

# DAC7615

## Quad, Serial Input, 12-Bit, Voltage Output DIGITAL-TO-ANALOG CONVERTER

### FEATURES

- LOW POWER: 20mW
- UNIPOLAR OR BIPOLAR OPERATION
- SETTLING TIME: 10 $\mu$ s to 0.012%
- 12-BIT LINEARITY AND MONOTONICITY:  
-40°C to +85°C
- DOUBLE-BUFFERED DATA INPUTS
- SMALL 20-LEAD SSOP PACKAGE

### APPLICATIONS

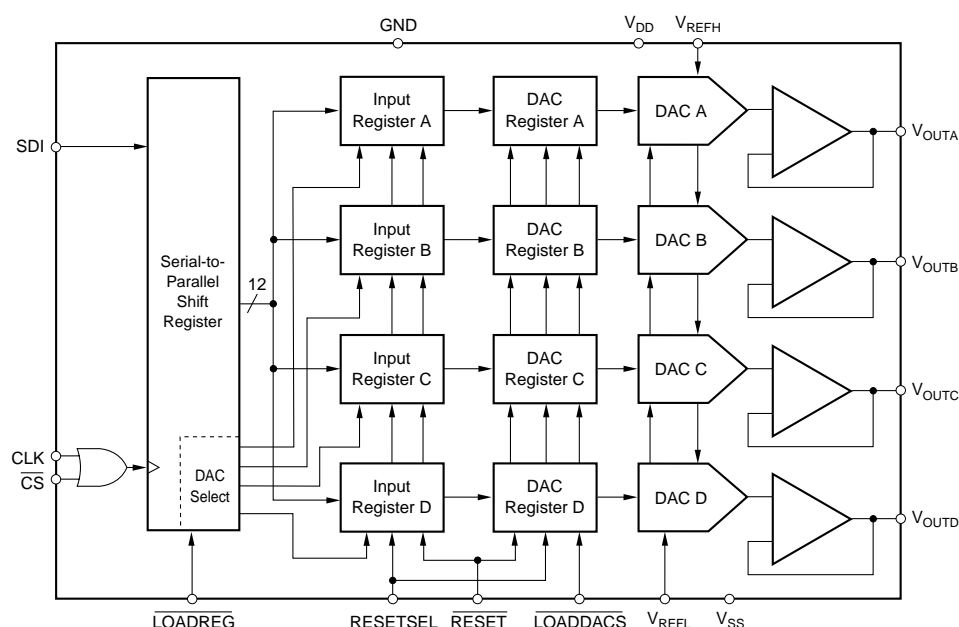
- PROCESS CONTROL
- ATE PIN ELECTRONICS
- CLOSED-LOOP SERVO-CONTROL
- MOTOR CONTROL
- DATA ACQUISITION SYSTEMS
- DAC-PER-PIN PROGRAMMERS

### DESCRIPTION

The DAC7615 is a quad, serial input, 12-bit, voltage output digital-to-analog converter (DAC) with guaranteed 12-bit monotonic performance over the -40°C to +85°C temperature range. An asynchronous reset clears all registers to either mid-scale (800<sub>H</sub>) or zero-scale (000<sub>H</sub>), selectable via the RESETSEL pin. The individual DAC inputs are double buffered to allow

for simultaneous update of all DAC outputs. The device can be powered from a single +5V supply or from dual +5V and -5V supplies.

Low power and small size makes the DAC7615 ideal for automatic test equipment, DAC-per-pin programmers, data acquisition systems, and closed-loop servo-control. The device is available in 16-pin plastic DIP, 16-lead SOIC, and 20-lead SSOP packages and is guaranteed over the -40°C to +85°C temperature range.



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# SPECIFICATIONS

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	DAC7615E, P, U			DAC7615EB, PB, UB			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
<b>ACCURACY</b>								
Linearity Error <sup>(1)</sup>	$V_{SS} = 0\text{V}$ or $-5\text{V}$	12		$\pm 2$	*		$\pm 1$	LSB <sup>(2)</sup>
Linearity Matching <sup>(3)</sup>	$V_{SS} = 0\text{V}$ or $-5\text{V}$			$\pm 2$			$\pm 1$	LSB
Differential Linearity Error	$V_{SS} = 0\text{V}$ or $-5\text{V}$			$\pm 1$			$\pm 1$	LSB
Monotonicity								Bits
Zero-Scale Error	Code = $000_H$			$\pm 4$			*	LSB
Zero-Scale Drift			2	5		*	*	ppm/ $^{\circ}\text{C}$
Zero-Scale Matching <sup>(3)</sup>				$\pm 2$			$\pm 1$	LSB
Full-Scale Error	Code = $FFF_H$			$\pm 4$			*	LSB
Full-Scale Matching <sup>(3)</sup>				$\pm 2$			$\pm 1$	LSB
Zero-Scale Error	Code = $00A_H$ , $V_{SS} = 0\text{V}$			$\pm 8$			*	LSB
Zero-Scale Drift	$V_{SS} = 0\text{V}$		5	10		*	*	ppm/ $^{\circ}\text{C}$
Zero-Scale Matching <sup>(3)</sup>	$V_{SS} = 0\text{V}$			$\pm 4$			$\pm 2$	LSB
Full-Scale Error	Code = $FFF_H$ , $V_{SS} = 0\text{V}$			$\pm 8$			*	LSB
Full-Scale Matching <sup>(3)</sup>	$V_{SS} = 0\text{V}$			$\pm 4$			$\pm 2$	LSB
Power Supply Rejection			30			*		ppm/V
<b>ANALOG OUTPUT</b>								
Voltage Output <sup>(4)</sup>	$V_{SS} = 0\text{V}$ or $-5\text{V}$	$V_{REFL}$		$V_{REFH}$	*		*	V
Output Current		$-1.25$		$+1.25$	*		*	mA
Load Capacitance	No Oscillation		100			*		pF
Short-Circuit Current			$+5, -15$			*		mA
Short-Circuit Duration			Indefinite			*		
<b>REFERENCE INPUT</b>								
$V_{REFH}$ Input Range	$V_{SS} = 0\text{V}$ or $-5\text{V}$	$V_{REFL} + 1.25$		$+2.5$	*		*	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
<b>DYNAMIC PERFORMANCE</b>								
Settling Time <sup>(5)</sup>	To $\pm 0.012\%$		5	10		*	*	$\mu\text{s}$
Channel-to-Channel Crosstalk	Full-Scale Step		0.1			*		LSB
Output Noise Voltage	On Any Other DAC, $R_L = 2\text{k}\Omega$ Bandwidth: 0Hz to 1MHz		40			*		nV/ $\sqrt{\text{Hz}}$
<b>DIGITAL INPUT/OUTPUT</b>								
Logic Family		TTL-Compatible CMOS					*	
Logic Levels								
$V_{IH}$	$ I_{IH}  \leq 10\mu\text{A}$	2.4		$V_{DD} + 0.3$	*		*	V
$V_{IL}$	$ I_{IL}  \leq 10\mu\text{A}$	$-0.3$		0.8	*		*	V
Data Format		Straight Binary				*		
<b>POWER SUPPLY REQUIREMENTS</b>								
$V_{DD}$	If $V_{SS} \neq 0\text{V}$	4.75		5.25	*		*	V
$V_{SS}$		$-5.25$		$-4.75$	*		*	V
$I_{DD}$			1.5	1.9		*	*	mA
$I_{SS}$		$-2.1$	$-1.6$		*	*	*	mA
Power Dissipation	$V_{SS} = -5\text{V}$		15	20		*	*	mW
	$V_{SS} = 0\text{V}$		7.5	10		*	*	mW
<b>TEMPERATURE RANGE</b>								
Specified Performance		$-40$		$+85$	*		*	$^{\circ}\text{C}$

\* Specification same as grade to the left.

