

DAC56

Monolithic 16-Bit Resolution DIGITAL-TO-ANALOG CONVERTER

FEATURES

- **COMPLETE D/A CONVERTER:**
Internal Voltage Reference
 $\pm 3V$ Output Operational Amplifier
Pinout Allows I_{OUT} ($\pm 1.0mA$) Option
No external components required
- **0.012% LINEARITY ERROR MAX**
- **12-BIT MONOTONICITY GUARANTEED
OVER 0°C TO +70°C**
- **$\pm 5V$ TO $\pm 12V$ POWER SUPPLY**
- **SETTLING TIME: $V_{OUT} = 1.5\mu s$;
 $I_{OUT} = 350ns$**
- **SERIAL DATA INPUT: Binary Two's
Complement**
- **16-PIN PLASTIC DIP AND SOIC**

DESCRIPTION

The DAC56 is a complete 16-bit monolithic D/A converter. Completely self-contained with a stable, low noise, internal zener voltage reference; high-speed current switches; a resistor ladder network; and a low noise output operational amplifier all on a single monolithic chip. The DAC56 operates over a wide power supply range from $\pm 5V$ to $\pm 12V$.

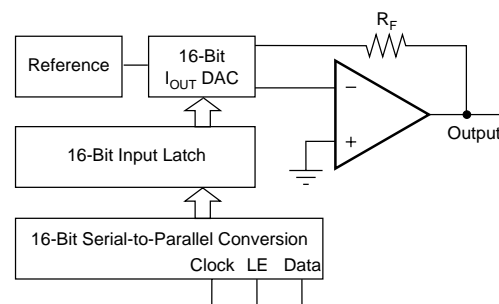
Differential linearity error (DLE) is guaranteed to meet specifications without external adjustment. However, provisions for an externally adjustable circuit controlling the MSB error, the differential linearity error at bipolar zero, makes the DLE at BPZ essentially zero and provides for high system performance. The I/V amplifier stage includes an output current limiting circuit to protect both amplifier and load from excessive current. This assures the user of high system reliability.

APPLICATIONS

- **PROCESS CONTROL**
- **ATE PIN ELECTRONICS LEVEL SETTING**
- **CLOSED-LOOP SERVO-CONTROL**
- **AUTO-CALIBRATION CIRCUIT FOR A/D
BOARDS**
- **UP-GRADE REPLACEMENT FOR
MULTIPLYING D/A**
- **X-Y PLOTTER**
- **DSP PROCESSOR BOARDS**

A high-speed interface is capable of clocking in data at a rate of 10MHz max, and its interface logic contains a serial data clock (input), serial data (input) and latch-enable (input). Serial data is clocked MSB first into a 16-bit register and then latched into a 16-bit parallel register.

The DAC56 is packaged in a 16-pin plastic DIP and 16-pin SOIC.



