



LTC1591/LTC1597

14-Bit and 16-Bit Parallel Low Glitch Multiplying DACs with 4-Quadrant Resistors

FEATURES

- True 16-Bit Performance Over Industrial Temperature Range
- DNL and INL: 1LSB Max
- On-Chip 4-Quadrant Resistors Allow Precise 0V to 10V, 0V to -10V or ±10V Outputs
- Pin Compatible 14- and 16-Bit Parts
- Asynchronous Clear Pin
 - LTC1591/LTC1597: Reset to Zero Scale
 - LTC1591-1/LTC1597-1: Reset to Midscale
- Glitch Impulse < 2nV-s
- 28-Lead SSOP Package
- Low Power Consumption: 10μW Typ
- Power-On Reset

APPLICATIONS

- Process Control and Industrial Automation
- Direct Digital Waveform Generation
- Software-Controlled Gain Adjustment
- Automatic Test Equipment

DESCRIPTION

The LTC[®]1591/LTC1597 are pin compatible, parallel input 14-bit and 16-bit multiplying current output DACs that operate from a single 5V supply. INL and DNL are accurate to 1LSB over the industrial temperature range in both 2- and 4-quadrant multiplying modes. True 16-bit 4-quadrant multiplication is achieved with on-chip 4-quadrant multiplication resistors.

These DACs include an internal deglitcher circuit that reduces the glitch impulse to less than 2nV-s (typ). The asynchronous CLR pin resets the LTC1591/LTC1597 to zero scale and LTC1591-1/LTC1597-1 to midscale.

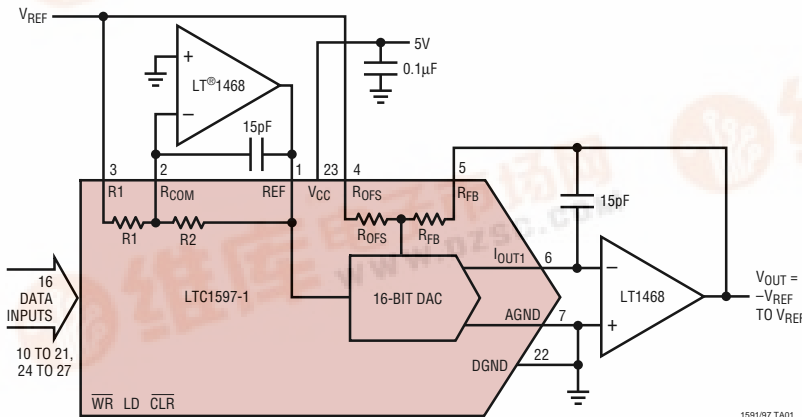
The LTC1591/LTC1597 are available in 28-pin SSOP and PDIP packages and are specified over the industrial temperature range.

For serial interface 16-bit current output DACs refer to the LTC1595/LTC1596 data sheet.

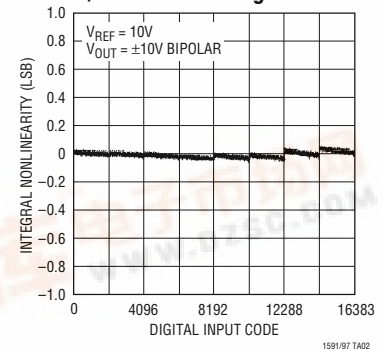
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TYPICAL APPLICATION

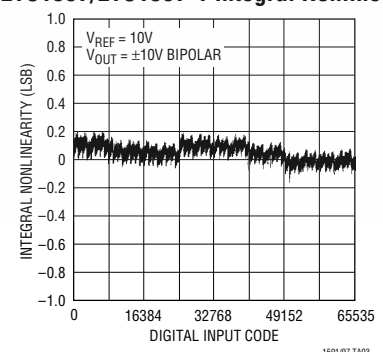
16-Bit, 4-Quadrant Multiplying DAC with a Minimum of External Components



LTC1591/LTC1591-1 Integral Nonlinearity



LTC1597/LTC1597-1 Integral Nonlinearity



LTC1591/LTC1597

ABSOLUTE MAXIMUM RATINGS (Note 1)

V_{CC} to AGND	-0.5V to 7V
V_{CC} to DGND	-0.5V to 7V
AGND to DGND	$V_{CC} + 0.5V$
DGND to AGND	$V_{CC} + 0.5V$
REF, R_{OFS} , R_{FB} , R1, R_{COM} to AGND, DGND	$\pm 25V$
Digital Inputs to DGND	-0.5V to ($V_{CC} + 0.5V$)
I_{OUT1} to AGND	-0.5V to ($V_{CC} + 0.5V$)
Maximum Junction Temperature	125°C

Operating Temperature Range	
LTC1591C/LTC1591-1C	
LTC1597C/LTC1597-1C	0°C to 70°C
LTC1591I/LTC1591-1I	
LTC1597I/LTC1597-1I	-40°C to 85°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

PACKAGE/ORDER INFORMATION

TOP VIEW		ORDER PART NUMBER	TOP VIEW		ORDER PART NUMBER
REF	1	LTC1591CG	REF	1	LTC1597ACG
R_{COM}	2	LTC1591CN	R_{COM}	2	LTC1597ACN
R1	3	LTC1591IG	R1	3	LTC1597BCG
R_{OFS}	4	LTC1591IN	R_{OFS}	4	LTC1597BCN
R_{FB}	5	LTC1591-1CG	R_{FB}	5	LTC1597-1ACG
I_{OUT1}	6	LTC1591-1CN	I_{OUT1}	6	LTC1597-1ACN
AGND	7	LTC1591-1IG	AGND	7	LTC1597-1BCG
LD	8	LTC1591-1IN	LD	8	LTC1597-1BCN
WR	9		WR	9	LTC1597-1AIG
D13	10		D15	10	LTC1597-1AIN
D12	11		D14	11	LTC1597BIG
D11	12		D13	12	LTC1597BIN
D10	13		D12	13	LTC1597-1AIG
D9	14		D11	14	LTC1597-1AIN
					LTC1597-1BIG
					LTC1597-1BIN
					LTC1597-1AIG
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ELECTRICAL CHARACTERISTICS

$V_{CC} = 5V \pm 10\%$, $V_{REF} = 10V$, $I_{OUT1} = AGND = DGND = 0V$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LTC1591/-1			LTC1597B/-1B			LTC1597A/-1A			UNITS	
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX		
Accuracy													
	Resolution		●	14		16		16				Bits	
	Monotonicity		●	14		16		16				Bits	
INL	Integral Nonlinearity	(Note 2) $T_A = 25^\circ C$ T_{MIN} to T_{MAX}	●		± 1		± 2		± 0.25	± 1		LSB	
					± 1		± 2		± 0.35	± 1		LSB	
DNL	Differential Nonlinearity	$T_A = 25^\circ C$ T_{MIN} to T_{MAX}	●		± 1		± 1		± 0.2	± 1		LSB	
					± 1		± 1		± 0.2	± 1		LSB	
GE	Gain Error	Unipolar Mode (Note 3) $T_A = 25^\circ C$ T_{MIN} to T_{MAX}	●		± 4		± 16		2	± 16		LSB	
					± 6		± 24		3	± 16		LSB	
		Bipolar Mode (Note 3) $T_A = 25^\circ C$ T_{MIN} to T_{MAX}	●		± 4		± 16		2	± 16		LSB	
					± 6		± 24		3	± 16		LSB	
	Gain Temperature Coefficient	(Note 4) $\Delta Gain/\Delta Temperature$	●		1	2		1	2		1	2	ppm/ $^\circ C$
	Bipolar Zero-Scale Error	$T_A = 25^\circ C$ T_{MIN} to T_{MAX}	●			± 3		± 10		± 5		LSB	
						± 5		± 16		± 8		LSB	
I_{LKG}	OUT1 Leakage Current	(Note 5) $T_A = 25^\circ C$ T_{MIN} to T_{MAX}	●		± 5		± 5		± 5		± 5	nA	
					± 15		± 15		± 15		± 15		nA
PSRR	Power Supply Rejection Ratio	$V_{CC} = 5V \pm 10$	●		± 0.1	± 1		± 0.4	± 2		± 0.4	± 2	LSB/V

