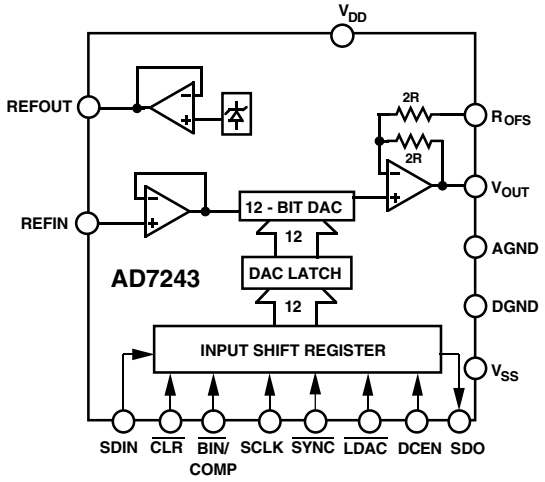
LC²MOS 12-Bit Serial DACPORT

AD7243

FEATURES
12-Bit CMOS DAC with
On-Chip Voltage Reference
Output Amplifier
Three Selectable Output Ranges
–5 V to +5 V, 0 V to +5 V, 0 V to +10 V
Serial Interface
300 kHz DAC Update Rate
Small Size: 16-Lead DIP or SOIC
Nonlinearity: ±1/2 LSB T_{MIN} to T_{MAX}
Low Power Dissipation: 100 mW Typical

APPLICATIONS
Process Control
Industrial Automation
Digital Signal Processing Systems
Input/Output Ports

FUNCTIONAL BLOCK DIAGRAM



GENERAL DESCRIPTION

The AD7243 is a complete 12-bit, voltage output, digital-to-analog converter with output amplifier and Zener voltage reference on a monolithic CMOS chip. No external trims are required to achieve full specified performance.

The output amplifier is capable of developing +10 V across a 2 kΩ load. The output voltage ranges with single supply operation are 0 V to +5 V or 0 V to +10 V, while an additional bipolar ±5 V output range is available with dual supplies. The ranges are selected using the internal gain resistor.

The data format is natural binary in both unipolar ranges, while either offset binary or two's complement format may be selected in the bipolar range. A $\overline{CLR}$ function is provided which sets the output to 0 V in both unipolar ranges and in the two's complement bipolar range, while with offset binary data format, the output is set to –REFIN. This function is useful as a power-on reset as it allows the output to be set to a known voltage level.

The AD7243 features a fast versatile serial interface which allows easy connection to both microcomputers and 16-bit digital signal processors with serial ports. The serial data may be applied at rates up to 5 MHz allowing a DAC update rate of 300 kHz. A serial data output capability is also provided which allows daisy chaining in multi-DAC systems. This feature allows any number of DACs to be used in a system with a simple 4-wire interface. All DACs may be updated simultaneously using $\overline{LDAC}$.

The AD7243 is fabricated on Linear Compatible CMOS (LC²MOS), an advanced, mixed technology process. It is packaged in 16-lead DIP and 16-lead SOIC packages.

PRODUCT HIGHLIGHTS

1. Complete 12-Bit DACPORT®
   The AD7243 is a complete, voltage output, 12-bit DAC on a single chip. The single chip design is inherently more reliable than multichip designs.
2. Single or Dual Supply Operation.
3. Minimum 3-wire interface to most DSP processors.
4. DAC Update Rate–300 kHz.
5. Serial Data Output allows easy daisy-chaining in multiple DAC systems.

DACPORT is a registered trademark of Analog Devices, Inc.

REV. A

Information furnished by Analog Devices is believed to be accurate and reliable. However, no responsibility is assumed by Analog Devices for its use, nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of Analog Devices.

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781/329-4700 World Wide Web Site: http://www.analog.com
Fax: 781/326-8703
© Analog Devices, Inc., 2000

AD7243–SPECIFICATIONS

(V_{DD} = +12 V to +15 V,[1] V_{SS} = 0 V or –12 V to –15 V,[1] AGND = DGND = 0 V, REFIN = +5 V, R_L = 2 kΩ, C_L = 100 pF to AGND. All Specifications T_{MIN} to T_{MAX} unless otherwise noted.)

Parameter	A[2]	B[2]	S[2]	Unit	Test Conditions/Comments
STATIC PERFORMANCE					
Resolution	12	12	12	Bits	
Relative Accuracy[3]	±1	±1/2	±1	LSB max	
Differential Nonlinearity[3]	±0.9	±0.9	±0.9	LSB max	Guaranteed Monotonic
Unipolar Offset Error[3]	±4	±4	±5	LSB max	V_{SS} = 0 V or –12 V to –15 V[1]; DAC Latch Contents All 0s
Bipolar Zero Error[3]	±5	±5	±6	LSB max	V_{SS} = –12 V to –15 V[1]; DAC Latch Contents All 0s
Full-Scale Error[3, 4]	±6	±6	±7	LSB max	
Full-Scale Temperature Coefficient[5]	±5	±5	±5	ppm of FSR/°C typ	Guaranteed By Process
REFERENCE OUTPUT					
Reference Output Range, REFOUT	4.95/5.05	4.95/5.05	4.95/5.05	V min/V max	
Reference Temperature Coefficient[5]	±25	±25	±30	ppm/°C typ	Guaranteed By Process
Reference Load Change (ΔREFOUT vs. I_L)	–1	–1	–1	mV max	Reference Load Current (I_L) Change (0–100 μA)
REFERENCE INPUT					
Reference Input Range, REFIN	4.95/5.05	4.95/5.05	4.95/5.05	V min/V max	5 V ±1% for Specified Performance
Input Current	5	5	5	μA max	
DIGITAL INPUTS					
Input High Voltage, V_{INH}	2.4	2.4	2.4	V min	
Input Low Voltage, V_{INL}	0.8	0.8	0.8	V max	
Input Current, I_{IN}	±1	±1	±1	μA max	V_{IN} = 0 V to V_{DD}
Input Capacitance[5]	8	8	8	pF max	
DIGITAL OUTPUT					
Serial Data Out (SDO)					
Output Low Voltage, V_{OL}	0.4	0.4	0.4	V max	I_{SINK} = 1.6 mA
Output High Voltage, V_{OH}	4.0	4.0	4.0	V min	I_{SOURCE} = 400 μA
ANALOG OUTPUT					
Output Range Resistor, R_{OFS}	15/30	15/30	15/30	kΩ min/max	Typically 20 kΩ. Guaranteed By Process
Output Voltage Ranges[6]	+5, +10	+5, +10	+5, +10	V	Single Supply; V_{SS} = 0 V
Output Voltage Ranges[6]	+5, +10, ±5	+5, +10, ±5	+5, +10, ±5	V	Dual Supply; V_{SS} = –12 V to –15 V
DC Output Impedance[5]	0.5	0.5	0.5	Ω typ	
AC CHARACTERISTICS[5]					
Voltage Output Settling-Time					Settling Time to Within ±1/2 LSB of Final Value
Positive Full-Scale Change	10	10	10	μs max	Typically 4 μs
Negative Full-Scale Change	10	10	10	μs max	Typically 5 μs
Digital-to-Analog Glitch Impulse[3]	30	30	30	nV secs typ	DAC Latch Contents Toggled Between All 0s and All 1s
Digital Feedthrough[3]	10	10	10	nV secs typ	$\overline{LDAC}$ = High
POWER REQUIREMENTS					
V_{DD} Range	+10.8/+16.5	+10.8/+16.5	+11.4/+15.75	V min/V max	For Specified Performance Unless Otherwise Stated
V_{SS} Range (Dual Supplies)	–10.8/–16.5	–10.8/–16.5	–11.4/–15.75	V min/V max	For Specified Performance Unless Otherwise Stated
I_{DD}	10	10	10	mA max	Output Unloaded; Typically 7 mA
I_{SS} (Dual Supplies)	2	2	2	mA max	Output Unloaded; Typically 1 mA

NOTES

[1]Power Supply Tolerance A, B Versions: ±10%; S Version: ±5%.

