



DAC7621

For most current data sheet and other product information, visit www.burr-brown.com

12-Bit, Parallel Input DIGITAL-TO-ANALOG CONVERTER

FEATURES

- **LOW POWER:** 2.5mW
- **FAST SETTling:** 7 μ s to 1 LSB
- **1mV LSB WITH 4.095V FULL-SCALE RANGE**
- **COMPLETE WITH REFERENCE**
- **12-BIT LINEARITY AND MONOTONICITY OVER INDUSTRIAL TEMP RANGE**
- **ASYNCHRONOUS RESET TO 0V**

APPLICATIONS

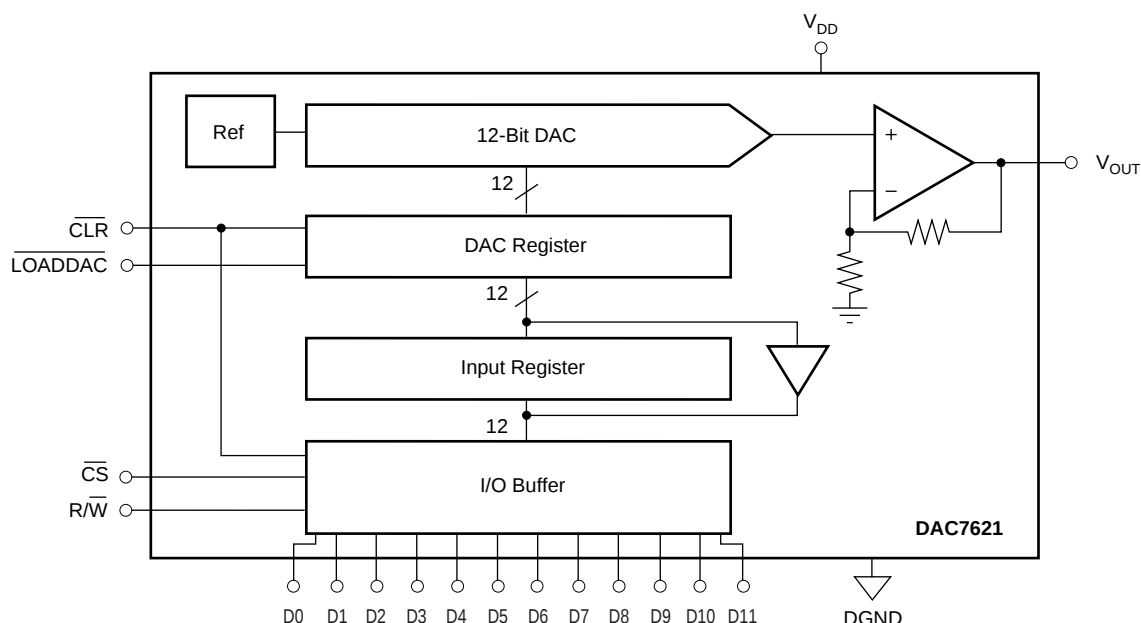
- **PROCESS CONTROL**
- **DATA ACQUISITION SYSTEMS**
- **CLOSED-LOOP SERVO-CONTROL**
- **PC PERIPHERALS**
- **PORTABLE INSTRUMENTATION**

DESCRIPTION

The DAC7621 is a 12-bit digital-to-analog converter (DAC) with guaranteed 12-bit monotonicity performance over the industrial temperature range. It requires a single +5V supply and contains an input register, latch, 2.435V reference, DAC, and high speed rail-to-rail output amplifier. For a full-scale step, the output will settle to 1 LSB within 7 μ s. The device consumes 2.5mW (0.5mA at 5V).

The parallel interface is compatible with a wide variety of microcontrollers. The DAC7621 accepts a 12-bit parallel word, has a double-buffered input logic structure and provides data readback. In addition, two control pins provide a chip select ($\overline{CS}$) function and asynchronous clear ($\overline{CLR}$) input. The $\overline{CLR}$ input can be used to ensure that the DAC7621 output is 0V on power-up or as required by the application.

The DAC7621 is available in a 20-lead SSOP package and is fully specified over the industrial temperature range of -40°C to $+85^{\circ}\text{C}$.



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

SPECIFICATIONS

ELECTRICAL

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

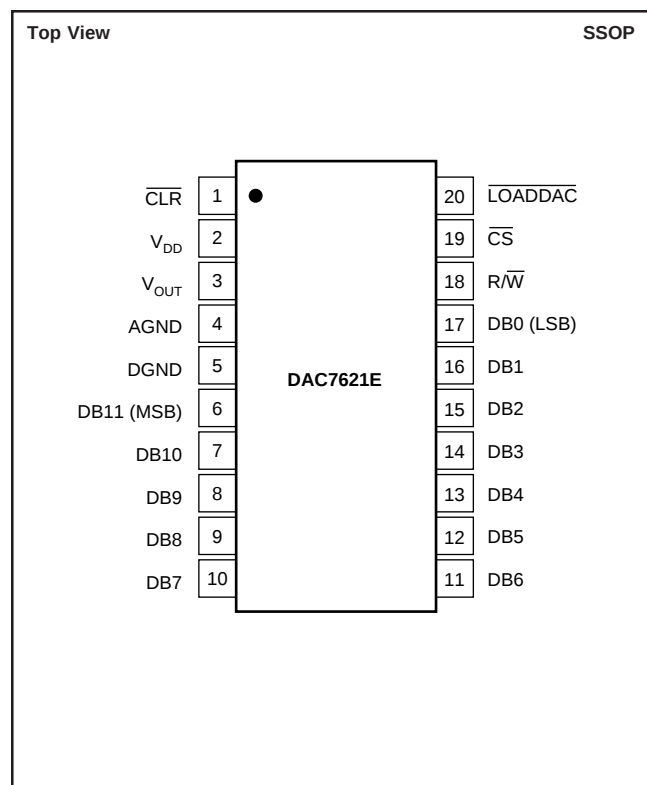
PARAMETER	CONDITIONS	DAC7621E			DAC7621EB			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
RESOLUTION		12			*			Bits
ACCURACY								
Relative Accuracy ⁽¹⁾	Guaranteed Monotonic Code 000 _H Code FFF _H	-2	±1/2	+2	-1	±1/4	+1	LSB
Differential Nonlinearity		-1	±1/2	+1	-1	±1/4	+1	LSB
Zero-Scale Error		-1	+1	+3	*	*	*	LSB
Full Scale Voltage		4.079	4.095	4.111	4.087	4.095	4.103	V
ANALOG OUTPUT								
Output Current	Code 800 _H $R_{LOAD} \geq 402\Omega$, Code 800 _H No Oscillation GND or V_{DD}	±5	±7	3	*	*	*	mA
Load Regulation			1			*		LSB
Capacitive Load			500			*		pF
Short-Circuit Current			±20			*		mA
Short-Circuit Duration			Indefinite			*		
DIGITAL INPUT								
Data Format		0.7 • V_{DD}	Parallel	0.3 • V_{DD} ±10 ±10	*	*	*	V
Data Coding			Straight Binary			*		V
Logic Family			CMOS			*		μA
Logic Levels						*		μA
V_{IH}								
V_{IL}								
I_{IH}								
I_{IL}								
DYNAMIC PERFORMANCE								
Settling Time ⁽²⁾ (t_S)	To ±1 LSB of Final Value		7			*		μs
DAC Glitch			5			*		nV-s
Digital Feedthrough			2			*		nV-s
POWER SUPPLY								
V_{DD}	$V_{IH} = 5\text{V}$, $V_{IL} = 0\text{V}$, No Load, at Code 000 _H $V_{IH} = 5\text{V}$, $V_{IL} = 0\text{V}$, No Load $\Delta V_{DD} = \pm 5\%$	+4.75	+5.0	+5.25	*	*	*	V
I_{DD}			0.5			*		mA
Power Dissipation			2.5			*		mW
Power Supply Sensitivity			0.001			*		%/%
TEMPERATURE RANGE								
Specified Performance		-40		+85	*		*	°C