$V_{CC} = 5V \pm 10\%$, $V_{REF} = 10V$, $I_{OUT1} = AGND = DGND = 0V$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Reference Input							
R_{REF}	DAC Input Resistance (Unipolar)	(Note 6)	●	4.5	6	10	k Ω
R1/R2	R1/R2 Resistance (Bipolar)	(Notes 6, 13)	●	9	12	20	k Ω
R_{OFS} , R_{FB}	Feedback and Offset Resistances	(Note 6)	●	9	12	20	k Ω

AC Performance (Note 4)

	Output Current Settling Time	(Notes 7, 8)			1		μs	
	Midscale Glitch Impulse	(Note 12)			2		nV-s	
	Digital-to-Analog Glitch Impulse	(Note 9)			1		nV-s	
	Multiplying Feedthrough Error	$V_{REF} = \pm 10V$, 10kHz Sine Wave			1		mV _{p-p}	
THD	Total Harmonic Distortion	(Note 10)			108		dB	
	Output Noise Voltage Density	(Note 11)			10		nV/ \sqrt{Hz}	
	Harmonic Distortion (Digital Waveform Generation)	Unipolar Mode (Note 14)	●					
				2nd Harmonic		94		dB
				3rd Harmonic		101		dB
				SFDR		94		dB
	Bipolar Mode (Note 14)							
				2nd Harmonic		94		dB
				3rd Harmonic		101		dB
				SFDR		94		dB

LTC1591/LTC1597

ELECTRICAL CHARACTERISTICS

$V_{CC} = 5V \pm 10\%$, $V_{REF} = 10V$, $I_{OUT1} = AGND = DGND = 0V$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
Analog Outputs (Note 4)							
C_{OUT}	Output Capacitance (Note 4)	DAC Register Loaded to All 1s: C_{OUT1}	●	115	130	pF	
		DAC Register Loaded to All 0s: C_{OUT1}	●	70	80	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		●	0.001	±1	μA	
C_{IN}	Digital Input Capacitance	(Note 4) $V_{IN} = 0V$	●		8	pF	
Timing Characteristics							
t_{DS}	Data to \overline{WR} Setup Time		●	60	20	ns	
t_{DH}	Data to \overline{WR} Hold Time		●	0	-12	ns	
t_{WR}	\overline{WR} Pulse Width		●	60	25	ns	
t_{LD}	LD Pulse Width		●	110	55	ns	
t_{CLR}	Clear Pulse Width		●	60	40	ns	
t_{LWD}	\overline{WR} to LD Delay Time		●	0		ns	
Power Supply							
V_{DD}	Supply Voltage		●	4.5	5	5.5	V
I_{DD}	Supply Current	Digital Inputs = 0V or V_{CC}	●		10	μA	

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

Note 1: Absolute Maximum Values are those beyond which the life of a device may be impaired.

Note 2: $\pm 1LSB = \pm 0.006\%$ of full scale = $\pm 61ppm$ of full scale for the LTC1591/LTC1591-1. $\pm 1LSB = \pm 0.0015\%$ of full scale = $\pm 15.3ppm$ of full scale for the LTC1597/LTC1597-1.

Note 3: Using internal feedback resistor.

Note 4: Guaranteed by design, not subject to test.

Note 5: $I_{(OUT1)}$ with DAC register loaded to all 0s.

Note 6: Typical temperature coefficient is 100ppm/°C.

Note 7: I_{OUT1} load = 100Ω in parallel with 13pF.

Note 8: To 0.006% for a full-scale change, measured from the rising edge of LD for the LTC1591/LTC1591-1. To 0.0015% for a full-scale change, measured from the rising edge of LD for the LTC1597/LTC1597-1.

Note 9: $V_{REF} = 0V$. DAC register contents changed from all 0s to all 1s or all 1s to all 0s.

Note 10: $V_{REF} = 6V_{RMS}$ at 1kHz. DAC register loaded with all 1s.

Note 11: Calculation from $e_n = \sqrt{4kTRB}$ where: k = Boltzmann constant (J/°K), R = resistance (Ω), T = temperature (°K), B = bandwidth (Hz).

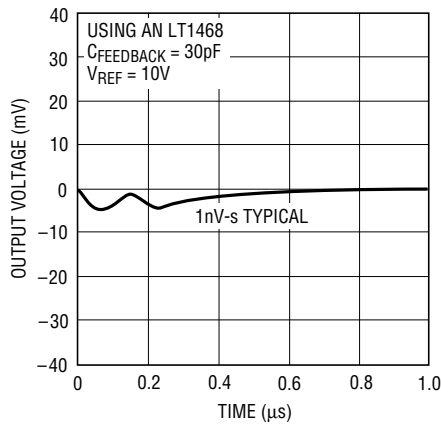
Note 12: Midscale transition code: 01 1111 1111 1111 to 10 0000 0000 0000 for the LTC1591/LTC1591-1 and 0111 1111 1111 1111 to 1000 0000 0000 0000 for the LTC1597/LTC1597-1.

Note 13: R1 and R2 are measured between R1 and R_{COM} , REF and R_{COM} .

Note 14: Measured using the LT1468 op amp in unipolar mode for I/V converter and LT1468 I/V and LT1001 reference inverter in bipolar mode. Sample Rate = 50kHz, Signal Frequency = 1kHz, $V_{REF} = 5V$, $T_A = 25^\circ C$.

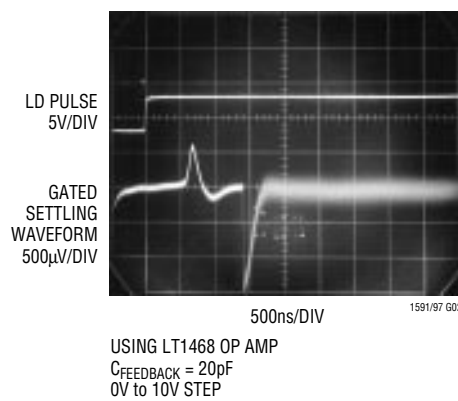
TYPICAL PERFORMANCE CHARACTERISTICS (LTC1591/LTC1597)

