



DAC7613

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12-Bit, Voltage Output DIGITAL-TO-ANALOG CONVERTER

FEATURES

- **LOW POWER:** 1.8mW
- **UNIPOLAR OR BIPOLAR OPERATION**
- **SETTLING TIME:** 10 μ s to 0.012%
- **12-BIT LINEARITY AND MONOTONICITY:** -40°C to +85°C
- **DATA READBACK**
- **DOUBLE-BUFFERED DATA INPUTS**
- **24-LEAD SSOP PACKAGE**

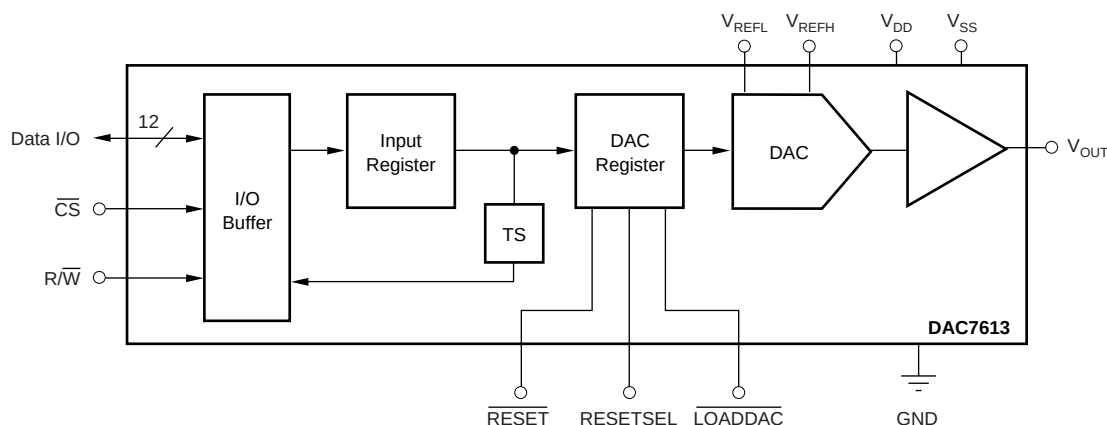
APPLICATIONS

- **PROCESS CONTROL**
- **CLOSED-LOOP SERVO-CONTROL**
- **MOTOR CONTROL**
- **DATA ACQUISITION SYSTEMS**

DESCRIPTION

The DAC7613 is a 12-bit, voltage output digital-to-analog converter with guaranteed 12-bit monotonic performance over the specified temperature range. The DAC7613 accepts a 12-bit parallel input data, has double-buffered DAC input logic and provides a readback mode of the internal input register. An asynchronous reset clears all registers to a mid-scale code of 800_H or to a zero-scale of 000_H. The DAC7613 can operate from a single +5V supply or from +5V and -5V supplies.

Low power and small size makes the DAC7613 ideal for data acquisition systems and closed-loop servo-control. The DAC7613 is available in a plastic SSOP-24 package, and offers guaranteed specifications over the -40°C to +85°C temperature range.



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SPECIFICATION

At $T_A = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, $V_{DD} = +5\text{V}$, $V_{SS} = -5\text{V}$, $V_{REFH} = +2.5\text{V}$, and $V_{REFL} = -2.5\text{V}$, unless otherwise noted.