[2]Temperature ranges are as follows: A, B Versions: –40°C to +85°C; S Version: –55°C to +125°C.

[3]See terminology.

[4]Measured with respect to REFIN and includes unipolar/bipolar offset error.

[5]Guaranteed by design and characterization, not production tested.

[6]0 V to +10 V output range is available only with $V_{DD} \geq$ +14.25 V.

Specifications subject to change without notice.

TIMING CHARACTERISTICS[1, 2] (V_{DD} = +10.8 V to +16.5 V, V_{SS} = 0 V or –10.8 V to –16.5 V, AGND = DGND = 0 V, R_L = 2 kΩ, C_L = 100 pF. All Specifications T_{MIN} to T_{MAX} unless otherwise noted.)

Parameter	Limit at +25°C, T_{MIN}, T_{MAX} (All Versions)	Units	Conditions/Comments
t_1[3]	200	ns min	SCLK Cycle Time
t_2	15	ns min	$\overline{SYNC}$ to SCLK Falling Edge Setup Time
t_3	70	ns min	$\overline{SYNC}$ to SCLK Hold Time
t_4	0	ns min	Data Setup Time
t_5	40	ns min	Data Hold Time
t_6	0	ns min	$\overline{SYNC}$ High to $\overline{LDAC}$ Low
t_7	20	ns min	$\overline{LDAC}$ Pulsewidth
t_8	0	ns min	$\overline{LDAC}$ High to $\overline{SYNC}$ Low
t_9	20	ns min	$\overline{CLR}$ Pulsewidth
t_{10}[4, 5]	160	ns max	SCLK Falling Edge to SDO Valid
t_{11}[4, 6]	>t_5	ns min	SCLK Falling Edge to SDO Invalid

NOTES
[1]Sample tested at +25°C to ensure compliance. All input signals are specified with tr = tf = 5 ns (10% to 90% of 5 V) and timed from a voltage level of 1.6 V.
[2]See Figures 7 & 8.
[3]SCLK mark/space ratio range is 40/60 to 60/40.
[4]SDO load capacitance is no greater than 50 pF.
[5]At 25°C t_{10} is 130 ns max.
[6]Guaranteed by design.

ABSOLUTE MAXIMUM RATINGS[1]

(T_A = +25°C unless otherwise noted)

V_{DD} to AGND, DGND . . . . . –0.3 V to +17 V
V_{SS} to AGND, DGND . . . . . +0.3 V to –17 V
AGND to DGND . . . . . –0.3 V to V_{DD} + 0.3 V
V_{OUT}[2] to AGND . . . . . –6 V to V_{DD} + 0.3 V
REFOUT to AGND . . . . . 0 V to V_{DD}
REFIN to AGND . . . . . –0.3 V to V_{DD} + 0.3 V
Digital Inputs to DGND . . . . . –0.3 V to V_{DD} + 0.3 V
SDO to DGND . . . . . –0.3 V to V_{DD} + 0.3 V
Operating Temperature Range
  Industrial (A, B Versions) . . . . . –40°C to +85°C
  Extended (S Version) . . . . . –55°C to +125°C
Storage Temperature Range . . . . . –65°C to +150°C
Lead Temperature (Soldering, 10 secs) . . . . . +300°C
Power Dissipation (Any Package) to +75°C . . . . . 450 mW
Derates above +75°C by . . . . . 6 mW/°C

NOTES
[1]Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Only one Absolute Maximum Rating may be applied at any time.
[2]The outputs may be shorted to voltages in this range provided the power dissipation of the package is not exceeded. Short circuit current is typically 80 mA.

ORDERING GUIDE

Model	Temperature Range	Relative Accuracy	Package Option[1]
AD7243AN	–40°C to +85°C	±1 LSB	N-16
AD7243BN	–40°C to +85°C	±1/2 LSB	N-16
AD7243AR	–40°C to +85°C	±1 LSB	R-16
AD7243BR	–40°C to +85°C	±1/2 LSB	R-16
AD7243AQ	–40°C to +85°C	±1 LSB	Q-16
AD7243BQ	–40°C to +85°C	±1/2 LSB	Q-16
AD7243SQ[2]	–55°C to +125°C	±1 LSB	Q-16

NOTES
[1]N = Plastic DIP; R = SOIC; Q = Cerdip.
[2]Available to /883B processing only. Contact your local sales office for military data sheet.

CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the AD7243 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high-energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.



TERMINOLOGY

Bipolar Zero Error
Bipolar Zero Error is the voltage measured at V_{OUT} when the DAC is configured for bipolar output and loaded with all 0s (Two's Complement Coding) or with 1000 0000 0000 (Offset Binary Coding). It is due to a combination of offset errors in the DAC, amplifier and mismatch between the internal gain resistors around the amplifier.

Full-Scale Error
Full-Scale Error is a measure of the output error when the amplifier output is at full scale (for the bipolar output range full scale is either positive or negative full scale). It is measured with respect to the reference input voltage and includes the offset errors.

Digital-to-Analog Glitch Impulse
This is the voltage spike that appears at V_{OUT} when the digital code in the DAC latch changes, before the output settles to its final value. The energy in the glitch is specified in nV secs, and is measured for an all codes change from 0000 0000 0000 to 1111 1111 1111 and vice versa.

Digital Feedthrough
This is a measure of the voltage spike that appears on V_{OUT} as a result of feedthrough from the digital inputs on the AD7243. It is measured with $\overline{LDAC}$ held high.

Relative Accuracy (Linearity)
Relative Accuracy, or endpoint linearity, is a measure of the maximum deviation of the DAC transfer function from a straight line passing through the endpoints of the transfer function. It is measured after allowing for zero and full-scale errors and is expressed in LSBs or as a percentage of full-scale reading.

Single Supply Linearity and Gain Error
The output amplifier on the AD7243 can have true negative offsets even when the part is operated from a single +15 V supply. However, because the negative supply rail (V_{SS}) is 0 V, the output cannot actually go negative. Instead, when the output offset voltage is negative, the output voltage sits at 0 V, resulting in the transfer function shown in Figure 1.