Midscale Glitch Impulse

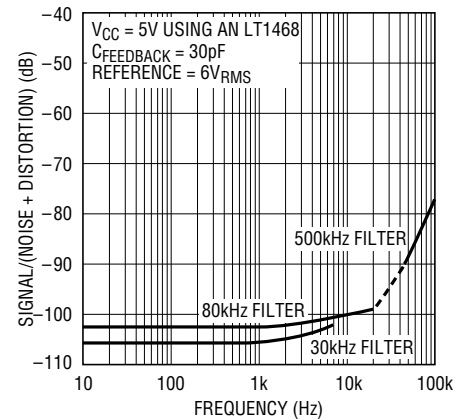


1591/97 G01

Full-Scale Settling Waveform

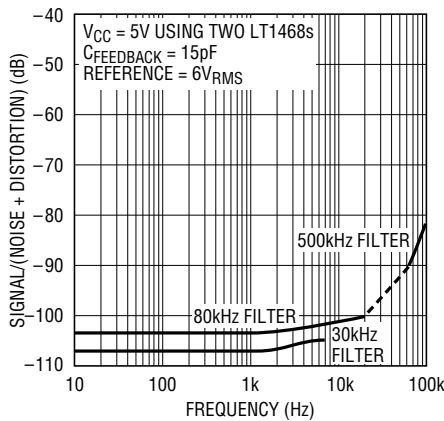


**Unipolar Multiplying Mode
Signal-to-(Noise + Distortion)
vs Frequency**



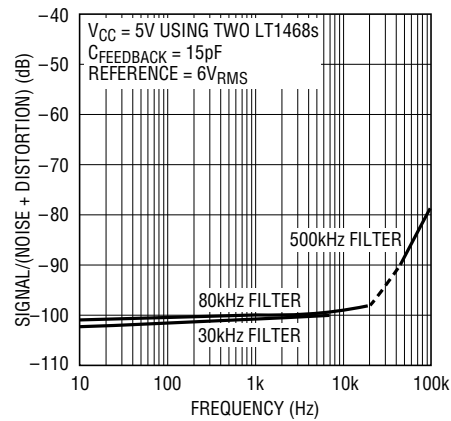
1591/97 G03

**Bipolar Multiplying Mode
Signal-to-(Noise + Distortion)
vs Frequency, Code = All Zeros**



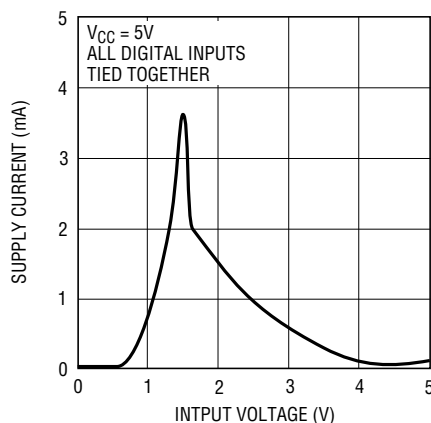
1591/97 G04

**Bipolar Multiplying Mode
Signal-to-(Noise + Distortion)
vs Frequency, Code = All Ones**



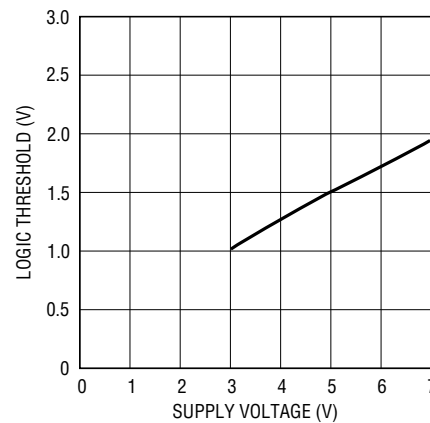
1591/97 G05

Supply Current vs Input Voltage



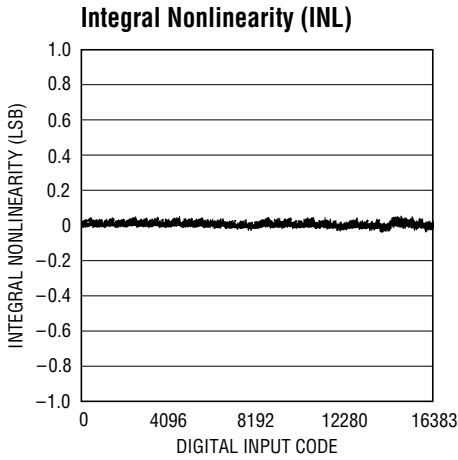
1591/97 G06

Logic Threshold vs Supply Voltage

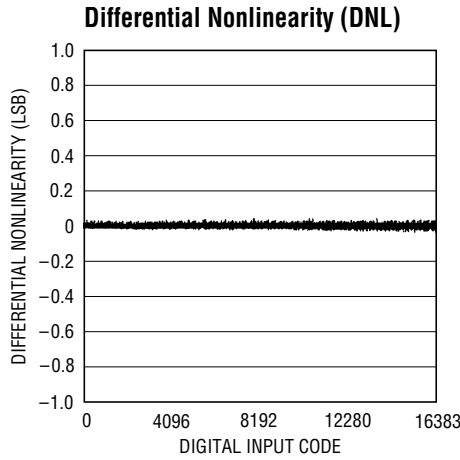


1591/97 G07

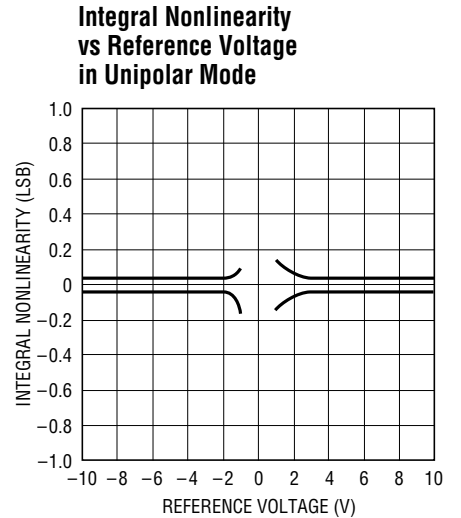
TYPICAL PERFORMANCE CHARACTERISTICS (LTC1591)



