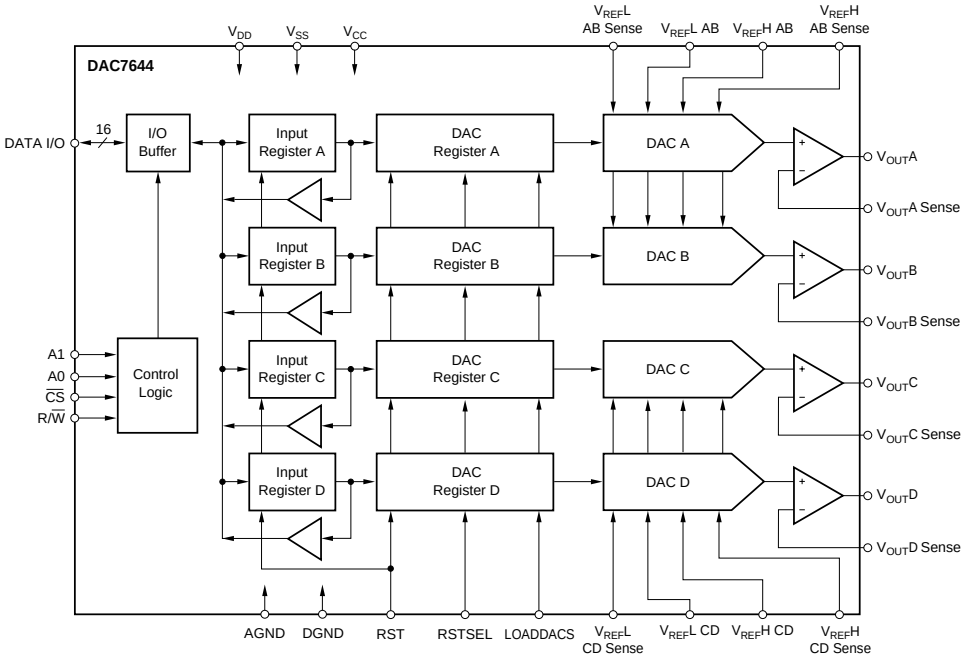
APPLICATIONS

- PROCESS CONTROL
- CLOSED-LOOP SERVO-CONTROL
- MOTOR CONTROL
- DATA ACQUISITION SYSTEMS
- DAC-PER-PIN PROGRAMMERS

DESCRIPTION

The DAC7644 is a 16-bit, quad voltage output digital-to-analog converter with guaranteed 15-bit monotonic performance over the specified temperature range. It accepts 16-bit parallel input data, has double-buffered DAC input logic (allowing simultaneous update of all DACs), and provides a readback mode of the internal input registers. Programmable asynchronous reset clears all registers to a mid-scale code of 8000_H or to a zero-scale of 0000_H. The DAC7644 can operate from a single +5V supply or from +5V and –5V supplies.

Low power and small size per DAC make the DAC7644 ideal for automatic test equipment, DAC-per-pin programmers, data acquisition systems, and closed-loop servo-control. The DAC7644 is available in a 48-lead SSOP package and offers guaranteed specifications over the –40°C to +85°C temperature range.



International Airport Industrial Park • Mailing Address: PO Box 11400, Tucson, AZ 85734 • Street Address: 6730 S. Tucson Blvd., Tucson, AZ 85706 • Tel: (520) 746-1111
Twx: 910-952-1111 • Internet: http://www.burr-brown.com/ • Cable: BBRCORP • Telex: 066-6491 • FAX: (520) 889-1510 • Immediate Product Info: (800) 548-6132

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SPECIFICATIONS (Dual Supply)

At $T_A = T_{MIN}$ to T_{MAX}, $V_{DD} = V_{CC} = +5V$, $V_{SS} = -5V$, $V_{REF}H = +2.5V$, and $V_{REF}L = -2.5V$, unless otherwise noted.

PARAMETER	CONDITIONS	DAC7644E			DAC7644EB			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
ACCURACY								
Linearity Error			±3	±4		±2	±3	LSB
Linearity Match			±4			±2		LSB
Differential Linearity Error			±2	±3		±1	±2	LSB
Monotonicity, T_{MIN} to T_{MAX}		14			15			Bits
Bipolar Zero Error			±1	±2		*	*	mV
Bipolar Zero Error Drift			5	10		*	*	ppm/°C
Full-Scale Error			±1	±2		*	*	mV
Full-Scale Error Drift			5	10		*	*	ppm/°C
Bipolar Zero Matching	Channel-to-Channel Matching		±1	±2		±1	±2	mV
Full Scale Matching	Channel-to-Channel Matching		±1	±2		±1	±2	mV
Power Supply Rejection Ratio (PSRR)	At Full Scale		10	100		*	*	ppm/V
ANALOG OUTPUT								
Voltage Output	$V_{REF} = -2.5V$, $R_L = 10k\Omega$, $V_{SS} = -5V$	$V_{REF}L$		$V_{REF}H$	*		*	V
Output Current		–1.25		+1.25	*		*	mA
Maximum Load Capacitance	No Oscillation		500			*		pF
Short-Circuit Current			–10, +30			*		mA
Short-Circuit Duration	GND or V_{CC} or V_{SS}		Indefinite			*		
REFERENCE INPUT								
Ref High Input Voltage Range		$V_{REF}L + 1.25$		+2.5	*		*	V
Ref Low Input Voltage Range		–2.5		$V_{REF}H - 1.25$	*		*	V
Ref High Input Current			500			*		µA
Ref Low Input Current			–500			*		µA
DYNAMIC PERFORMANCE								
Settling Time	To ±0.003%, 5V Output Step		8	10		*	*	µs
Channel-to-Channel Crosstalk	See Figure 5.		0.5			*		LSB
Digital Feedthrough			2			*		nV-s
Output Noise Voltage	f = 10kHz		60			*		$nV/\sqrt{Hz}$
DAC Glitch	$7FFF_H$ to 8000_H or 8000_H to $7FFF_H$		40			*		nV-s
DIGITAL INPUT								
V_{IH}		0.7 • V_{DD}			*			V
V_{IL}				0.3 • V_{DD}			*	V
I_{IH}				±10			*	µA
I_{IL}				±10			*	µA
DIGITAL OUTPUT								
V_{OH}	$I_{OH} = -0.8mA$	3.6	4.5		*	*		V
V_{OL}	$I_{OL} = 1.2mA$		0.3	0.4		*	*	V
POWER SUPPLY								
V_{DD}		+4.75	+5.0	+5.25	*	*	*	V
V_{CC}		+4.75	+5.0	+5.25	*	*	*	V
V_{SS}		–5.25	–5.0	–4.75	*	*	*	V
I_{CC}			1.5	2		*	*	mA
I_{DD}			50			*		µA
I_{SS}		–2.3	–1.5		*	*		mA
Power			15	20		*	*	mW
TEMPERATURE RANGE								
Specified Performance		–40		+85	*		*	°C

* Specifications same as DAC7644E.

SPECIFICATIONS (Single Supply)

At $T_A = T_{MIN}$ to T_{MAX}, $V_{DD} = V_{CC} = +5V$, $V_{SS} = 0V$, $V_{REF}H = +2.5V$, and $V_{REF}L = 0V$, unless otherwise noted.

PARAMETER	CONDITIONS	DAC7644E			DAC7644EB			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
ACCURACY								
Linearity Error(1)			±3	±4		±2	±3	LSB
Linearity Match			±4			±2		LSB
Differential Linearity Error			±2	±3		±1	±2	LSB
Monotonicity, T_{MIN} to T_{MAX}		14			15			Bits
Zero Scale Error			±1	±2		✻	✻	mV
Zero Scale Error Drift			5	10		✻	✻	ppm/°C
Full-Scale Error			±1	±2		✻	✻	mV
Full-Scale Error Drift			5	10		✻	✻	ppm/°C
Zero Scale Matching	Channel-to-Channel Matching		±1	±2		±1	±2	mV
Full-Scale Matching	Channel-to-Channel Matching		±1	±2		±1	±2	mV
Power Supply Rejection Ratio (PSRR)	At Full Scale		10	100		✻	✻	ppm/V
ANALOG OUTPUT								
Voltage Output	$V_{REF}L = 0V$, $V_{SS} = 0V$, $R_L = 10k\Omega$	0		$V_{REF}H$	✻		✻	V
Output Current		–1.25		+1.25	✻		✻	mA
Maximum Load Capacitance	No Oscillation		500			✻		pF
Short-Circuit Current			±30			✻		mA
Short-Circuit Duration	GND or V_{CC}		Indefinite			✻		
REFERENCE INPUT								
Ref High Input Voltage Range		$V_{REF}L + 1.25$		+2.5	✻		✻	V
Ref Low Input Voltage Range		0		$V_{REF}H - 1.25$	✻		✻	V
Ref High Input Current			250			✻		µA
Ref Low Input Current			–250			✻		µA
DYNAMIC PERFORMANCE								
Settling Time	To ±0.003%, 2.5V Output Step		8	10		✻	✻	µs
Channel-to-Channel Crosstalk	See Figure 6.		0.5			✻		LSB
Digital Feedthrough			2			✻		nV-s
Output Noise Voltage, f = 10kHz			60			✻		$nV/\sqrt{Hz}$
DAC Glitch	$7FFF_H$ to 8000_H or 8000_H to $7FFF_H$		40			✻		nV-s
DIGITAL INPUT								
V_{IH}		0.7 • V_{DD}			✻			V
V_{IL}				0.3 • V_{DD}			✻	V
I_{IH}				±10			✻	µA
I_{IL}				±10			✻	µA
DIGITAL OUTPUT								
V_{OH}	$I_{OH} = –0.8mA$	3.6	4.5		✻	✻		V
V_{OL}	$I_{OL} = 1.2mA$		0.3	0.4		✻	✻	V
POWER SUPPLY								
V_{DD}		+4.75	+5.0	+5.25	✻	✻	✻	V
V_{CC}		+4.75	+5.0	+5.25	✻	✻	✻	V
V_{SS}		0	0	0	✻	✻	✻	V
I_{CC}			1.5	2		✻	✻	mA
I_{DD}			50			✻		µA
Power			7.5	10		✻	✻	mW
TEMPERATURE RANGE								
Specified Performance		–40		+85	✻		✻	°C

NOTE: (1) If $V_{SS} = 0V$ specification applies at Code 0040_H and above due to possible negative zero-scale error.

✻ Specifications same as DAC7644E.

ABSOLUTE MAXIMUM RATINGS[1]

V_{CC} and V_{DD} to V_{SS}	–0.3V to 11V
V_{CC} and V_{DD} to GND	–0.3V to 5.5V
$V_{REF}L$ to V_{SS}	–0.3V to (V_{CC} – V_{SS})
V_{CC} to $V_{REF}H$	–0.3V to (V_{CC} – V_{SS})
$V_{REF}H$ to $V_{REF}L$	–0.3V to (V_{CC} – V_{SS})
Digital Input Voltage to GND	–0.3V to V_{DD} + 0.3V
Digital Output Voltage to GND	–0.3V to V_{DD} + 0.3V
Maximum Junction Temperature	+150°C
Operating Temperature Range	–40°C to +85°C
Storage Temperature Range	–65°C to +125°C
Lead Temperature (soldering, 10s)	+300°C

NOTE: (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.

ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Burr-Brown 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.

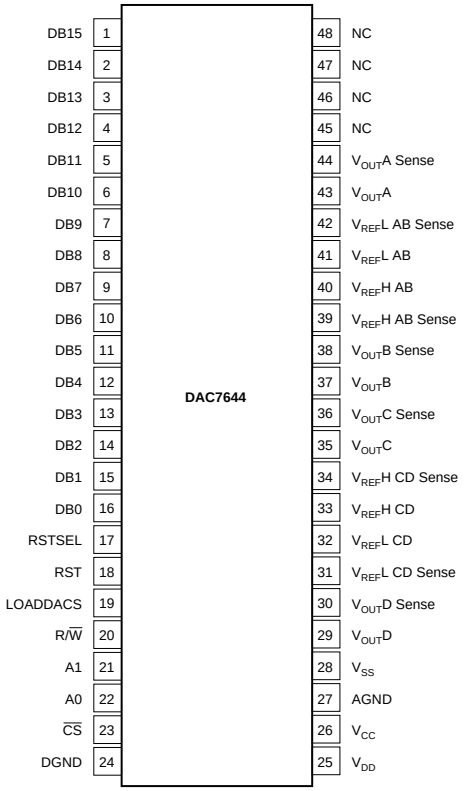
PACKAGE/ORDERING INFORMATION

PRODUCT	LINEARITY ERROR (LSB)	DIFFERENTIAL NONLINEARITY (LSB)	PACKAGE	PACKAGE DRAWING NUMBER[1]	SPECIFICATION TEMPERATURE RANGE	ORDERING NUMBER[2]	TRANSPORT MEDIA
DAC7644E	±4	±3	48-Lead SSOP	333	–40°C to +85°C	DAC7644E	Rails
"	"	"	"	"	"	DAC7644E/1K	Tape and Reel
DAC7644EB	±3	±2	48-Lead SSOP	333	–40°C to +85°C	DAC7644EB	Rails
"	"	"	"	"	"	DAC7644EB/1K	Tape and Reel

NOTES: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book. (2) Models with a slash (/) are available only in Tape and Reel in the quantities indicated (e.g., /1K indicates 1000 devices per reel). Ordering 1000 pieces of "DAC7644/1K" will get a single 1000-piece Tape and Reel. For detailed Tape and Reel mechanical information, refer to Appendix B of Burr-Brown IC Data Book.