NOTES: (1) If  $V_{SS} = 0\text{V}$ , specification applies at code  $00A_H$  and above. (2) LSB means Least Significant Bit, with  $V_{REFH}$  equal to  $+2.5\text{V}$  and  $V_{REFL}$  equal to  $-2.5\text{V}$ , one LSB is  $1.22\text{mV}$ . (3) All DAC outputs will match within the specified error band. (4) Ideal output voltage, does not take into account zero or full-scale error. (5) If  $V_{SS} = -5\text{V}$ , full-scale step from code  $000_H$  to  $FFF_H$  or vice-versa. If  $V_{SS} = 0\text{V}$ , full-scale positive step from code  $000_H$  to  $FFF_H$  and negative step from code  $FFF_H$  to  $00A_H$ .

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## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

$V_{DD}$ 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 $V_{DD} + 0.3V$
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.

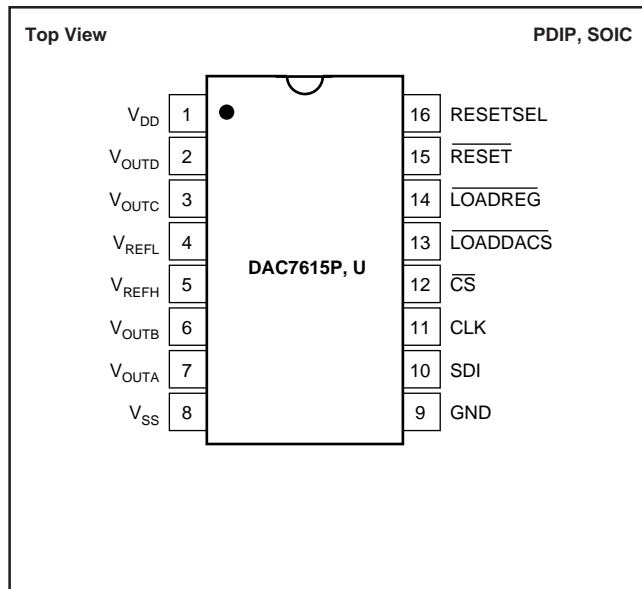
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## PACKAGE/ORDERING INFORMATION

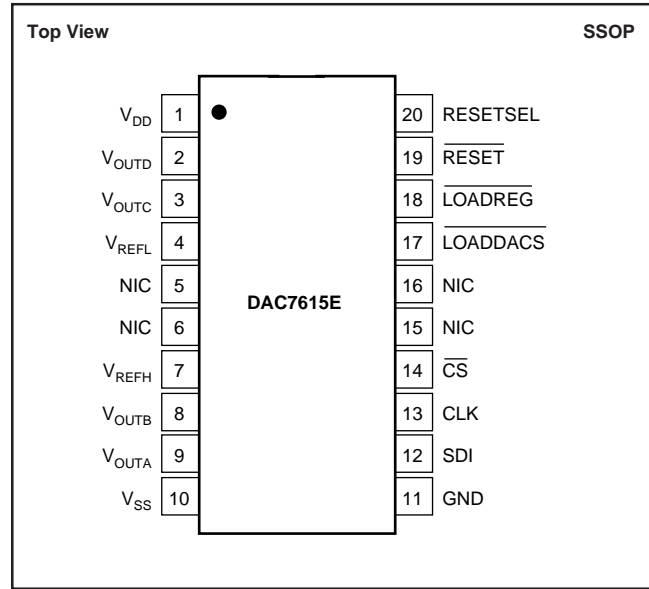
PRODUCT	MAXIMUM LINEARITY ERROR (LSB)	MAXIMUM DIFFERENTIAL LINEARITY (LSB)	PACKAGE	PACKAGE DRAWING NUMBER <sup>(1)</sup>	SPECIFICATION TEMPERATURE RANGE	ORDERING NUMBER <sup>(2)</sup>	TRANSPORT MEDIA
DAC7615P	±2	±1	16-Pin DIP	180	–40°C to +85°C	DAC7615P	Rails
DAC7615PB	"	"	"	"	"	DAC7615PB	Rails
DAC7615U	±2	±1	16-Lead SOIC	211	–40°C to +85°C	DAC7615U	Rails
"	"	"	"	"	"	DAC7615U/1K	Tape and Reel
DAC7615UB	±1	±1	16-Lead SOIC	211	–40°C to +85°C	DAC7615UB	Rails
"	"	"	"	"	"	DAC7615UB/1K	Tape and Reel
DAC7615E	±2	±1	20-Lead SSOP	334	–40°C to +85°C	DAC7615E	Rails
"	"	"	"	"	"	DAC7615E/1K	Tape and Reel
DAC7615EB	±1	±1	20-Lead SSOP	334	–40°C to +85°C	DAC7615EB	Rails
"	"	"	"	"	"	DAC7615EB/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 "DAC7615EB/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—P, U Packages