* Same specification as for DAC7621E.

NOTES: (1) This term is sometimes referred to as Linearity Error or Integral Nonlinearity (INL). (2) Specification does not apply to negative-going transitions where the final output voltage will be within 3 LSBs of ground. In this region, settling time may be double the value indicated.

The information provided herein is believed to be reliable; however, BURR-BROWN assumes no responsibility for inaccuracies or omissions. BURR-BROWN assumes no responsibility for the use of this information, and all use of such information shall be entirely at the user's own risk. Prices and specifications are subject to change without notice. No patent rights or licenses to any of the circuits described herein are implied or granted to any third party. BURR-BROWN does not authorize or warrant any BURR-BROWN product for use in life support devices and/or systems.

PIN CONFIGURATION



PIN DESCRIPTIONS

PIN	LABEL	DESCRIPTION
1	$\overline{CLR}$	Reset. Resets the DAC register to zero. Active LOW. Asynchronous input.
2	V_{DD}	Positive Power Supply
3	V_{OUT}	DAC Output Voltage
4	AGND	Analog Ground
5	DGND	Digital Ground
6	DB11	Data Bit 11, MSB
7	DB10	Data Bit 10
8	DB9	Data Bit 9
9	DB8	Data Bit 8
10	DB7	Data Bit 7
11	DB6	Data Bit 6
12	DB5	Data Bit 5
13	DB4	Data Bit 4
14	DB3	Data Bit 3
15	DB2	Data Bit 2
16	DB1	Data Bit 1
17	DB0	Data Bit 0, LSB
18	$R/\overline{W}$	Read and Write Control
19	$\overline{CS}$	Chip Select. Active LOW.
20	LOADDAC	Loads the internal DAC register. The DAC register is a transparent latch and is transparent when LOADDAC is LOW (regardless of the state of CS or CLK).

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

V_{DD} to GND	-0.3V to 6V
Digital Inputs to GND	-0.3V to $V_{DD} + 0.3V$
V_{OUT} to GND	-0.3V to $V_{DD} + 0.3V$
Power Dissipation	325mW
Thermal Resistance, θ_{JA}	150°C/W
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.

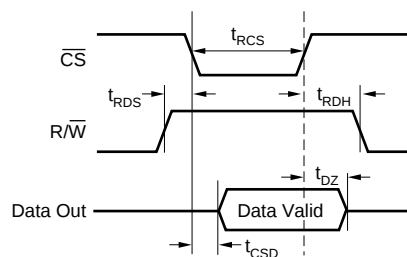
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

PACKAGE/ORDERING INFORMATION

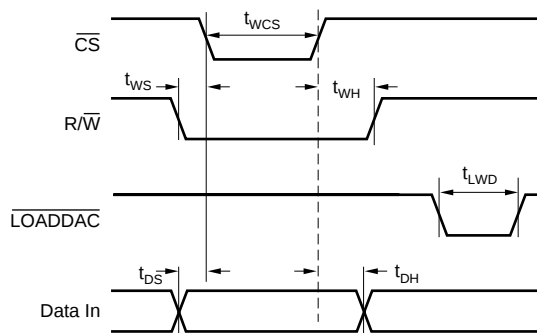
PRODUCT	MINIMUM RELATIVE ACCURACY (LSB)	DIFFERENTIAL NONLINEARITY (LSB)	SPECIFICATION TEMPERATURE RANGE	PACKAGE	PACKAGE DRAWING NUMBER ⁽¹⁾	ORDERING NUMBER ⁽²⁾	TRANSPORT MEDIA
DAC7621E	±2	±1	-40°C to +85°C	20-Lead SSOP	334	DAC7621E	Rails
"	"	"	"	"	"	DAC7621E/1K	Tape and Reel
DAC7621EB	±1	±1	-40°C to +85°C	20-Lead SSOP	334	DAC7621EB	Rails
"	"	"	"	"	"	DAC7621EB/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 "DAC7621E/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.

