Improved Industry Standard Serial 12-Bit Multiplying DACs

FEATURES

- **Improved Direct Replacement for AD7543 and DAC-8143**
- **Low Cost**
- **DNL and INL over Temperature: ±0.5LSB**
- Easy, Fast and Flexible Serial Interface
- Daisy-Chain 3-Wire Interface for Multiple DAC Systems (LTC8143)
- 1LSB Maximum Gain Error over Temperature Eliminates Adjustment
- Asynchronous Clear Input for Initialization
- 4-Quadrant Multiplication
- Low Power Consumption
- 16-Pin PDIP and SO Packages

APPLICATIONS

- Process Control and Industrial Automation
- Remote Microprocessor-Controlled Systems
- Digitally Controlled Filters and Power Supplies
- Programmable Gain Amplifiers
- Automatic Test Equipment

DESCRIPTION

The LTC®7543/LTC8143 are serial-input 12-bit multiplying digital-to-analog converters (DACs). They are superior pin compatible replacements for the AD7543 and DAC-8143. Improvements include better accuracy, better stability over temperature and supply variations, lower sensitivity to output amplifier offset, tighter timing specifications and lower output capacitance.

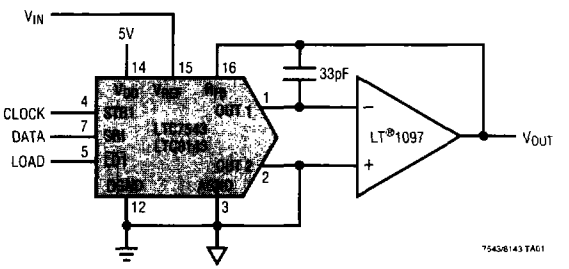
An easy-to-use serial interface includes an asynchronous CLEAR input for systems requiring initialization to a known state. The LTC8143 has a serial data output to allow daisy-chaining multiple DACs on a 3-wire interface bus.

These DACs are extremely versatile. They can be used for 2-quadrant and 4-quadrant multiplying, programmable gain and single supply applications, such as noninverting voltage output and biased or offset ground mode.

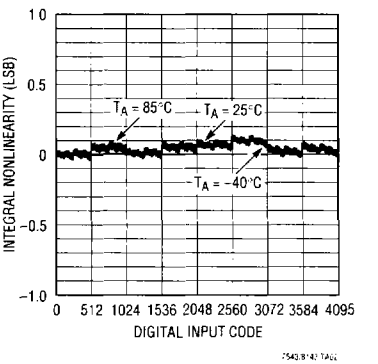
Parts are available in 16-pin PDIP and SO packages and are specified over the extended industrial temperature range, –40°C to 85°C.

TYPICAL APPLICATION

Multiplying DAC Has Easy 3-Wire Serial Interface



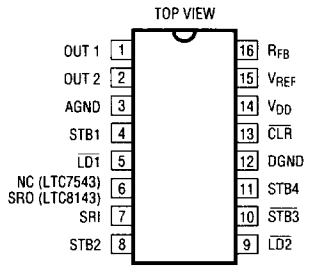
Integral Nonlinearity over Temperature



ABSOLUTE MAXIMUM RATINGS

V_{DD} to AGND ..... −0.5V to 7V
V_{DD} to DGND ..... −0.5V to 7V
AGND to DGND ..... V_{DD} + 0.5V
DGND to AGND ..... V_{DD} + 0.5V
Digital Inputs to DGND ..... −0.5V to (V_{DD} + 0.5V)
V_{OUT1}, V_{OUT2} to AGND ..... −0.5V to (V_{DD} + 0.5V)
V_{REF} to AGND, DGND ..... ±25V
V_{RFB} to AGND, DGND ..... ±25V
Maximum Junction Temperature ..... 150°C
Operating Temperature Range ..... −40°C to 85°C
Storage Temperature Range ..... −65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

PACKAGE/ORDER INFORMATION



N PACKAGE
16-LEAD PDIP
SW PACKAGE
16-LEAD PLASTIC SO WIDE

T_{JMAX} = 150°C, θ_{JA} = 100°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 130°C/W (SW)

ORDER PART NUMBER
LTC7543GKN
LTC7543KN
LTC7543GKSW
LTC7543KSW
LTC8143EN
LTC8143FN
LTC8143ESW
LTC8143FSW

Consult factory for Military grade parts.