## PIN CONFIGURATION—E Package



## PIN DESCRIPTIONS—P, U Packages

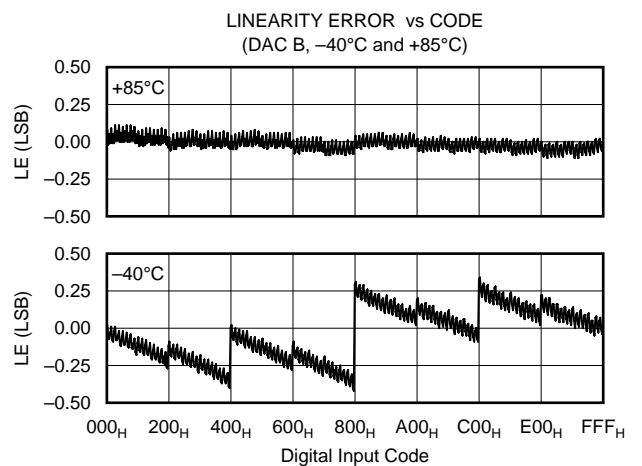
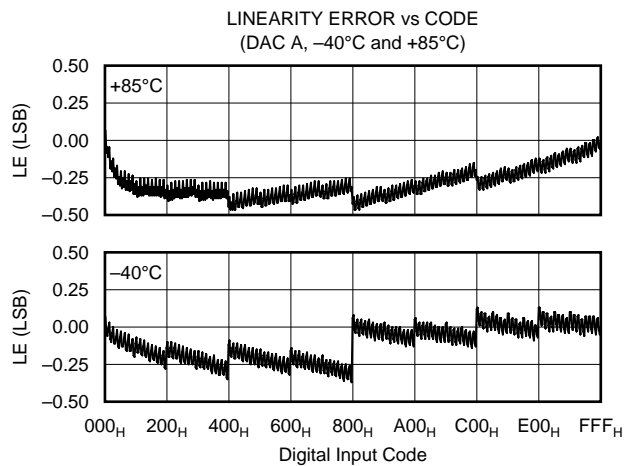
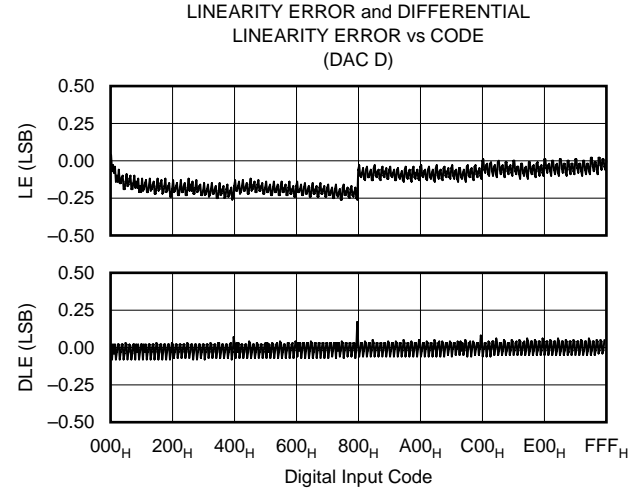
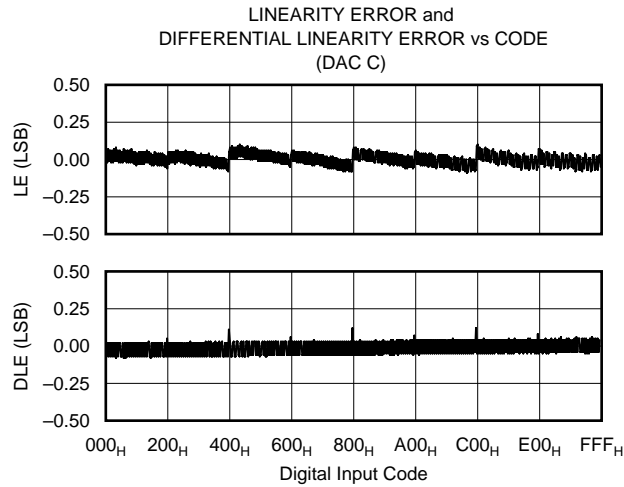
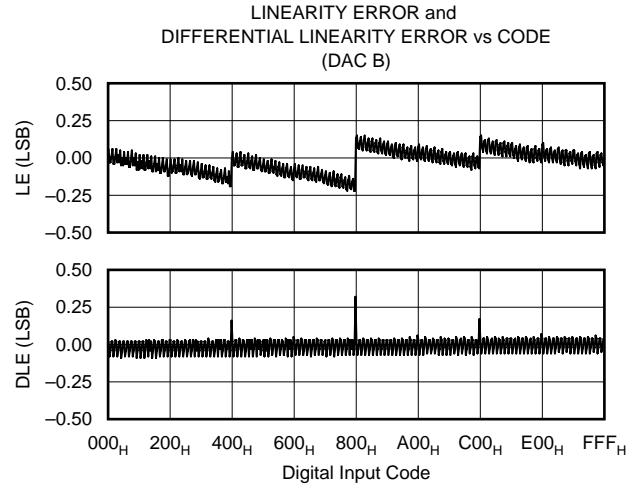
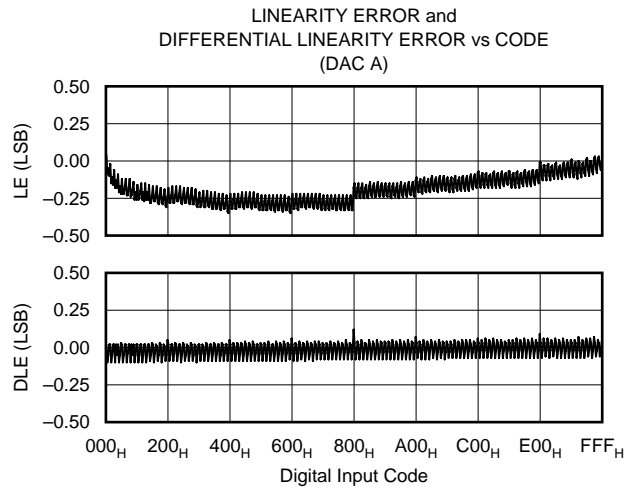
PIN	LABEL	DESCRIPTION
1	$V_{DD}$	Positive Analog Supply Voltage, +5V nominal.
2	$V_{OUTD}$	DAC D Voltage Output
3	$V_{OUTC}$	DAC C Voltage Output
4	$V_{REFL}$	Reference Input Voltage Low. Sets minimum output voltage for all DACs.
5	$V_{REFH}$	Reference Input Voltage High. Sets maximum output voltage for all DACs.
6	$V_{OUTB}$	DAC B Voltage Output
7	$V_{OUTA}$	DAC A Voltage Output
8	$V_{SS}$	Negative Analog Supply Voltage, 0V or –5V nominal.
9	GND	Ground
10	SDI	Serial Data Input
11	CLK	Serial Data Clock
12	$\overline{CS}$	Chip Select Input
13	$\overline{LOADDACs}$	All DAC registers become transparent when $\overline{LOADDACs}$ is LOW. They are in the latched state when $\overline{LOADDACs}$ is HIGH.
14	$\overline{LOADREG}$	The selected input register becomes transparent when $\overline{LOADREG}$ is LOW. It is in the latched state when $\overline{LOADREG}$ is HIGH.
15	$\overline{RESET}$	Asynchronous Reset Input. Sets DAC and input registers to either zero-scale (000 <sub>H</sub> ) or mid-scale (800 <sub>H</sub> ) when LOW. RESETSEL determines which code is active.
16	RESETSEL	When LOW, a LOW on $\overline{RESET}$ will cause the DAC and input registers to be set to code 000 <sub>H</sub> . When RESETSEL is HIGH, a LOW on $\overline{RESET}$ will set the registers to code 800 <sub>H</sub> .

## PIN DESCRIPTIONS—E Package

PIN	LABEL	DESCRIPTION
1	$V_{DD}$	Positive Analog Supply Voltage, +5V nominal.
2	$V_{OUTD}$	DAC D Voltage Output
3	$V_{OUTC}$	DAC C Voltage Output
4	$V_{REFL}$	Reference Input Voltage Low. Sets minimum output voltage for all DACs.
5	NIC	Not Internally Connected.
6	NIC	Not Internally Connected.
7	$V_{REFH}$	Reference Input Voltage High. Sets maximum output voltage for all DACs.
8	$V_{OUTB}$	DAC B Voltage Output
9	$V_{OUTA}$	DAC A Voltage Output
10	$V_{SS}$	Negative Analog Supply Voltage, 0V or –5V nominal.
11	GND	Ground
12	SDI	Serial Data Input
13	CLK	Serial Data Clock
14	$\overline{CS}$	Chip Select Input
15	NIC	Not Internally Connected.
16	NIC	Not Internally Connected.
17	$\overline{LOADDACs}$	All DAC registers becomes transparent when $\overline{LOADDACs}$ is LOW. They are in the latched state when $\overline{LOADDACs}$ is HIGH.
18	$\overline{LOADREG}$	The selected input register becomes transparent when $\overline{LOADREG}$ is LOW. It is in the latched state when $\overline{LOADREG}$ is HIGH.
19	$\overline{RESET}$	Asynchronous Reset Input. Sets all DAC registers to either zero-scale (000 <sub>H</sub> ) or mid-scale (800 <sub>H</sub> ) when LOW. RESETSEL determines which code is active.
20	RESETSEL	When LOW, a LOW on $\overline{RESET}$ will cause all DAC registers to be set to code 000 <sub>H</sub> . When RESETSEL is HIGH, a LOW on $\overline{RESET}$ will set the registers to code 800 <sub>H</sub> .