TIMING DIAGRAMS



Data Output Timing



Digital Input Timing

TIMING SPECIFICATIONS

$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$

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

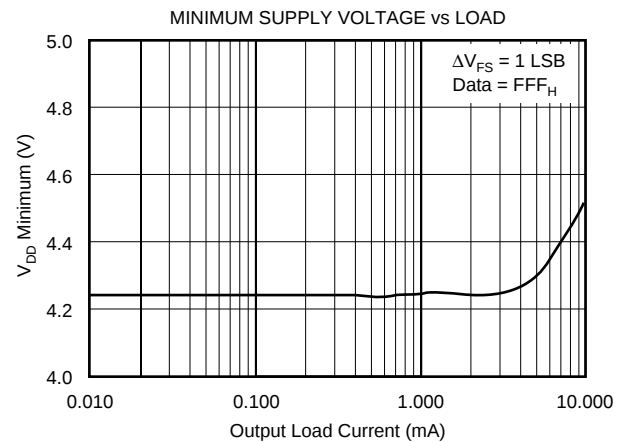
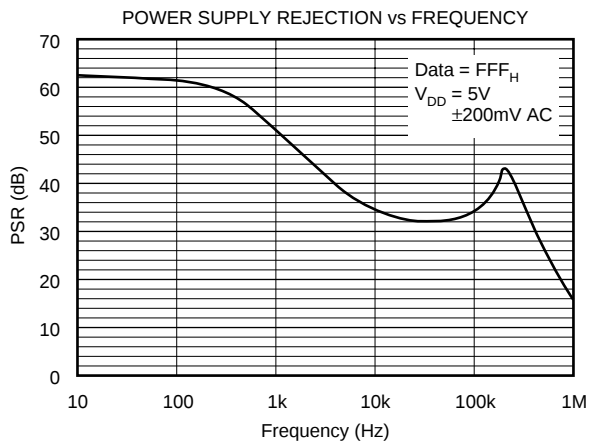
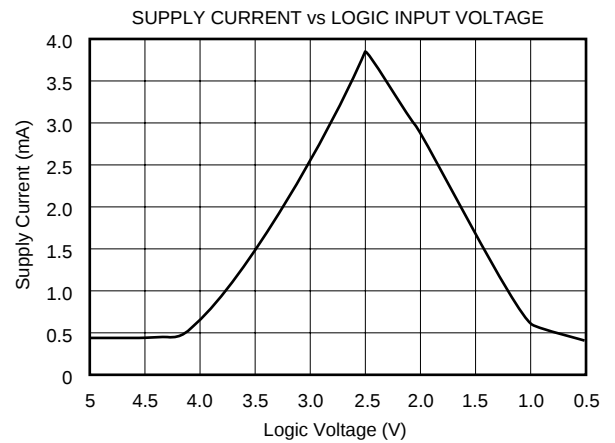
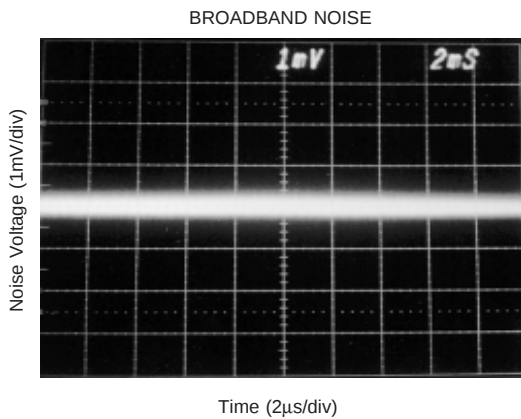
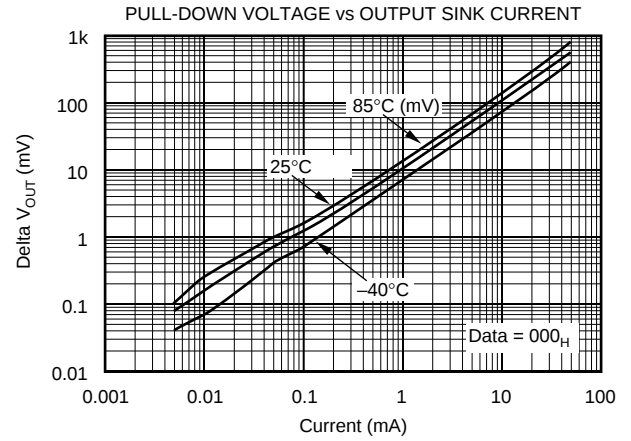
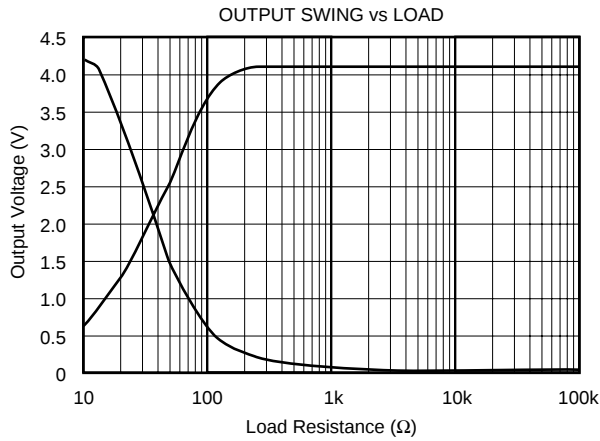
LOGIC TRUTH TABLE

$R/\overline{W}$	$\overline{CS}$	$\overline{LOADDAC}$	INPUT REGISTER	DAC REGISTER	MODE
L	L	L	Write	Write	Write
L	L	H	Write	Hold	Write Input
H	L	H	Read	Hold	Read Input
X	H	L	Hold	Update	Update
X	H	H	Hold	Hold	Hold

X = Don't Care.