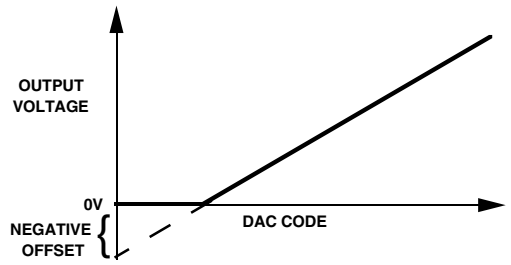


Figure 1. Effect of Negative Offset (Single Supply)

AD7243 PIN FUNCTION DESCRIPTIONS (DIP and SOIC PIN NUMBERS)

Pin	Mnemonic	Description
1	REFIN	Voltage Reference Input. It is internally buffered before being applied to the DAC. The nominal reference voltage for specified operation of the AD7243 is 5 V.
2	REFOUT	Voltage Reference Output. The internal 5 V analog reference is provided at this pin. To operate the part - using its internal reference, REFOUT should be connected to REFIN.
3	$\overline{CLR}$	Clear, Logic Input. Taking this input low sets V_{OUT} to 0 V in both unipolar ranges and the two's complement bipolar range and to –REFIN in the offset binary bipolar range.
4	$\overline{BIN}$/COMP	Logic Input. This input selects the data format to be either binary or two's complement. In both unipolar ranges, natural binary format is selected by connecting this input to a Logic "0." In the bipolar configuration, offset binary format is selected with a Logic "0" while a Logic "1" selects two's complement format.
5	SCLK	Serial Clock, Logic Input. Data is clocked into the input register on each falling SCLK edge.
6	SDIN	Serial Data In, Logic Input. The 16-bit serial data word is applied to this input.
7	$\overline{SYNC}$	Data Synchronization Pulse, Logic Input. Taking this input low initializes the internal logic in readiness for a new data word.
8	DGND	Digital Ground. Ground reference for all digital circuitry.
9	$\overline{LDAC}$	Load DAC, Logic Input. Updates the DAC output. The DAC output is updated on the falling edge of this signal or alternatively if this line is permanently low, an automatic update mode is selected whereby the DAC is updated on the 16th falling SCLK pulse.
10	DCEN	Daisy-Chain Enable, Logic Input. Connect this pin high if a daisy-chain interface is being used, otherwise this pin must be connected low.
11	SDO	Serial Data Out, Logic Output. With DCEN at Logic "1" this output is enabled, and the serial data in the input shift register is clocked out on each falling SCLK edge.
12	AGND	Analog Ground. Ground reference for all analog circuitry.
13	R_{OFS}	Output Offset Resistor for the amplifier. It is connected to V_{OUT} for the +5 V range, to AGND for the +10 V range and to REFIN for the –5 V to +5 V range.
14	V_{OUT}	Analog Output Voltage. This is the buffer amplifier output voltage. Three different output voltage ranges can be chosen: 0 V to +5 V, 0 to +10 V and –5 V to +5 V.
15	V_{SS}	Negative Power Supply (used for the output amplifier only, may be connected to 0 V for single supply operation or to –12 V to –15 V for dual supplies).
16	V_{DD}	Positive Power Supply (+12 V to +15 V).

TERMINOLOGY (Continued)

This "knee" is an offset effect, not a linearity error, and the transfer function would have followed the dotted line if the output voltage could have gone negative.

Normally, linearity is measured between zero (all 0s input code) and full scale (all 1s input code) after offset and full scale have been adjusted out or allowed for, but this is not possible in single supply operation if the offset is negative, due to the knee in the transfer function. Instead, linearity of the AD7243 in the unipolar mode is measured between full scale and the lowest code which is guaranteed to produce a positive output voltage. This code is calculated from the maximum specification for negative offset. For the A and B versions the linearity is measured between Codes 3 and 4095. For the S grade, linearity is measured between Code 5 and Code 4095.

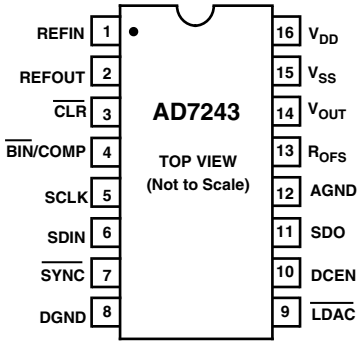
Differential Nonlinearity

Differential Nonlinearity is the difference between the measured change and the ideal 1 LSB change between any two adjacent codes. A specified differential nonlinearity of ±1 LSB or less over the operating temperature range ensures monotonicity.

Unipolar Offset Error

Unipolar Offset Error is the measured output voltage from V_{OUT} with all zeros loaded into the DAC latch when the DAC is configured for unipolar output. It is due to a combination of the offset errors in the DAC and output amplifier.

PIN CONFIGURATION
DIP and SOIC



CIRCUIT INFORMATION

D/A Section

The AD7243 contains a 12-bit voltage mode D/A converter consisting of highly stable thin film resistors and high speed NMOS single-pole, double-throw switches. The output voltage from the converter has the same polarity as the reference voltage, REFIN, allowing single supply operation.

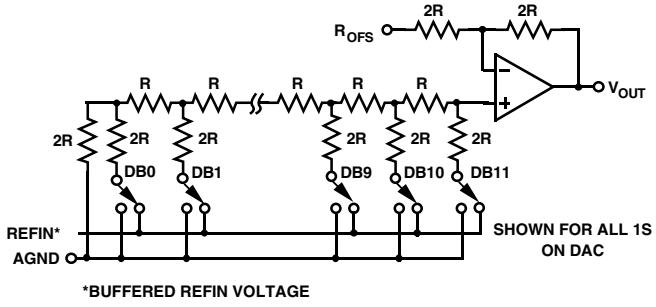


Figure 2. D/A Simplified Circuit Diagram

Internal Reference

The AD7243 has an on-chip temperature compensated buried Zener reference which is factory trimmed to 5 V ± 50 mV. The reference voltage is provided at the REFOUT pin. This reference can be used to provide the reference voltage for the D/A converter (by connecting the REFOUT pin to the REFIN pin.)

The reference voltage can also be used as a reference for other components and is capable of providing up to 500 μA to an external load. The maximum recommended capacitance on REFOUT for normal operation is 50 pF. If the reference is required for external use with capacitive loads greater than 50 pF then it should be decoupled to AGND with a 200 Ω resistor in series with a parallel combination of a 10 μF tantalum capacitor and a 0.1 μF ceramic capacitor.

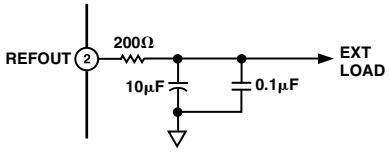


Figure 3. Reference Decoupling Scheme

External Reference

In some applications, the user may require a system reference or some other external reference to drive the AD7243. References such as the AD586 provide an ideal external reference source (see Figure 10). The REFIN voltage is internally buffered by a unity gain amplifier before being applied to the D/A converter. The D/A converter is scaled for a 5 V reference and the device is tested with 5 V applied to REFIN. Other reference voltages may be used with degraded performance. Figure 4 shows the typical degradation in linearity vs. REFIN.