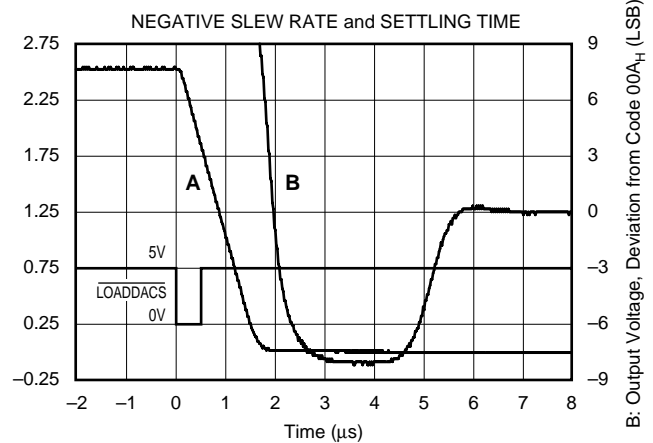
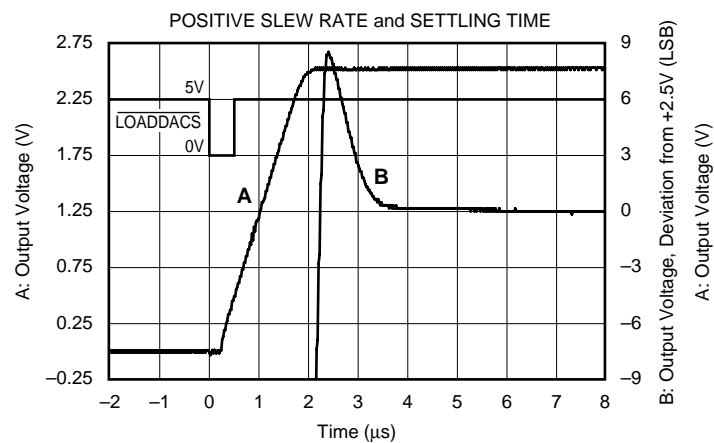
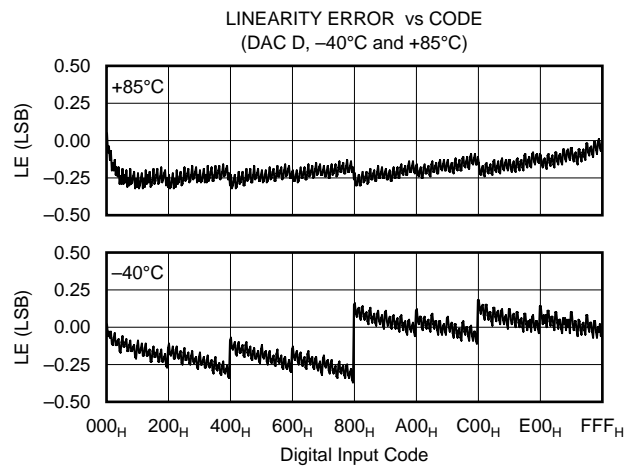
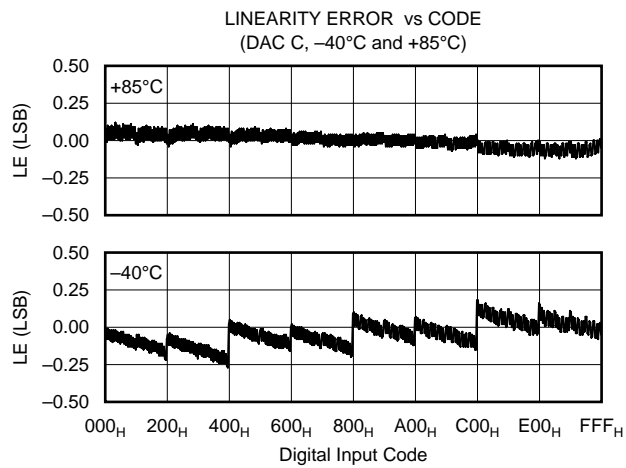
# TYPICAL PERFORMANCE CURVES: $V_{SS} = 0V$

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



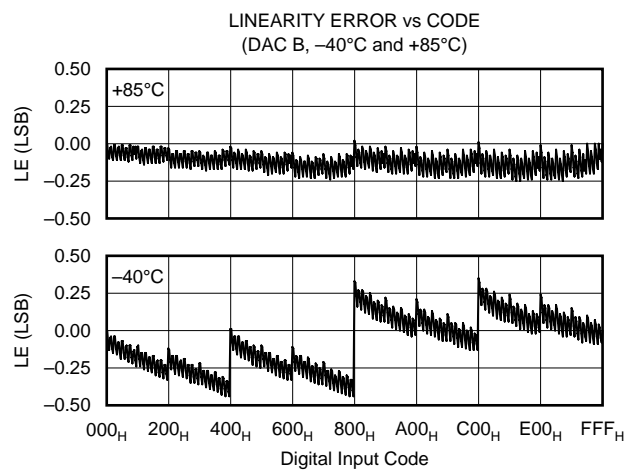
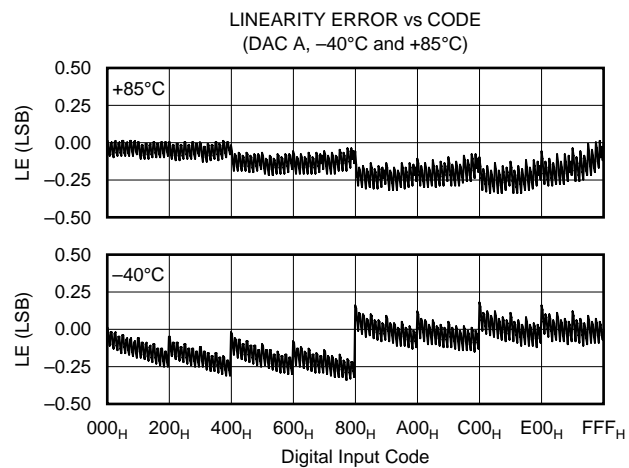
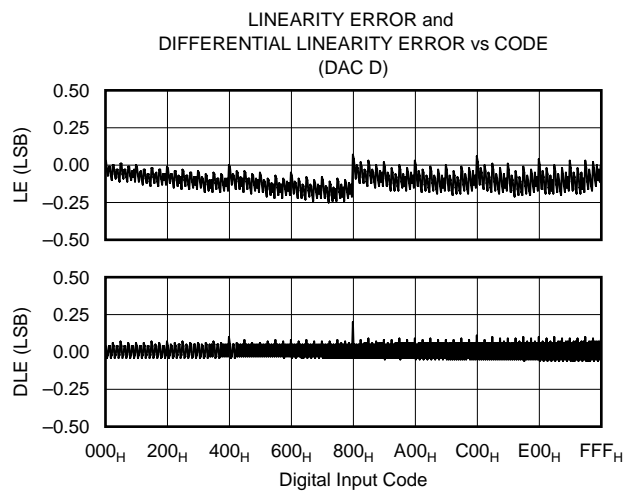
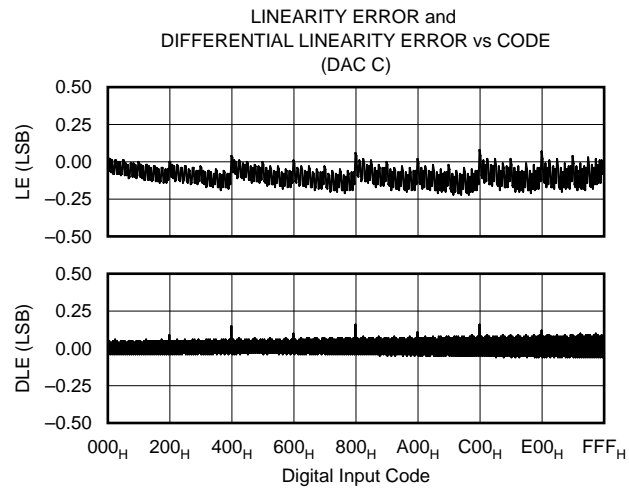
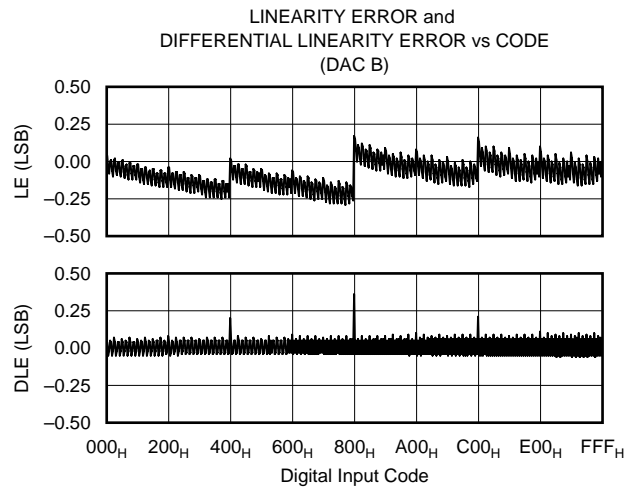
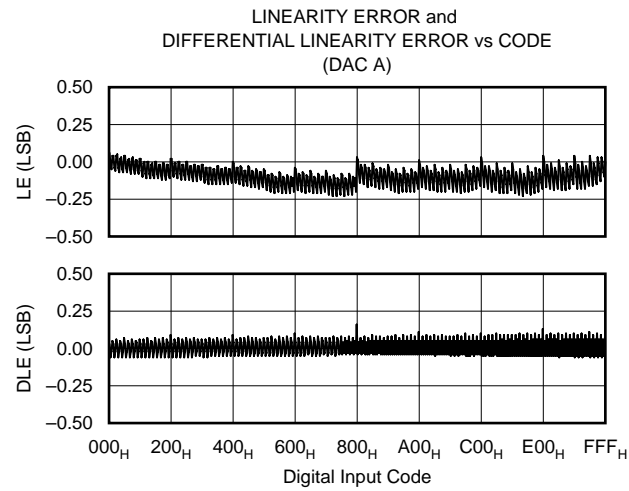
# TYPICAL PERFORMANCE CURVES: $V_{SS} = 0V$ (CONT)