PIN CONFIGURATION

Top View **SSOP**



PIN DESCRIPTIONS

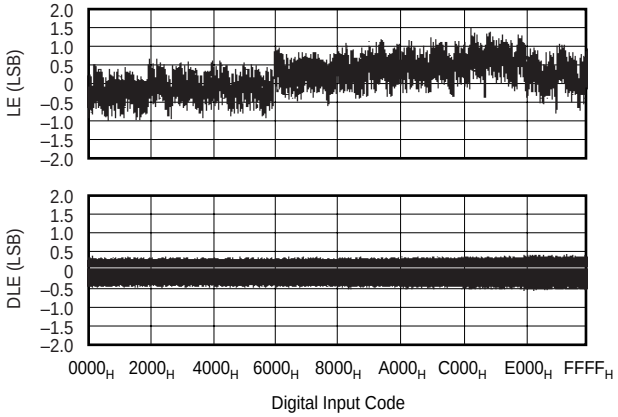
PIN	NAME	DESCRIPTION	PIN	NAME	DESCRIPTION
1	DB15	Data Bit 15, MSB	23	$\overline{CS}$	Chip Select. Active LOW.
2	DB14	Data Bit 14	24	DGND	Digital Ground
3	DB13	Data Bit 13	25	V_{DD}	Positive Power Supply (digital)
4	DB12	Data Bit 12	26	V_{CC}	Positive Power Supply (analog)
5	DB11	Data Bit 11	27	AGND	Analog Ground
6	DB10	Data Bit 10	28	V_{SS}	Negative Power Supply
7	DB9	Data Bit 9	29	$V_{OUT}D$	DAC D Voltage Output
8	DB8	Data Bit 8	30	$V_{OUT}D$ Sense	DAC D's Output Amplifier Inverting Input. Used to close the feedback loop at the load.
9	DB7	Data Bit 7			
10	DB6	Data Bit 6	31	$V_{REF}L$ CD Sense	DAC C and D Reference Low Sense Input
11	DB5	Data Bit 5	32	$V_{REF}L$ CD	DAC C and D Reference Low Input
12	DB4	Data Bit 4	33	$V_{REF}H$ CD	DAC C and D Reference High Input
13	DB3	Data Bit 3	34	$V_{REF}H$ CD Sense	DAC C and D Reference High Sense Input
14	DB2	Data Bit 2	35	$V_{OUT}C$	DAC C Voltage Output
15	DB1	Data Bit 1	36	$V_{OUT}C$ Sense	DAC C's Output Amplifier Inverting Input. Used to close the feedback loop at the load.
16	DB0	Data Bit 0, LSB			
17	RSTSEL	Reset Select. Determines the action of RST. If HIGH, a RST command will set the DAC registers to mid-scale. If LOW, a RST command will set the DAC registers to zero.	37	$V_{OUT}B$	DAC B Voltage Output
			38	$V_{OUT}B$ Sense	DAC B's Output Amplifier Inverting Input. Used to close the feedback loop at the load.
			39	$V_{REF}H$ AB Sense	DAC A and B Reference High Sense Input
18	RST	Reset, Rising Edge Triggered. Depending on the state of RSTSEL, the DAC registers are set to either mid-scale or zero.	40	$V_{REF}H$ AB	DAC A and B Reference High Input
			41	$V_{REF}L$ AB	DAC A and B Reference Low Input
			42	$V_{REF}L$ AB Sense	DAC A and B Reference Low Sense Input
19	LOADDACS	DAC Output Registers Load Control. Rising edge triggered.	43	$V_{OUT}A$	DAC A Voltage Input
20	R/$\overline{W}$	Enabled by the $\overline{CS}$, Controls Data Read and Write from the Input Registers.	44	$V_{OUT}A$ Sense	DAC A's Output Amplifier Inverting Input. Used to close the feedback loop at the load.
21	A1	Enabled by the $\overline{CS}$, in Combination With A0 Selects the Individual DAC Input Registers.	45	NC	No Connection
			46	NC	No Connection
22	A0	Enabled by the $\overline{CS}$, in Combination With A1 Selects the Individual DAC Input Registers.	47	NC	No Connection
			48	NC	No Connection

TYPICAL PERFORMANCE CURVES: V_{SS} = 0V

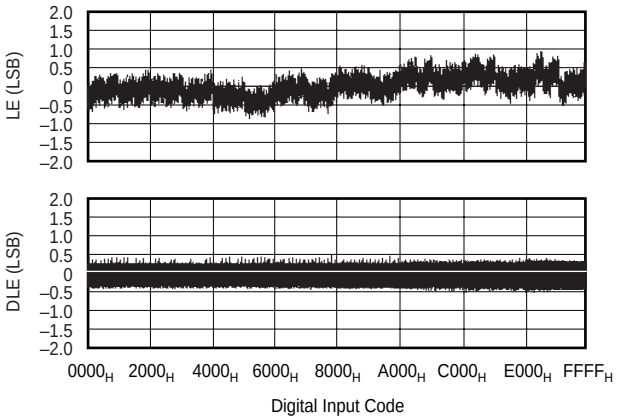
At T_A = +25°C, V_{DD} = V_{CC} = +5V, V_{SS} = 0V, V_{REFH} = +2.5V, V_{REFL} = 0V, representative unit, unless otherwise specified.

+25°C

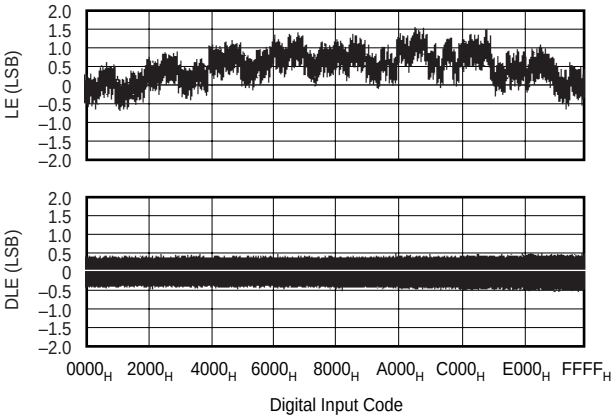
LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC A, +25°C)



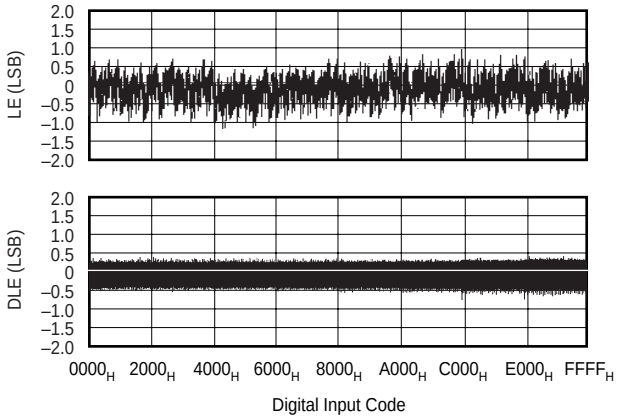
LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC B, +25°C)



LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC C, +25°C)

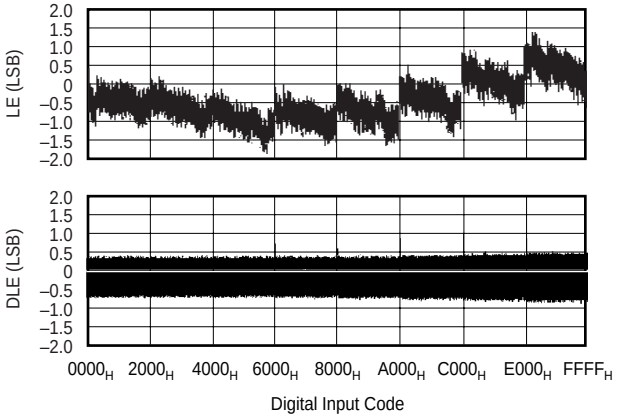


LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC D, +25°C)

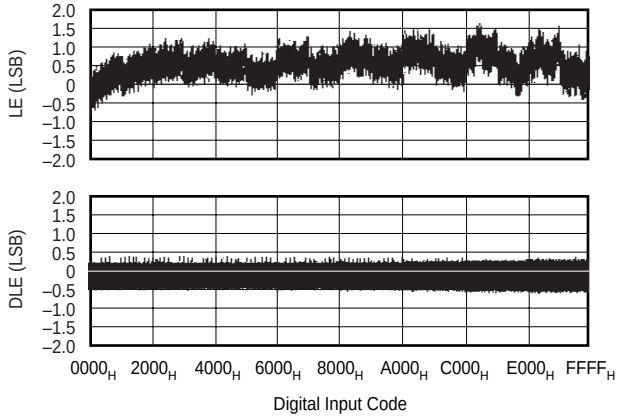


+85°C

LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC B, +85°C)



LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC B, +85°C)

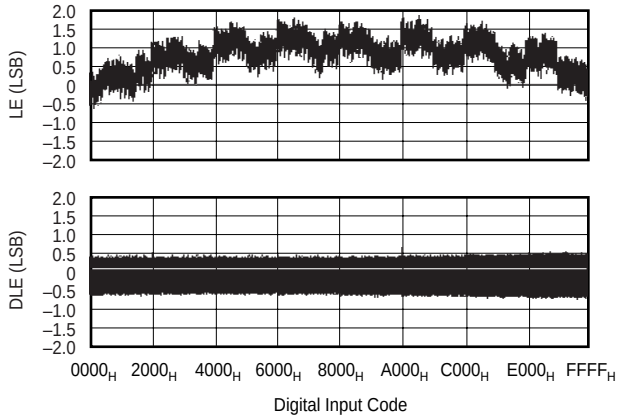


TYPICAL PERFORMANCE CURVES: V_{SS} = 0V (CONT)

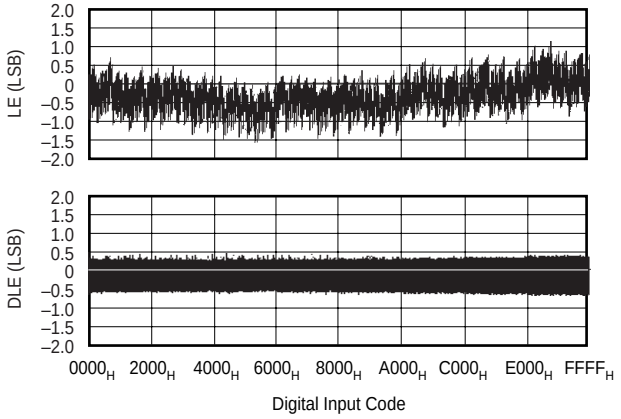
At T_A = +25°C, V_{DD} = V_{CC} = +5V, V_{SS} = 0V, V_{REFH} = +2.5V, V_{REFL} = 0V, representative unit, unless otherwise specified.

+85°C (cont)

LINEARITY ERROR AND DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC C, +85°C)

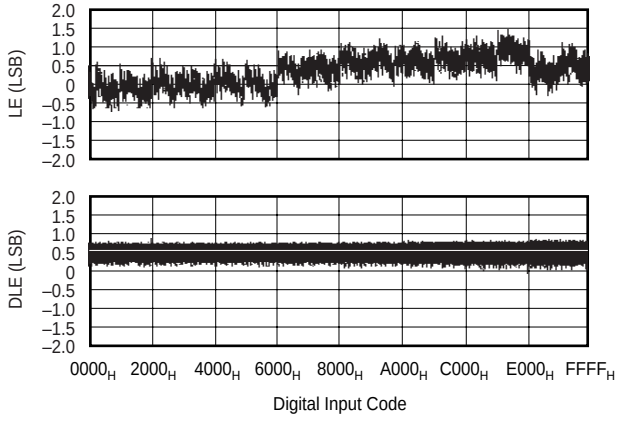


LINEARITY ERROR AND DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC D, +85°C)

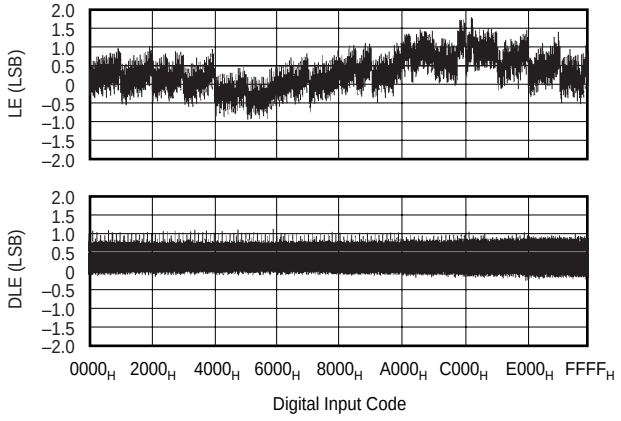


–40°C

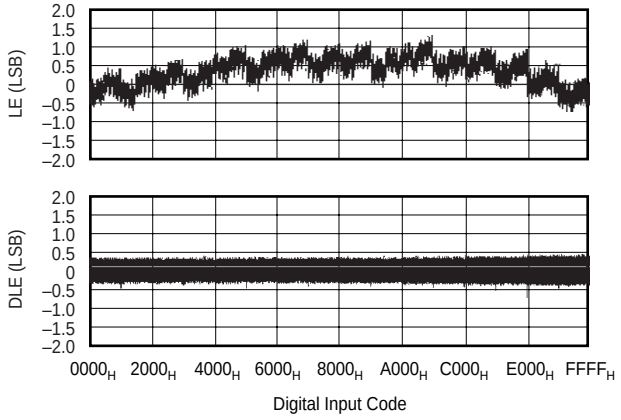
LINEARITY ERROR AND DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC A, –40°C)



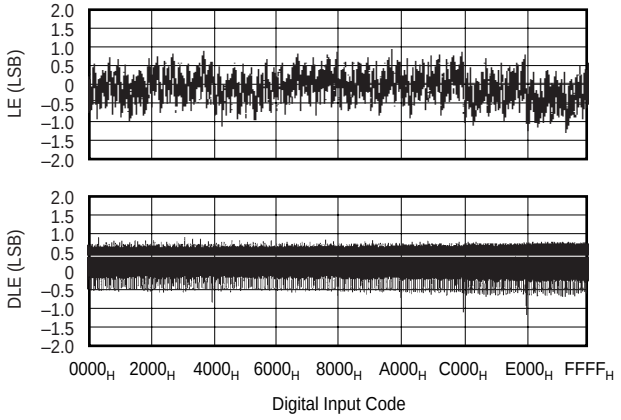
LINEARITY ERROR AND DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC B, –40°C)



LINEARITY ERROR AND DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC C, –40°C)



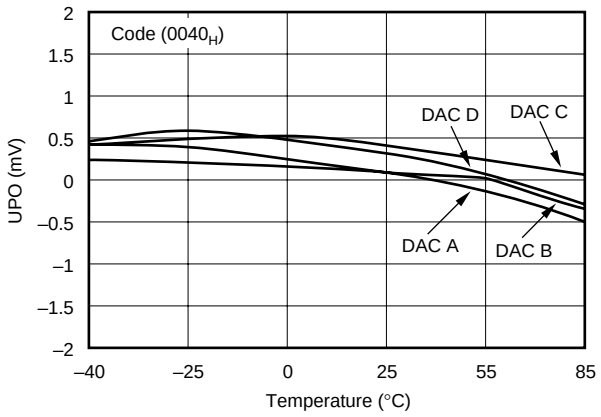
LINEARITY ERROR AND DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC D, –40°C)



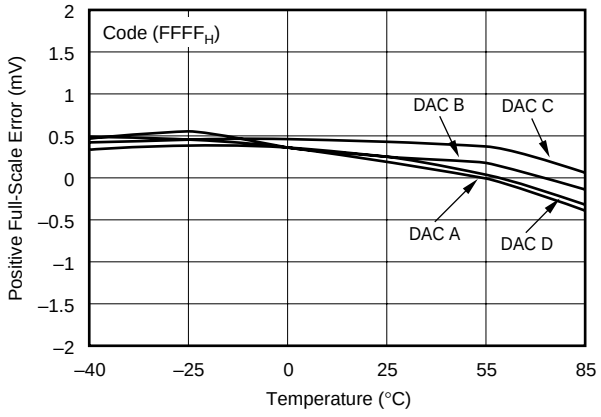
TYPICAL PERFORMANCE CURVES: V_{SS} = 0V (CONT)

At T_A = +25°C, V_{DD} = V_{CC} = +5V, V_{SS} = 0V, V_{REFH} = +2.5V, V_{REFL} = 0V, representative unit, unless otherwise specified.