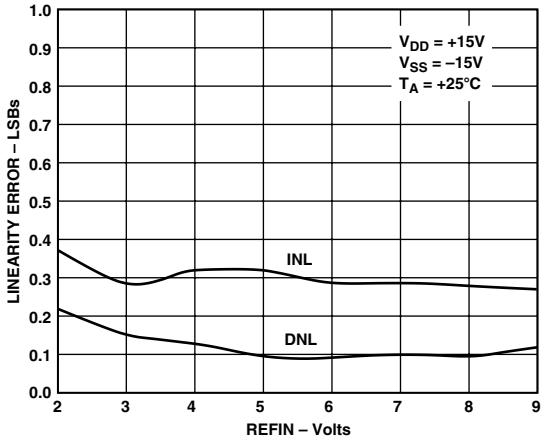


Figure 4. Typical Linearity vs. REFIN Voltage

Op Amp Section

The output of the voltage mode D/A converter is buffered by a noninverting CMOS amplifier. The R_{OFS} input allows three output voltage ranges to be selected. The buffer amplifier is capable of developing +10 V across a 2 kΩ load to AGND.

The output amplifier can be operated from a single +12 V to +15 V supply by tying V_{SS} = 0 V.

The amplifier can also be operated from dual supplies to allow an additional bipolar output range of –5 V to +5 V. Dual supplies are necessary for the bipolar output range but can also be used for the unipolar ranges to give faster settling time to voltages near

0 V, to allow full sink capability of 2.5 mA over the entire output range and to eliminate the effects of negative offsets on the transfer characteristic (outlined previously). A plot of the output sink capability of the amplifier is shown in Figure 5.

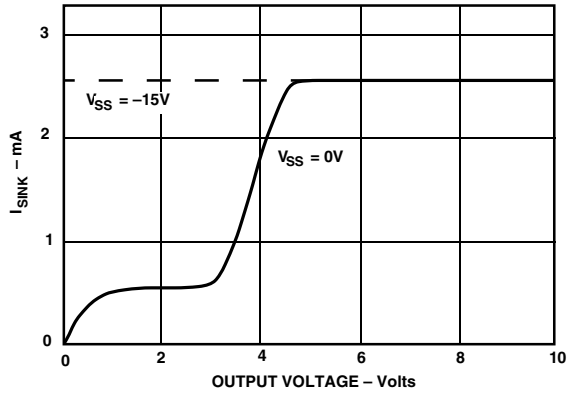


Figure 5. Amplifier Sink Current

DIGITAL INTERFACE

The AD7243 contains an input serial to parallel shift register and a DAC latch. A simplified diagram of the input loading circuitry is shown in Figure 6. Serial data on the SDIN input is loaded to the input register under control of DCEN, $\overline{\text{SYNC}}$ and SCLK. When a complete word is held in the shift register, it may then be loaded into the DAC latch under control of $\overline{\text{LDAC}}$. Only the data in the DAC latch determines the analog output on the AD7243.

The DCEN (daisy-chain enable) input is used to select either a standalone mode or a daisy-chain mode. The loading format is slightly different depending on which mode is selected.

Serial Data Loading Format (Standalone Mode)

With DCEN at Logic 0 the standalone mode is selected. In this mode a low $\overline{\text{SYNC}}$ input provides the frame synchronization signal which tells the AD7243 that valid serial data on the SDIN input will be available for the next 16 falling edges of SCLK. An internal counter/decoder circuit provides a low gating signal so that only 16 data bits are clocked into the input shift register. After 16 SCLK pulses the internal gating signal goes inactive (high) thus locking out any further clock pulses. Therefore, either a continuous clock or a burst clock source may be used to clock in the data.

The $\overline{\text{SYNC}}$ input should be taken high after the complete 16-bit word is loaded in.

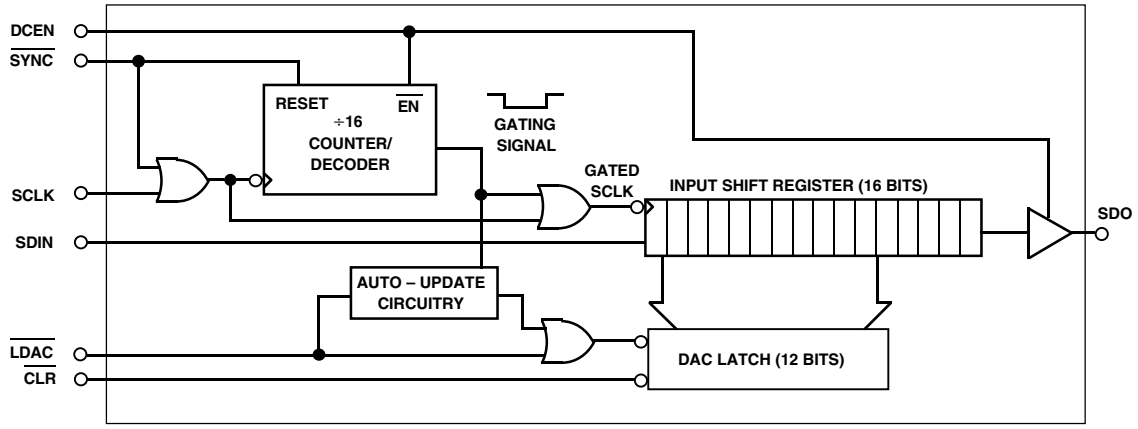


Figure 6. Simplified Loading Structure

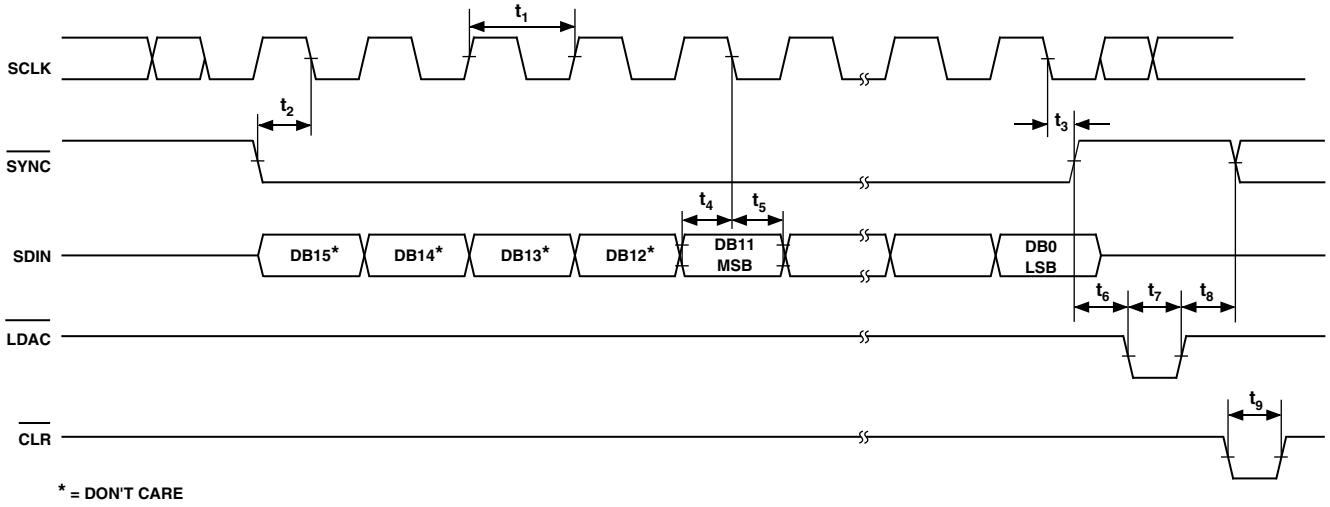


Figure 7. Timing Diagram (Standalone Mode)

Although 16 bits of data are clocked into the input register, only the latter 12 bits get transferred into the DAC latch. The first 4 bits in the 16 bit stream are don't cares since their value does not affect the DAC latch data. Therefore, the data format is 4 don't cares followed by the 12-bit data word with the LSB as the last bit in the serial stream.