PARAMETER	CONDITIONS	DAC7613E			DAC7613EB			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
ACCURACY								
Linearity Error ⁽¹⁾	$V_{SS} = 0\text{V}$ or -5V			± 2			± 1	LSB ⁽²⁾
Differential Linearity Error	$V_{SS} = 0\text{V}$ or -5V			± 1			± 1	LSB
Monotonicity	T_{MIN} to T_{MAX}	12			*			Bits
Zero-Scale Error	Code = 000_H			± 4			*	LSB
Zero-Scale Drift			2	5		*	*	ppm/ $^{\circ}\text{C}$
Full-Scale Error	Code = FFF_H			± 4			*	LS
Zero-Scale Error	Code = $00A_H$, $V_{SS} = 0\text{V}$			± 8			*	LSB
Zero-Scale Drift	$V_{SS} = 0\text{V}$		5	10		*	*	ppm/ $^{\circ}\text{C}$
Full-Scale Error	Code = FFF_H , $V_{SS} = 0\text{V}$			± 8			*	LSB
Power Supply Rejection			30			*		ppm/V
ANALOG OUTPUT								
Voltage Output ⁽³⁾	$V_{REFL} = 0\text{V}$, $V_{SS} = 0\text{V}$	0		V_{REFH}	*		*	V
	$V_{SS} = -5\text{V}$	V_{REFL}		V_{REFH}	*		*	V
Output Current		-1.25		+1.25	*		*	mA
Load Capacitance	No Oscillation		100			*		pF
Short-Circuit Current			+5, -15			*		mA
Short-Circuit Duration			Indefinite			*		
REFERENCE INPUT								
V_{REFH} Input Range	$V_{SS} = 0\text{V}$ or -5V	$V_{REFL} + 1.25$		+2.5	*		*	V
V_{REFL} Input Range	$V_{SS} = 0\text{V}$	0		$V_{REFH} - 1.25$	*		*	V
V_{REFL} Input Range	$V_{SS} = -5\text{V}$	-2.5		$V_{REFH} - 1.25$	*		*	V
DYNAMIC PERFORMANCE								
Settling Time ⁽⁴⁾	To $\pm 0.012\%$		5	10		*	*	μs
Output Noise Voltage	0Hz to 1MHz		40			*		nV/ $\sqrt{\text{Hz}}$
DIGITAL INPUT/OUTPUT								
Logic Family			CMOS		*			
Logic Levels								
V_{IH}	$I_{IH} \leq \pm 10\mu\text{A}$	$0.7 V_{DD}$		$V_{DD} + 0.3$	*		*	V
V_{IL}	$I_{IL} \leq \pm 10\mu\text{A}$	-0.3		$0.3 V_{DD}$	*		*	V
V_{OH}	$I_{OH} = -0.8\text{mA}$	3.6		V_{DD}	*		*	V
V_{OL}	$I_{OL} = 1.6\text{mA}$	0.0		0.4	*		*	V
Data Format		Straight Binary				*		
POWER SUPPLY REQUIREMENTS								
V_{DD}		4.75		5.25	*		*	V
V_{SS}	If $V_{SS} \neq 0\text{V}$	-5.25		-4.75	*		*	V
I_{DD}			0.35	0.5		*	*	mA
I_{SS}		-0.65	-0.45		*	*	*	mA
Power Dissipation	$V_{SS} = -5\text{V}$		4	5.75		*	*	mW
	$V_{SS} = 0\text{V}$		1.8	2.5		*	*	mW
TEMPERATURE RANGE								
Specified Performance		-40		+85	*		*	$^{\circ}\text{C}$

NOTES: (1) If $V_{SS} = 0\text{V}$, specification applies at code $00A_H$ and above. (2) LSB means Least Significant Bit, when V_{REFH} equals +2.5V and V_{REFL} equals -2.5V, then one LSB equals 1.22mV. (3) Ideal output voltage, does not take into account zero or full-scale error. (4) If $V_{SS} = -5\text{V}$, full-scale 5V step. If $V_{SS} = 0\text{V}$, full-scale positive 2.5V step and negative step from code FFF_H to $00A_H$.

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ABSOLUTE MAXIMUM RATINGS⁽¹⁾

V_{DD} to V_{SS}	–0.3V to 11V
V_{DD} to GND	–0.3V to 5.5V
V_{REFL} to V_{SS}	–0.3V to ($V_{DD} - V_{SS}$)
V_{DD} to V_{REFH}	–0.3V to ($V_{DD} - V_{SS}$)
V_{REFH} to V_{REFL}	–0.3V to ($V_{DD} - V_{SS}$)
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 +150°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.

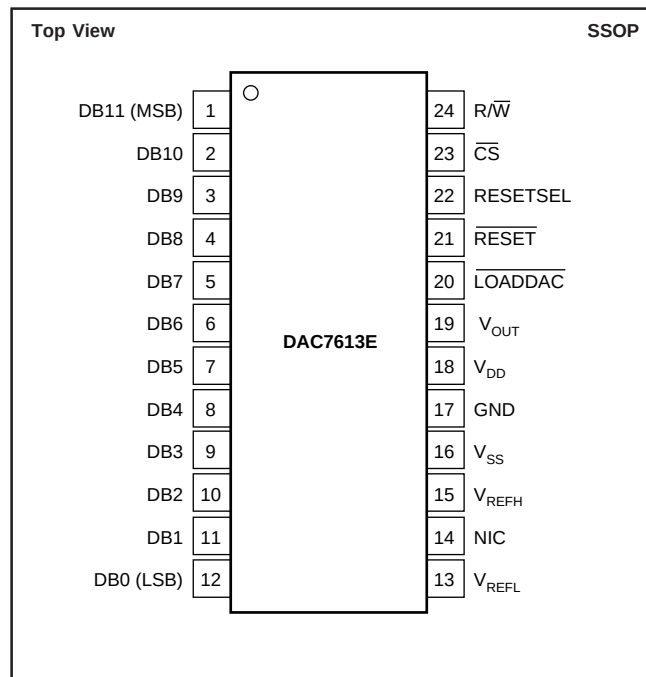
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