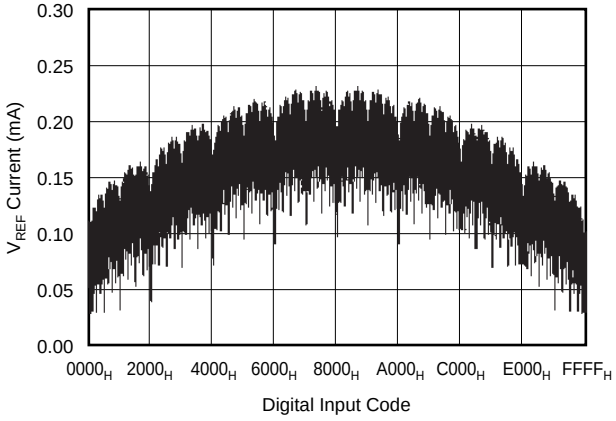
ZERO-SCALE ERROR vs TEMPERATURE



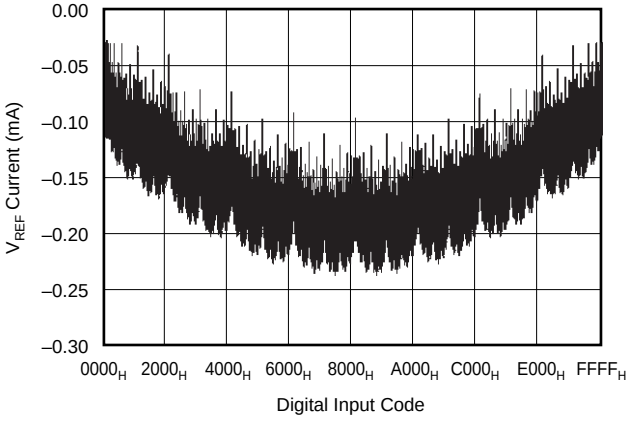
FULL-SCALE ERROR vs TEMPERATURE



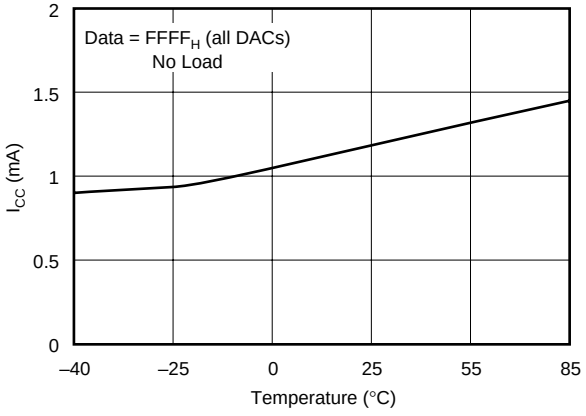
V_{REFH} CURRENT vs CODE
(all DACs sent to indicated code)



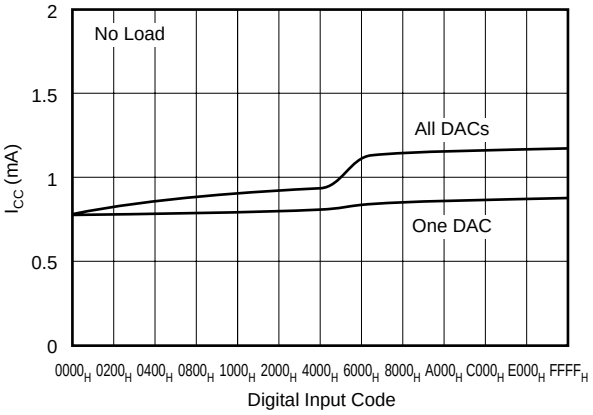
V_{REFL} CURRENT vs CODE
(all DACs sent to indicated code)



POSITIVE SUPPLY CURRENT vs TEMPERATURE



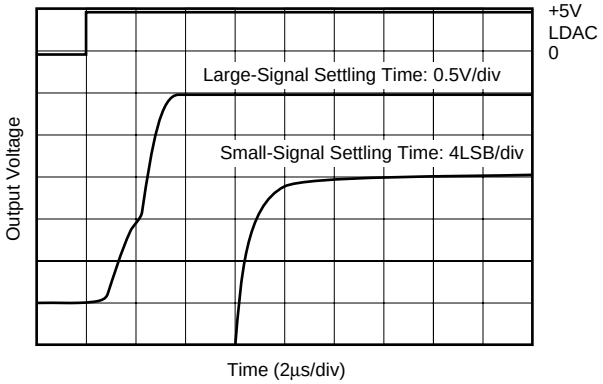
POSITIVE SUPPLY CURRENT
vs DIGITAL INPUT CODE



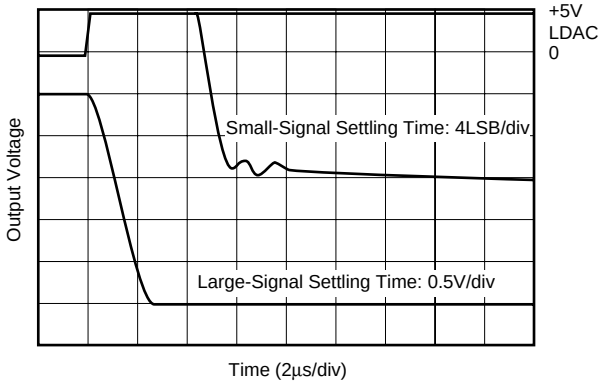
TYPICAL PERFORMANCE CURVES: V_{SS} = 0V (CONT)

At T_A = +25°C, V_{DD} = V_{CC} = +5V, V_{SS} = 0V, V_{REFH} = +2.5V, V_{REFL} = 0V, representative unit, unless otherwise specified.

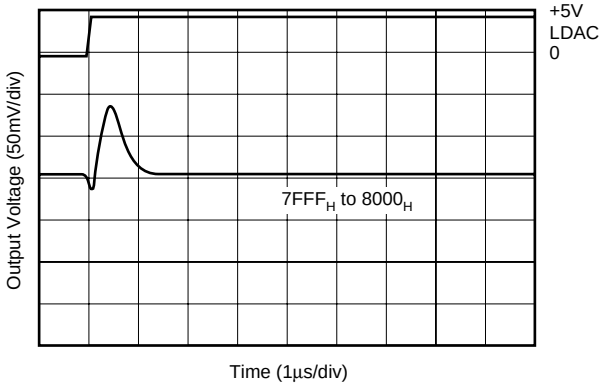
OUTPUT VOLTAGE vs SETTLING TIME
(0V to +2.5V)



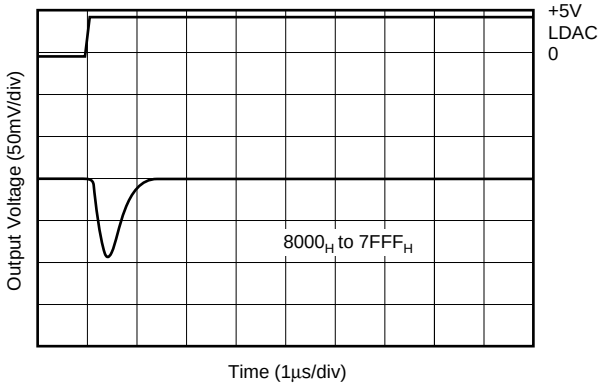
OUTPUT VOLTAGE vs SETTLING TIME
(+2.5V to 2mV)



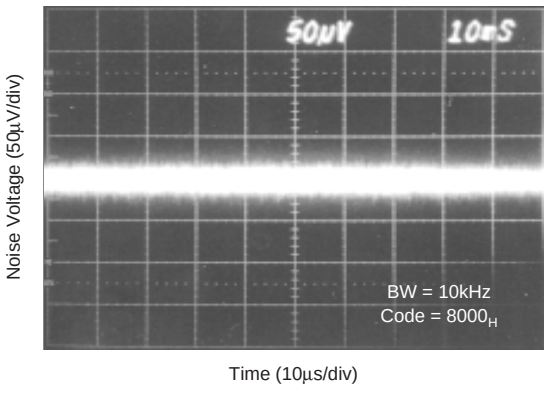
OUTPUT VOLTAGE
vs MIDSCALE GLITCH PERFORMANCE



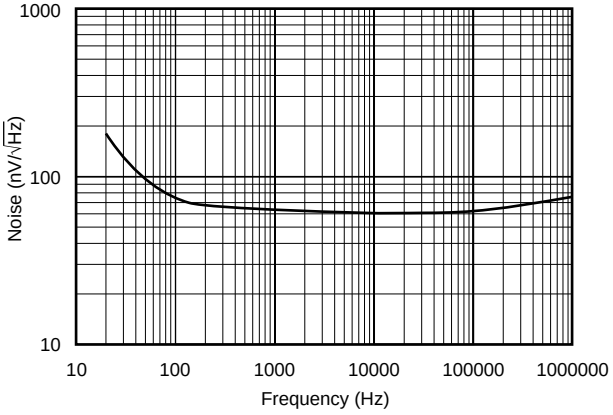
OUTPUT VOLTAGE
vs MIDSCALE GLITCH PERFORMANCE



BROADBAND NOISE



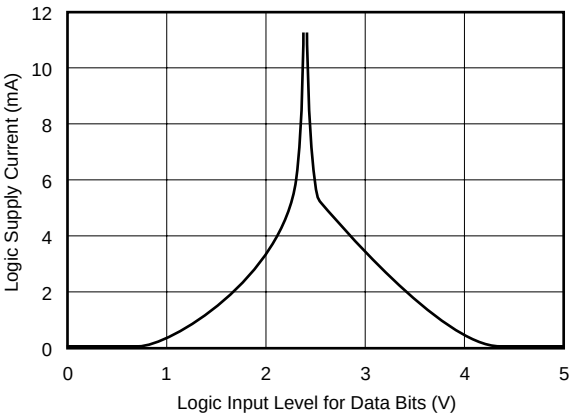
OUTPUT NOISE VOLTAGE vs FREQUENCY



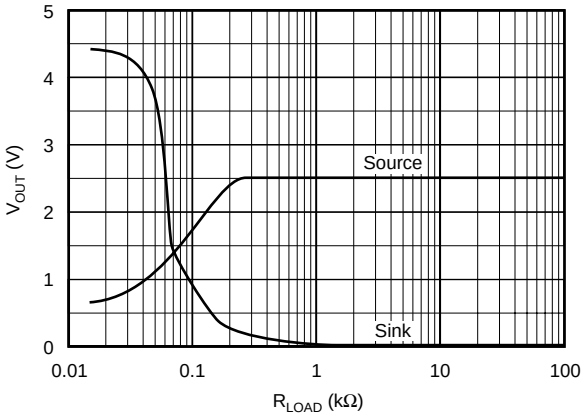
TYPICAL PERFORMANCE CURVES: V_{SS} = 0V (CONT)

At T_A = +25°C, V_{DD} = V_{CC} = +5V, V_{SS} = 0V, V_{REFH} = +2.5V, V_{REFL} = 0V, representative unit, unless otherwise specified.

LOGIC SUPPLY CURRENT
vs LOGIC INPUT LEVEL FOR DATA BITS



V_{OUT} vs R_{LOAD}

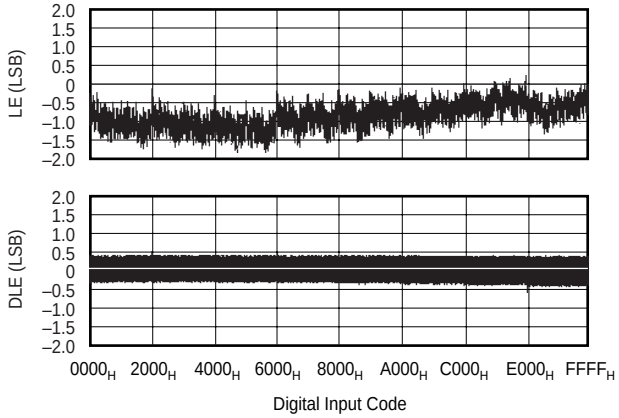


TYPICAL PERFORMANCE CURVES: V_{SS} = –5V

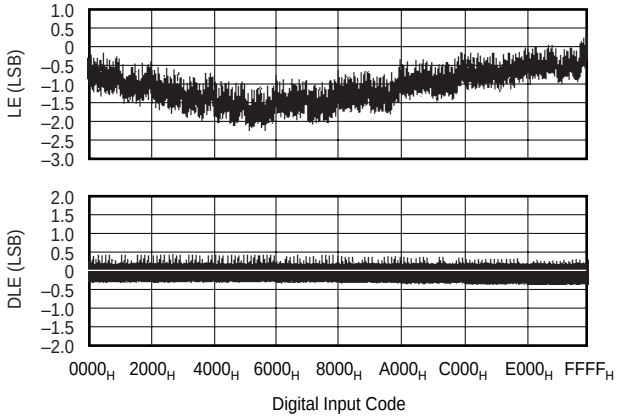
At T_A = +25°C, V_{DD} = V_{CC} = +5V, V_{SS} = –5V, V_{REFH} = +2.5V, V_{REFL} = –2.5V, representative unit, unless otherwise specified.