SPECIFICATIONS

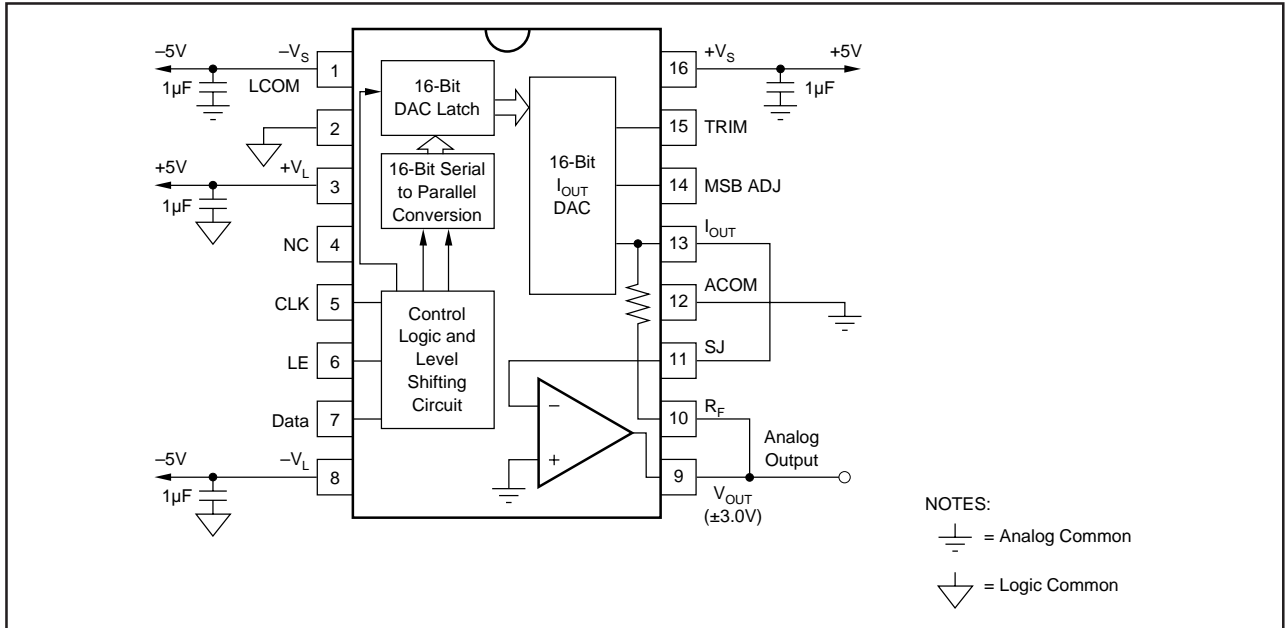
ELECTRICAL

All specifications at +25°C, and power supply voltage of ±5V, unless otherwise noted.

PARAMETER	CONDITIONS	DAC56			UNITS
		MIN	TYP	MAX	
DIGITAL INPUT Resolution Digital Input Level: ⁽¹⁾ V _{IH} V _{IL} I _{IH} • V _I = +2.7V I _{IL} • V _I = +0.4V Input Clock Frequency		+2.4 0	16	+V _L +0.8 +1 -50	Bits V V μA μA MHz
ACCURACY Integral Linearity Error Differential Linearity Error Gain Error Bipolar Zero Error Monotonicity	0°C to +70°C			±0.012 ±0.024 ±1.5 ±0.5 12	% of FSR ⁽³⁾ % of FSR % of FSR % of FSR Bits
TEMPERATURE DRIFT Gain Drift Bipolar Zero Drift Linearity Drift Differential Linearity Drift	0°C to +70°C		±60 ±20	±0.012 ±0.024	ppm of FSR/°C ppm of FSR/°C % of FSR % of FSR
POWER SUPPLY SENSITIVITY Gain Bipolar Zero	±V _S = ±V _L = ±5VDC		±0.0045 ±0.0015		% of FSR/%V % of FSR/%V
SETTLING TIME Voltage Output 6V Step 1LSB Current Output 1mA Step Slew Rate	to ±0.006% of FSR 10 to 100Ω Load 1kΩ Load ⁽³⁾		1.5 1 350 350 12		μs μs ns ns V/μs
ANALOG OUTPUT Voltage Output Configuration Bipolar Range Output Current Output Impedance Short Circuit Duration Current Output Configuration Bipolar Range Output Impedance		±2.66 ±8	±3.0 0.1 Indefinite to Common ±1 1.2	±3.34	V mA Ω mA kΩ
WARMUP TIME		1			min
POWER SUPPLY REQUIREMENTS⁽⁴⁾ Supply Voltage +V _S and +V _L -V _S and -V _L Supply Drain (No Load) +V (+V _S and +V _L = +5V) -V (-V _S and -V _L = -5V) +V (+V _S and +V _L = +12V) -V (-V _S and -V _L = -12V) Power Dissipation V _S and V _L = ±5V V _S and V _L = ±12V		+4.75 -4.75	+5.00 -5.00 +10 -25 +12 -27 175 468	+13.2 -13.2 +17 -35 +12 -27 260	V V mA mA mA mA mW mW
TEMPERATURE RANGE Specification Storage		0 -60		70 100	°C °C