PACKAGE/ORDERING INFORMATION

PRODUCT	MAXIMUM LINEARITY ERROR (LSB)	MAXIMUM DIFFERENTIAL LINEARITY ERROR (LSB)	PACKAGE	PACKAGE DRAWING NUMBER	SPECIFICATION TEMPERATURE RANGE	ORDERING NUMBER ⁽¹⁾	TRANSPORT MEDIA
DAC7613E "	±2 "	±1 "	SSOP-24 "	338 "	–40°C to +85°C "	DAC7613E DAC7613E/1K	Rails Tape and Reel
DAC7613EB "	±1 "	±1 "	SSOP-24 "	338 "	–40°C to +85°C "	DAC7613EB DAC7613EB/1K	Rails Tape and Reel

NOTE: (1) 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 “DAC7613E/1K” will get a single 1000-piece Tape and Reel.

PIN CONFIGURATION

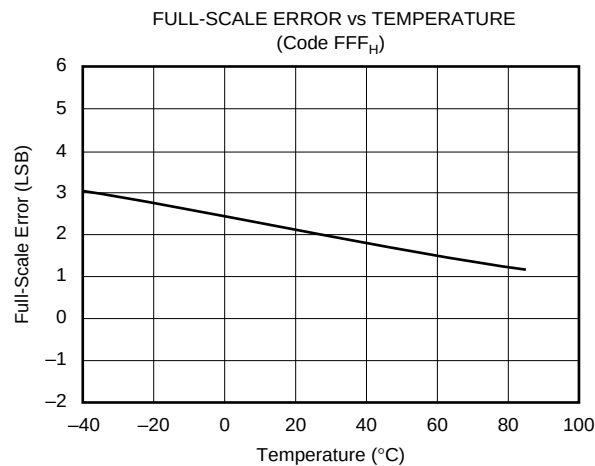
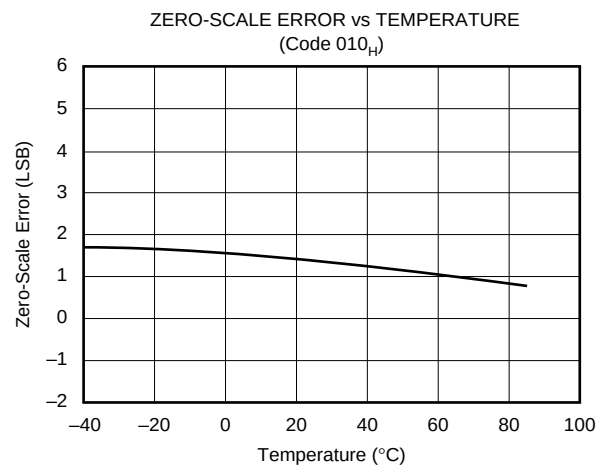
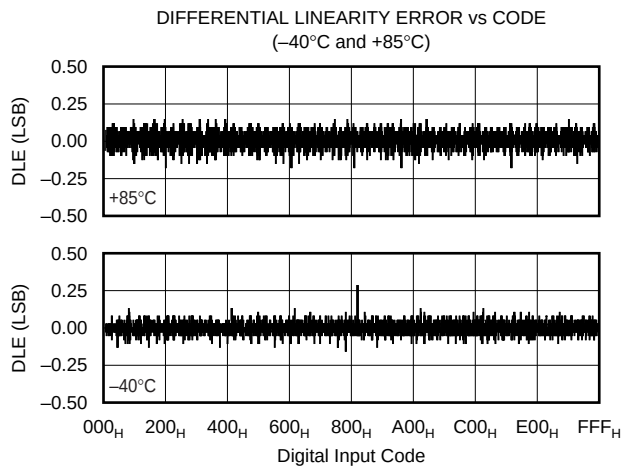
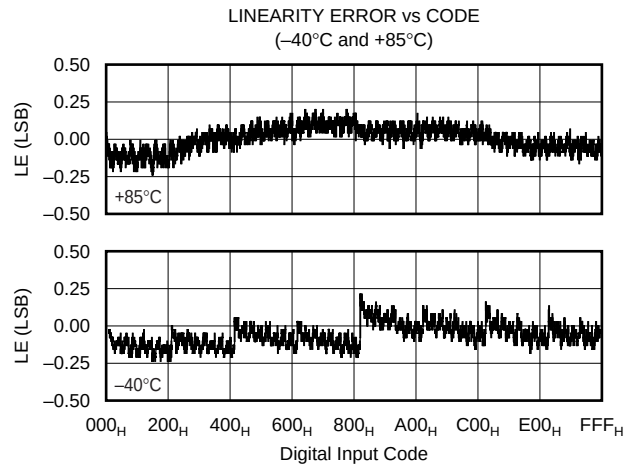
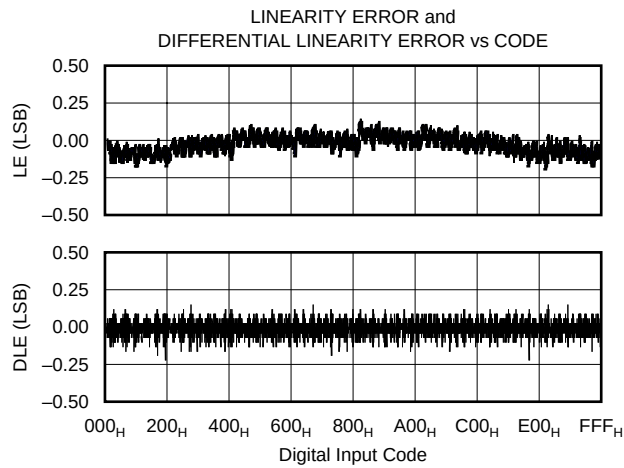