ACCURACY CHARACTERISTICS (LTC7543)

V_{DD} = 5V, V_{REF} = 10V, V_{OUT1} = V_{OUT2} = AGND = DGND =0V, T_A = T_{MIN} to T_{MAX}, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS		LTC7543GK MIN	LTC7543GK TYP	LTC7543GK MAX	LTC7543K MIN	LTC7543K TYP	LTC7543K MAX	UNITS
	Resolution		●	12			12			Bits
INL	Integral Nonlinearity (Relative Accuracy)	(Note 1)	●			±0.5			±0.5	LSB
DNL	Differential Nonlinearity	Guaranteed Monotonic, T_{MIN} to T_{MAX}	●			±0.5			±0.5	LSB
GE	Gain Error	(Note 2) T_A = 25°C				±1			±2	LSB
		T_{MIN} to T_{MAX}	●			±1			±2	LSB
	Gain Temperature Coefficient (ΔGain/ΔTemp)	(Note 3)	●		1	5		1	5	ppm/°C
I_{LKG}	Output Leakage Current	(Note 4) T_A = 25°C				±1			±1	nA
		T_{MIN} to T_{MAX}	●			±10			±10	nA
	Zero-Scale Error	T_A = 25°C				±0.006			±0.006	LSB
		T_{MIN} to T_{MAX}	●			±0.06			±0.06	LSB
PSRR	Power Supply Rejection Ratio	V_{DD} = 5V ±5%	●		±0.0001	±0.002		±0.0001	±0.002	%/%

6

ACCURACY CHARACTERISTICS (LTC8143)

V_{DD} = 5V, V_{REF} = 10V, V_{OUT1} = V_{OUT2} = AGND = DGND = 0V, T_A = T_{MIN} to T_{MAX}, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS			LTC8143E MIN	LTC8143E TYP	LTC8143E MAX	LTC8143F MIN	LTC8143F TYP	LTC8143F MAX	UNITS
	Resolution			●	12			12			Bits
INL	Integral Nonlinearity (Relative Accuracy)	(Note 1)		●			±0.5			±1	LSB
DNL	Differential Nonlinearity	Guaranteed Monotonic, T_{MIN} to T_{MAX}		●			±0.5			±1	LSB
GE	Gain Error	(Note 2)	T_A = 25°C				±1			±2	LSB
			T_{MIN} to T_{MAX}	●			±2			±2	LSB
	Gain Temperature Coefficient (ΔGain/ΔTemp)	(Note 3)		●		1	5		1	5	ppm/°C
I_{LKG}	Output Leakage Current	(Note 4)	T_A = 25°C				±5			±5	nA
			T_{MIN} to T_{MAX}	●			±25			±25	nA
	Zero-Scale Error		T_A = 25°C				±0.03			±0.03	LSB
			T_{MIN} to T_{MAX}	●			±0.15			±0.15	LSB
PSRR	Power Supply Rejection Ratio	V_{DD} = 5V ±5%		●		±0.0001	±0.002		±0.0001	±0.002	%/%

ELECTRICAL CHARACTERISTICS

V_{DD} = 5V, V_{REF} = 10V, V_{OUT1} = V_{OUT2} = AGND = DGND = 0V, T_A = T_{MIN} to T_{MAX}, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS			LTC7543/LTC8143 ALL GRADES MIN	TYP	MAX	UNITS
Reference Input								
R_{REF}	V_{REF} Input Resistance	(Note 5)		●	8	11	15	kΩ
AC Performance (Note 3)								
	Output Current Settling Time	(Notes 6, 7)		●		0.25	1	µs
	Multiplying Feedthrough Error	V_{REF} = ±10V, 10kHz Sinewave		●		0.8	2	mV_{P-P}
	Digital-to-Analog Glitch Energy	(Notes 6, 8)		●		2	20	nV-sec
THD	Total Harmonic Distortion	(Note 9)		●		−108	−92	dB
	Output Noise Voltage Density	(Note 10)		●			13	$nV/\sqrt{Hz}$
Analog Outputs (Note 3)								
C_{OUT}	Output Capacitance	DAC Register Loaded to All 1s	C_{OUT1}	●		60	90	pF
			C_{OUT2}	●		20	60	pF
		DAC Register Loaded to All 0s	C_{OUT1}	●		30	60	pF
			C_{OUT2}	●		50	90	pF
Digital Inputs								
V_{IH}	Digital Input High Voltage			●	2.4			V
V_{IL}	Digital Input Low Voltage			●			0.8	V
I_{IN}	Digital Input Current	V_{IN} = 0V to V_{DD}		●		0.001	±1	µA
C_{IN}	Digital Input Capacitance	(Note 3), V_{IN} = 0V		●			8	pF
Digital Outputs: SRO (LTC8143 Only)								
V_{OH}	Digital Output High	I_{OH} = −200µA		●	4			V
V_{OL}	Digital Output Low	I_{OL} = 1.6mA		●			0.4	V