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



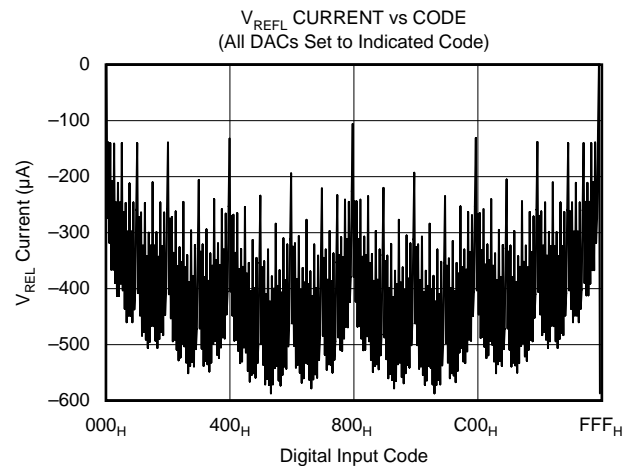
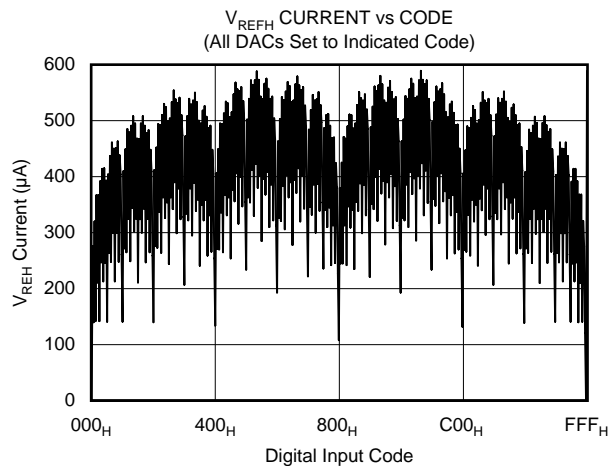
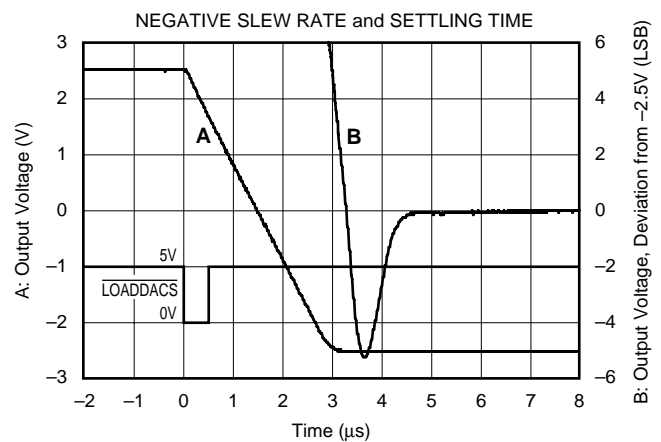
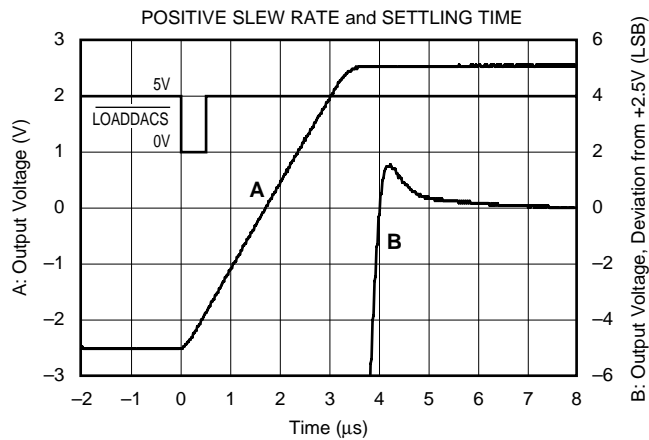
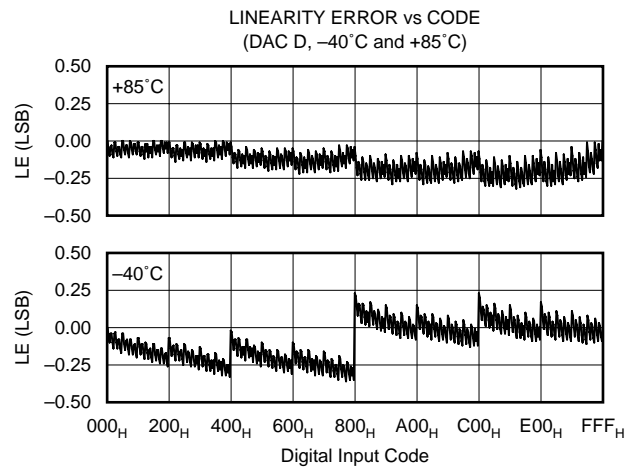
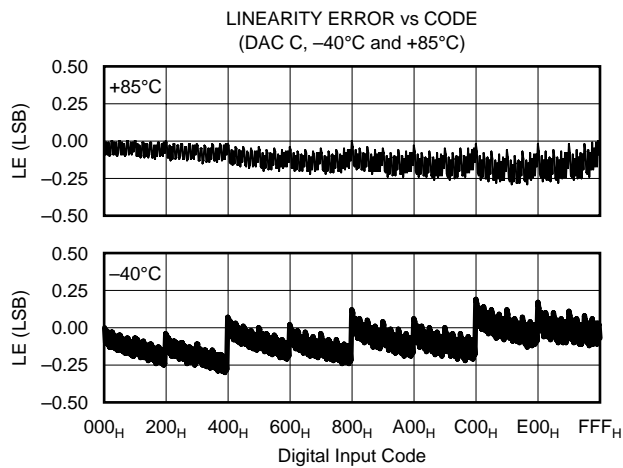
# TYPICAL PERFORMANCE CURVES: $V_{SS} = -5V$