PIN DESCRIPTIONS

PIN	LABEL	DESCRIPTION
1	DB11	Data Bit 11, MSB
2	DB10	Data Bit 10
3	DB9	Data Bit 9
4	DB8	Data Bit 8
5	DB7	Data Bit 7
6	DB6	Data Bit 6
7	DB5	Data Bit 5
8	DB4	Data Bit 4
9	DB3	Data Bit 3
10	DB2	Data Bit 2
11	DB1	Data Bit 1
12	DB0	Data Bit 0, LSB
13	V _{REFL}	Reference Input Voltage Low. Sets minimum output voltage for the DAC.
14	NIC	Not Internally Connected
15	V _{REFH}	Reference Input Voltage High. Sets maximum output voltage for the DAC.
16	V _{SS}	Negative Analog Supply Voltage, 0V or –5V nominal.
17	GND	Ground
18	V _{DD}	Positive Power Supply
19	V _{OUT}	DAC Voltage Output
20	LOADDAC	The selected DAC register becomes transparent when $\overline{\text{LOADDAC}}$ is LOW. It is in the latched state when $\overline{\text{LOADDAC}}$ is HIGH.
21	RESET	Asynchronous Reset Input. Sets the DAC register to either zero-scale (000 _H) or mid-scale (800 _H) when LOW. RESETSEL determines which code is active.
22	RESETSEL	When LOW, a LOW on $\overline{\text{RESET}}$ will cause the DAC register to be set to code 000 _H . When RESETSEL is HIGH, a LOW on $\overline{\text{RESET}}$ will set the registers to code 800 _H .
23	CS	Chip Select. Active LOW.
24	R/W	Enabled by $\overline{\text{CS}}$. Controls data read and write from the input register.