+25°C

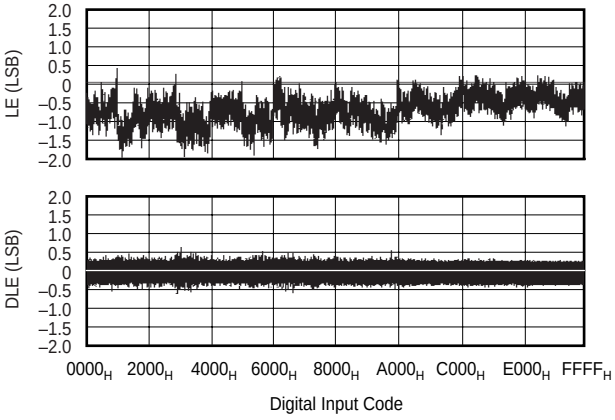
LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC A, +25°C)



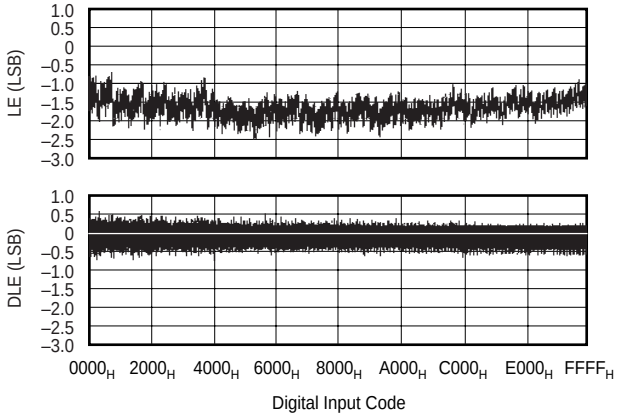
LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC B, +25°C)



LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC C, +25°C)

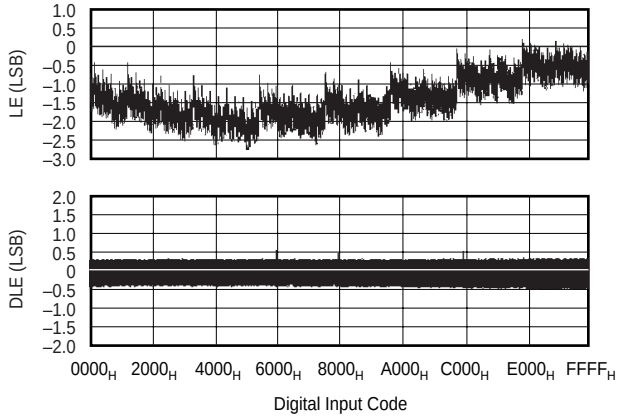


LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC D, +25°C)

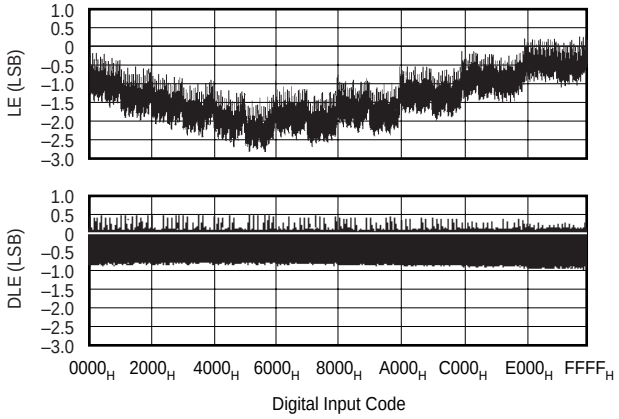


+85°C

LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC A, +85°C)



LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC B, +85°C)

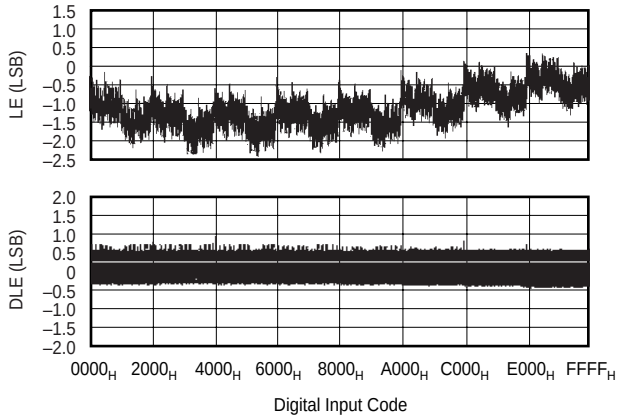


TYPICAL PERFORMANCE CURVES: V_{SS} = –5V (CONT)

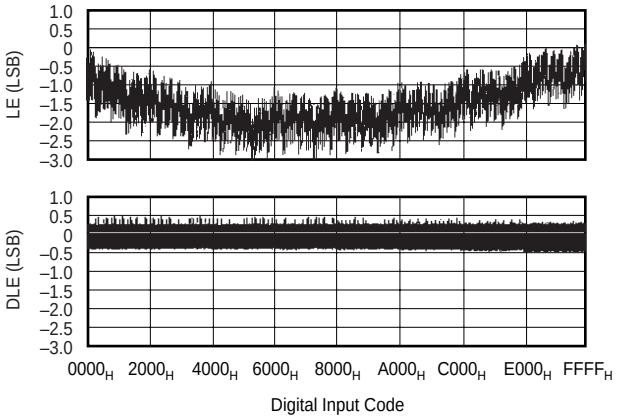
At T_A = +25°C, V_{DD} = V_{CC} = +5V, V_{SS} = –5V, V_{REFH} = +2.5V, V_{REFL} = –2.5V, representative unit, unless otherwise specified.

+85°C (cont)

LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC C, +85°C)

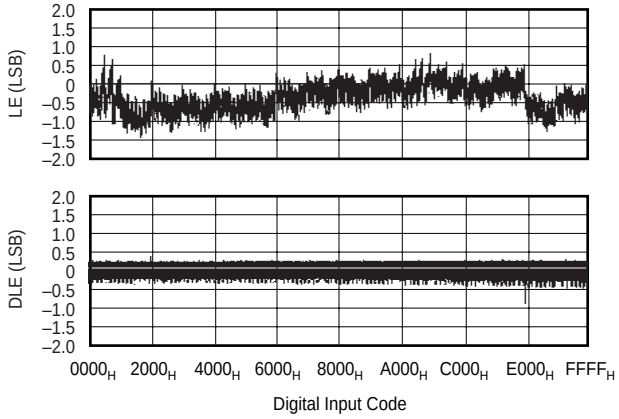


LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC D, +85°C)

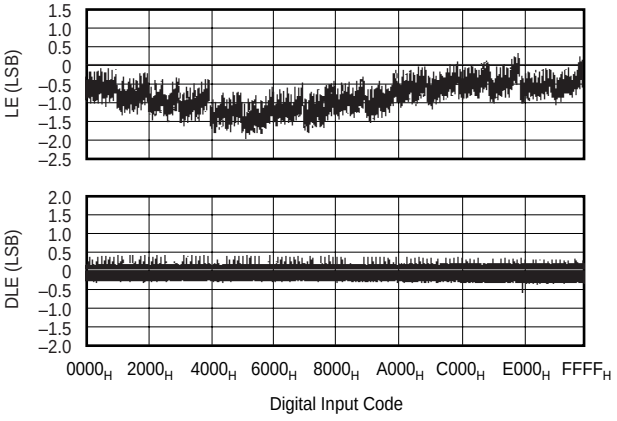


–40°C

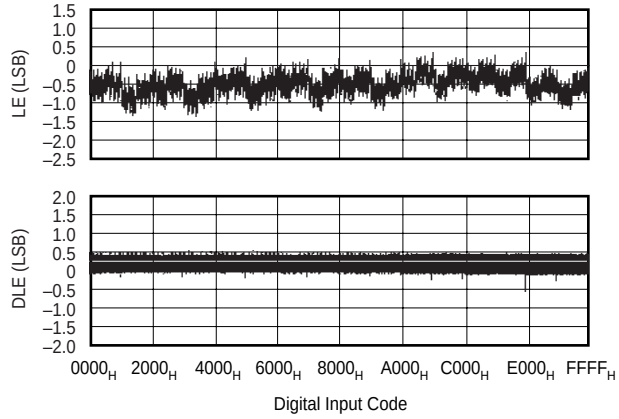
LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC A, –40°C)



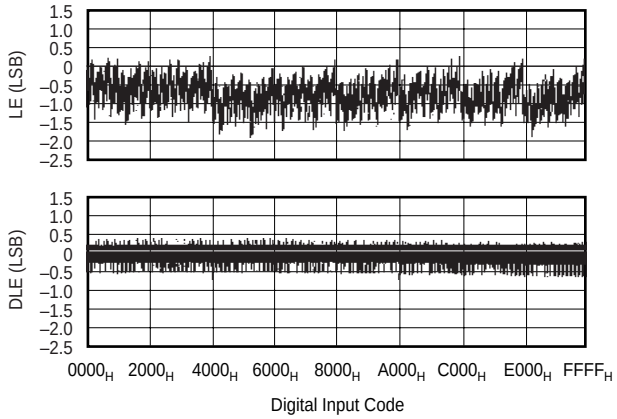
LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC B, –40°C)



LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC C, –40°C)



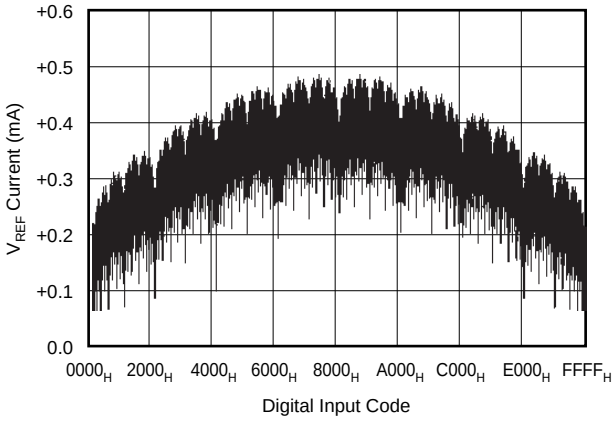
LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
(DAC D, –40°C)



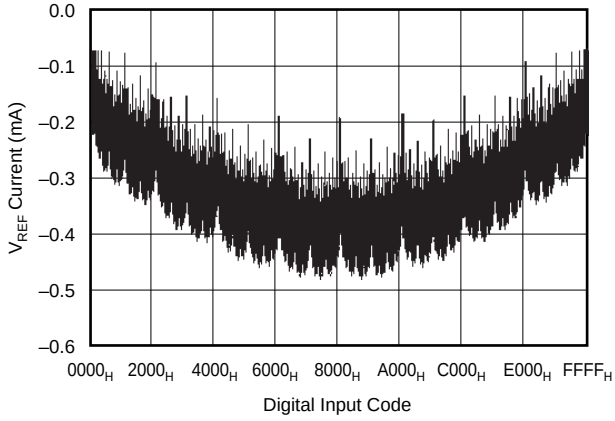
TYPICAL PERFORMANCE CURVES: V_{SS} = –5V (CONT)

At T_A = +25°C, V_{DD} = V_{CC} = +5V, V_{SS} = –5V, V_{REFH} = +2.5V, V_{REFL} = –2.5V, representative unit, unless otherwise specified.