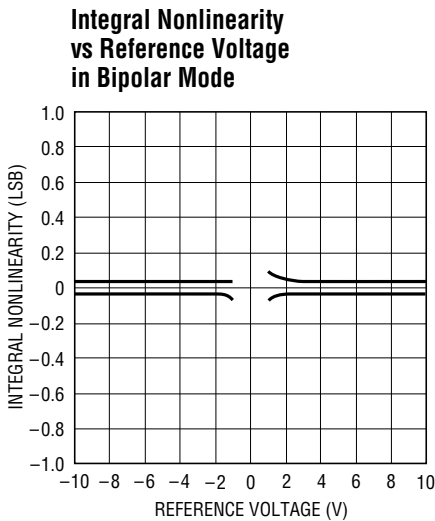
1591 G01



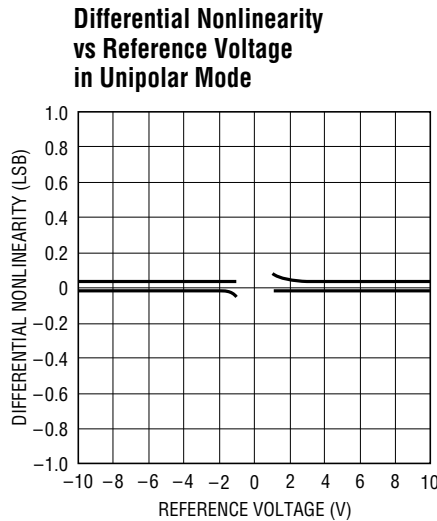
1591 G02



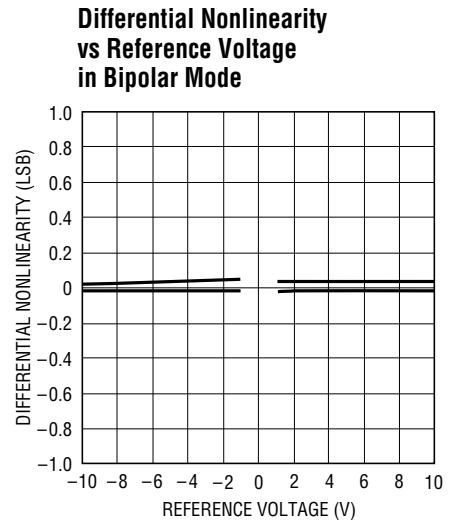
1591 G03



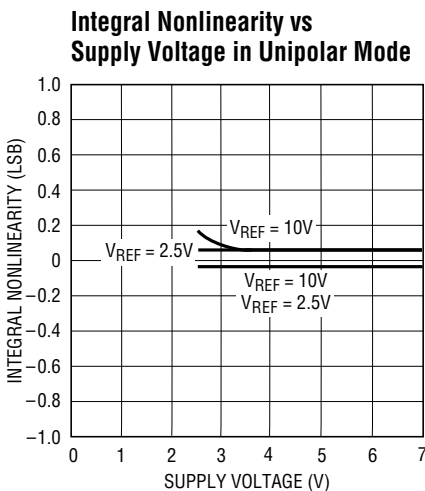
1591 G04



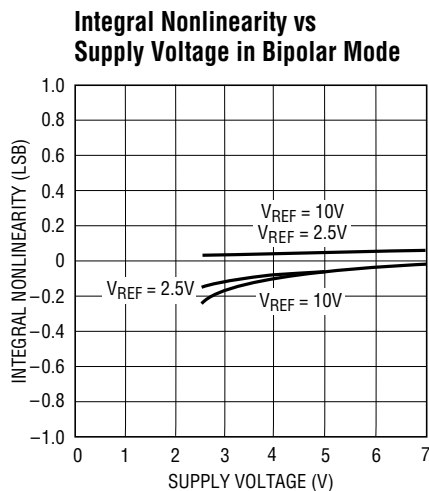
1591 G05



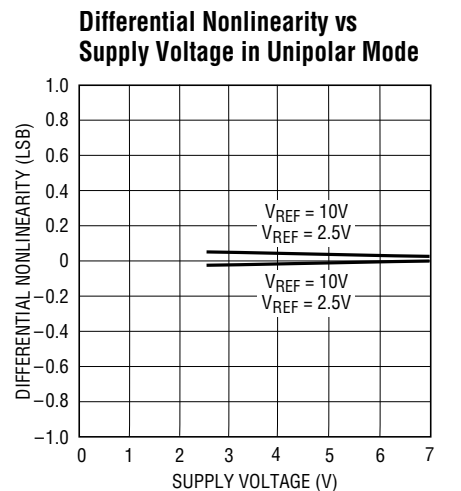
1591 G06



1591 G07



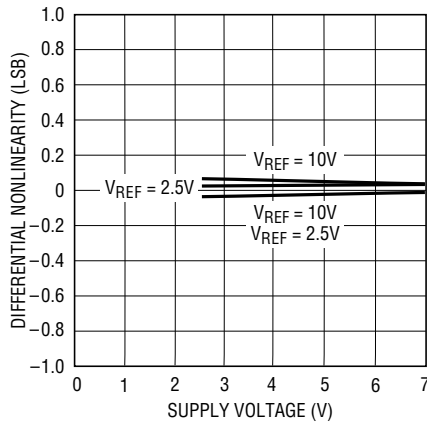
1591 G08



1591 G09

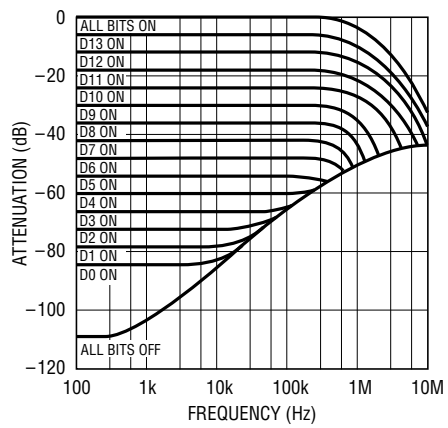
TYPICAL PERFORMANCE CHARACTERISTICS (LTC1591)

Differential Nonlinearity vs Supply Voltage in Bipolar Mode

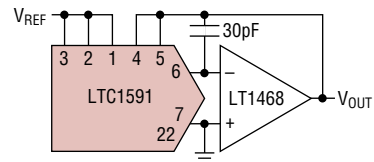


1591G10

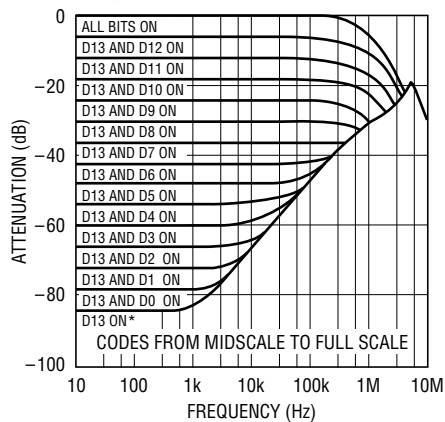
Unipolar Multiplying Mode Frequency Response vs Digital Code



1591G11

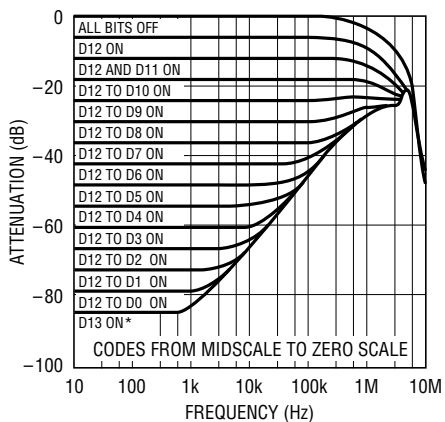


Bipolar Multiplying Mode Frequency Response vs Digital Code



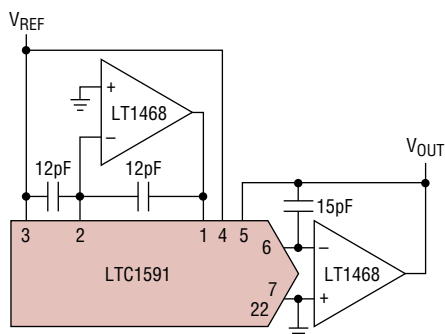
1591G12

Bipolar Multiplying Mode Frequency Response vs Digital Code

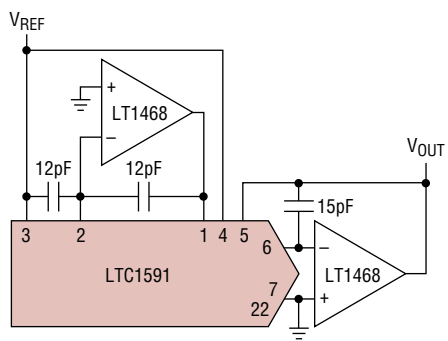


1591G13

*DAC ZERO VOLTAGE OUTPUT LIMITED BY BIPOLAR ZERO ERROR TO -84dB TYPICAL (-70dB MAX)

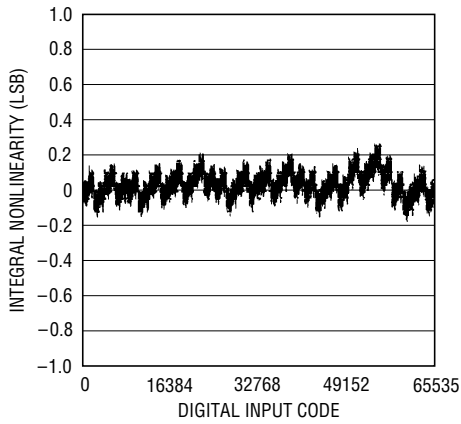


*DAC ZERO VOLTAGE OUTPUT LIMITED BY BIPOLAR ZERO ERROR TO -84dB TYPICAL (-70dB MAX)



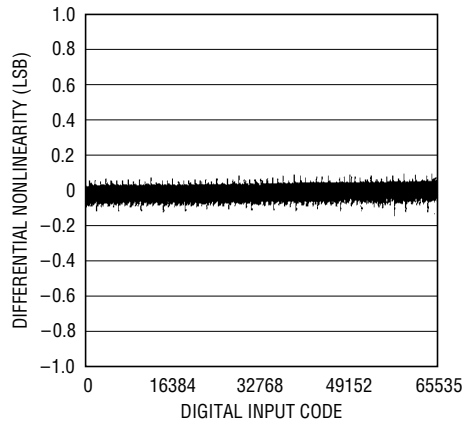
TYPICAL PERFORMANCE CHARACTERISTICS (LTC1597)

Integral Nonlinearity (INL)



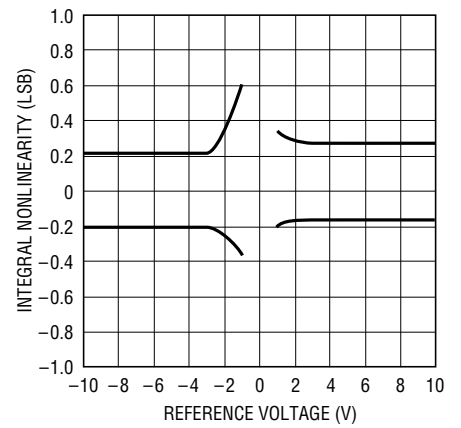
1597 G01

Differential Nonlinearity (DNL)