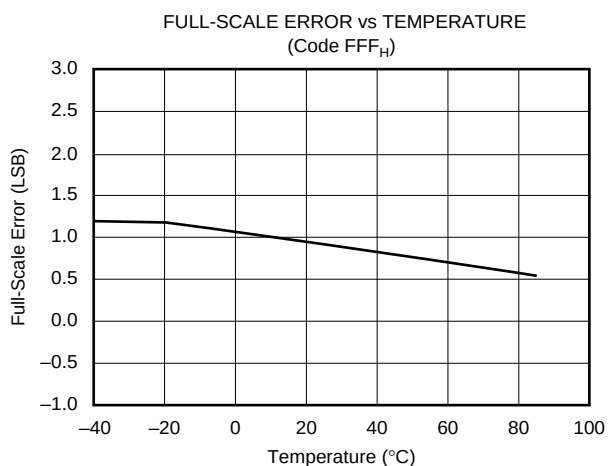
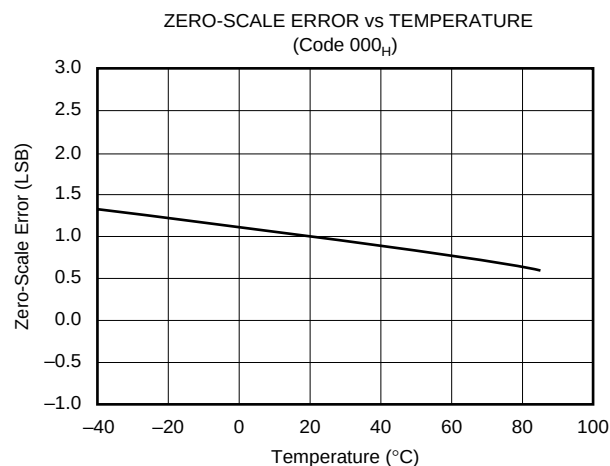
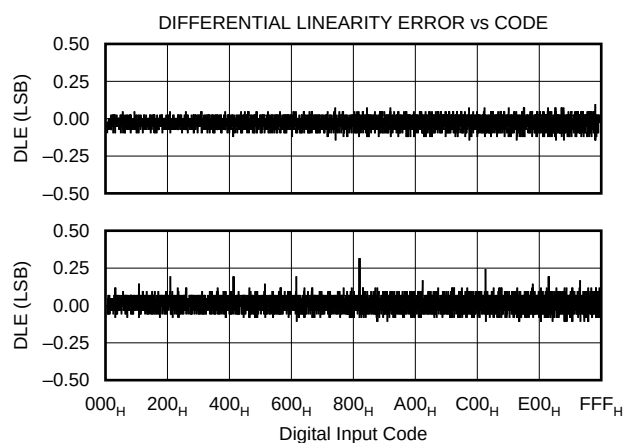
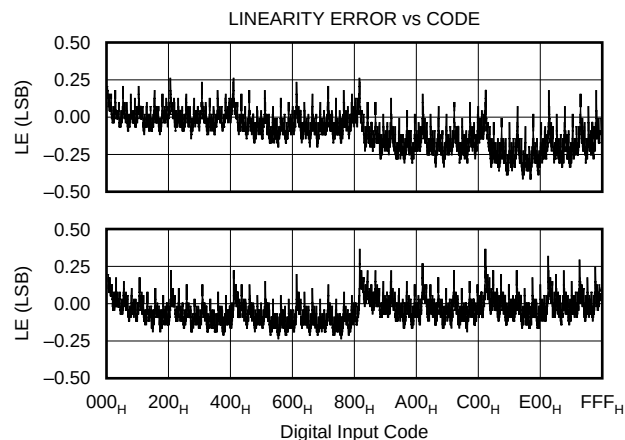
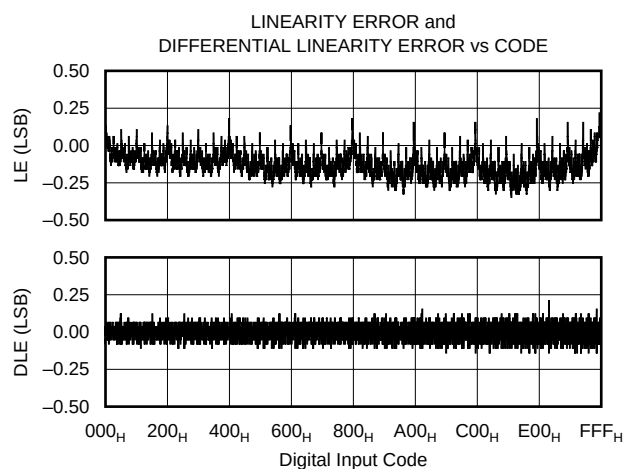
TYPICAL PERFORMANCE CURVES: $V_{SS} = 0V$

At $T_A = +25^\circ C$, $V_{DD} = +5V$, $V_{REFH} = +2.5V$, and $V_{REFL} = 0V$, representative unit, unless otherwise specified.



TYPICAL PERFORMANCE CURVES: $V_{SS} = -5V$

At $T_A = +25^\circ C$, $V_{DD} = +5V$, $V_{REFH} = +2.5V$, and $V_{REFL} = 0V$, representative unit, unless otherwise specified.



THEORY OF OPERATION

The DAC7613 is a 12-bit, voltage output Digital-to-Analog Converter (DAC). The architecture is a classic R-2R ladder configuration followed by an operational amplifier that serves as a buffer. The minimum voltage output (“zero-scale”) and maximum voltage output (“full-scale”) are set by the external voltage references (V_{REFL} and V_{REFH} , respectively). The digital input is a 12-bit parallel word and the DAC input

register offers a readback capability. The converter can be powered from a single +5V supply or a dual $\pm 5V$ supply. The device offers a reset function which immediately sets the DAC output voltage and DAC register to mid-scale (code 800_H) or to zero-scale (code 000_H), depending on the status of the reset selection. See Figures 1 and 2 for the basic operation of the DAC7613.