NOTES: (1) Logic input levels are TTL-/CMOS-compatible. (2) FSR means full-scale range and is equivalent to 6V (±3V) for DAC56 in the V_{OUT} mode. (3) Measured with an active clamp to provide a low impedance for approximately 200ns. (4) All specifications assume +V_S connected to +V_L and -V_S connected to -V_L. If supplies are connected separately, -V_L must not be more negative than -V_S to assure proper operation. No similar restriction applies to the value of +V_L with respect to +V_S.

PIN CONFIGURATION



PIN ASSIGNMENTS

PIN	NAME	FUNCTION
1	-V _S	Analog Negative Supply
2	LCOM	Logic Common
3	+V _L	Logic Positive Supply
4	NC	No Connection
5	CLK	Clock Input
6	LE	Latch Enable Input
7	DATA	Serial Data Input
8	-V _L	Logic Negative Supply
9	V _{OUT}	Voltage Output
10	R _F	Feedback Resistor
11	SJ	Summing Junction
12	ACOM	Analog Common
13	I _{OUT}	Current Output
14	MSB ADJ	MSB Adjustment Terminal
15	TRIM	MSB Trim-pot Terminal
16	+V _S	Analog Positive Supply

ABSOLUTE MAXIMUM RATINGS

DC Supply Voltage	±15VDC
Input Logic Voltage	-1V to +V _S /+V _L
Power Dissipation	850mW
Operating Temperature	-25°C to +70°C
Storage Temperature	-80°C to +100°C
Lead Temperature (soldering, 10s)	+300°C

ELECTROSTATIC DISCHARGE SENSITIVITY

Electrostatic discharge can cause damage ranging from performance degradation to complete device failure. Burr-Brown Corporation recommends that all integrated circuits be handled and stored using appropriate ESD protection methods.

PACKAGE INFORMATION

PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER ⁽¹⁾
DAC56P	16-Pin Plastic DIP	180
DAC56U	16-Pin SOIC	211

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book.

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.

OPERATING INSTRUCTIONS

The accuracy of a D/A converter is described by the transfer function as shown in Figure 1. Digital input to analog output converter relationships are shown in Table I. The errors in the D/A converter are combinations of analog errors due to the linear circuitry, matching and tracking properties of the ladder and scaling networks, power supply rejection, and reference errors. In summary, these errors consist of initial errors including gain, offset, linearity, differential linearity, and power supply sensitivity. Gain drift over temperature rotates the line (Figure 1) about the bipolar zero point and offset drift shifts the line left or right over the operating temperature range. Most of the offset and gain drift is due to the drift of the internal reference zener diode with temperature or time.

The converter is designed so that these drifts are in opposite directions. This way the bipolar zero voltage is virtually unaffected by variations in the reference voltage.

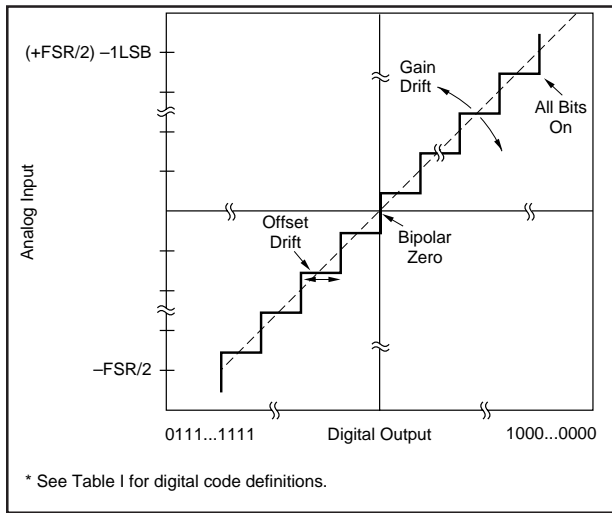


FIGURE 1. Input vs Output for an Ideal Bipolar D/A Converter.