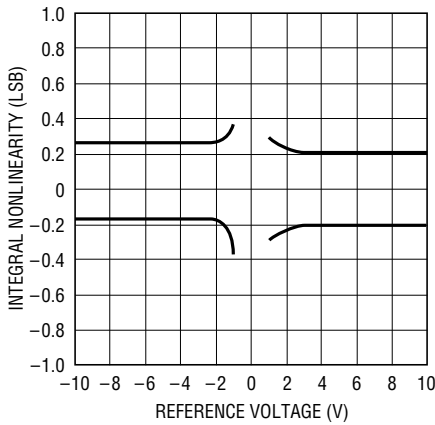
1597 G02

Integral Nonlinearity vs Reference Voltage in Unipolar Mode



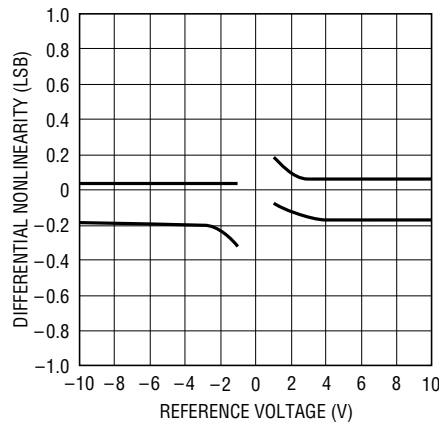
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Integral Nonlinearity vs Reference Voltage in Bipolar Mode



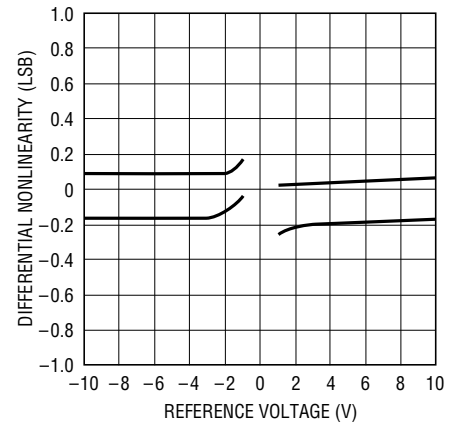
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Differential Nonlinearity vs Reference Voltage in Unipolar Mode



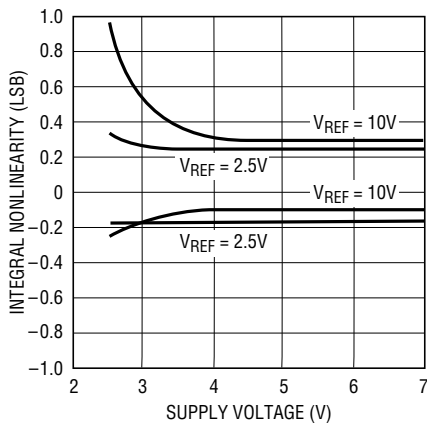
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Differential Nonlinearity vs Reference Voltage in Bipolar Mode



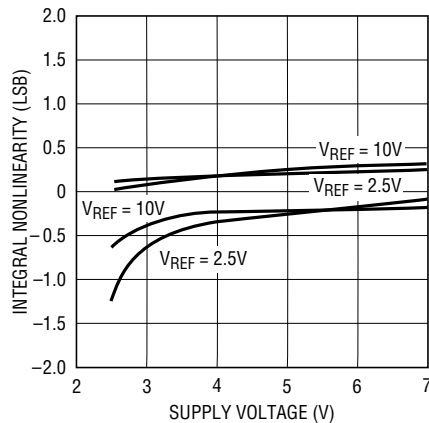
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Integral Nonlinearity vs Supply Voltage in Unipolar Mode



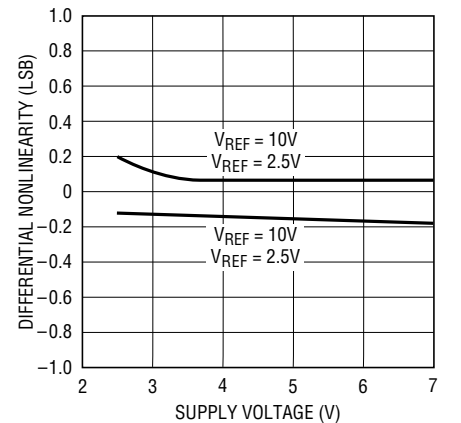
1597 G07

Integral Nonlinearity vs Supply Voltage in Bipolar Mode



1597 G08

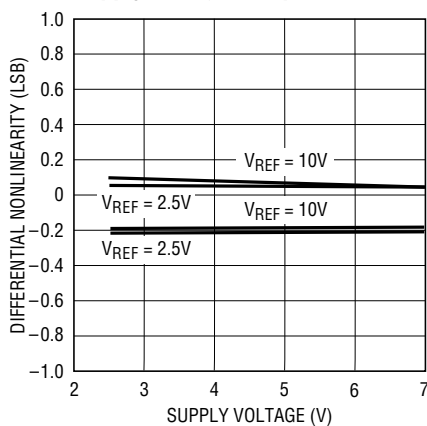
Differential Nonlinearity vs Supply Voltage in Unipolar Mode



1597 G09

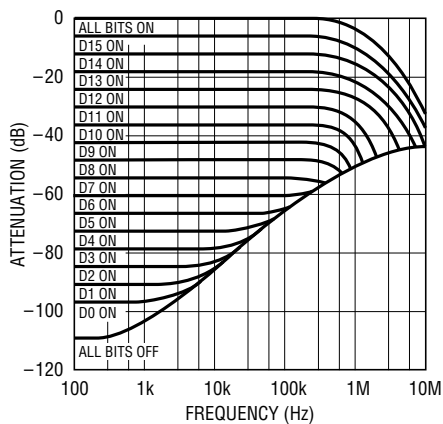
TYPICAL PERFORMANCE CHARACTERISTICS (LTC1597)

Differential Nonlinearity vs Supply Voltage in Bipolar Mode

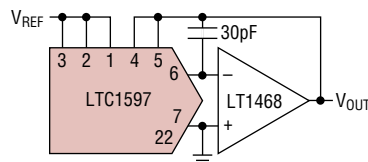


1597 G10

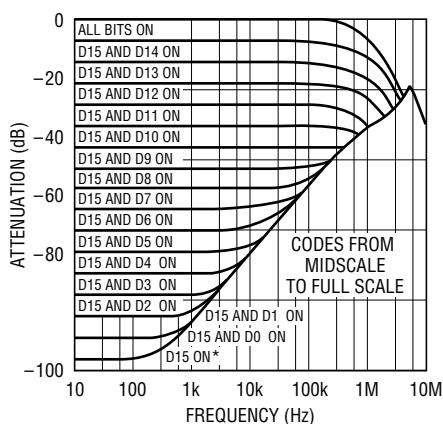
Unipolar Multiplying Mode Frequency Response vs Digital Code



1597G11

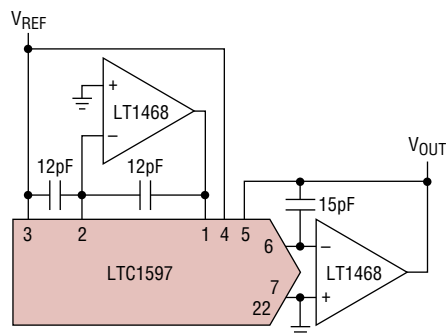


Bipolar Multiplying Mode Frequency Response vs Digital Code

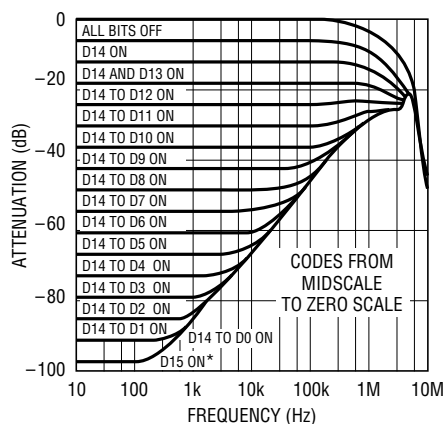


1597 G12

*DAC ZERO VOLTAGE OUTPUT LIMITED BY BIPOLAR ZERO ERROR TO -96dB TYPICAL (-78dB MAX, A GRADE)

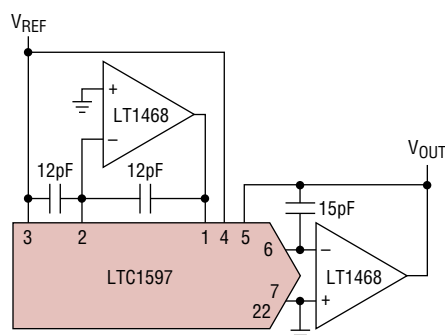


Bipolar Multiplying Mode Frequency Response vs Digital Code



1597 G13

*DAC ZERO VOLTAGE OUTPUT LIMITED BY BIPOLAR ZERO ERROR TO -96dB TYPICAL (-78dB MAX, A GRADE)



LTC1591/LTC1597

PIN FUNCTIONS

LTC1591

REF (Pin 1): Reference Input and 4-Quadrant Resistor R2. Typically $\pm 10V$, accepts up to $\pm 25V$. In 2-Quadrant mode this is the reference input. In 4-quadrant mode, this pin is driven by external inverting reference amplifier.