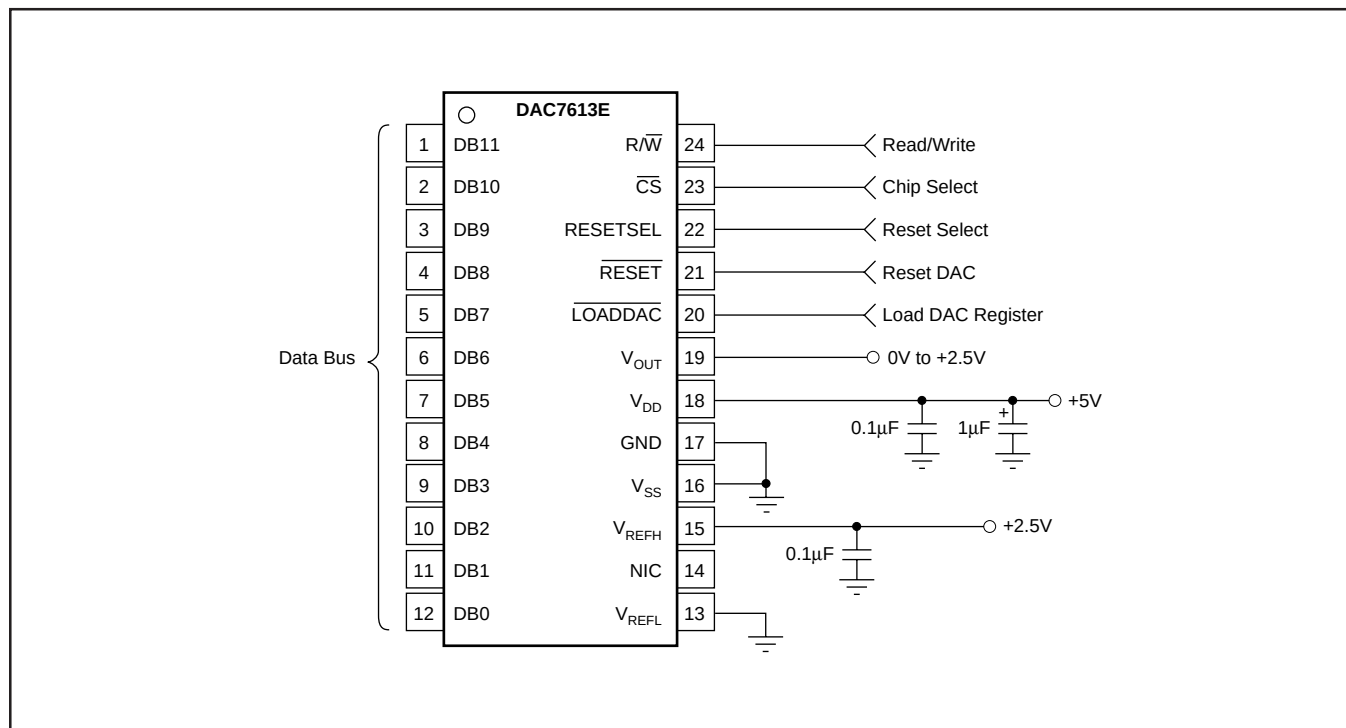


FIGURE 1. Basic Single-Supply Operation of the DAC7613.