There are two ways in which the DAC latch and hence the analog output may be updated. The status of the $\overline{\text{LDAC}}$ input is examined after $\overline{\text{SYNC}}$ is taken low. Depending on its status, one of two update modes is selected.

If $\overline{\text{LDAC}}$ = 0, then the automatic update mode is selected. In this mode the DAC latch and analog output are updated automatically when the last bit in the serial data stream is clocked in. The update thus takes place on the sixteenth falling SCLK edge.

If $\overline{\text{LDAC}}$ = 1, then the automatic update is disabled and the DAC latch is updated by taking $\overline{\text{LDAC}}$ low any time after the 16-bit data transfer is complete. The update now occurs on the falling edge of $\overline{\text{LDAC}}$. Note that the $\overline{\text{LDAC}}$ input must be taken back high again before the next data transfer is initiated.

Serial Data Loading Format (Daisy-Chain Mode)

By connecting DCEN high the daisy-chain mode is enabled. This mode of operation is designed for multi-DAC systems where several AD7243s may be connected in cascade (see Figure 16). In this mode the internal gating circuitry on SCLK is disabled, and a serial data output facility is enabled. The internal gating signal is permanently active (low) so that the SCLK signal is continuously applied to the input shift register when $\overline{\text{SYNC}}$ is low. The data is clocked into the register on each falling SCLK edge after $\overline{\text{SYNC}}$ going low. If more than 16 clock pulses are applied, the data ripples out of the shift register and appears on the SDO line. By connecting this line to the SDIN input on the next AD7243 in the chain, a multi-DAC interface may be constructed. Sixteen SCLK pulses are required for each DAC in the system. Therefore, the total number of clock cycles must equal 16N where N is the total number of devices in the chain. When the serial transfer to all devices is complete, $\overline{\text{SYNC}}$ should be taken high. This prevents any further data being clocked into the input register.

A continuous SCLK source may be used if it can be arranged that $\overline{\text{SYNC}}$ is held low for the correct number of clock cycles. Alternatively, a burst clock containing the exact number of clock cycles may be used and $\overline{\text{SYNC}}$ taken high some time later.

When the transfer to all input registers is complete, a common $\overline{\text{LDAC}}$ signal updates all DAC latches with the lower 12 bits of data in each input register. All analog outputs are therefore updated simultaneously on the falling edge of $\overline{\text{LDAC}}$.

Clear Function ($\overline{\text{CLR}}$)

The clear function bypasses the input shift register and loads the DAC Latch with all 0s. It is activated by taking $\overline{\text{CLR}}$ low. In all ranges except the Offset Binary bipolar range (–5 V to +5 V) the output voltage is reset to 0 V. In the offset binary bipolar range the output is set to –REFIN. The clear function is especially useful at power-up as it enables the output to be reset to a known state.

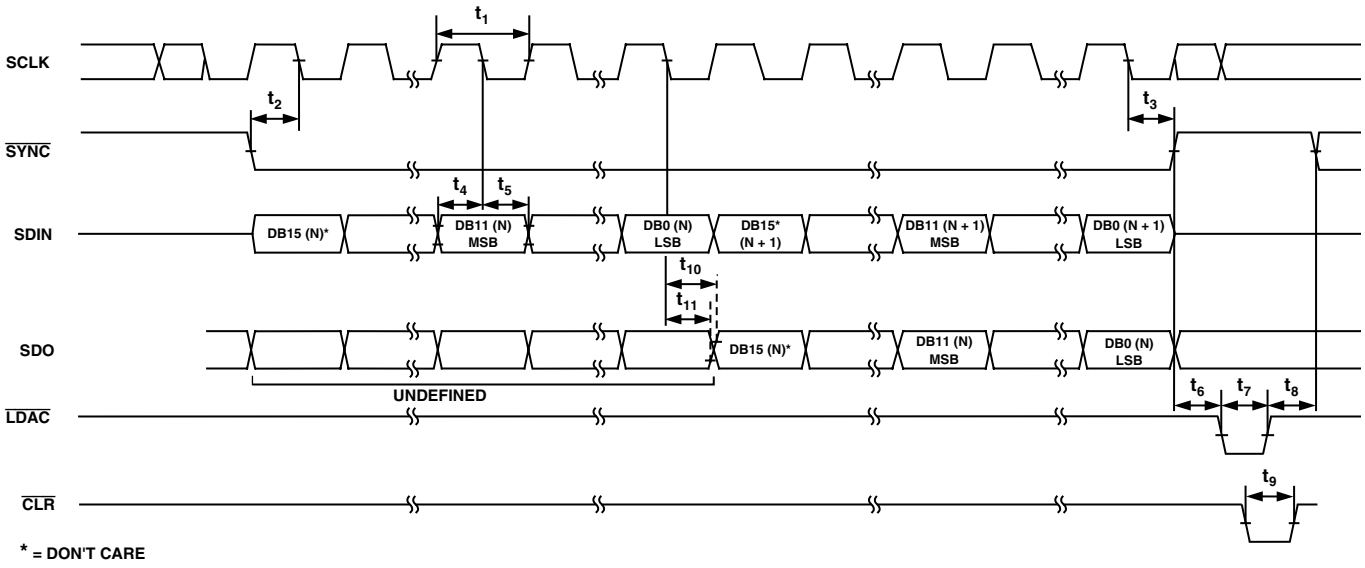


Figure 8. Timing Diagram (Daisy-Chain Mode)

APPLYING THE AD7243

Power Supply Decoupling

To achieve optimum performance when using the AD7243, the V_{DD} and V_{SS} lines should each be decoupled to DGND using 0.1 μF capacitors. In noisy environments it is recommended that 10 μF capacitors be connected in parallel with the 0.1 μF capacitors.

The internal scaling resistors provided on the AD7243 allow several output voltage ranges. The part can produce unipolar output ranges of 0 V to +5 V or 0 V to +10 V and a bipolar output range of ±5 V. Connections for the various ranges are outlined below.

Unipolar (0 V to +10 V) Configuration

The first of the configurations provides an output voltage range of 0 V to +10 V. This is achieved by connecting the output offset resistor R_{OFS} (Pin 13) to AGND. Natural Binary data format is selected by connecting $\overline{BIN}$/COMP (Pin 4) to DGND. In this configuration, the AD7243 can be operated using either single or dual supplies. Note that the V_{DD} supply must be ≥+14.25 V for this range in order to maintain sufficient amplifier headroom. Dual supplies may be used to improve settling time and give increased current sink capability for the amplifier. Figure 9 shows the connection diagram for unipolar operation of the AD7243. Table I shows the digital code vs. analog output for this configuration.