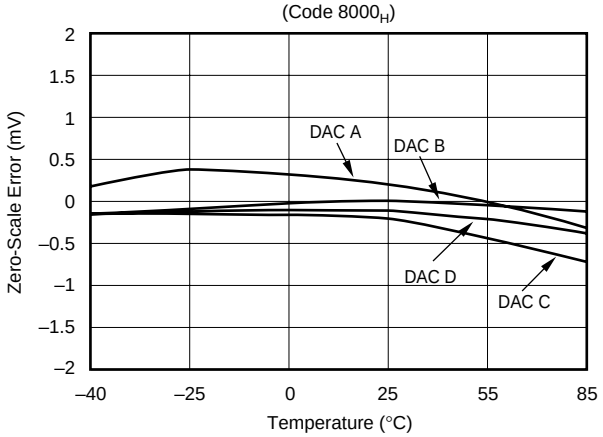
V_{REFH} CURRENT vs CODE
(all DACs sent to indicated code)



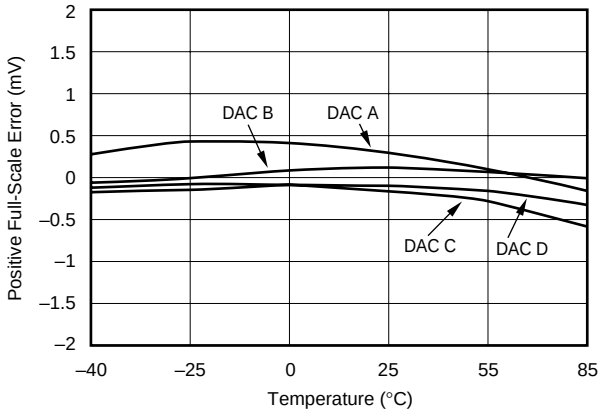
V_{REFL} CURRENT vs CODE
(all DACs sent to indicated code)



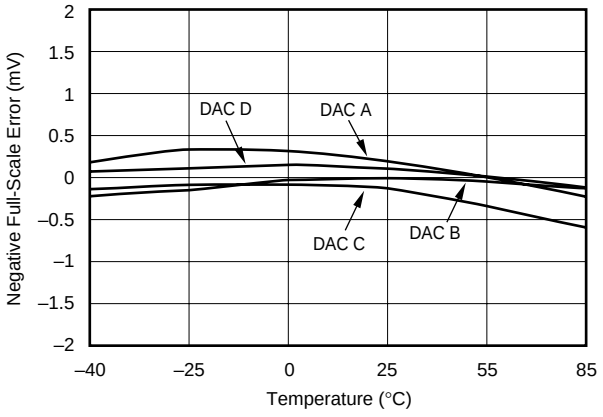
ZERO-SCALE ERROR vs TEMPERATURE
(Code 8000_H)



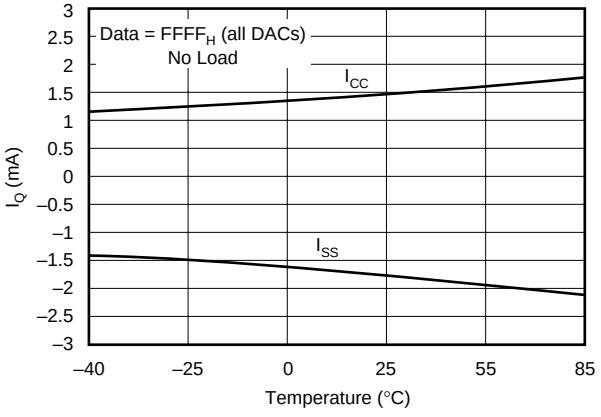
POSITIVE FULL-SCALE ERROR vs TEMPERATURE
(Code $FFFF_H$)



NEGATIVE FULL-SCALE ERROR vs TEMPERATURE
(Code 0000_H)



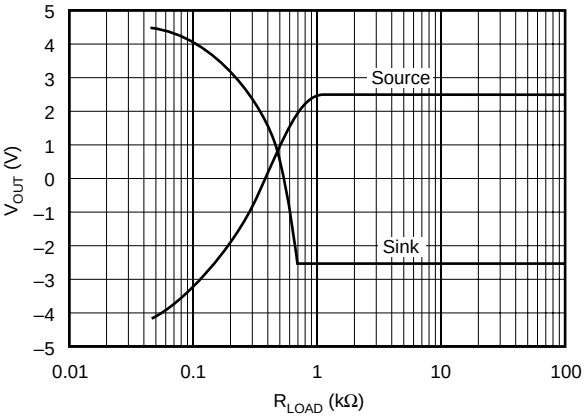
POWER SUPPLY CURRENT
vs TEMPERATURE



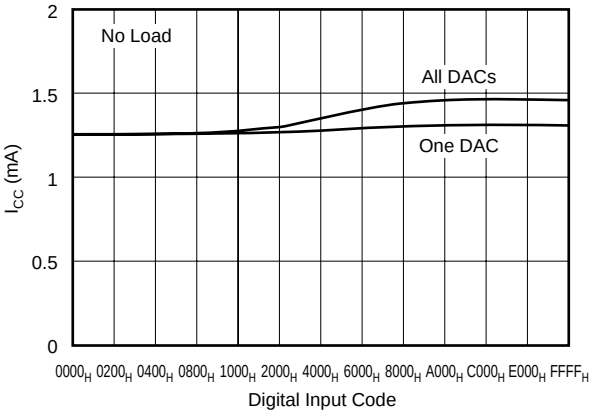
TYPICAL PERFORMANCE CURVES: V_{SS} = –5V (CONT)

At T_A = +25°C, V_{DD} = V_{CC} = +5V, V_{SS} = –5V, V_{REFH} = +2.5V, V_{REFL} = –2.5V, representative unit, unless otherwise specified.

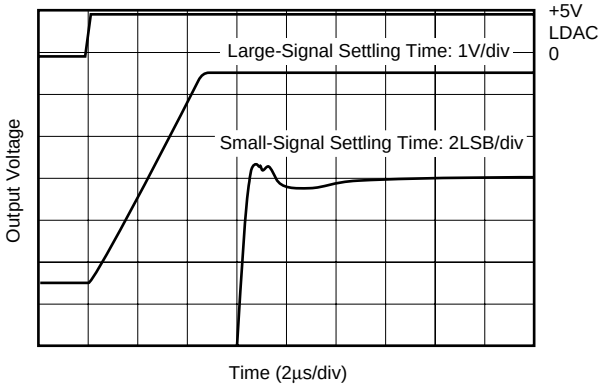
V_{OUT} vs R_{LOAD}



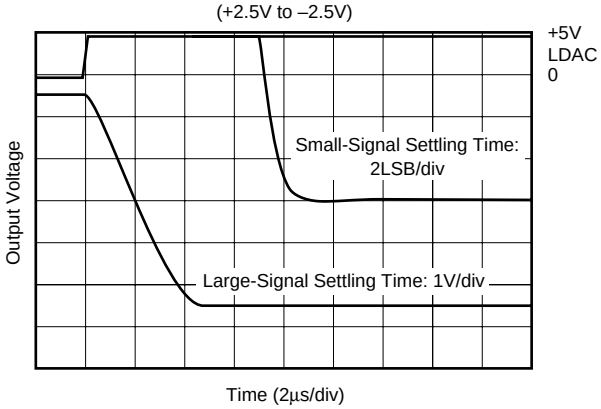
POSITIVE SUPPLY CURRENT vs DIGITAL INPUT CODE



OUTPUT VOLTAGE vs SETTLING TIME (–2.5V to +2.5V)



OUTPUT VOLTAGE vs SETTLING TIME (+2.5V to –2.5V)



THEORY OF OPERATION

The DAC7644 is a quad voltage output, 16-bit digital-to-analog converter (DAC). The architecture is an R-2R ladder configuration with the three MSB's segmented followed by an operational amplifier that serves as a buffer. Each DAC has its own R-2R ladder network, segmented MSBs and output op amp (see Figure 1). The minimum voltage output (zero-scale) and maximum voltage output (full-scale) are set by the external voltage references ($V_{REF}L$ and $V_{REF}H$, respectively). The digital input is a 16-bit parallel word and the DAC input registers offer a readback capability. The converters can be powered from either a single +5V supply or a dual ±5V supply. The device offers a reset function which immediately sets all DAC output voltages and DAC registers to mid-scale code 8000_H or to zero-scale, code 0000_H. See Figures 2 and 3 for the basic operation of the DAC7644.

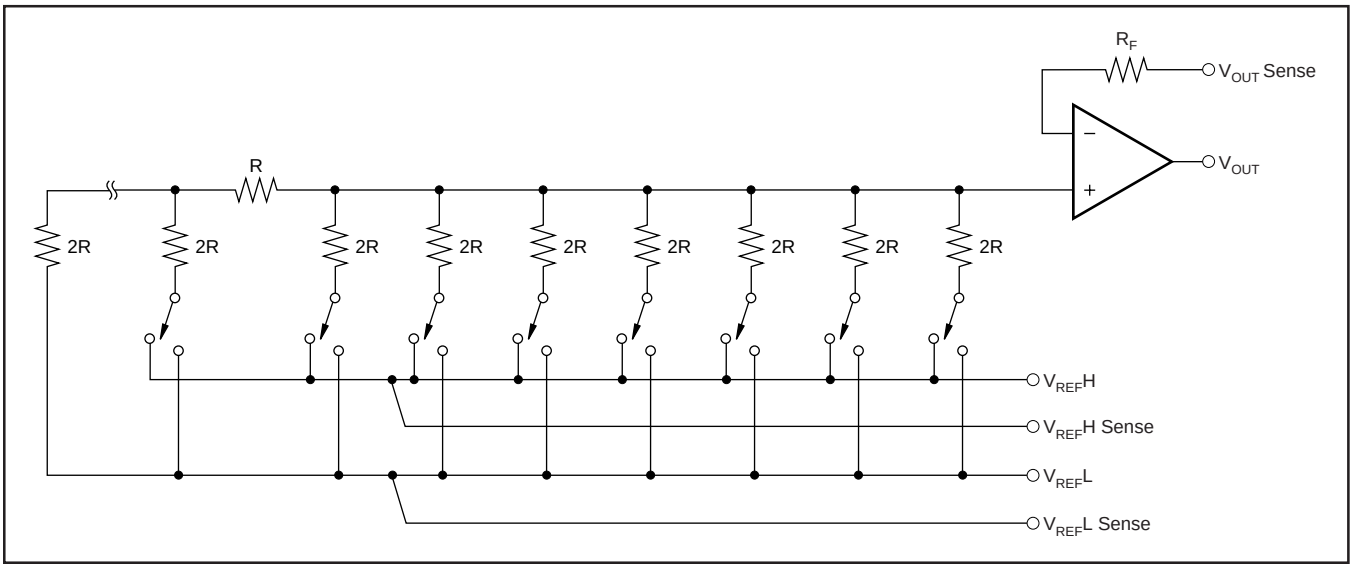


FIGURE 1. DAC7644 Architecture.

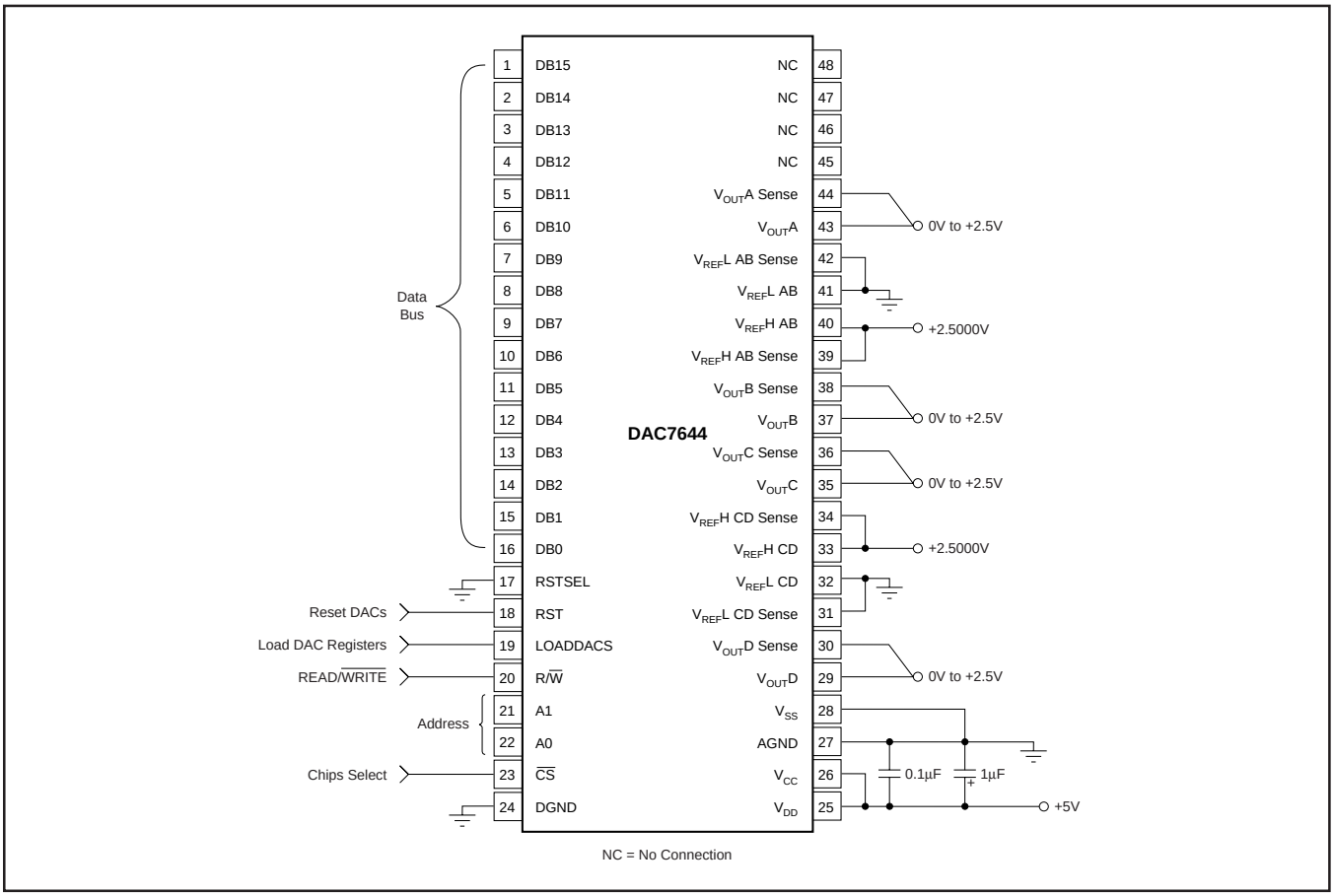


FIGURE 2. Basic Single-Supply Operation of the DAC7644.