R_{COM} (Pin 2): Center Tap Point of the Two 4-Quadrant Resistors R1 and R2. Normally tied to the inverting input of an external amplifier in 4-quadrant operation, otherwise shorted to the REF pin. See Figures 1a and 2a.

R1 (Pin 3): 4-Quadrant Resistor R1. In 2-quadrant operation short to the REF pin. In 4-quadrant mode tie to R_{OFS} (Pin 4).

R_{OFS} (Pin 4): Bipolar Offset Resistor. Typically swings $\pm 10V$, accepts up to $\pm 25V$. In 2-quadrant operation tie to R_{FB}. In 4-quadrant operation tie to R1.

R_{FB} (Pin 5): Feedback Resistor. Normally tied to the output of the current to voltage converter op amp. Swings to $\pm V_{REF}$. V_{REF} is typically $\pm 10V$.

LTC1597

REF (Pin 1): Reference Input and 4-Quadrant Resistor R2. Typically $\pm 10V$, accepts up to $\pm 25V$. In 2-Quadrant mode this is the reference input. In 4-quadrant mode, this pin is driven by external inverting reference amplifier.

R_{COM} (Pin 2): Center Tap Point of the Two 4-Quadrant Resistors R1 and R2. Normally tied to the inverting input of an external amplifier in 4-quadrant operation, otherwise shorted to the REF pin. See Figures 1b and 2b.

R1 (Pin 3): 4-Quadrant Resistor R1. In 2-quadrant operation short to the REF pin. In 4-quadrant mode tie to R_{OFS} (Pin 4).

R_{OFS} (Pin 4): Bipolar Offset Resistor. Typically swings $\pm 10V$, accepts up to $\pm 25V$. In 2-quadrant operation tie to R_{FB}. In 4-quadrant operation tie to R1.

R_{FB} (Pin 5): Feedback Resistor. Normally tied to the output of the current to voltage converter op amp. Swings to $\pm V_{REF}$. V_{REF} is typically $\pm 10V$.

I_{OUT1} (Pin 6): DAC Current Output. Tie to the inverting input of the current to voltage converter op amp.

AGND (Pin 7): Analog Ground. Tie to ground.

LD (Pin 8): DAC Digital Input Load Control Input. When LD is taken to a logic high, data is loaded from the input register into the DAC register, updating the DAC output.

WR (Pin 9): DAC Digital Write Control Input. When \overline{WR} is taken to a logic low, data is loaded from the digital input pins into the 14-bit wide input register.

DB13 to D2 (Pins 10 to 21): Digital Input Data Bits.

DGND (Pin 22): Digital Ground. Tie to ground.

V_{CC} (Pin 23): The Positive Supply Input. $4.5V \leq V_{CC} \leq 5.5V$. Requires a bypass capacitor to ground.

DB1, DB0 (Pins 24, 25): Digital Input Data Bits.

NC (Pins 26, 27): No Connect.

CLR (Pin 28): Digital Clear Control Function for the DAC. When \overline{CLR} is taken to a logic low, it sets the DAC output and all internal registers to zero code for the LTC1591 and midscale code for the LTC1591-1.

I_{OUT1} (Pin 6): DAC Current Output. Tie to the inverting input of the current to voltage converter op amp.

AGND (Pin 7): Analog Ground. Tie to ground.

LD (Pin 8): DAC Digital Input Load Control Input. When LD is taken to a logic high, data is loaded from the input register into the DAC register, updating the DAC output.

WR (Pin 9): DAC Digital Write Control Input. When \overline{WR} is taken to a logic low, data is loaded from the digital input pins into the 16-bit wide input register.

DB15 to D4 (Pins 10 to 21): Digital Input Data Bits.

DGND (Pin 22): Digital Ground. Tie to ground.

V_{CC} (Pin 23): The Positive Supply Input. $4.5V \leq V_{CC} \leq 5.5V$. Requires a bypass capacitor to ground.

DB3 to DB0 (Pins 24 to 27): Digital Input Data Bits.

CLR (Pin 28): Digital Clear Control Function for the DAC. When \overline{CLR} is taken to a logic low, it sets the DAC output and all internal registers to zero code for the LTC1597 and midscale code for the LTC1597-1.

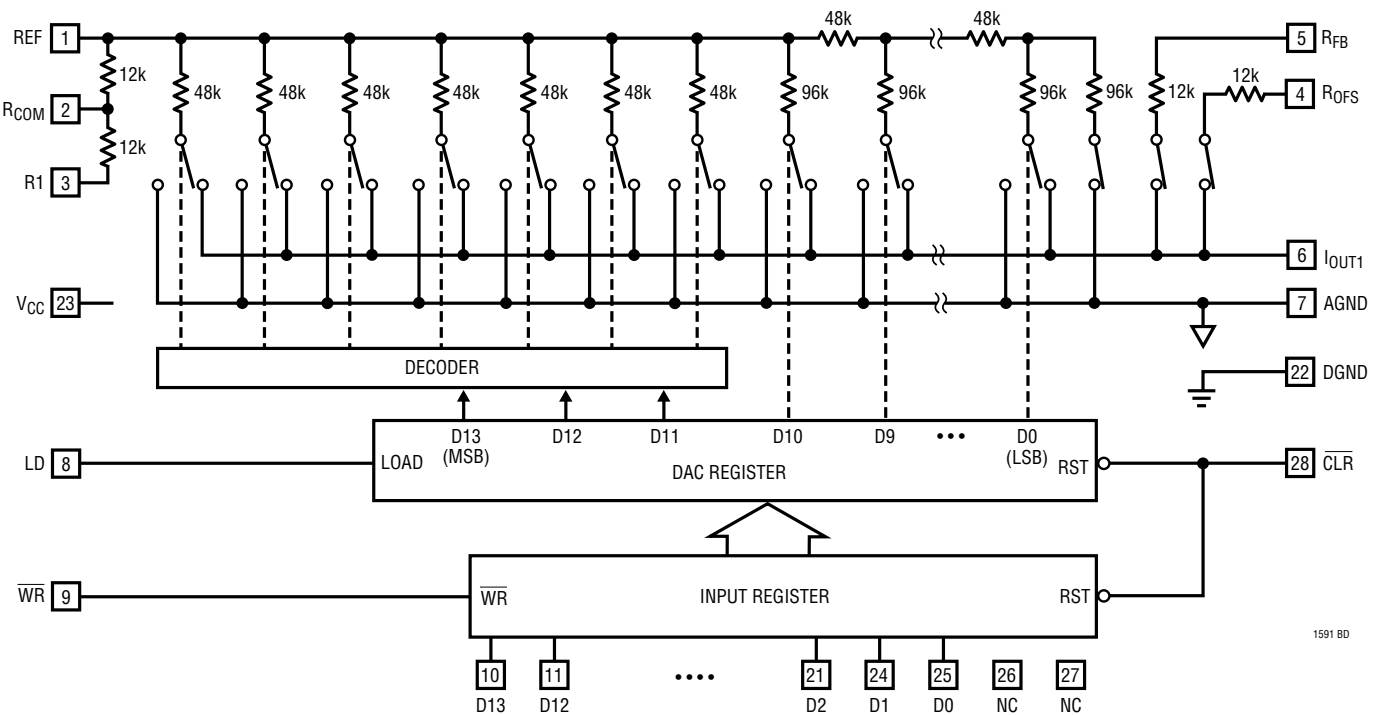
TRUTH TABLE

Table 1

CONTROL INPUTS			REGISTER OPERATION
CLR	WR	LD	
0	X	X	Reset Input and DAC Register to All 0s for LTC1591/LTC1597 and Midscale for LTC1591-1/LTC1597-1 (Asynchronous Operation)
1	0	0	Load Input Register with All 14/16 Data Bits
1	1	1	Load DAC Register with the Contents of the Input Register
1	0	1	Input and DAC Register Are Transparent
1			CLK = LD and WR Tied Together. The 14/16 Data Bits Are Loaded into the Input Register on the Falling Edge of the CLK and Then Loaded into the DAC Register on the Rising Edge of the CLK
1	1	0	No Register Operation