ELECTRICAL CHARACTERISTICS

V_{DD} = 5V, V_{REF} = 10V, V_{OUT1} = V_{OUT2} = AGND = DGND = 0V, T_A = T_{MIN} to T_{MAX}, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS		LTC7543/LTC8143 ALL GRADES MIN	TYP	MAX	UNITS
Timing Characteristics (Note 3)							
t_{DS1}	Serial Input to Strobe Setup Time (t_{STB} = 80ns)	STB1 Used as the Strobe	●	50	5		ns
t_{DS2}		STB2 Used as the Strobe	●	20	–5		ns
t_{DS3}		$\overline{STB3}$ Used as the Strobe	●	0	–30		ns
t_{DS4}		STB4 Used as the Strobe	●	0	–30		ns
t_{DH1}	Serial Input to Strobe Hold Time (t_{STB} = 80ns)	STB1 Used as the Strobe	●	30	10		ns
t_{DH2}		STB2 Used as the Strobe	●	50	25		ns
t_{DH3}		$\overline{STB3}$ Used as the Strobe	●	80	55		ns
t_{DH4}		STB4 Used as the Strobe	●	80	55		ns
t_{SRI}	Serial Input Data Pulse Width		●	80			ns
t_{STB1}, t_{STB2}, t_{STB3}, t_{STB4}	Strobe Pulse Width	(Note 11)	●	80			ns
$t_{\overline{STB1}}$, $t_{\overline{STB2}}$, $t_{\overline{STB3}}$, t_{STB4}	$\overline{Strobe}$ Pulse Width	(Note 12)	●	80			ns
t_{LD1}, t_{LD2}	Load Pulse Width		●	140			ns
t_{ASB}	LSB Strobed into Input Register to Load DAC Register Time		●	0			ns
t_{CLR}	Clear Pulse Width		●	80			ns
SRO Timing Characteristics (LTC8143 Only)							
t_{PD}	STB2, $\overline{STB3}$, STB4 Strobe to SRO Propagation Delay	C_L = 50pF	●		120	220	ns
t_{PD1}	STB1 to SRO Propagation Delay	C_L = 50pF	●		80	150	ns
Power Supply							
V_{DD}	Supply Voltage		●	4.75	5	5.25	V
I_{DD}	Supply Current	Digital Inputs = 0V or V_{DD}	●			0.1	mA
		Digital Inputs = V_{IH} or V_{IL}	●			2	mA

The ● denotes specifications which apply over the full operating temperature range.

Note 1: ±0.5LSB = ±0.012% of full scale.

Note 2: Using internal feedback resistor.

Note 3: Guaranteed by design, not subject to test.

Note 4: I_{OUT1} with DAC register loaded with all 0s or I_{OUT2} with DAC register loaded with all 1s.

Note 5: Typical temperature coefficient is 100ppm/°C.

Note 6: OUT 1 load = 100Ω in parallel with 13pF.

Note 7: To 0.01% for a full-scale change, measured from falling edge of $\overline{LD1}$ or $\overline{LD2}$.

Note 8: V_{REF} = 0V. DAC register contents changed from all 0s to all 1s or from all 1s to all 0s.