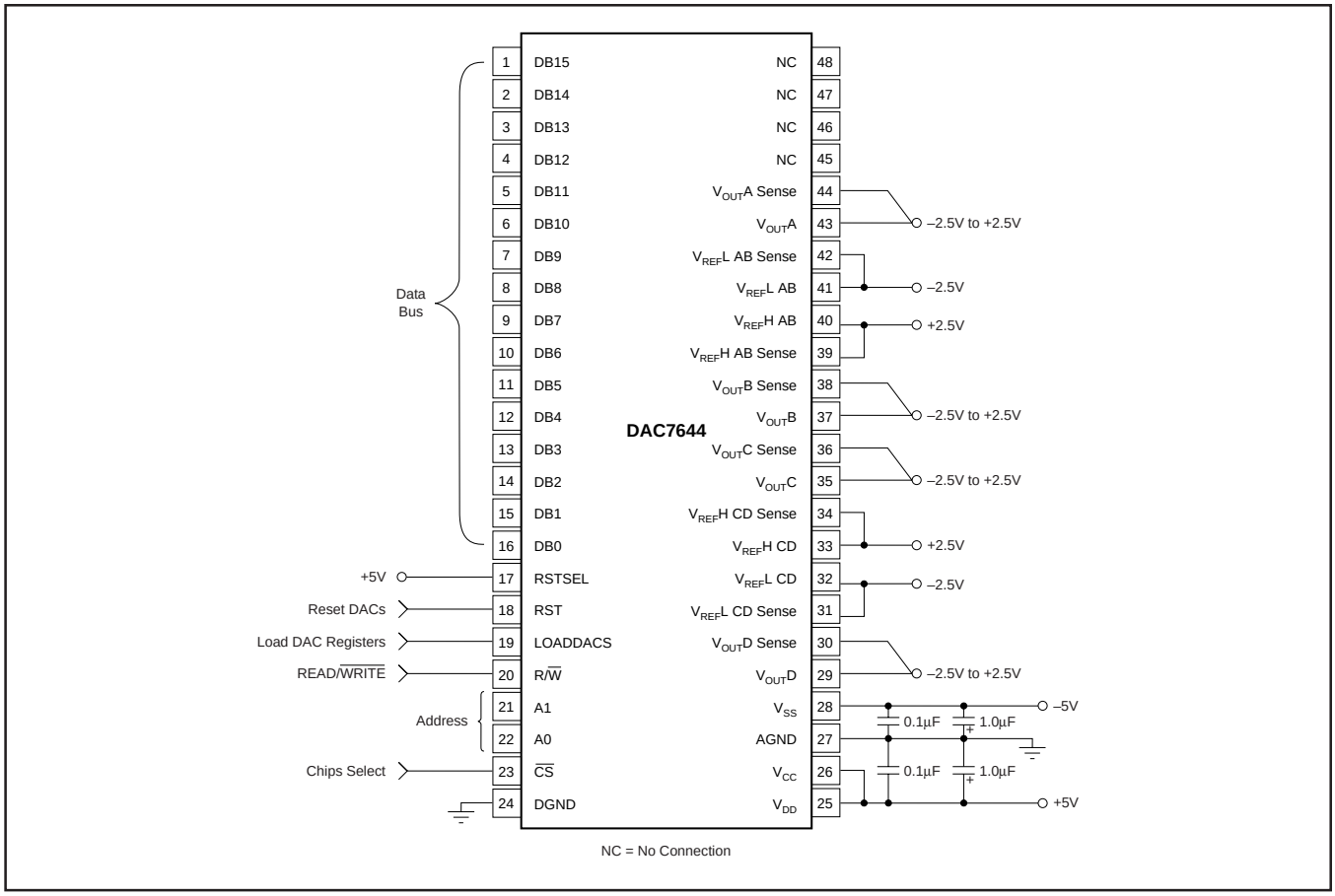


FIGURE 3. Basic Dual-Supply Operation of the DAC7644.

ANALOG OUTPUTS

When V_{SS} = –5V (dual supply operation), the output amplifier can swing to within 2.25V of the supply rails, guaranteed over the –40°C to +85°C temperature range. With V_{SS} = 0V (single-supply operation), and with R_{LOAD} also connected to ground, the output can swing to ground. Care must also be taken when measuring the zero-scale error when V_{SS} = 0V. Since the output voltage cannot swing below ground, the output voltage may not change for the first few digital input codes (0000_H, 0001_H, 0002_H, etc.) if the output amplifier has a negative offset. At the negative limit of –2mV, the first specified output starts at code 0040_H.

Due to the high accuracy of these D/A converters, system design problems such as grounding and contact resistance become very important. A 16-bit converter with a 2.5V full-scale range has a 1LSB value of 38µV. With a load current of 1mA, series wiring and connector resistance (see Figure 4) of only 40mΩ (R_{W2}) will cause a voltage drop of 40µV. To understand what this means in terms of a system layout, the resistivity of a typical 1 ounce copper-clad printed circuit board is 1/2 mΩ per square. For a 1mA load, a 10 milli-inch wide printed circuit conductor 600 milli-inches long will result in a voltage drop of 30µV.

The DAC7644 offers a force and sense output configuration for the high open-loop gain output amplifier. This feature allows the loop around the output amplifier to be closed at the load (see Figure 4), thus ensuring an accurate output voltage.

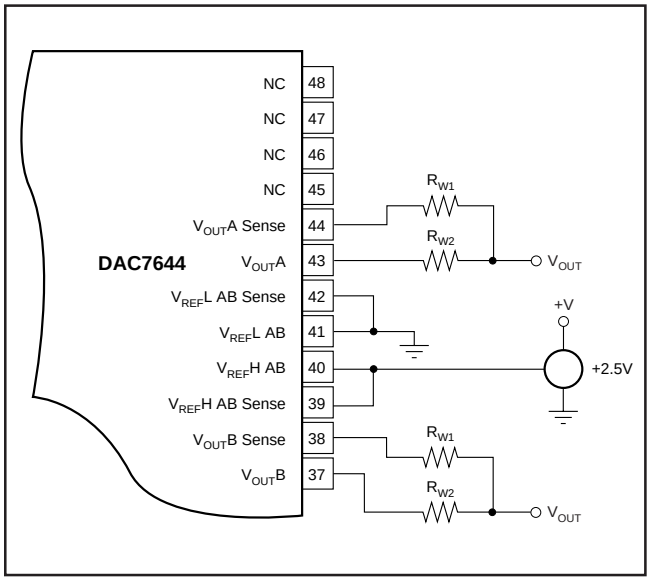


FIGURE 4. Analog Output Closed-Loop Configuration (1/2 DAC7644). R_W represents wiring resistances.

REFERENCE INPUTS

The reference inputs, $V_{REF}L$ and $V_{REF}H$, can be any voltage between V_{SS} + 2.5V and V_{CC} – 2.5V provided that $V_{REF}H$ is at least 1.25V greater than $V_{REF}L$. The minimum output of each DAC is equal to $V_{REF}L$ plus a small offset voltage (essentially, the offset of the output op amp). The maximum output is equal to $V_{REF}H$ plus a similar offset voltage. Note that V_{SS} (the negative power supply) must either be connected to ground or must be in the range of –4.75V to –5.25V. The voltage on V_{SS} sets several bias points within the converter. If V_{SS} is not in one of these two configurations, the bias values may be in error and proper operation of the device is not guaranteed.

The current into the $V_{REF}H$ input and out of $V_{REF}L$ depends on the DAC output voltages and can vary from a few microamps to approximately 0.5mA. The reference input appears as a varying load to the reference. If the reference can sink or source the required current, a reference buffer is not required. The DAC7644 features a reference drive and sense connection such that the internal errors caused by the changing reference current and the circuit impedances can be minimized. Figures 5 through 12 show different reference configurations and the effect on the linearity and differential linearity.

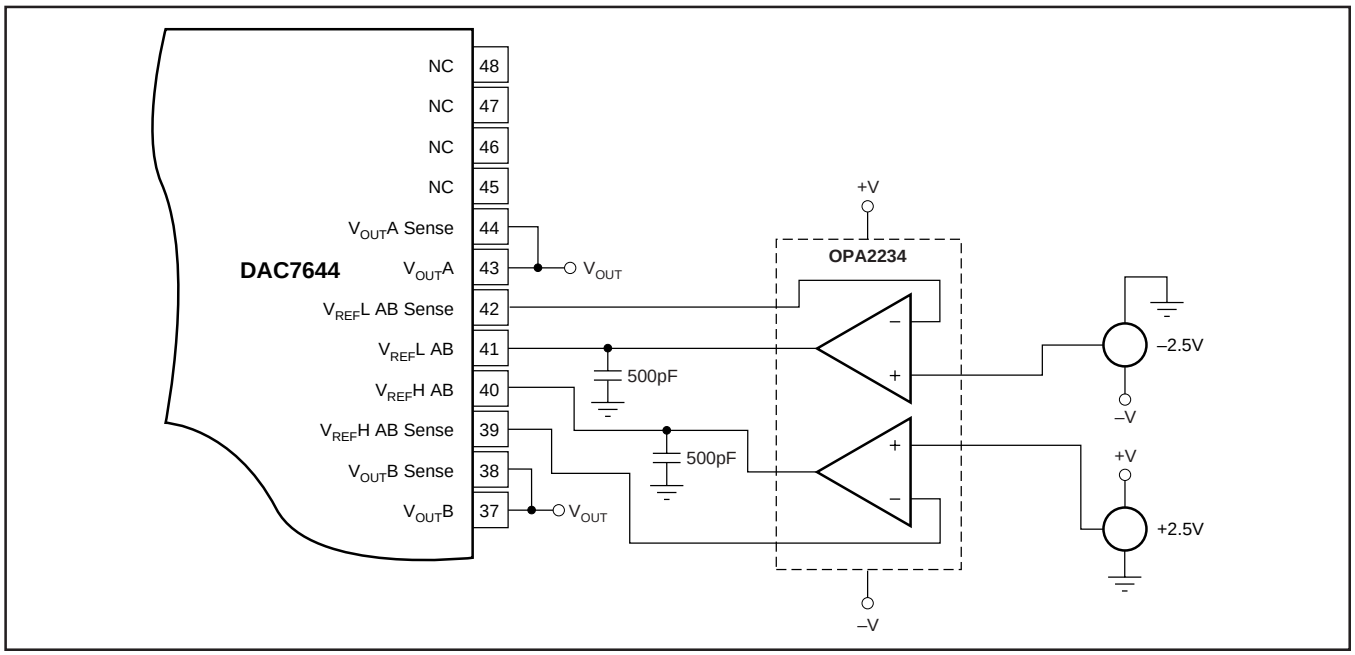


FIGURE 5. Dual Supply Configuration-Buffered References, used for Dual Supply Performance Curves (1/2 DAC7644).

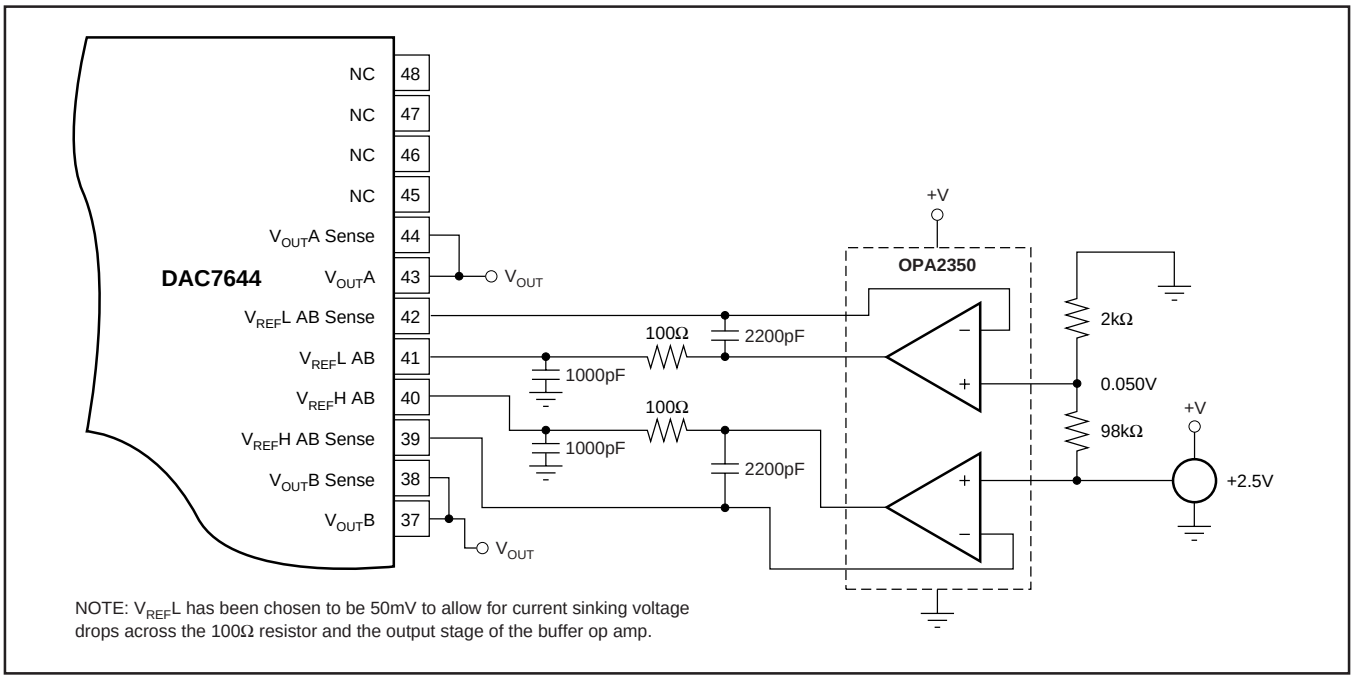


FIGURE 6. Single-Supply Buffered Reference with a Reference Low of 50mV (1/2 DAC7644).

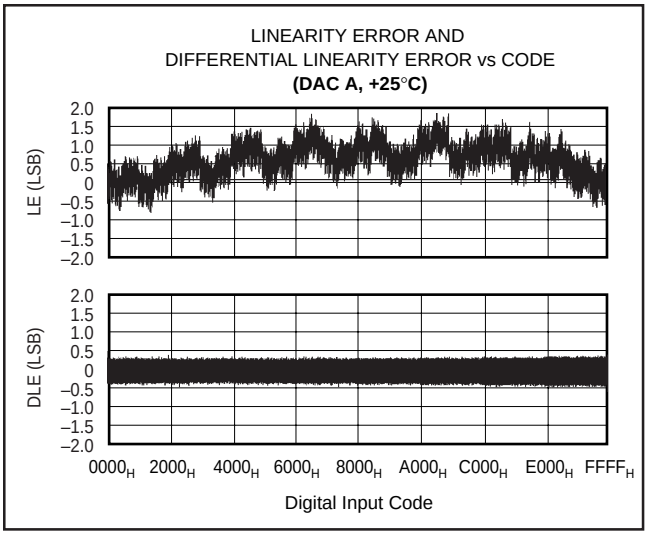


FIGURE 7. Integral Linearity and Differential Linearity Error Curves for Figure 6.