BLOCK DIAGRAMS

LTC1591



APPLICATIONS INFORMATION

Description

The LTC1591/LTC1597 are 14-/16-bit multiplying, current output DACs with a full parallel 14-/16-bit digital interface. The devices operate from a single 5V supply and provide both unipolar 0V to $-10V$ or 0V to 10V and bipolar $\pm 10V$ output ranges from a 10V or $-10V$ reference input. They have three additional precision resistors on chip for bipolar operation. Refer to the block diagrams regarding the following description.

The 14-/16-bit DACs consist of a precision R-2R ladder for the 11/13LSBs. The 3MSBs are decoded into seven segments of resistor value R. Each of these segments and the R-2R ladder carries an equally weighted current of one eighth of full scale. The feedback resistor R_{FB} and 4-quadrant resistor R_{OFS} have a value of R/4. 4-quadrant resistors R1 and R2 have a magnitude of R/4. R1 and R2 together with an external op amp (see Figure 2) inverts the reference input voltage and applies it to the 14-/16-bit DAC input REF, in 4-quadrant operation. The REF pin presents a constant input impedance of R/8 in unipolar mode and R/12 in bipolar mode. The output impedance of the current output pin I_{OUT1} varies with DAC input code. The I_{OUT1} capacitance due to the NMOS current steering switches also varies with input code from 70pF to 115pF. An added feature of these devices, especially for waveform generation, is a proprietary deglitcher that reduces glitch energy to below 2nV-s over the DAC output voltage range.

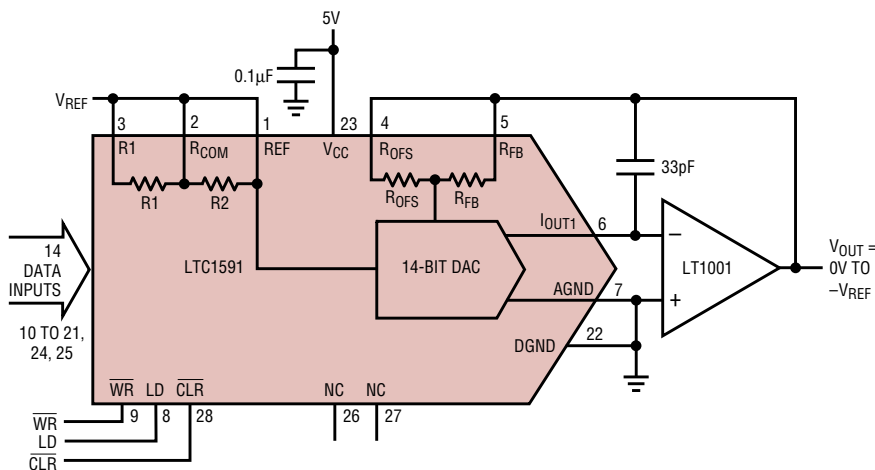
Digital Section

The LTC1591/LTC1597 are 14-/16-bit wide full parallel data bus inputs. The devices are double-buffered with two 14-/16-bit registers. The double-buffered feature permits the update of several DACs simultaneously. The input register is loaded directly from a 16-bit microprocessor bus when the WR pin is brought to a logic low level. The second register (DAC register) is updated with the data from the input register when the LD pin is brought to a logic high level. Updating the DAC register updates the DAC output with the new data. To make both registers transparent for flowthrough mode, tie WR low and LD high. However, this defeats the deglitcher operation and output glitch impulse may increase. The deglitcher is activated on the rising edge of the LD pin. The versatility of the interface also allows the use of the input and DAC registers in a master slave or edge-triggered configuration. This mode of operation occurs when WR and LD are tied together. The asynchronous clear pin resets the LTC1591/LTC1597 to zero scale and the LTC1591-1/LTC1597-1 to midscale. CLR resets both the input and DAC registers. These devices also have a power-on reset. Table 1 shows the truth table for the LTC1591/LT1597.

Unipolar Mode

(2-Quadrant Multiplying, $V_{OUT} = 0V$ to $-V_{REF}$)

The LTC1591/LTC1597 can be used with a single op amp to provide 2-quadrant multiplying operation as shown in Figure 1. With a fixed $-10V$ reference, the circuits shown give a precision unipolar 0V to 10V output swing.



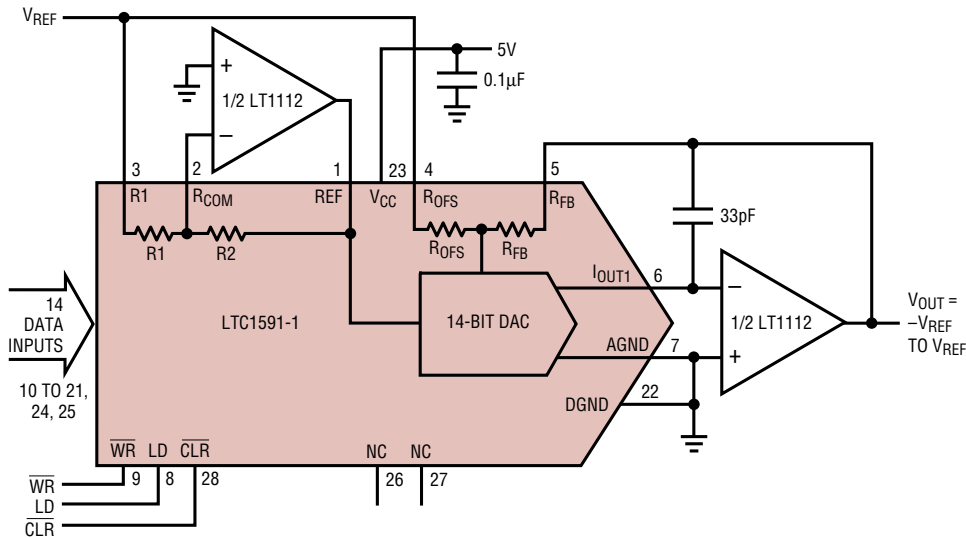
Unipolar Binary Code Table

DIGITAL INPUT BINARY NUMBER IN DAC REGISTER		ANALOG OUTPUT V_{OUT}
MSB	LSB	
1111	1111 11	$-V_{REF}$ (16,383/16,384)
1000	0000 00	$-V_{REF}$ (8,192/16,384) = $-V_{REF}/2$
0000	0000 01	$-V_{REF}$ (1/16,384)
0000	0000 00	0V

1591/97 F01a

Figure 1a. Unipolar Operation (2-Quadrant Multiplication) $V_{OUT} = 0V$ to $-V_{REF}$