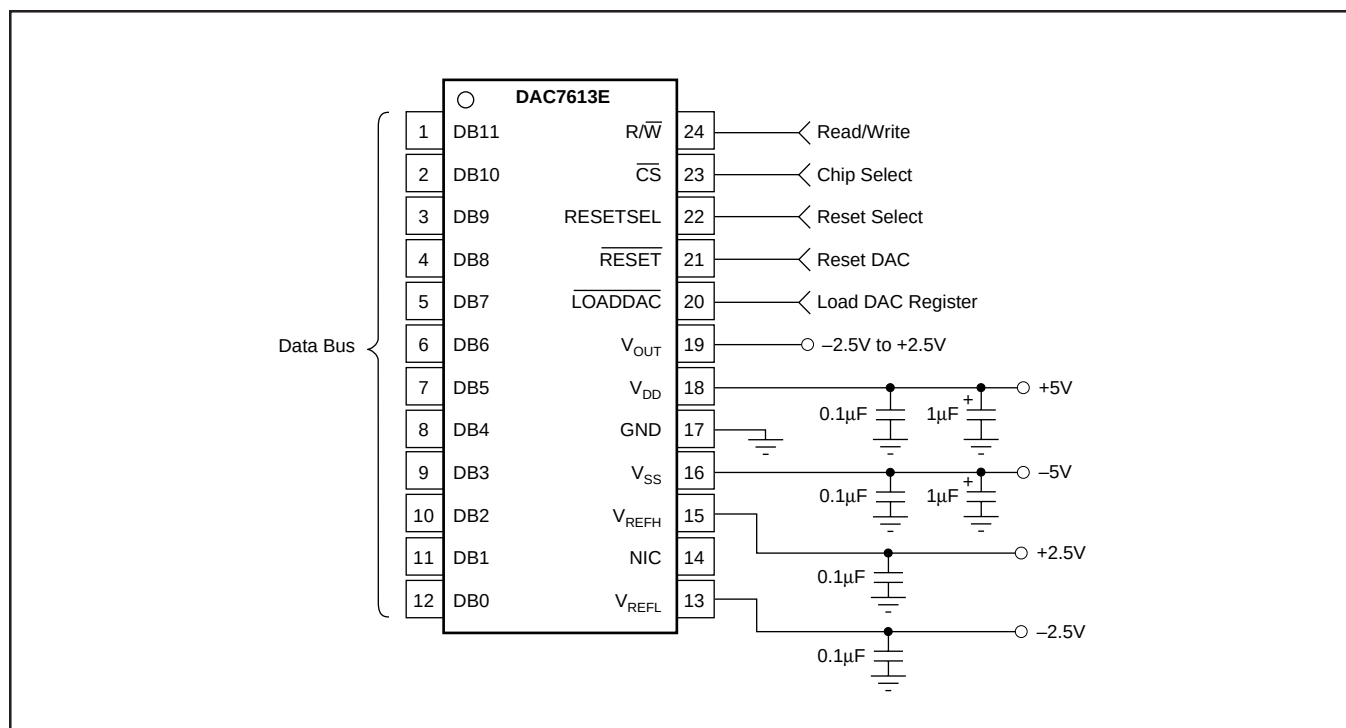


FIGURE 2. Basic Dual-Supply Operation of the DAC7613.

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 $-40^{\circ}C$ to $+85^{\circ}C$ temperature range. With $V_{SS} = 0V$ (single-supply operation), the output can swing to ground. Note that the settling time of the output op amp will be longer with voltages very near ground. Additionally, care must 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 (000_H, 001_H, 002_H, etc.) if the output amplifier has a negative offset.

The behavior of the output amplifier can be critical in some applications. Under short-circuit conditions (DAC output shorted to ground), the output amplifier can sink a great deal more current than it can source. See the Specifications table for more details concerning short-circuit current.

REFERENCE INPUTS

The reference inputs, V_{REFL} and V_{REFH} , can be any voltage between $V_{SS} + 2.25V$ and $V_{DD} - 2.25V$ provided that V_{REFH} is at least 1.25V greater than V_{REFL} . The minimum output of each DAC is equal to V_{REFL} plus a small offset voltage (essentially, the offset of the output op amp). The maximum output is equal to V_{REFH} 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_{REFH} input depends on the DAC output voltages and can vary from a few microamps to approximately 0.1 milliamp. The V_{REFH} source will not be required to sink current, only source it. Bypassing the reference voltage or voltages with at least a 0.1 μF capacitor placed as close to the DAC7613 package is strongly recommended.

DIGITAL INTERFACE

Table I shows the basic control logic for the DAC7613. Note that the internal register is level triggered and not edge triggered. When the appropriate signal is LOW, the register becomes transparent. When this signal is returned HIGH, the digital word currently in the register is latched. The first register (the input register) is triggered via the R/W, and CS inputs. The second register (the DAC register) is transparent when $\overline{LOADDAC}$ input is pulled LOW.

The double-buffered architecture is mainly designed so that the DAC input register can be written at any time and then the DAC voltage updated by pulling $\overline{LOADDAC}$ LOW.

$\overline{R/W}$	$\overline{CS}$	RST	$\overline{LOADDAC}$	INPUT REGISTER	DAC REGISTER	MODE
L	L	H	L	Write	Write	Write
L	L	H	H	Write	Hold	Write Input
H	L	H	H	Read	Hold	Read Input
X	H	H	L	Hold	Update	Update
X	H	H	H	Hold	Hold	Hold
X	H	L	X	Hold	Reset	Reset
X = Don't Care.						