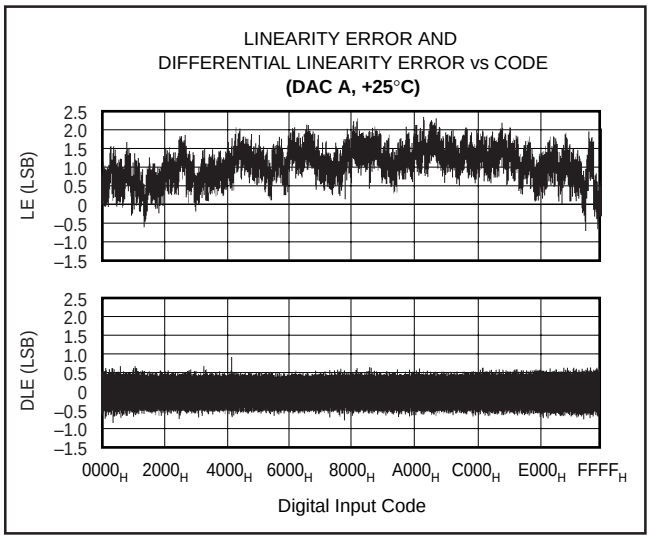


FIGURE 8. Integral Linearity and Differential Linearity Error Curves for Figure 9.

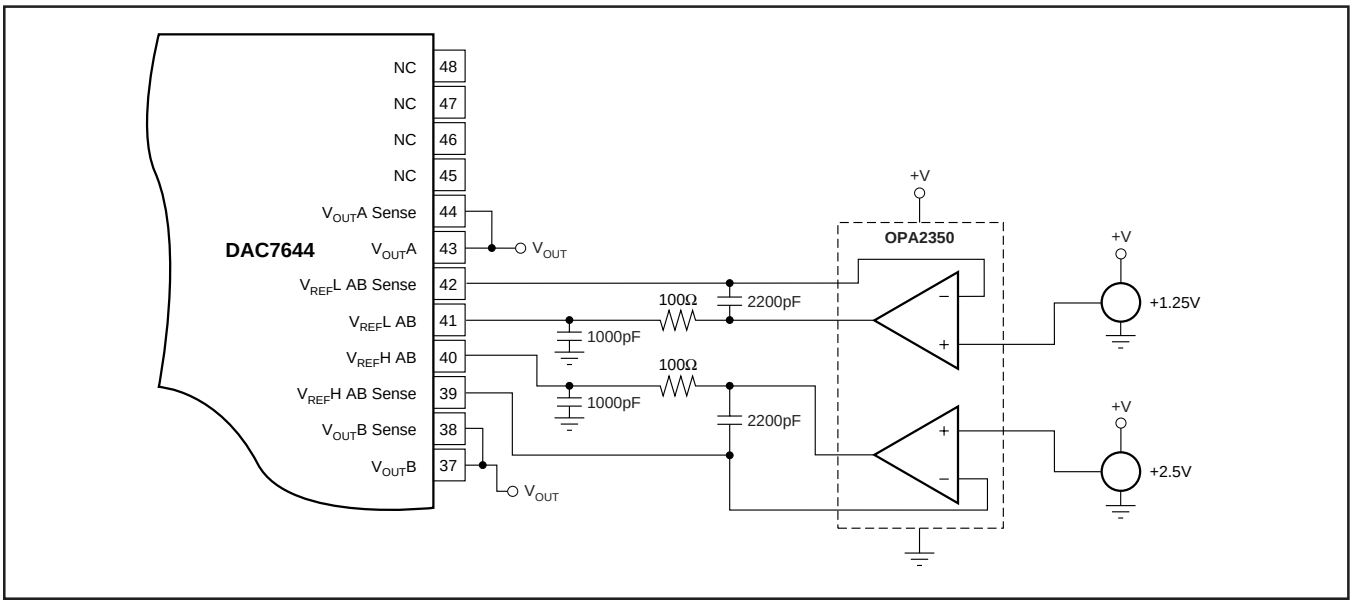


FIGURE 9. Single-Supply Buffered Reference with $V_{REF}L$ = +1.25V and $V_{REF}H$ = +2.5V (1/2 DAC7644).

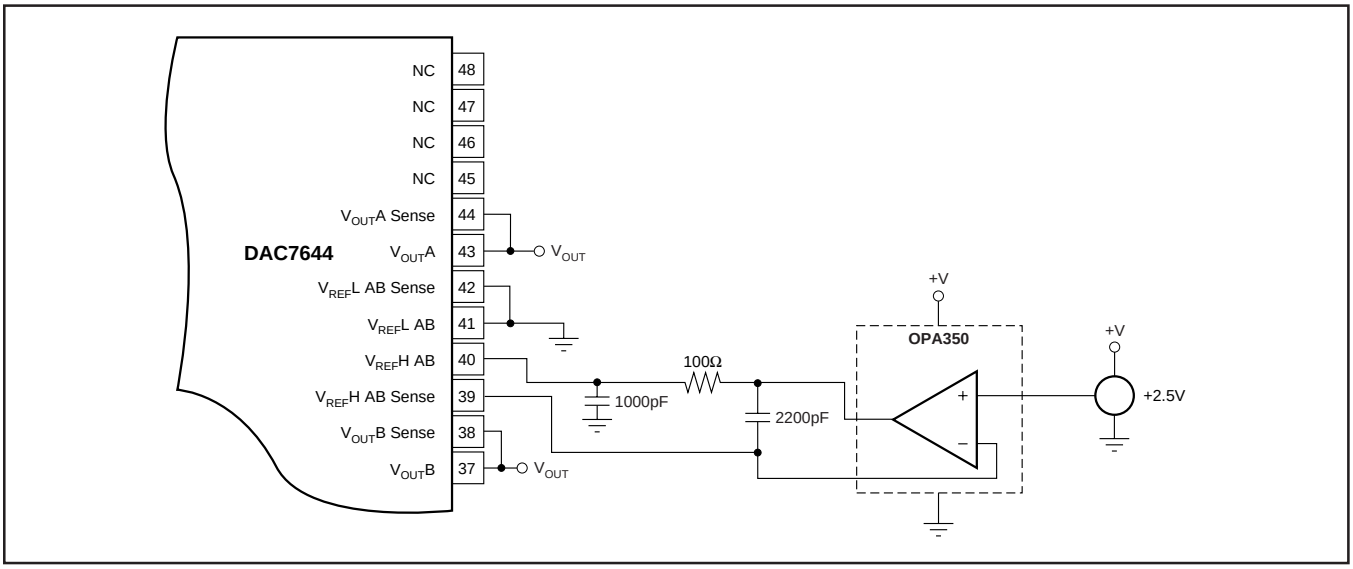


FIGURE 10. Single-Supply Buffered $V_{REF}H$ (1/2 DAC7644).

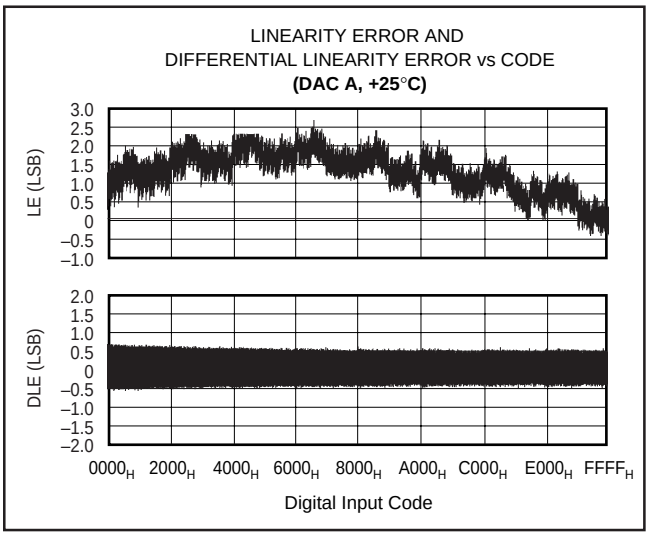


FIGURE 11. Linearity and Differential Linearity Error Curves for Figure 10.

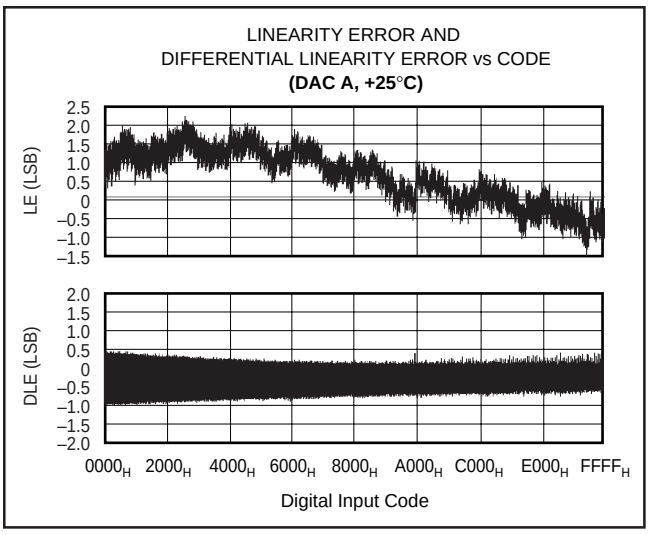


FIGURE 13. Linearity and Differential Linearity Error Curves for Figure 12.

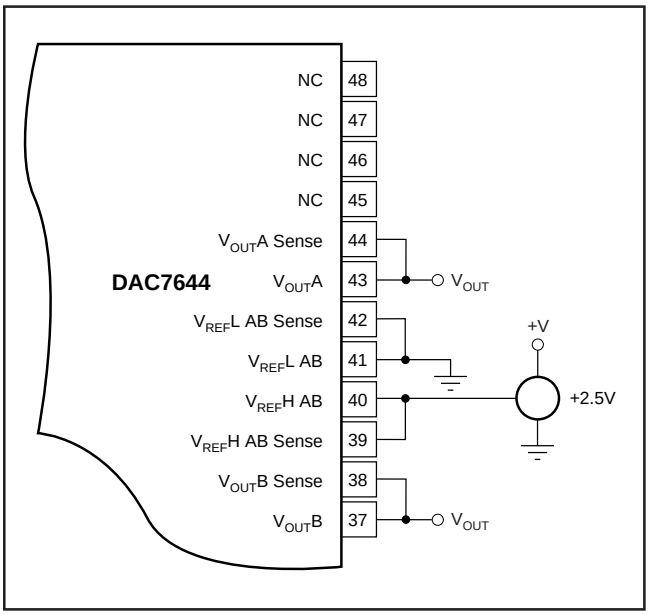


FIGURE 12. Low Cost Single-Supply Configuration.

DIGITAL INTERFACE

Table I shows the basic control logic for the DAC7644. Note that each internal register is edge triggered and not level triggered. When the LOADDACS signal is transitioned to HIGH, the digital word currently in the register is latched. The first set of registers (the input registers) are triggered via the A0, A1, R/$\overline{W}$, and $\overline{CS}$ inputs. Only one of these registers is transparent at any given time.

The double-buffered architecture is designed mainly so each DAC input register can be written to at any time and then all DAC voltages updated simultaneously by the rising edge of LOADDACS. It also allows a DAC input register to be written to at any point and the DAC voltages to be synchronously changed via a trigger signal connected to LOADDACS.

A1	A0	R/$\overline{W}$	$\overline{CS}$	RST	RSTSEL	LOADDACS	INPUT REGISTER	DAC REGISTER	MODE	DAC
L	L	L	L	H	X	X	Write	Hold	Write Input	A
L	H	L	L	H	X	X	Write	Hold	Write Input	B
H	L	L	L	H	X	X	Write	Hold	Write Input	C
H	H	L	L	H	X	X	Write	Hold	Write Input	D
L	L	H	L	H	X	X	Read	Hold	Read Input	A
L	H	H	L	H	X	X	Read	Hold	Read Input	B
H	L	H	L	H	X	X	Read	Hold	Read Input	C
H	H	H	L	H	X	X	Read	Hold	Read Input	D
X	X	X	H	H	X	↑	Hold	Write	Update	All
X	X	X	H	H	X	H	Hold	Hold	Hold	All
X	X	X	X	↑	L	X		Reset to Zero	Reset to Zero	All
X	X	X	X	↑	H	X		Reset to Midscale	Reset to Midscale	All

TABLE I. DAC7644 Logic Truth Table.

DIGITAL TIMING

Figure 14 and Table II provide detailed timing for the digital interface of the DAC7644.

DIGITAL INPUT CODING

The DAC7644 input data is in Straight Binary format. The output voltage is given by Equation 1.

$$V_{OUT} = V_{REF}L + \frac{(V_{REF}H - V_{REF}L) \bullet N}{65,536} \quad (1)$$

where N is the digital input code. This equation does not include the effects of offset (zero-scale) or gain (full-scale) errors.