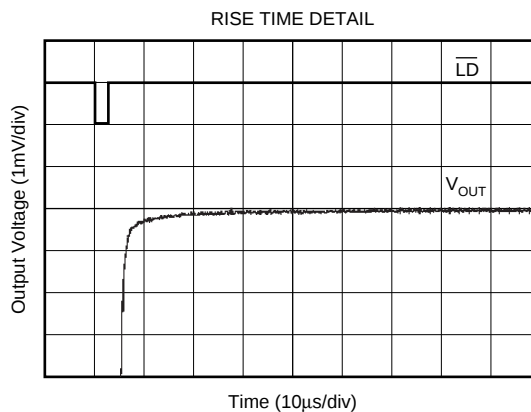
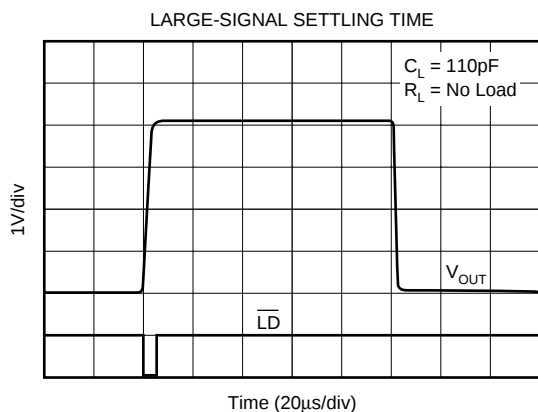
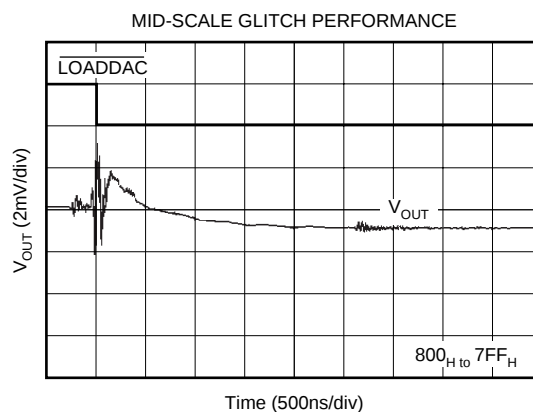
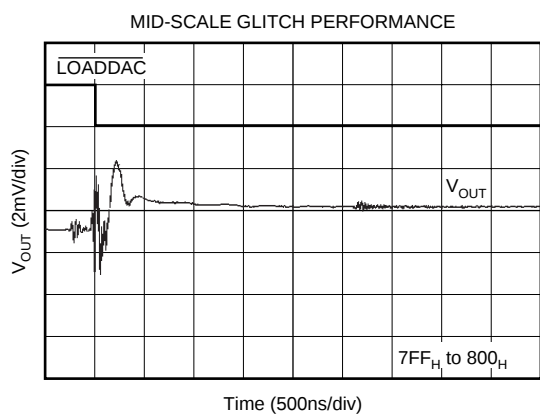
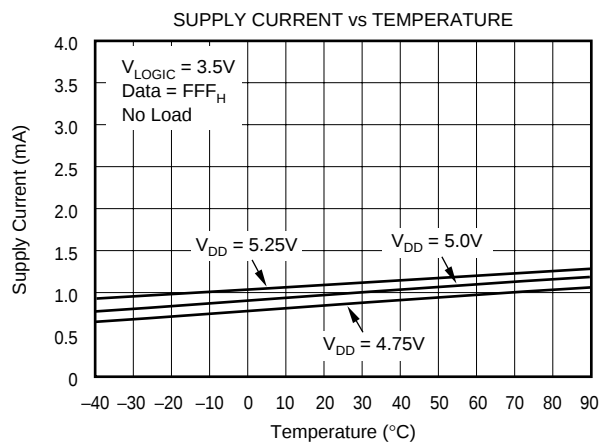
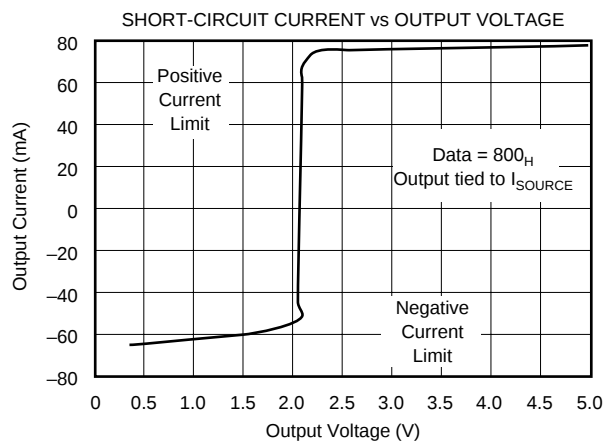
TYPICAL PERFORMANCE CURVES

At $T_A = +25^\circ$, and $V_{DD} = 5V$, unless otherwise specified.



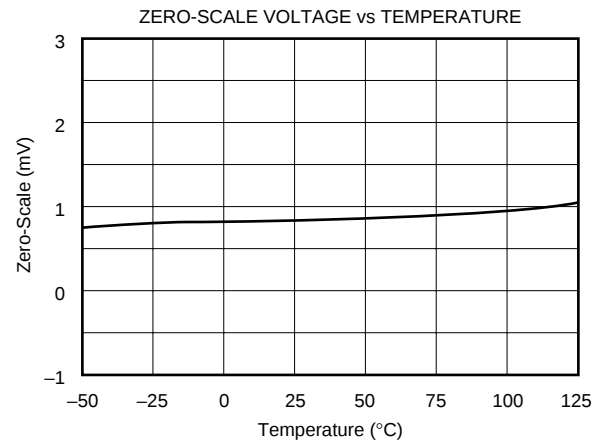
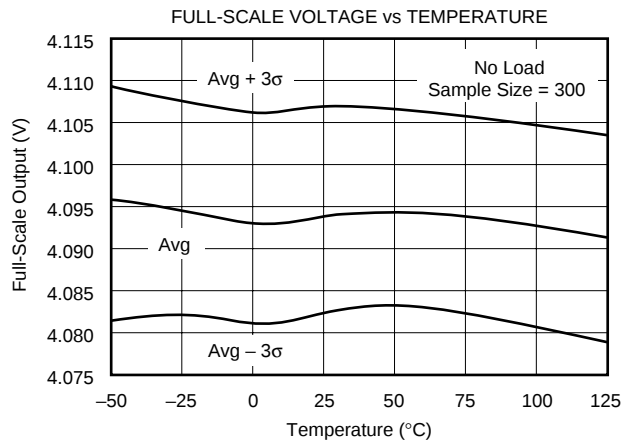
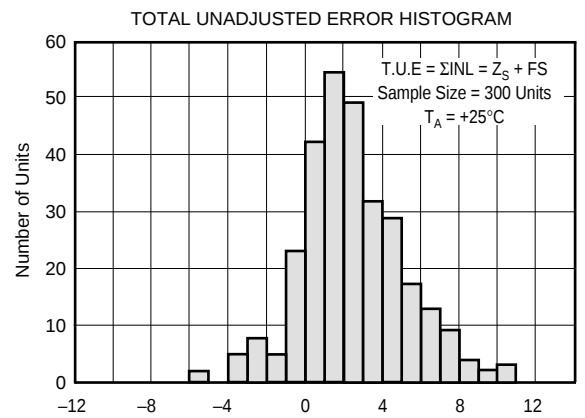
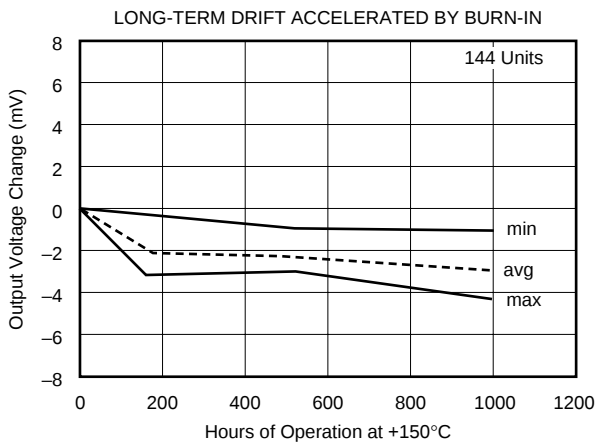
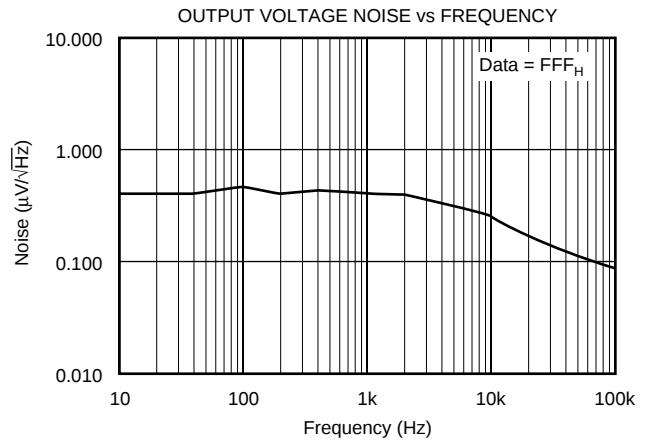
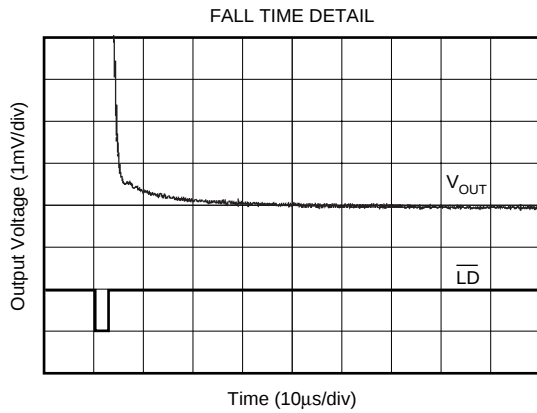
TYPICAL PERFORMANCE CURVES (CONT)