DIGITAL INPUT	ANALOG OUTPUT		
	DAC Output	Voltage (V), V _{OUT} Mode	Current (mA), I _{OUT} Mode
Binary Two's Complement (BTC)			
7FFF _H	+ Full Scale	+2.999908	-0.999970
8000 _H	- Full Scale	-3.000000	+1.000000
0000 _H	Bipolar Zero	0.000000	0.000000
FFFF _H	Zero -1LSB	-0.000092	+0.030500μA

TABLE I. Digital Input to Analog Output Relationship.

DIGITAL INPUT CODES

The DAC56 accepts serial input data (MSB first) in Binary Two's Complement form—Refer to Table I for input/output relationships.

POWER SUPPLY CONNECTIONS

Power supply decoupling capacitors should be added as shown in the Connection Diagram (Figure 2), for optimum performance and noise rejection.

These capacitors (1μF tantalum recommended) should be connected as close as possible to the converter.

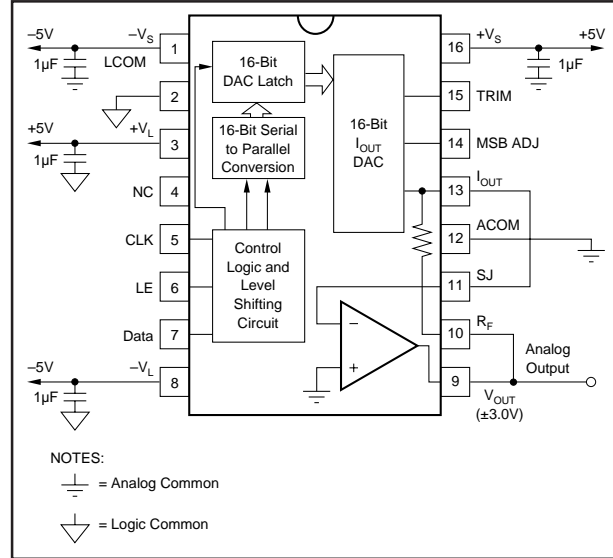


FIGURE 2. Connection Diagram.

MSB ERROR ADJUSTMENT (OPTIONAL)

Differential linearity error at all codes of the DAC56 is guaranteed to meet specifications without an external adjustment. However, if adjustment of the differential linearity error at bipolar zero is desired, it can be trimmed essentially to zero using the circuit as shown in Figure 3.

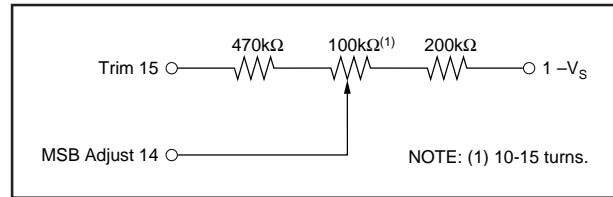


FIGURE 3. MSB Adjustment Circuit.

After allowing ample warm-up time (5 to 10 minutes) to assure stable operation, select the input code FFFF_H. Measure the output voltage using a 6-1/2 digit voltmeter and record the measurement. Change the digital input code to 0000_H. Adjust the 100kΩ potentiometer (TCR of 100ppm per °C or less is recommended) to make the output voltage read 1LSB more than the voltage reading of the previous code (ex. 1LSB = 92μV at FSR = 6V).

If the MSB adjustment circuit is not used, pins 14 and 15 should be left open.