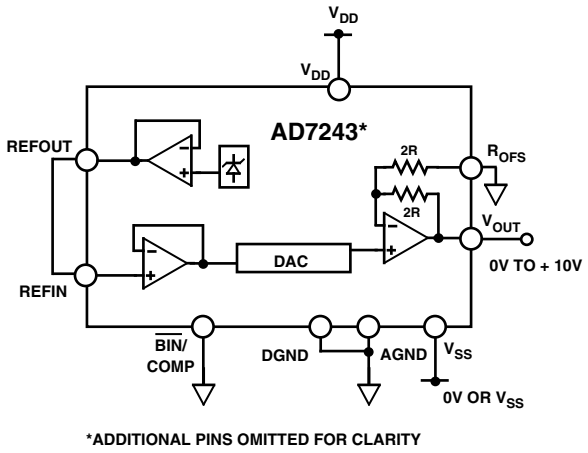


Figure 9. Unipolar (0 V to +10 V) Configuration

Table I. Unipolar Code Table (0 V to +10 V Range)

Input Data Word MSB LSB	Analog Output, V_{OUT}
XXXX 1111 1111 1111	+2 REFIN × (4095/4096)
XXXX 1000 0000 0001	+2 REFIN × (2049/4096)
XXXX 1000 0000 0000	+2 REFIN × (2048/4096) = +REFIN
XXXX 0111 1111 1111	+2 REFIN × (2047/4096)
XXXX 0000 0000 0001	+2 REFIN × (1/4096)
XXXX 0000 0000 0000	0 V

X = Don't Care.
Note: 1 LSB = 2 REFIN/4096.

Unipolar (0 V to +5 V) Configuration

The 0 V to +5 V output voltage range is achieved by connecting R_{OFS} to V_{OUT}. Once again, the AD7243 can be operated using either single or dual supplies. The table for output voltage vs. digital code is as in Table I, with 2REFIN replaced by REFIN. Note, for this range, 1 LSB = REFIN • (2^{-12}) = (REFIN/4096).

Bipolar (±5 V) Configuration

The bipolar configuration for the AD7243, which gives an output range of –5 V to +5 V, is achieved by connecting R_{OFS} to REFIN. The AD7243 must be operated from dual supplies to achieve this output voltage range. Either offset binary or two's complement data format may be selected. Figure 10 shows the connection diagram for bipolar operation. An AD586 provides the reference voltage for the DAC but this could be provided by the on-chip reference by connecting REFOUT to REFIN.

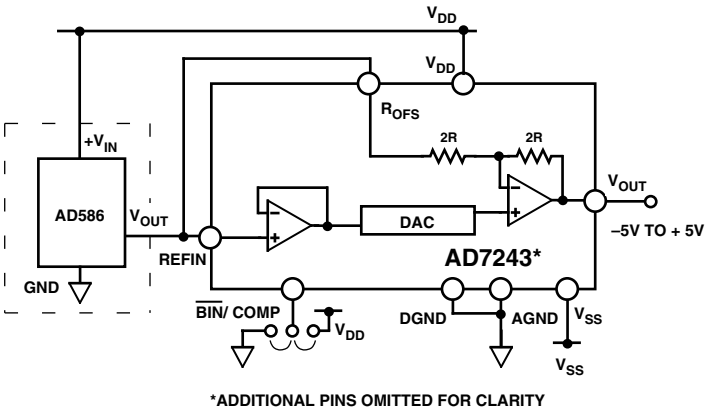


Figure 10. Bipolar Configuration with External Reference

Bipolar Operation (Two's Complement Data Format)

The AD7243 is configured for two's complement data format by connecting $\overline{BIN}$/COMP (Pin 4) high. The analog output vs. digital code is shown in Table II.

Table II. Two's Complement Bipolar Code Table

Input Data Word MSB LSB	Analog Output, V_{OUT}
XXXX 0111 1111 1111	+REFIN × (2047/2048)
XXXX 0000 0000 0001	+REFIN × (1/2048)
XXXX 0000 0000 0000	0 V
XXXX 1111 1111 1111	–REFIN × (1/2048)
XXXX 1000 0000 0001	–REFIN × (2047/2048)
XXXX 1000 0000 0000	–REFIN × (2048/2048) = –REFIN

X = Don't Care.
Note: 1 LSB = REFIN/2048.

Bipolar Operation (Offset Binary Data Format)

The AD7243 is configured for Offset Binary data format by connecting $\overline{BIN}$/COMP (Pin 4) low. The analog output vs. digital code may be obtained by inverting the MSB in Table II.

MICROPROCESSOR INTERFACING

Microprocessor interfacing to the AD7243 is via a serial bus which uses standard protocol compatible with DSP processors and microcontrollers. The communications channel requires a three-wire interface consisting of a clock signal, a data signal and a synchronization signal. The AD7243 requires a 16-bit data word with data valid on the falling edge of SCLK. For all the interfaces, the DAC update may be done automatically when all the data is clocked in or it may be done under control of $\overline{\text{LDAC}}$.

Figures 11 to 16 show the AD7243 configured for interfacing to a number of popular DSP processors and microcontrollers.

AD7243–ADSP-2101/ADSP-2102 Interface

Figure 11 shows a serial interface between the AD7243 and the ADSP-2101/ADSP-2102 DSP processor. The ADSP-2101/ ADSP-2102 contains two serial ports, and either port may be used in the interface. The data transfer is initiated by $\overline{\text{TFS}}$ going low. Data from the ADSP-2101/ADSP-2102 is clocked into the AD7243 on the falling edge of SCLK. When the data transfer is complete, $\overline{\text{TFS}}$ is taken high. In the interface shown the DAC is updated using an external timer which generates an $\overline{\text{LDAC}}$ pulse. This could also be done using a control or decoded address line from the processor. Alternatively, the $\overline{\text{LDAC}}$ input could be hard wired low and in this case the update takes place automatically on the sixteenth falling edge of SCLK.

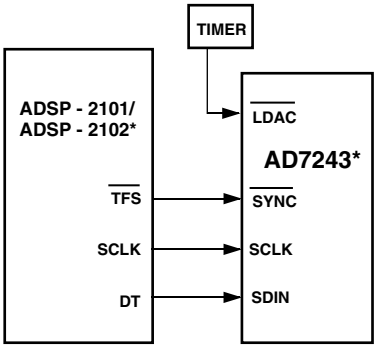


Figure 11. AD7243–ADSP-2101/ADSP-2102 Interface

AD7243–DSP56000 Interface

A serial interface between the AD7243 and the DSP56000 is shown in Figure 12. The DSP56000 is configured for Normal Mode Asynchronous operation with Gated Clock. It is also set up for a 16-bit word with SCK and SC2 as outputs and the FSL control bit set to a "0." SCK is internally generated on the DSP56000 and applied to the AD7243 SCLK input. Data from the DSP56000 is valid on the falling edge of SCK. The SC2 output provides the framing pulse for valid data. This line must be inverted before being applied to the $\overline{\text{SYNC}}$ input of the AD7243.

The $\overline{\text{LDAC}}$ input of the AD7243 is connected to DGND so the update of the DAC latch takes place automatically on the sixteenth falling edge of SCLK. An external timer could also be used as in the previous interface if an external update is required.