At $T_A = +25^\circ$, and $V_{DD} = 5V$, unless otherwise specified.



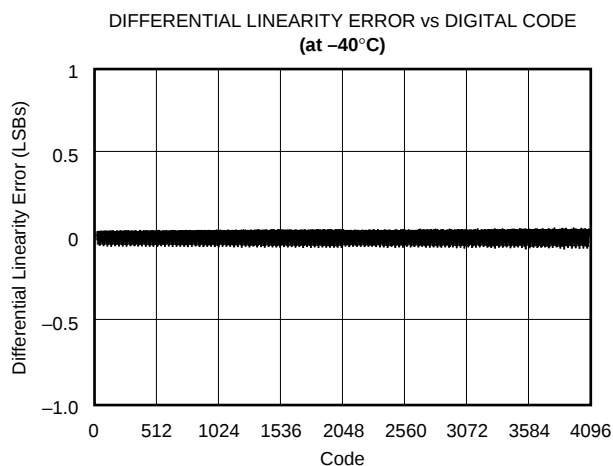
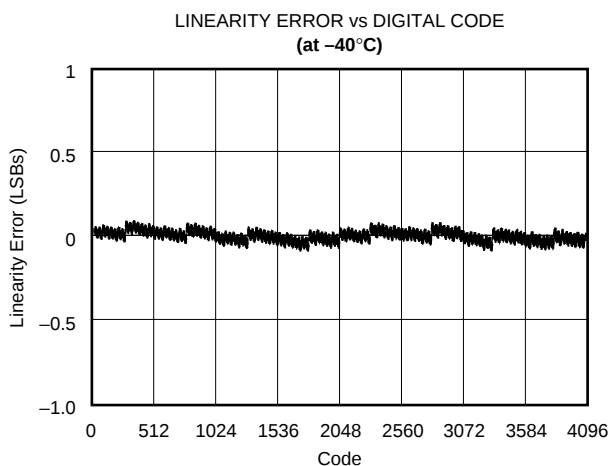
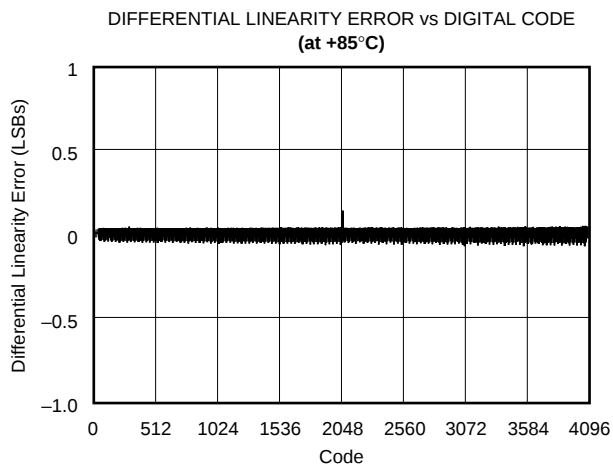
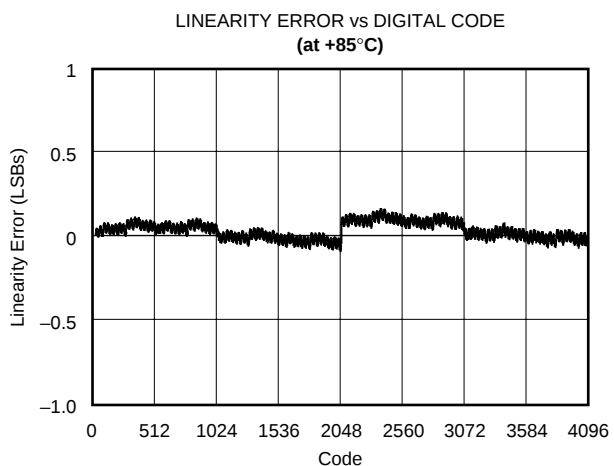
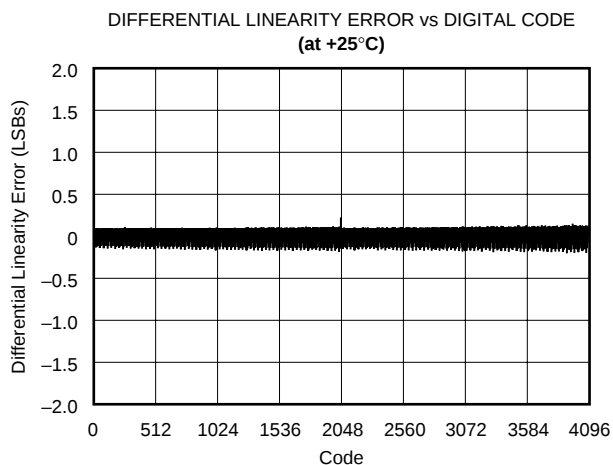
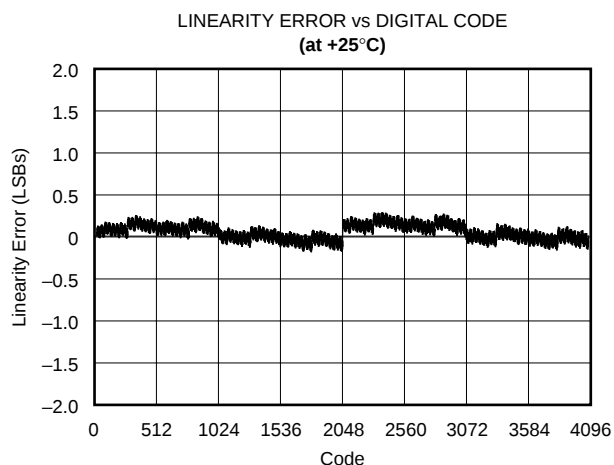
TYPICAL PERFORMANCE CURVES (CONT)