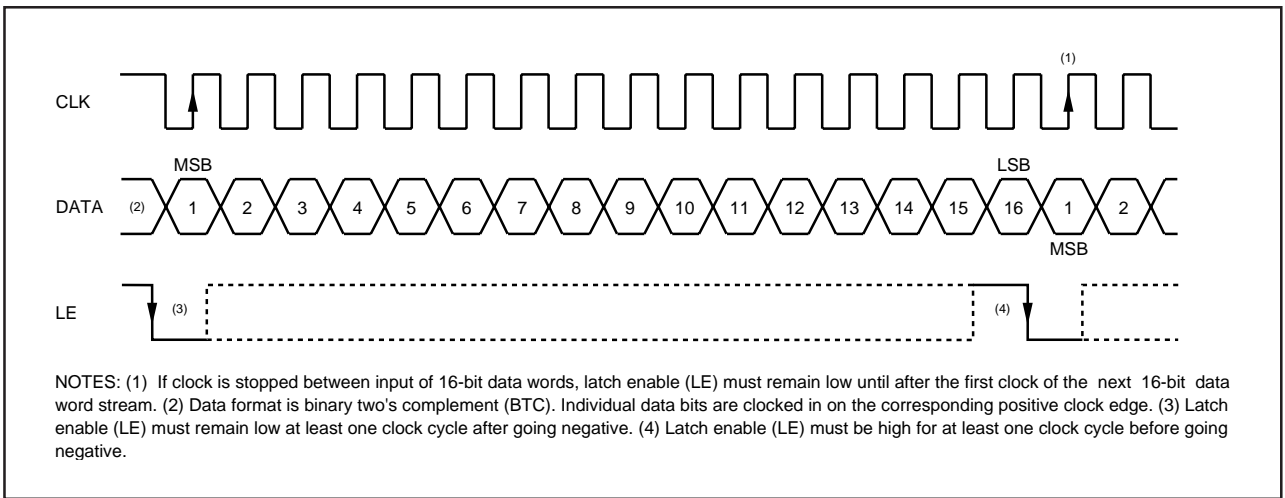


FIGURE 4. Input Timing Diagram.

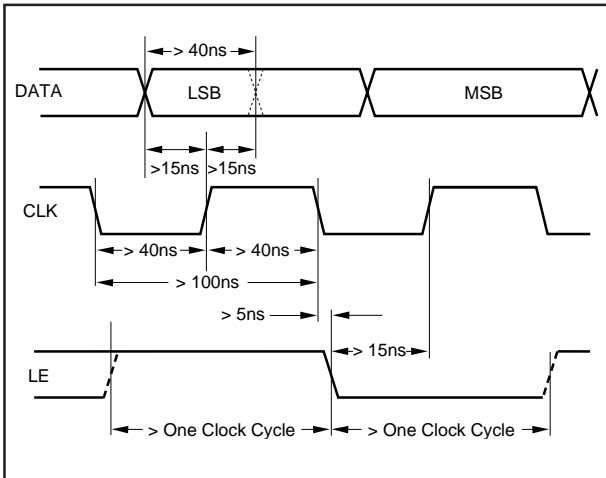


FIGURE 5. Input Timing Relationships.

INPUT TIMING CONSIDERATIONS

Figures 4 and 5 refer to the input timing required to interface the inputs of DAC56 to a serial input data stream. Serial data is accepted in Binary Two's Complement with the MSB being loaded first. Data is clocked in on positive going clock (CLK, pin 5) edges and is latched into the DAC input register on negative going latch enable (LE, pin 6) edges.

The latch enable input must be high for at least one clock cycle before going low, and then must be held low for at least one clock cycle. The last 16 data bits clocked into the serial input register are those that are transferred to the DAC input register when latch enable goes low. In other words, when more than 16 clock cycles occur between a latch enable, only the data present during the last 16 clocks will be transferred to the DAC input register.

Figure 4 gives the general input format required for the DAC56. Figure 5 shows the specific relationships between the various signals and their timing constraints.

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
DAC56P	OBSOLETE	PDIP	N	16		TBD	Call TI	Call TI
DAC56U	OBSOLETE	CDIP SB	JVF	16		TBD	Call TI	Call TI
DAC56U/1K	OBSOLETE	CDIP SB	JVF	16		TBD	Call TI	Call TI

⁽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) 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.

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.

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 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.

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.

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

Products		Applications	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	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