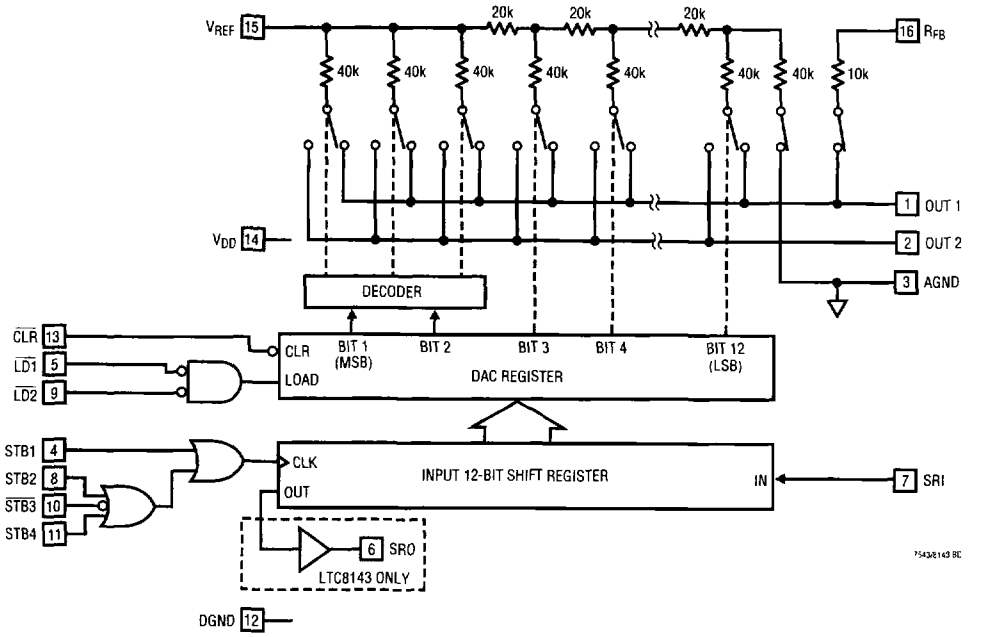
Note 9: V_{REF} = $6V_{RMS}$ at 1kHz. DAC register loaded with all 1s.

Note 10: Calculation from $e_n = \sqrt{4KTRB}$ where: K = Boltzmann constant (J/K°); R = resistance (Ω); T = resistor temperature (°K); B = bandwidth (Hz).

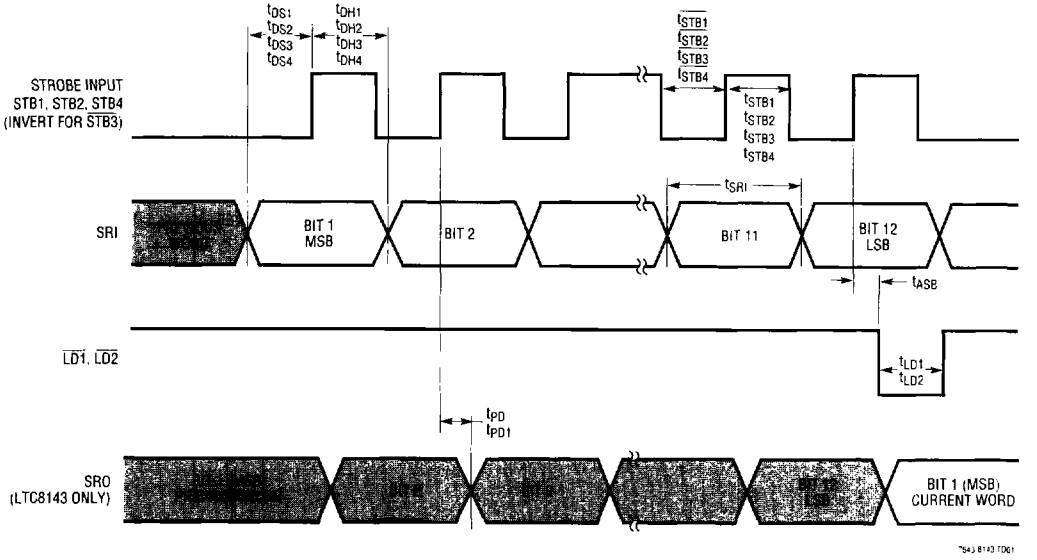
Note 11: Minimum high time for STB1, STB2, STB4. Minimum low time for $\overline{STB3}$.

Note 12. Minimum low time for STB1, STB2, STB4. Minimum high time for $\overline{STB3}$.