At $T_A = +25^\circ$, and $V_{DD} = 5V$, unless otherwise specified.



TYPICAL PERFORMANCE CURVES (CONT)

At $T_A = +25^\circ$, and $V_{DD} = 5V$, unless otherwise specified.



OPERATION

The DAC7621 is a 12-bit digital-to-analog converter (DAC) complete with an input shift register, DAC register, laser-trimmed 12-bit DAC, on-board reference, and a rail-to-rail output amplifier. Figure 1 shows the basic operation of the DAC7621.

INTERFACE

Figure 1 shows the basic connection between a microcontroller and the DAC7621. The interface consists of a Read/Write ($R/\overline{W}$), data, and a load DAC signal ($\overline{LOADDAC}$). In addition, a chip select ($\overline{CS}$) input is available to enable the DAC7621 when there are multiple devices. The data format is Straight Binary. An asynchronous clear input ($\overline{CLR}$) is provided to simplify start-up or periodic resets. Table I shows the relationship between input code and output voltage.

DAC7621 Full-Scale Range = 4.095V Least Significant Bit = 1mV		
DIGITAL INPUT CODE STRAIGHT OFFSET BINARY	ANALOG OUTPUT (V)	DESCRIPTION
FFF _H	+4.095	Full Scale
801 _H	+2.049	Midscale + 1 LSB
800 _H	+2.048	Midscale
7FF _H	+2.047	Midscale – 1 LSB
000 _H	0	Zero Scale

TABLE I. Digital Input Code and Corresponding Ideal Analog Output.

The digital data into the DAC7621 is double-buffered. This means that new data can be entered into the DAC without disturbing the old data and the analog output of the converter. At some point after the data has been entered into the serial shift register, this data can be transferred into the DAC register. This transfer is accomplished with a HIGH to LOW transition of the $\overline{LOADDAC}$ pin. However, the $\overline{LOADDAC}$ pin makes the DAC register transparent. If new data becomes available on the bus register while $\overline{LOADDAC}$ is LOW, the DAC output voltage will change as the data changes. To prevent this, $\overline{CS}$ must be returned HIGH prior to changing data on the bus.

At any time, the contents of the DAC register can be set to 000_H (analog output equals 0V) by taking the $\overline{CLR}$ input LOW. The DAC register will remain at this value until $\overline{CLR}$ is returned HIGH and $\overline{LOADDAC}$ is taken LOW to allow the contents of the input register to be transferred to the DAC register. If $\overline{LOADDAC}$ is LOW when $\overline{CLR}$ is taken LOW, the DAC register will be set to 000_H and the analog output driven to 0V. When $\overline{CLR}$ is returned HIGH, the DAC register and the analog output will respond accordingly.

DIGITAL-TO-ANALOG CONVERTER

The internal DAC section is a 12-bit voltage output device that swings between ground and the internal reference voltage. The DAC is realized by a laser-trimmed R-2R ladder network which is switched by N-channel MOSFETs. The DAC output is internally connected to the rail-to-rail output operational amplifier.

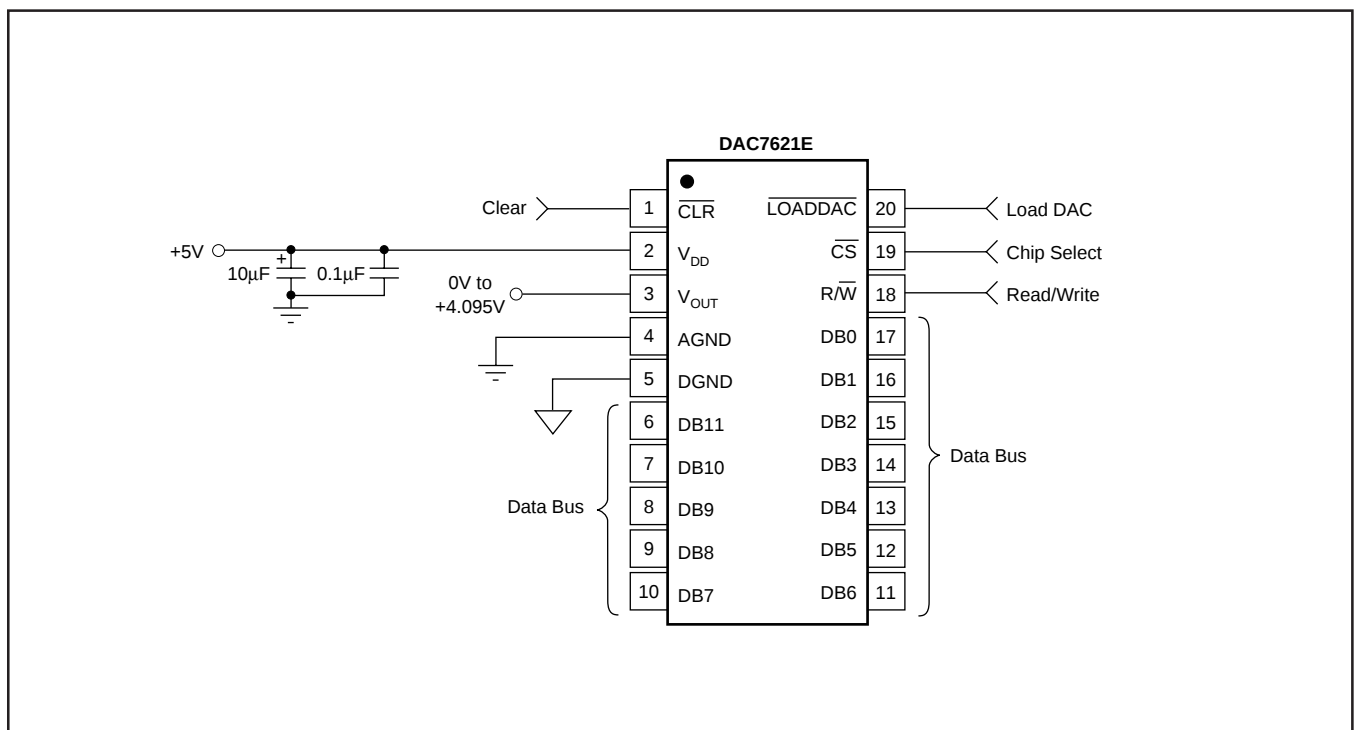


FIGURE 1. Basic Operation of the DAC7621.