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



# TYPICAL PERFORMANCE CURVES: $V_{SS} = -5V$ (CONT)

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



# THEORY OF OPERATION

The DAC7615 is a quad, serial input, 12-bit, voltage output DAC. The architecture is a classic R-2R ladder configuration followed by an operational amplifier that serves as a buffer. Each DAC has its own R-2R ladder network and output op amp, but all share the reference voltage inputs. The minimum voltage output (“zero-scale”) and maximum voltage output (“full-scale”) are set by external voltage references ( $V_{REFL}$  and  $V_{REFH}$ , respectively). The digital input is a 16-bit serial word that contains the 12-bit DAC code and a 2-bit address code that selects one of the four DACs (the two remaining bits are unused). The converter can be powered from a single +5V supply or a dual  $\pm 5V$  supply. Each device offers a reset function which immediately sets all DAC output voltages and internal registers to either zero-scale (code 000<sub>H</sub>) or mid-scale (code 800<sub>H</sub>). The reset code is selected by the state of the RESETSEL pin (LOW = 000<sub>H</sub>, HIGH = 800<sub>H</sub>). See Figures 1 and 2 for the basic operation of the DAC7615.

## ANALOG OUTPUTS

When  $V_{SS} = -5V$  (dual supply operation), the output amplifier can swing to within 2.25V of the supply rails, 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. Also, care must be taken when measuring the zero-scale error when  $V_{SS} = 0V$ . If the output amplifier has a negative offset, the output voltage may not change for the first few digital input codes (000<sub>H</sub>, 001<sub>H</sub>, 002<sub>H</sub>, etc.) since the output voltage cannot swing below ground.

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.

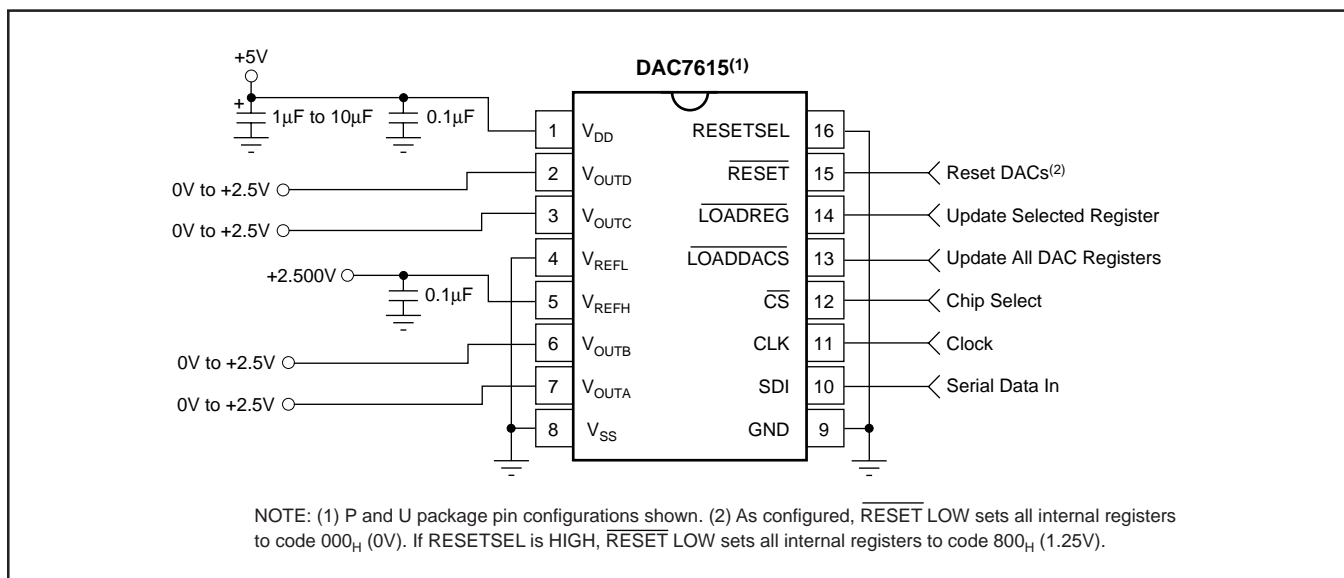


FIGURE 1. Basic Single-Supply Operation of the DAC7615.

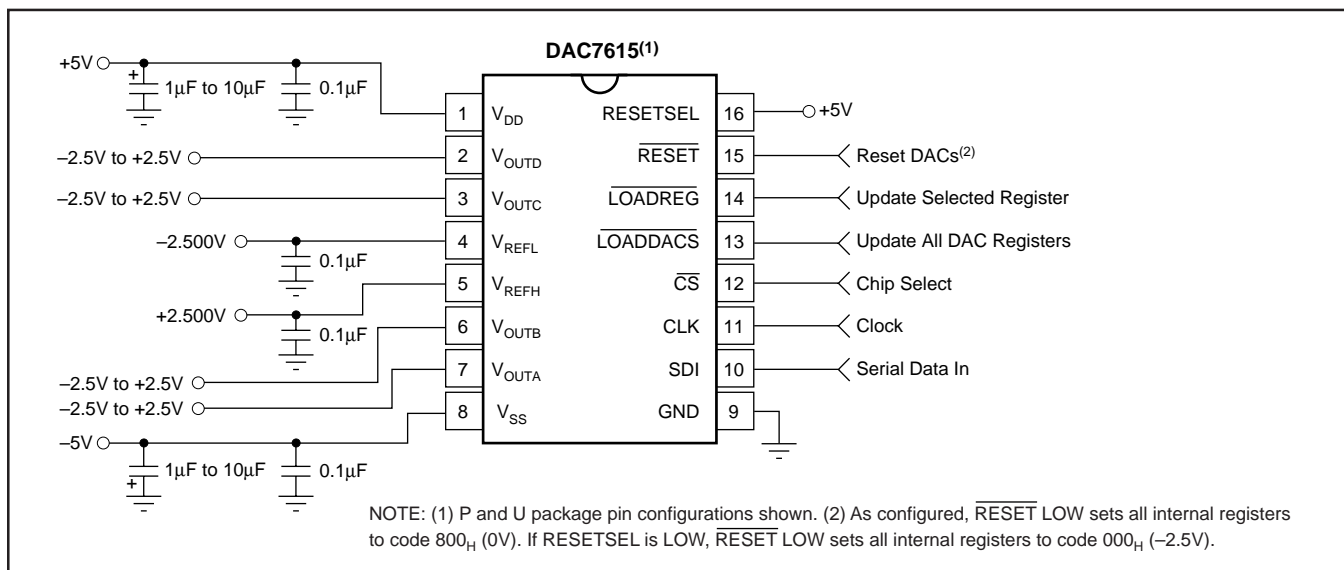


FIGURE 2. Basic Dual-Supply Operation of the DAC7615.