TABLE I. DAC7613 Control Logic Truth Table.

DIGITAL TIMING

Figure 3 and Table II provide detailed timing for the digital interface of the DAC7613.

DIGITAL INPUT CODING

The DAC7613 input data is in Straight Binary format. The output voltage is given by the following equation:

$$V_{OUT} = V_{REFL} + \frac{(V_{REFH} - V_{REFL}) \cdot N}{4096} \quad (1)$$

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

SYMBOL	DESCRIPTION	MIN	TYP	MAX	UNITS
t_{RCS}	$\overline{CS}$ LOW for Read	200			ns
t_{RDS}	$R/\overline{W}$ HIGH to $\overline{CS}$ LOW	10			ns
t_{RDH}	$R/\overline{W}$ HIGH after $\overline{CS}$ HIGH	0			ns
t_{DZ}	$\overline{CS}$ HIGH to Data Bus in High Impedance		100		ns
t_{CSD}	$\overline{CS}$ LOW to Data Bus Valid		100	160	ns
t_{WCS}	$\overline{CS}$ LOW for Write	50			ns
t_{WS}	$R/\overline{W}$ LOW to $\overline{CS}$ LOW	0			ns
t_{WH}	$R/\overline{W}$ LOW after $\overline{CS}$ HIGH	5			ns
t_{DS}	Data Valid to $\overline{CS}$ LOW	0			ns
t_{DH}	Data Valid after $\overline{CS}$ HIGH	5			ns
t_{LWD}	$\overline{LOADDAC}$ LOW	50			ns
t_{RESET}	RESET LOW	50			ns

TABLE II. Timing Specifications ($T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$).

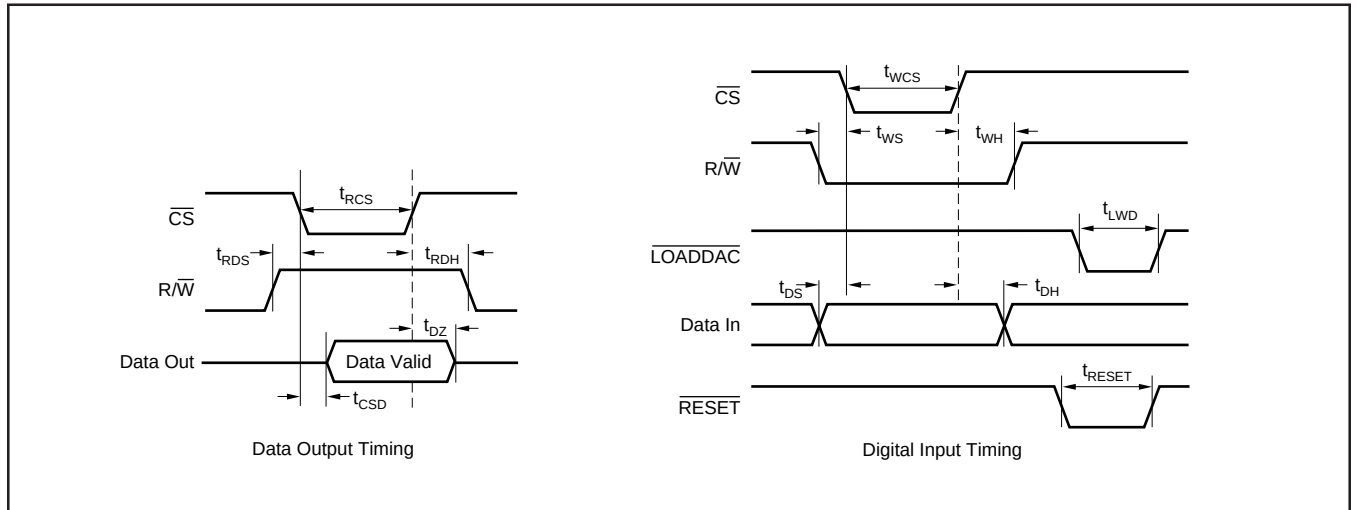


FIGURE 3. Digital Input and Output Timing.

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)
DAC7613E	Obsolete	Production	SSOP (DB) 24	-	-	Call TI	Call TI	-40 to 85	DAC7613E
DAC7613EB	Obsolete	Production	SSOP (DB) 24	-	-	Call TI	Call TI	-40 to 85	DAC7613E B
DAC7613EB/1K	Obsolete	Production	SSOP (DB) 24	-	-	Call TI	Call TI	-40 to 85	DAC7613E B

⁽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.

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