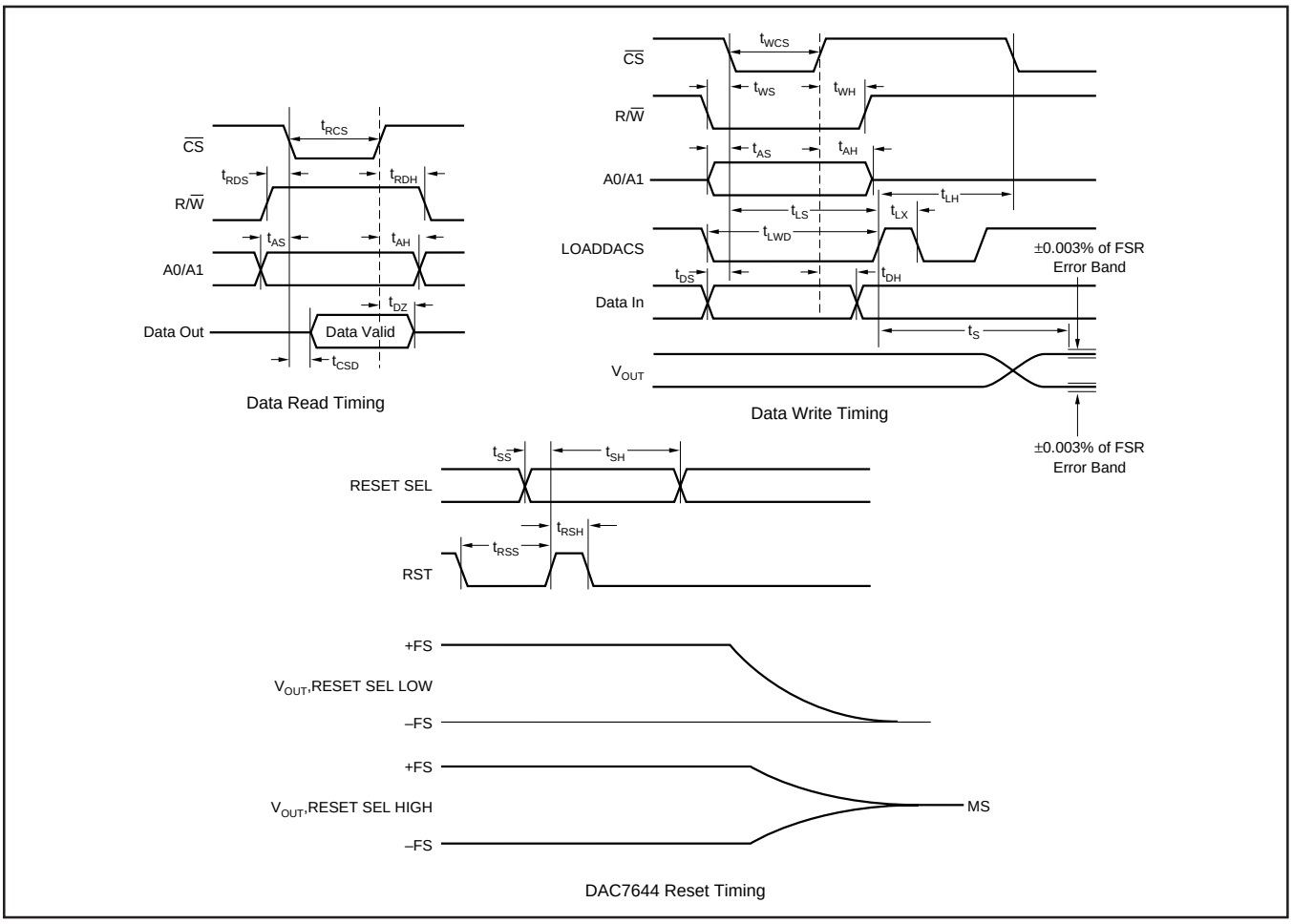


FIGURE 14. Digital Input and Output Timing.

SYMBOL	DESCRIPTION	MIN	TYP	MAX	UNITS
t_{RCS}	$\overline{CS}$ LOW for Read	150			ns
t_{RDS}	R/$\overline{W}$ HIGH to $\overline{CS}$ LOW	10			ns
t_{RDH}	R/$\overline{W}$ HIGH after $\overline{CS}$ HIGH	10			ns
t_{DZ}	$\overline{CS}$ HIGH to Data Bus in High Impedance	10		100	ns
t_{CSD}	$\overline{CS}$ LOW to Data Bus Valid		100	150	ns
t_{WCS}	$\overline{CS}$ LOW for Write	40			ns
t_{WS}	R/$\overline{W}$ LOW to $\overline{CS}$ LOW	0			ns
t_{WH}	R/$\overline{W}$ LOW after $\overline{CS}$ HIGH	10			ns
t_{AS}	Address Valid to $\overline{CS}$ LOW	0			ns
t_{AH}	Address Valid after $\overline{CS}$ HIGH	10			ns
t_{LS}	$\overline{CS}$ LOW to LOADDACS HIGH	30			ns
t_{LH}	$\overline{CS}$ LOW after LOADDACS HIGH	100			ns
t_{LX}	LOADDACS HIGH	100			ns
t_{DS}	Data Valid to $\overline{CS}$ LOW	0			ns
t_{DH}	Data Valid after $\overline{CS}$ HIGH	10			ns
t_{LWD}	LOADDACS LOW	100			ns
t_{SS}	RSTSEL Valid Before RESET HIGH	0			ns
t_{SH}	RSTSEL Valid After RESET HIGH	200			ns
t_{RSS}	RESET LOW Before RESET HIGH	10			ns
t_{RSH}	RESET LOW After RESET HIGH	10			ns
t_S	Settling Time			10	µs

TABLE II. Timing Specifications (T_A = –40°C to +85°C).

DIGITALLY-PROGRAMMABLE CURRENT SOURCE

The DAC7644 offers a unique set of features that allows a wide range of flexibility in designing applications circuits such as programmable current sources. The DAC7644 offers both a differential reference input as well as an open-loop configuration around the output amplifier. The open-loop configuration around the output amplifier allows transistor to be placed within the loop to implement a digitally-programmable, uni-directional current source. The availability of a differential reference also allows programmability for both the full-scale and zero-scale currents. The output current is calculated as:

$$I_{OUT} = \left(\left(\frac{V_{REF}H - V_{REF}L}{R_{SENSE}}\right) \bullet \left(\frac{N\ Value}{65,536}\right)\right) + \left(V_{REF}L / R_{SENSE}\right) \quad (2)$$

Figure 15 shows a DAC7644 in a 4mA to 20mA current output configuration. The output current can be determined by Equation 3:

$$I_{OUT} = \left(\left(\frac{2.5V - 0.5V}{125\Omega}\right) \bullet \left(\frac{N\ Value}{65,536}\right)\right) + \left(\frac{0.5V}{125\Omega}\right) \quad (3)$$

At full-scale, the output current is 16mA plus the 4mA for the zero current. At zero scale the output current is the offset current of 4mA (0.5V/125Ω).

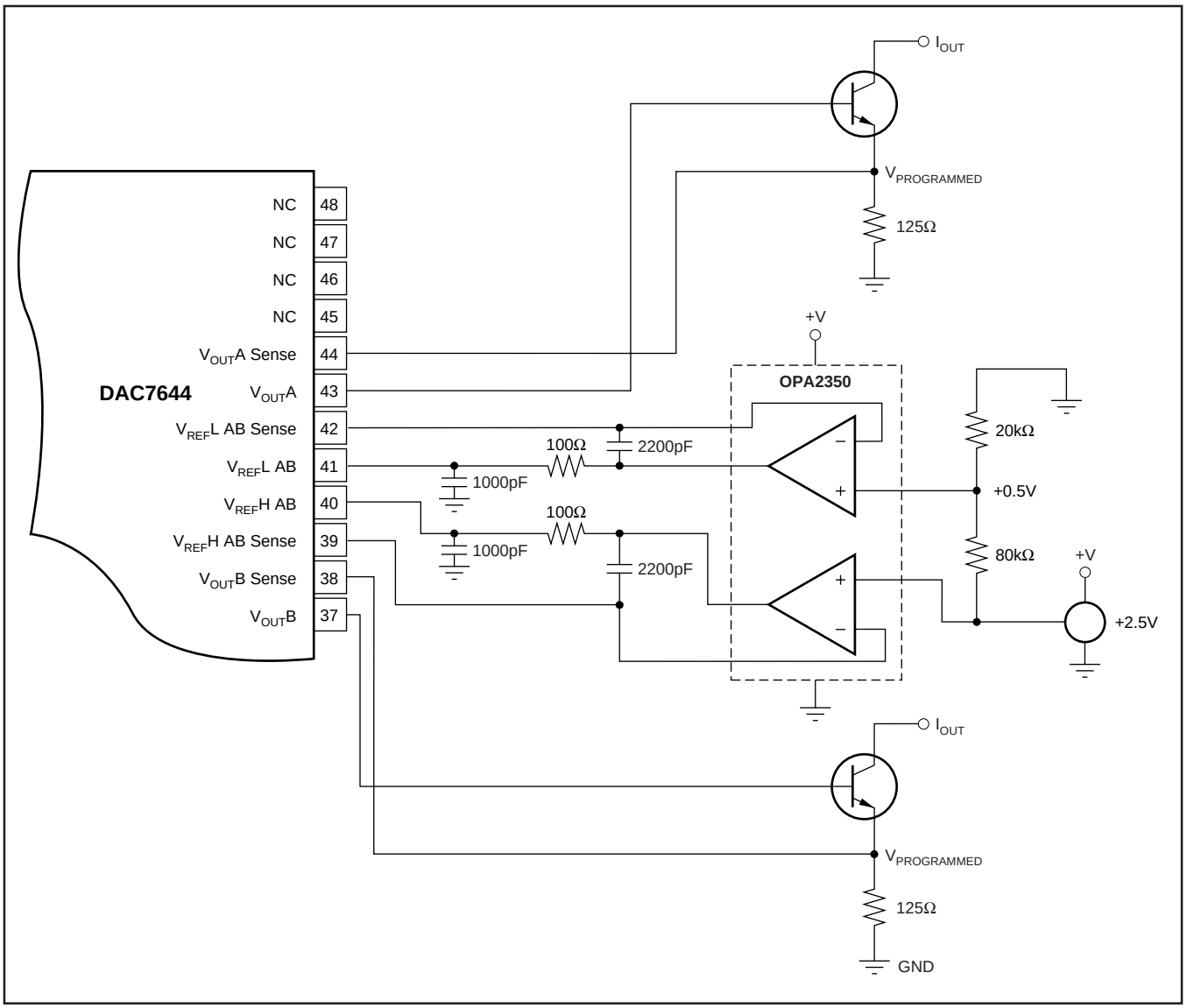


FIGURE 15. 4-to-20mA Digitally Controlled Current Source (1/2 DAC7644).

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
DAC7644E	ACTIVE	SSOP	DL	48	25	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 85	DAC7644E B	Samples
DAC7644E/1K	ACTIVE	SSOP	DL	48	1000	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 85	DAC7644E B	Samples
DAC7644E/1KG4	ACTIVE	SSOP	DL	48	1000	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 85	DAC7644E B	Samples
DAC7644EB	ACTIVE	SSOP	DL	48	25	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 85	DAC7644E B	Samples
DAC7644EB/1K	ACTIVE	SSOP	DL	48	1000	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 85	DAC7644E B	Samples
DAC7644EB/1KG4	ACTIVE	SSOP	DL	48	1000	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 85	DAC7644E B	Samples
DAC7644EBG4	ACTIVE	SSOP	DL	48	25	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 85	DAC7644E B	Samples

(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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

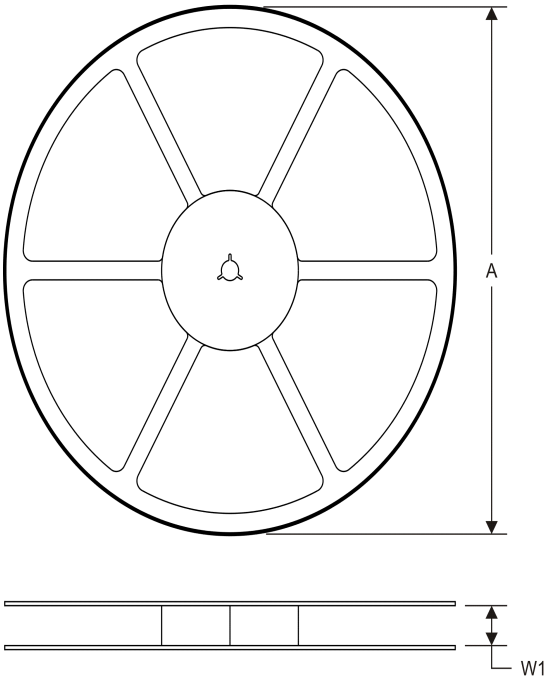
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

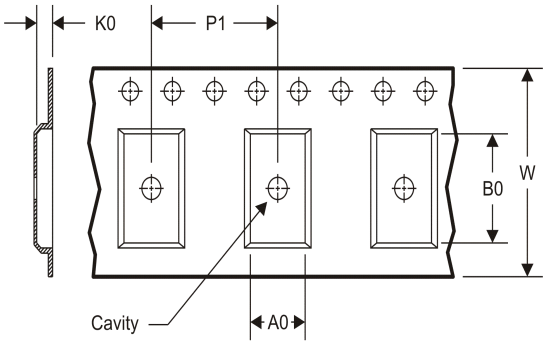
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



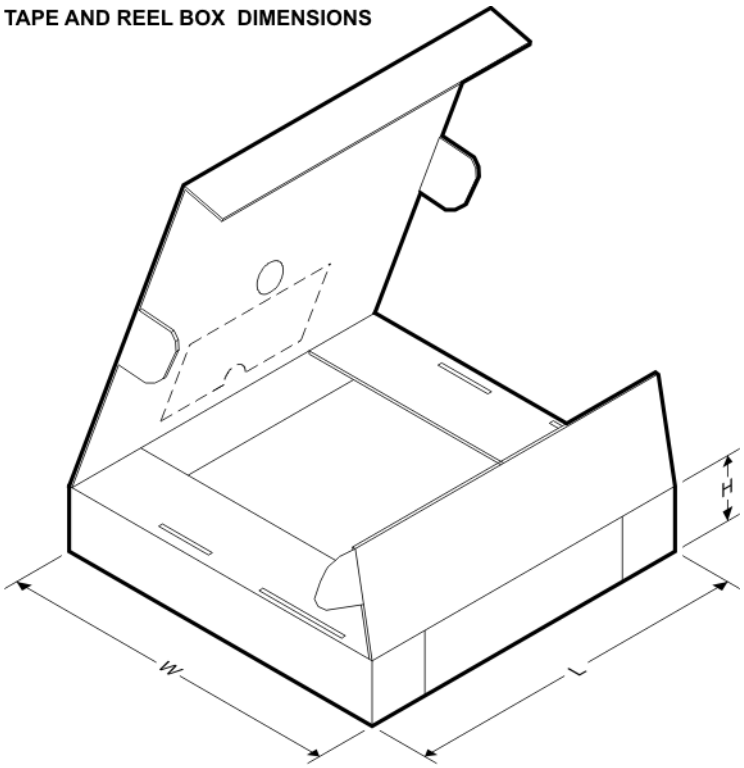
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

TAPE AND REEL INFORMATION

*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
DAC7644E/1K	SSOP	DL	48	1000	330.0	32.4	11.35	16.2	3.1	16.0	32.0	Q1
DAC7644EB/1K	SSOP	DL	48	1000	330.0	32.4	11.35	16.2	3.1	16.0	32.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DAC7644E/1K	SSOP	DL	48	1000	367.0	367.0	55.0
DAC7644EB/1K	SSOP	DL	48	1000	367.0	367.0	55.0

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