## 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  $V_{REFL} - 1LSB$  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 reference inputs depends on the DAC output voltages and can vary from a few microamps to approximately 0.6 milliamp. Bypassing the reference voltage or voltages with a 0.1 $\mu F$  capacitor placed as close as possible to the DAC7615 package is strongly recommended.

## DIGITAL INTERFACE

Figure 3 and Table I provide the basic timing for the DAC7615. The interface consists of a serial clock (CLK), serial data (SDI), a load register signal ( $\overline{LOADREG}$ ), and a "load all DAC registers" signal ( $\overline{LOADDACS}$ ). In addition, a chip select ( $\overline{CS}$ ) input is available to enable serial communication when there are multiple serial devices. An asyn-

SYMBOL	DESCRIPTION	MIN	TYP	MAX	UNITS
$t_{DS}$	Data Valid to CLK Rising	25			ns
$t_{DH}$	Data Held Valid after CLK Rises	20			ns
$t_{CH}$	CLK HIGH	30			ns
$t_{CL}$	CLK LOW	50			ns
$t_{CSS}$	$\overline{CS}$ LOW to CLK Rising	55			ns
$t_{CSH}$	CLK HIGH to $\overline{CS}$ Rising	15			ns
$t_{LD1}$	$\overline{LOADREG}$ HIGH to CLK Rising	40			ns
$t_{LD2}$	CLK Rising to $\overline{LOADREG}$ LOW	15			ns
$t_{LDRW}$	$\overline{LOADREG}$ LOW Time	45			ns
$t_{LDDW}$	$\overline{LOADDACS}$ LOW Time	45			ns
$t_{RSSH}$	RESETSEL Valid to RESET LOW	25			ns
$t_{RSTW}$	RESET LOW Time	70			ns
$t_s$	Settling Time	10			$\mu s$

TABLE I. Timing Specifications ( $T_A = -40^\circ C$  to  $+85^\circ C$ ).

chronous reset input ( $\overline{RESET}$ ) is provided to simplify start-up conditions, periodic resets, or emergency resets to a known state.

The DAC code and address are provided via a 16-bit serial interface as shown in Figure 3. The first two bits select the input register that will be updated when  $\overline{LOADREG}$  goes LOW (see Table II). The next two bits are not used. The last 12 bits are the DAC code which is provided, most significant bit first.

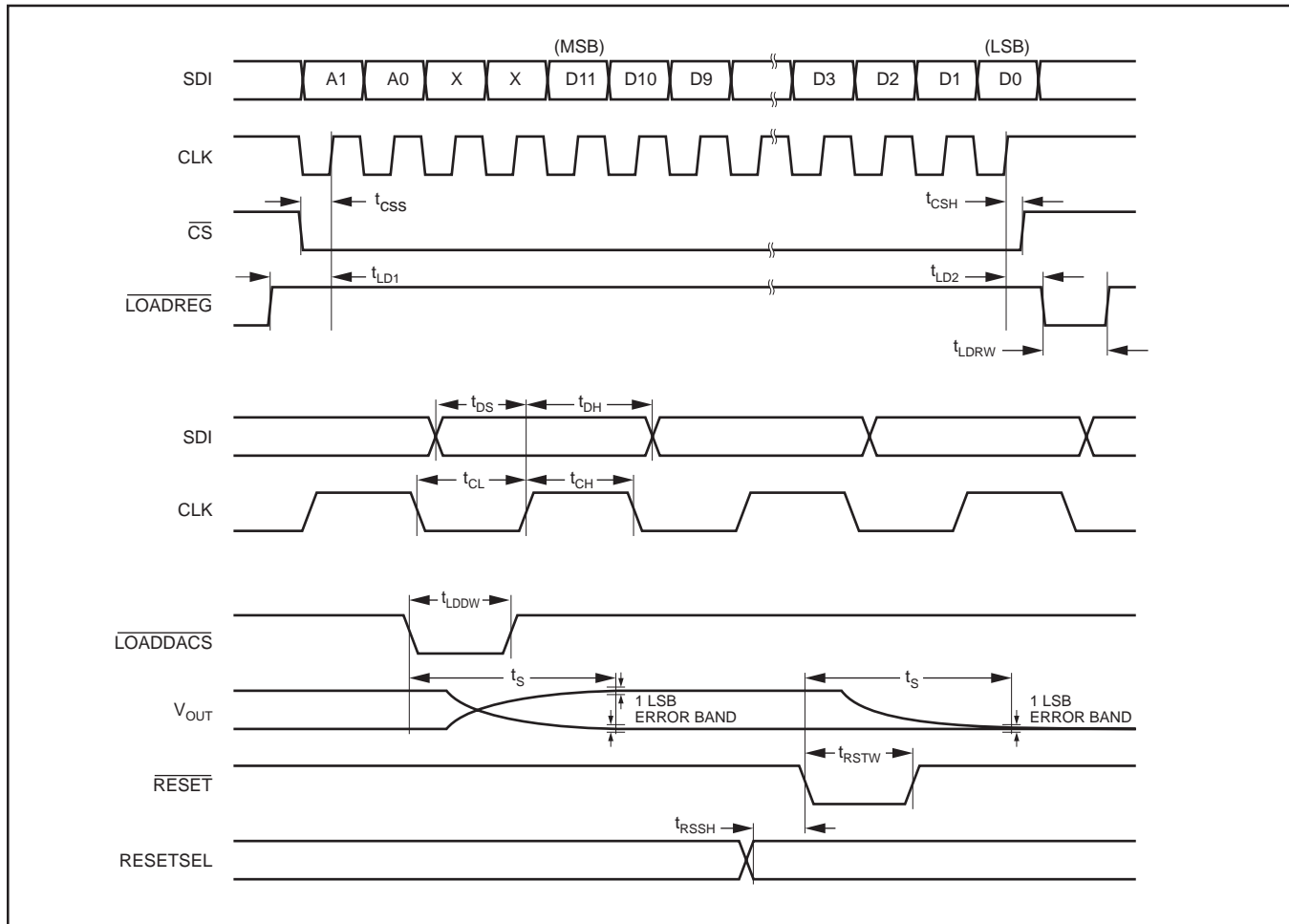


FIGURE 3. DAC7615 Timing.

A1	A0	LOADREG	LOADDACS	RESET	SELECTED INPUT REGISTER	STATE OF SELECTED INPUT REGISTER	STATE OF ALL DAC REGISTERS
L <sup>(1)</sup>	L	L	H <sup>(2)</sup>	H	A	Transparent	Latched
L	H	L	H	H	B	Transparent	Latched
H	L	L	H	H	C	Transparent	Latched
H	H	L	H	H	D	Transparent	Latched
X <sup>(3)</sup>	X	H	L	H	NONE	(All Latched)	Transparent
X	X	H	H	H	NONE	(All Latched)	Latched
X	X	X	X	L	ALL	Reset <sup>(4)</sup>	Reset <sup>(4)</sup>

NOTES: (1) L = Logic LOW. (2) H = Logic HIGH. (3) X = Don't Care. (4) Resets to either 000H or 800H, per the RESETSEL state (LOW = 000H, HIGH = 800H). When RESET rises, all registers that are in their latched state retain the reset value.

TABLE II. Control Logic Truth Table.