BLOCK DIAGRAM



TIMING DIAGRAM



TRUTH TABLES

Table 1. LTC7543/LTC8143 Input Register

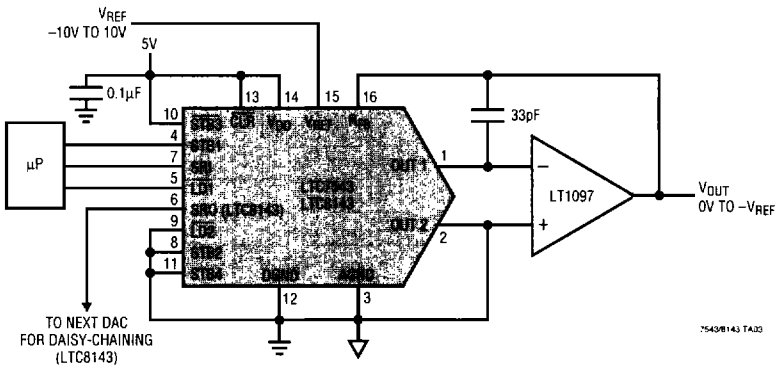
CONTROL INPUTS				Input Register Operation
STB1	STB2	$\overline{STB3}$	STB4	(LTC8143: SRO Operation)
↓	0	1	0	Serial Data Bit on SRI Loaded into Input Register, MSB First (LTC8143: Data Bit or SRI Appears on SRO Pin After 12 Clocked Bits)
0	↓	1	0	
0	0	↑	0	
0	0	1	↓	
1	X	X	X	No Input Register Operation (LTC8143: No SRO Operation)
X	1	X	X	
X	X	0	X	
X	X	X	1	

Table 2. LTC7543/LTC8143 DAC Register

CONTROL INPUTS			
$\overline{CLR}$	$\overline{LD1}$	$\overline{LD2}$	DAC Register Operation
0	X	X	Reset DAC Register to All 0s (Asynchronous Operation; No Effect on Input Register)
1	1	X	No DAC Register Operation
1	X	1	
1	0	0	Load DAC Register with the Contents of Input Register

TYPICAL APPLICATIONS

Unipolar Operation (2-Quadrant Multiplication)

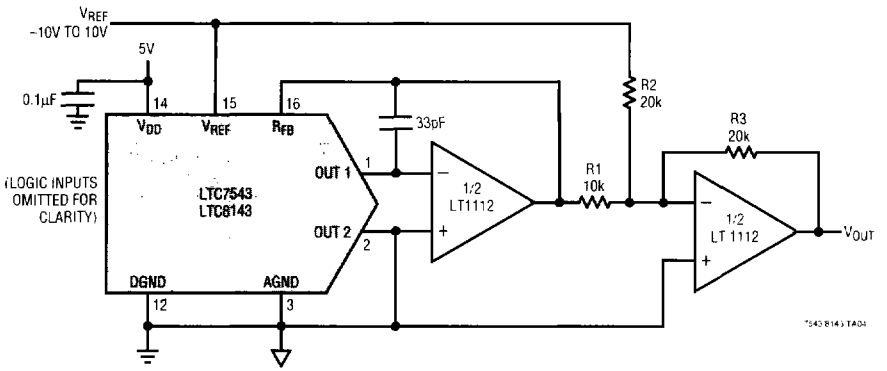


Unipolar Binary Code Table

DIGITAL INPUT BINARY NUMBER IN DAC REGISTER			ANALOG OUTPUT V_{OUT}
MSB		LSB	
1111	1111	1111	$-V_{REF}$ (4095/4096)
1000	0000	0000	$-V_{REF}$ (2048/4096) = $-V_{REF}/2$
0000	0000	0001	$-V_{REF}$ (1/4096)
0000	0000	0000	0V

TYPICAL APPLICATIONS

Bipolar Operation (4-Quadrant Multiplication)



Bipolar Offset Binary Code Table

DIGITAL INPUT BINARY NUMBER IN DAC REGISTER			ANALOG OUTPUT V_{OUT}
MSB		LSB	
1111	1111	1111	V_{REF} (2047/2048)
1000	0000	0001	V_{REF} (1/2048)
1000	0000	0000	0V
0111	1111	1111	$-V_{REF}$ (1/2048)
0000	0000	0000	$-V_{REF}$ (2048/2048) = $-V_{REF}$

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC1257	Complete Serial I/O V_{OUT} 12-Bit DAC	5V to 15V Single Supply in 8-Pin SO and PDIP
LTC1451/LTC1452/LTC1453	Complete Serial I/O V_{OUT} 12-Bit DACs	3V/5V Single Supply in 8-Pin SO and PDIP
LTC7541A	Parallel I/O Mulitplying 12-Bit DAC	12-Bit Wide Input
LTC8043	Serial Mulitplying 12-Bit DAC	8-Pin SO and PDIP