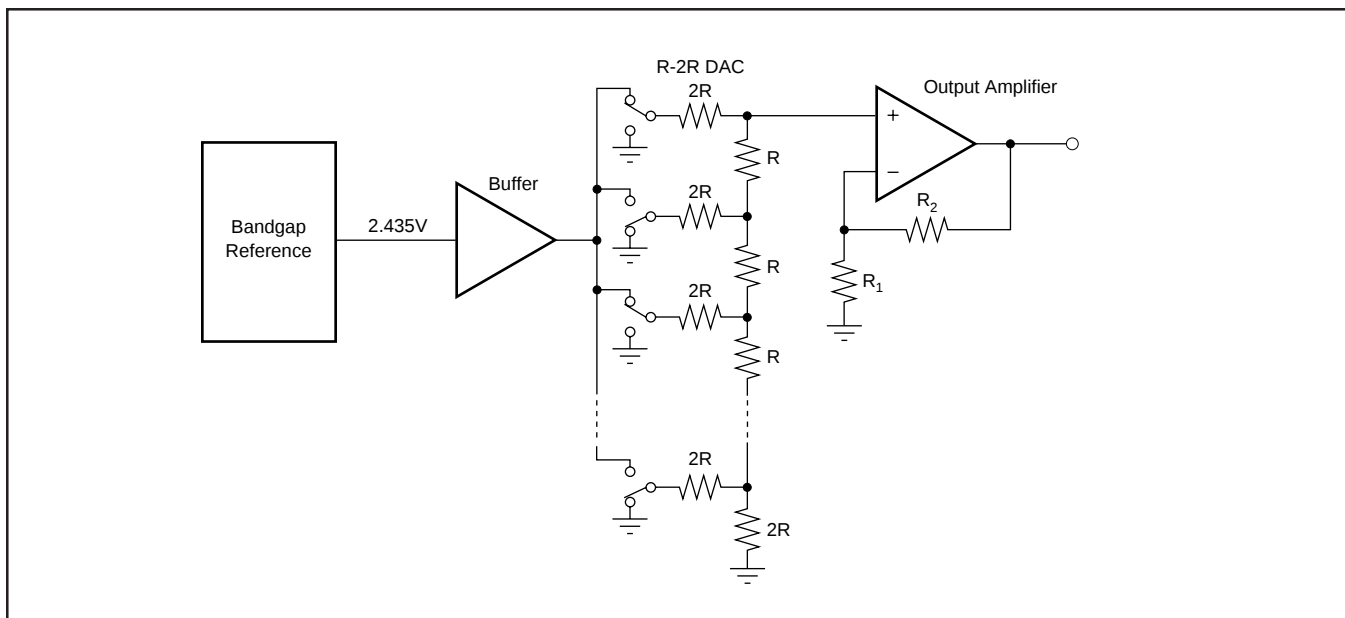


FIGURE 2. Simplified Schematic of Analog Portion.

OUTPUT AMPLIFIER

A precision, low-power amplifier buffers the output of the DAC section and provides additional gain to achieve a 0V to 4.095V range. The amplifier has low offset voltage, low noise, and a set gain of 1.682V/V ($4.095/2.435$). See Figure 2 for an equivalent circuit schematic of the analog portion of the DAC7621.

The output amplifier has a 7 μ s typical settling time to ± 1 LSB of the final value. Note that there are differences in the settling time for negative-going signals versus positive-going signals.

The rail-to-rail output stage of the amplifier provides the full-scale range of 0V to 4.095V while operating on a supply voltage as low as 4.75V. In addition to its ability to drive resistive loads, the amplifier will remain stable while driving capacitive loads of up to 500pF. See Figure 3 for an equivalent circuit schematic of the amplifier's output driver and the Typical Performance Curves section for more information regarding settling time, load driving capability, and output noise.

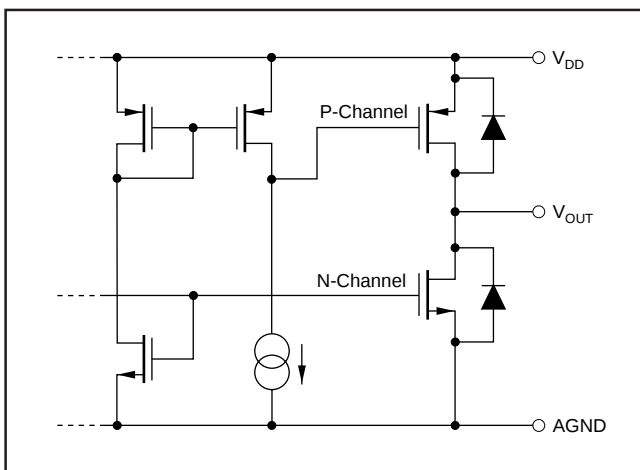


FIGURE 3. Simplified Driver Section of Output Amplifier.

POWER SUPPLY

A BiCMOS process and careful design of the bipolar and CMOS sections of the DAC7621 result in a very low power device. Bipolar transistors are used where tight matching and low noise are needed to achieve analog accuracy, and CMOS transistors are used for logic, switching functions and for other low power stages.

If power consumption is critical, it is important to keep the logic levels on the digital inputs ($R/\overline{W}$, CLK, $\overline{CS}$, $\overline{LOADDAC}$, $\overline{CLR}$) as close as possible to either V_{DD} or ground. This will keep the CMOS inputs (see “Supply Current vs Logic Input Voltages” in the Typical Performance Curves) from shunting current between V_{DD} and ground.

The DAC7621 power supply should be bypassed as shown in Figure 1. The bypass capacitors should be placed as close to the device as possible, with the 0.1 μ F capacitor taking priority in this regard. The “Power Supply Rejection vs Frequency” graph in the Typical Performance Curves section shows the PSRR performance of the DAC7621. This should be taken into account when using switching power supplies or DC/DC converters.