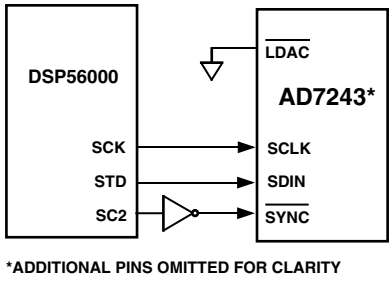


Figure 12. AD7243–DSP56000 Interface

AD7243–TMS32020 Interface

Figure 13 shows a serial interface between the AD7243 and the TMS32020 DSP processor. In this interface, the CLKX and FSX signals for the TMS32020 should be generated using external clock/timer circuitry. The FSX pin of the TMS32020 must be configured as an input. Data from the TMS32020 is valid on the falling edge of CLKX.

The clock/timer circuitry generates the $\overline{\text{LDAC}}$ signal for the AD7243 to synchronize the update of the output with the serial transmission. Alternatively, the automatic update mode may be selected by connecting $\overline{\text{LDAC}}$ to DGND.

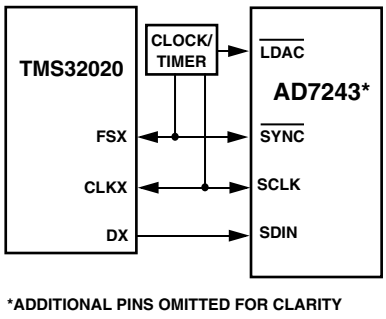


Figure 13. AD7243–TMS32020 Interface

AD7243–87C51 Interface
A serial interface between the AD7243 and the 87C51 microcontroller is shown in Figure 14. TXD of the 87C51 drives SCLK of the AD7243, while RXD drives the serial data line of the part. The $\overline{SYNC}$ signal is derived from the port line P3.3.

The 87C51 provides the LSB of its SBUF register as the first bit in the serial data stream. Therefore, the user will have to ensure that the data in the SBUF register is arranged correctly so that the don't care bits are the first to be transmitted to the AD7243 and the last bit to be sent is the LSB of the word to be loaded to the AD7243. When data is to be transmitted to the part, P3.3 is taken low. Data on RXD is valid on the falling edge of TXD. The 87C51 transmits its serial data in 8-bit bytes with only eight falling clock edges occurring in the transmit cycle. To load data to the AD7243, P3.3 is left low after the first eight bits are transferred and a second byte of data is then transferred serially to the AD7243. When the second serial transfer is complete, the P3.3 line is taken high.

Figure 14 shows the $\overline{LDAC}$ input of the AD7243 hard wired low. As a result, the DAC latch and the analog output will be updated on the sixteenth falling edge of TXD after the $\overline{SYNC}$ signal for the DAC has gone low. Alternatively, the scheme used in previous interfaces, whereby the $\overline{LDAC}$ input is driven from a timer, can be used.

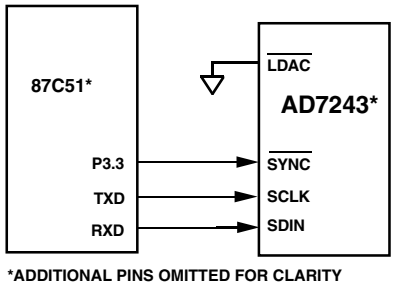


Figure 14. AD7243–87C51 Interface

AD7243–68HC11 Interface
Figure 15 shows a serial interface between the AD7243 and the 68HC11 microcontroller. SCK of the 68HC11 drives SCLK of the AD7243 while the MOSI output drives the serial data line of the AD7243. The $\overline{SYNC}$ signal is derived from a port line (PC7 shown).

For correct operation of this interface, the 68HC11 should be configured such that its CPOL bit is a 0 and its CPHA bit is a 1. When data is to be transmitted to the part, PC7 is taken low. When the 68HC11 is configured like this, data on MOSI is valid on the falling edge of SCK. The 68HC11 transmits its serial data in 8-bit bytes with only eight falling clock edges occurring in the transmit cycle. To load data to the AD7243, PC7 is left low after the first eight bits are transferred and a second byte of data is then transferred serially to the AD7243. When the second serial transfer is complete, the PC7 line is taken high.

Figure 15 shows the $\overline{LDAC}$ input of the AD7243 hardwired low. As a result, the DAC latch and the analog output of the DAC will be updated on the sixteenth falling edge of SCK after the respective $\overline{SYNC}$ signal has gone low. Alternatively, the scheme used in previous interfaces, whereby the $\overline{LDAC}$ input is driven from a timer, can be used.

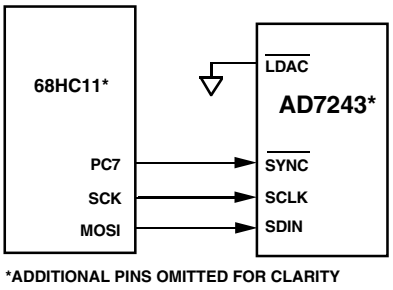


Figure 15. AD7243–68HC11 Interface

Multiple DAC Daisy-Chain Interface
A multi-DAC serial interface is shown in Figure 16. This scheme may be used with all of the interfaces previously discussed if more than one DAC is required in a system. To enable the facility the DCEN pin must be connected high on all devices, including the last device in the chain.

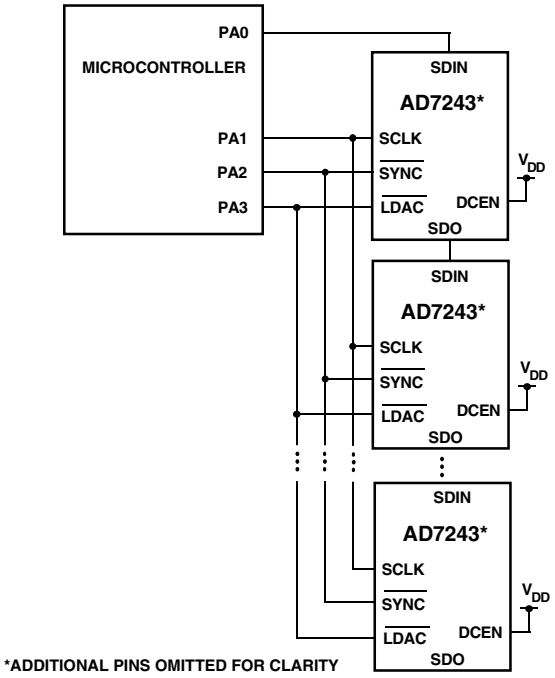


Figure 16. AD7243 Daisy-Chain Configuration

Common clock, data, and synchronization signals are applied to all DACs in the chain. The loading sequence starts by taking $\overline{SYNC}$ low. The data is then clocked into the input registers on the falling edge of SCLK. Sixteen clock pulses are required for each DAC in the chain. The data ripples through the input registers with the first 16-bit word filling the last register in the chain after 16N clock pulses where N = the total number of DACs in the chain.

When valid data has been loaded into all the registers, the $\overline{SYNC}$ input should be taken high and a common $\overline{LDAC}$ pulse used to update all the DACs simultaneously.

APPLICATIONS

OPTO-ISOLATED INTERFACE

In many process control type applications it is necessary to provide an isolation barrier between the controller and the unit being controlled. Opto-isolators can provide voltage isolation in excess of 3 kV. The serial loading structure of the AD7243 makes it ideal for opto-isolated interfaces as the number of interface lines is kept to a minimum.