$\overline{CS}^{(1)}$	CLK <sup>(1)</sup>	LOADREG	RESET	SERIAL SHIFT REGISTER
H <sup>(2)</sup>	X <sup>(3)</sup>	H	H	No Change
L <sup>(4)</sup>	L	H	H	No Change
L	↑ <sup>(5)</sup>	H	H	Advanced One Bit
↑	L	H	H	Advanced One Bit
H <sup>(6)</sup>	X	L <sup>(7)</sup>	H	No Change
H <sup>(6)</sup>	X	H	L <sup>(8)</sup>	No Change

NOTES: (1)  $\overline{CS}$  and CLK are interchangeable. (2) H = Logic HIGH. (3) X = Don't Care. (4) L = Logic LOW (5) = Positive Logic Transition. (6) A HIGH value is suggested in order to avoid a "false clock" from advancing the shift register and changing the shift register. (7) If data is clocked into the serial register while LOADREG is LOW, the selected input register will change as the shift register bits "flow" through A1 and A0. This will corrupt the data in each input register that has been erroneously selected. (8) RESET LOW causes no change in the contents of the serial shift register.

TABLE III. Serial Shift Register Truth Table.

Note that  $\overline{CS}$  and CLK are combined with an OR gate and the output controls the serial-to-parallel shift register internal to the DAC7615 (see the block diagram on the front of this data sheet). These two inputs are completely interchangeable. In addition, care must be taken with the state of CLK when  $\overline{CS}$  rises at the end of a serial transfer. If CLK is LOW when  $\overline{CS}$  rises, the OR gate will provide a rising edge to the shift register, shifting the internal data one additional bit. The result will be incorrect data and possible selection of the wrong input register.

If both  $\overline{CS}$  and CLK are used, then  $\overline{CS}$  should rise only when CLK is HIGH. If not, then either  $\overline{CS}$  or CLK can be used to operate the shift register. See Table III for more information.

The digital data into the DAC7615 is double-buffered. This allows new data to be entered for each DAC without disturbing the analog outputs. When the new settings have been entered into the device, all of the DAC outputs can be updated simultaneously. The transfer from the input registers to the DAC registers is accomplished with a HIGH to LOW transition on the LOADDACS input.

Because the DAC registers become transparent when LOADDACS is LOW, it is possible to keep this pin LOW and update each DAC via LOADREG. However, as each new data word is entered into the device, the corresponding output will update immediately when LOADREG is taken LOW.

### Digital Input Coding

The DAC7615 input data is in Straight Binary format. The output voltage is given by the following equation:

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

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

## LAYOUT

A precision analog component requires careful layout, adequate bypassing, and clean, well-regulated power supplies. As the DAC7615 offers single-supply operation, it will often be used in close proximity with digital logic, microcontrollers, microprocessors, and digital signal processors. The more digital logic present in the design and the higher the switching speed, the more difficult it will be to achieve good performance from the converter.

Because the DAC7615 has a single ground pin, all return currents, including digital and analog return currents, must flow through the GND pin. Ideally, GND would be connected directly to an analog ground plane. This plane would be separate from the ground connection for the digital components until they were connected at the power entry point of the system (see Figure 4).

The power applied to  $V_{DD}$  (as well as  $V_{SS}$ , if not grounded) should be well regulated and low noise. Switching power supplies and DC/DC converters will often have high-frequency glitches or spikes riding on the output voltage. In addition, digital components can create similar high-frequency spikes as their internal logic switches states. This noise can easily couple into the DAC output voltage through various paths between the power connections and analog output.

As with the GND connection,  $V_{DD}$  should be connected to a +5V power supply plane or trace that is separate from the connection for digital logic until they are connected at the power entry point. In addition, the 1 $\mu$ F to 10 $\mu$ F and 0.1 $\mu$ F capacitors shown in Figure 4 are strongly recommended. In some situations, additional bypassing may be required, such as a 100 $\mu$ F electrolytic capacitor or even a “Pi” filter made up of inductors and capacitors—all designed to essentially lowpass filter the +5V supply, removing the high frequency noise (see Figure 4).

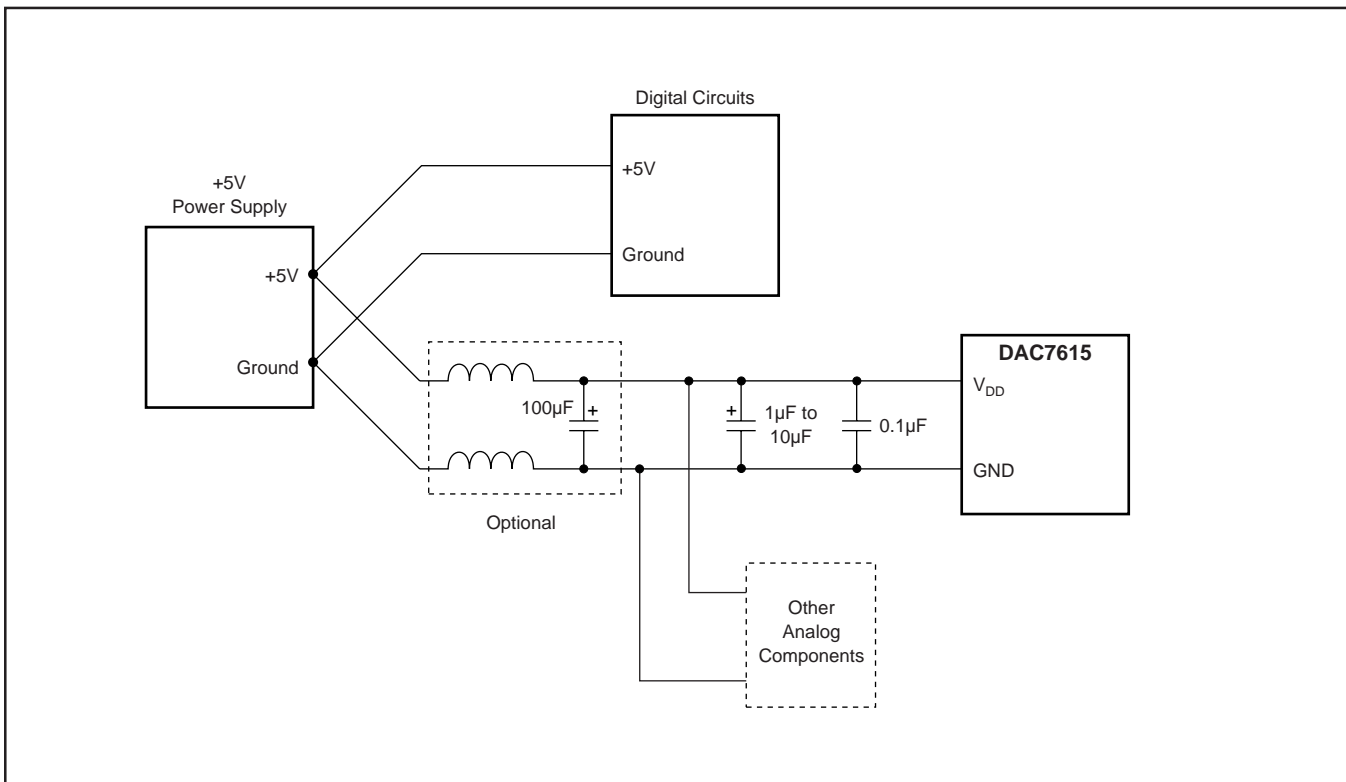


FIGURE 4. Suggested Power and Ground Connections for a DAC7615 Sharing a +5V Supply with a Digital System.

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