In addition to offering guaranteed performance with V_{DD} in the 4.75V to 5.25V range, the DAC7621 will operate with reduced performance down to 4.5V. Operation between 4.5V and 4.75V will result in longer settling time, reduced performance, and current sourcing capability. Consult the “ V_{DD} vs Load Current” graph in the Typical Performance Curves section for more information.

APPLICATIONS

POWER AND GROUNDING

The DAC7621 can be used in a wide variety of situations—from low power, battery operated systems to large-scale industrial process control systems. In addition, some applications require better performance than others, or are particularly sensitive to one or two specific parameters. This diversity makes it difficult to define definite rules to follow concerning the power supply, bypassing, and grounding. The following discussion must be considered in relation to the desired performance and needs of the particular system.

A precision analog component requires careful layout, adequate bypassing, and a clean, well-regulated power supply. As the DAC7621 is a single-supply, +5V component, it will often be used in conjunction 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.

The DAC7621 has separate analog ground and digital ground pins. The current through DGND is mostly switching transients and are up to 4mA peak in amplitude. The current through AGND is typically 0.5mA.

For best performance, separate analog and digital ground planes with a single interconnection point to minimize ground loops. The analog pins are located adjacent to each other to help isolate analog from digital signals. Analog signals should be routed as far as possible from digital

signals and should cross them at right angles. A solid analog ground plane around the D/A package, as well as under it in the vicinity of the analog and power supply pins, will isolate the D/A from switching currents. It is recommended that DGND and AGND be connected directly to the ground planes under the package.

If several DAC7621s are used, or if sharing supplies with other components, connecting the AGND and DGND lines together at the power supplies once, rather than at each chip, may produce better results.

The power applied to V_{DD} 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 V_{DD} and V_{OUT} .

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 10 μ F and 0.1 μ F capacitors shown in Figure 4 are strongly recommended and should be installed as close to V_{DD} and ground as possible. In some situations, additional bypassing may be required such as a 100 μ 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).

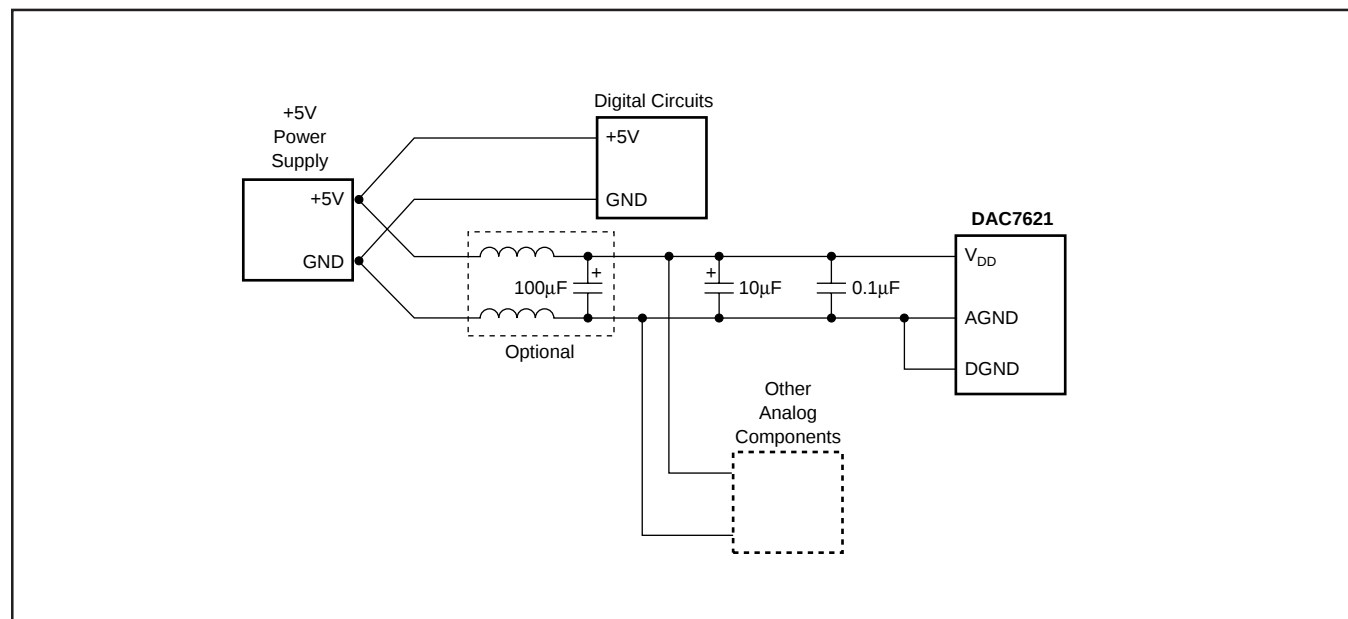


FIGURE 4. Suggested Power and Ground Connections for a DAC7621 Sharing a +5V Supply with a Digital System with a Single Ground Plane.

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
DAC7621E	ACTIVE	SSOP	DB	20	70	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
DAC7621E/1K	ACTIVE	SSOP	DB	20	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
DAC7621E/1KG4	ACTIVE	SSOP	DB	20	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
DAC7621EB	ACTIVE	SSOP	DB	20	70	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
DAC7621EB/1K	ACTIVE	SSOP	DB	20	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
DAC7621EB/1KG4	ACTIVE	SSOP	DB	20	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
DAC7621EBG4	ACTIVE	SSOP	DB	20	70	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
DAC7621EG4	ACTIVE	SSOP	DB	20	70	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR

⁽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.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

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
DAC7621E/1K	SSOP	DB	20	1000	330.0	16.4	8.2	7.6	3.0	12.0	16.0	Q1
DAC7621EB/1K	SSOP	DB	20	1000	330.0	16.4	8.2	7.6	3.0	12.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DAC7621E/1K	SSOP	DB	20	1000	375.0	340.0	57.0
DAC7621EB/1K	SSOP	DB	20	1000	375.0	340.0	57.0

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
RF/IF and ZigBee® Solutions	www.ti.com/lprf

Applications

Audio	www.ti.com/audio
Automotive	www.ti.com/automotive
Broadband	www.ti.com/broadband
Digital Control	www.ti.com/digitalcontrol
Medical	www.ti.com/medical
Military	www.ti.com/military
Optical Networking	www.ti.com/opticalnetwork
Security	www.ti.com/security
Telephony	www.ti.com/telephony
Video & Imaging	www.ti.com/video
Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2008, Texas Instruments Incorporated