Figure 17 shows a 4-channel isolated interface using the AD7243. The DCEN pin must be connected high to enable the daisy-chain facility. Four channels with 12-bit resolution are provided in the circuit shown, but this may be expanded to accommodate any number of DAC channels without any extra isolation circuitry.

The sequence of events to program the output channels is as follows:

1. Take the $\overline{SYNC}$ line low.
2. Transmit the data as four 16-bit words. A total of 64 clock pulses is required to clock the data through the chain.
3. Take the $\overline{SYNC}$ line high.
4. Pulse the $\overline{LDAC}$ line low. This updates all output channels simultaneously on the falling edge of $\overline{LDAC}$.

To reduce the number of opto-couplers, the $\overline{LDAC}$ line could be driven from a one shot which is triggered by the rising edge on the $\overline{SYNC}$ line. A low level pulse of 50 ns duration or greater is all that is required to update the outputs.

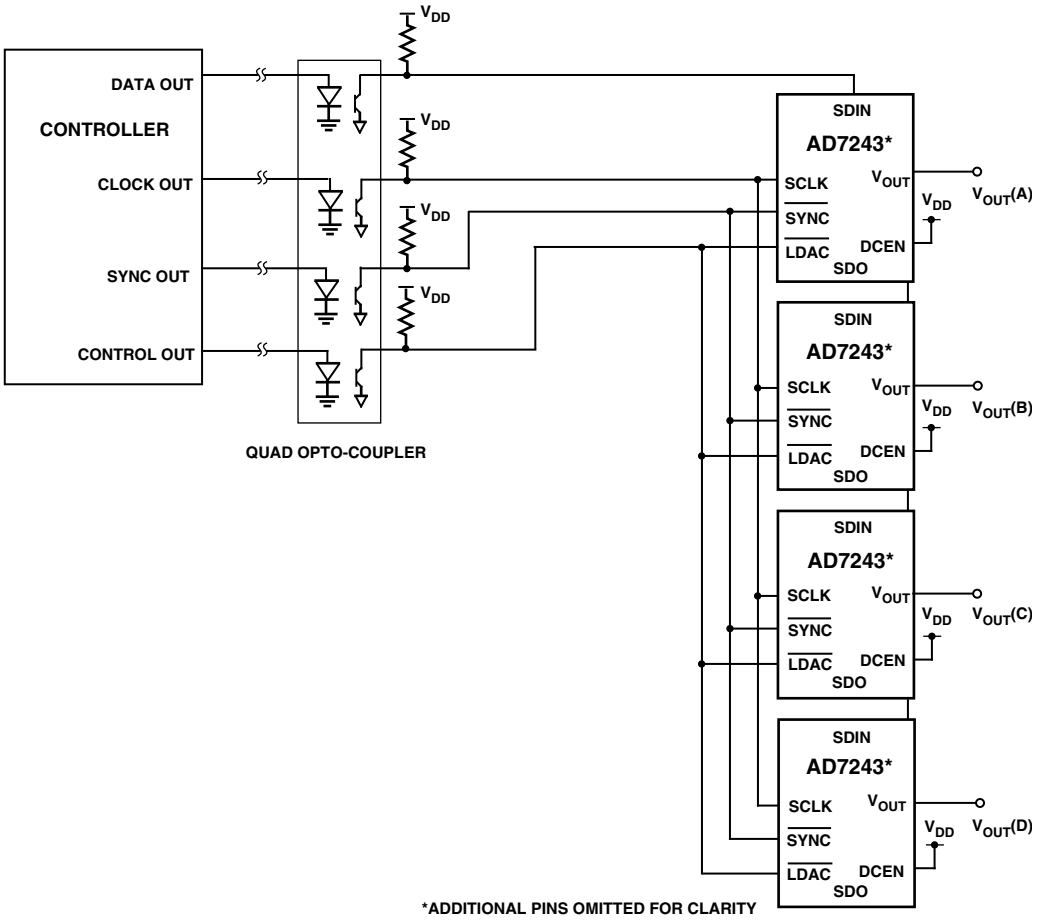
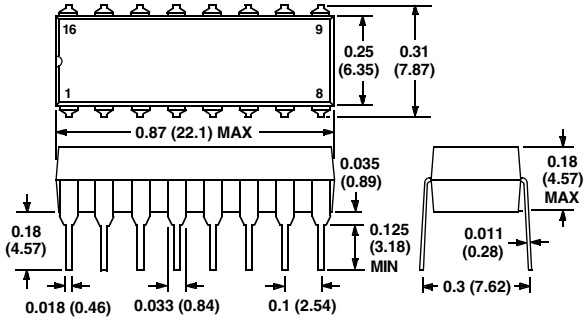


Figure 17. Four-Channel Opto-Isolated Interface

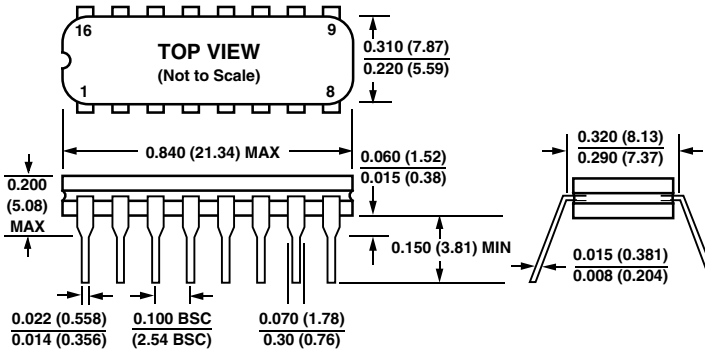
OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

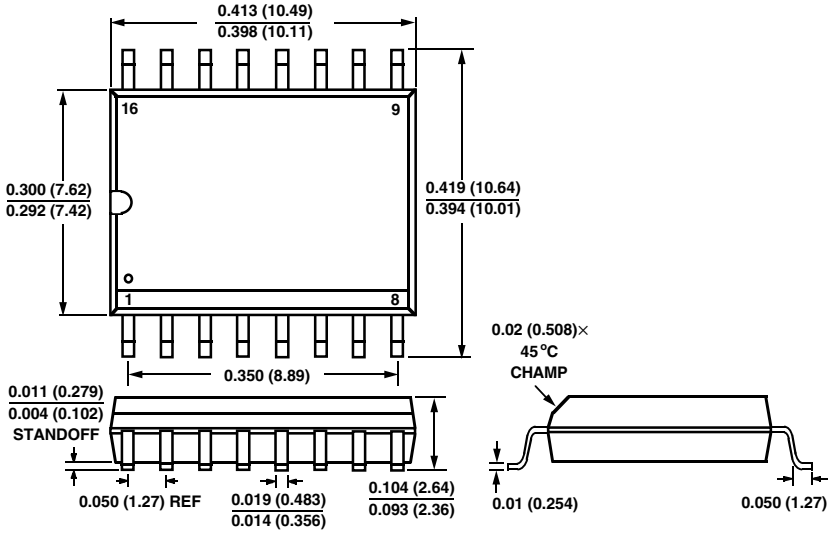
Plastic DIP (N-16)



Cerdip (Q-16)



SOIC (R-16)



C1498a–1–6/00 (rev. A) 00993

PRINTED IN U.S.A.