APPLICATIONS INFORMATION

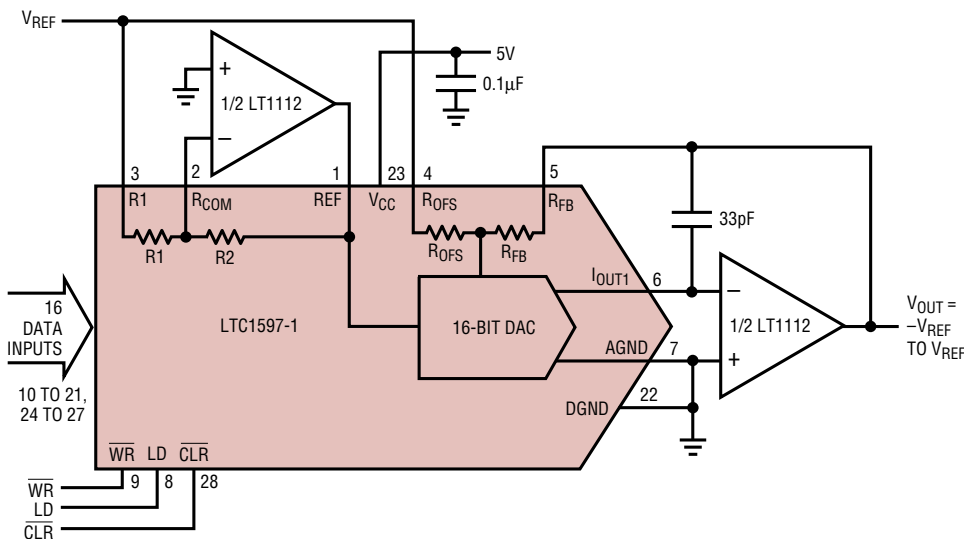


Bipolar Offset Binary Code Table

DIGITAL INPUT BINARY NUMBER IN DAC REGISTER				ANALOG OUTPUT V_{OUT}
MSB			LSB	
1111	1111	1111	11	V_{REF} (8,191/8,192)
1000	0000	0000	01	V_{REF} (1/8,192)
1000	0000	0000	00	0V
0111	1111	1111	11	$-V_{REF}$ (1/8,192)
0000	0000	0000	00	$-V_{REF}$

1591/97 F02a

Figure 2a. Bipolar Operation (4-Quadrant Multiplication) $V_{OUT} = -V_{REF}$ to V_{REF}



Bipolar Offset Binary Code Table

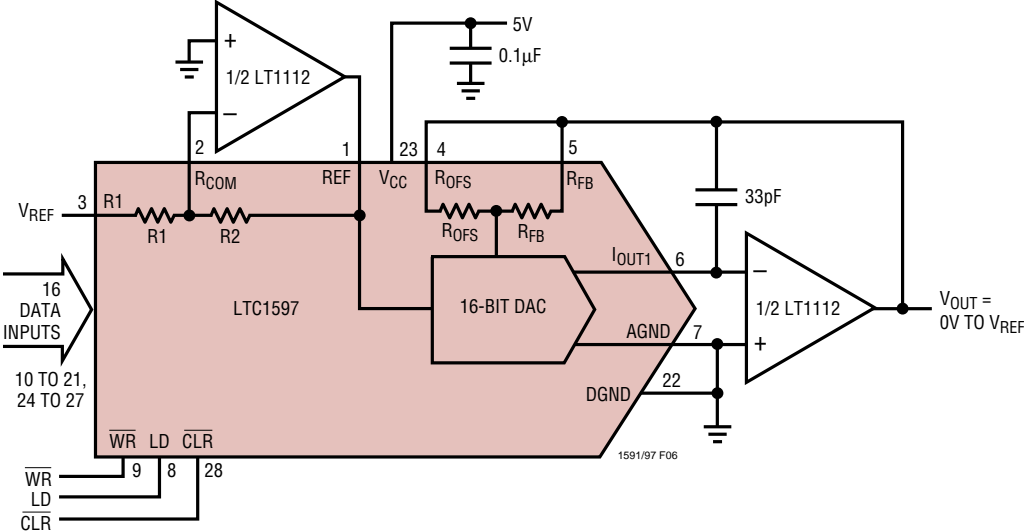
DIGITAL INPUT BINARY NUMBER IN DAC REGISTER				ANALOG OUTPUT V_{OUT}
MSB			LSB	
1111	1111	1111	1111	V_{REF} (32,767/32,768)
1000	0000	0000	0001	V_{REF} (1/32,768)
1000	0000	0000	0000	0V
0111	1111	1111	1111	$-V_{REF}$ (1/32,768)
0000	0000	0000	0000	$-V_{REF}$

1591/97 F02b

Figure 2b. Bipolar Operation (4-Quadrant Multiplication) $V_{OUT} = -V_{REF}$ to V_{REF}

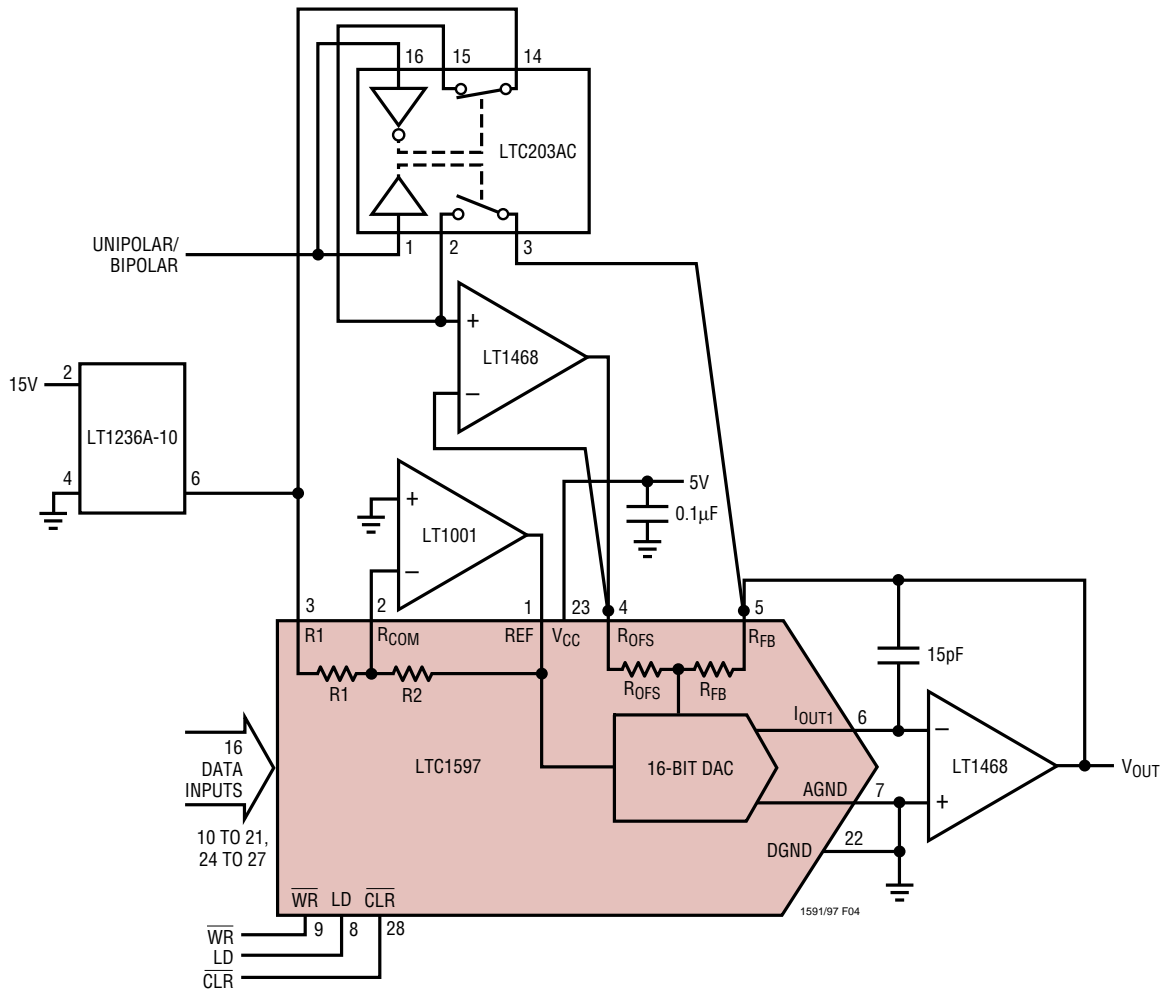
TYPICAL APPLICATIONS

Noninverting Unipolar Operation (2-Quadrant Multiplication) $V_{OUT} = 0V$ to V_{REF}



TYPICAL APPLICATIONS

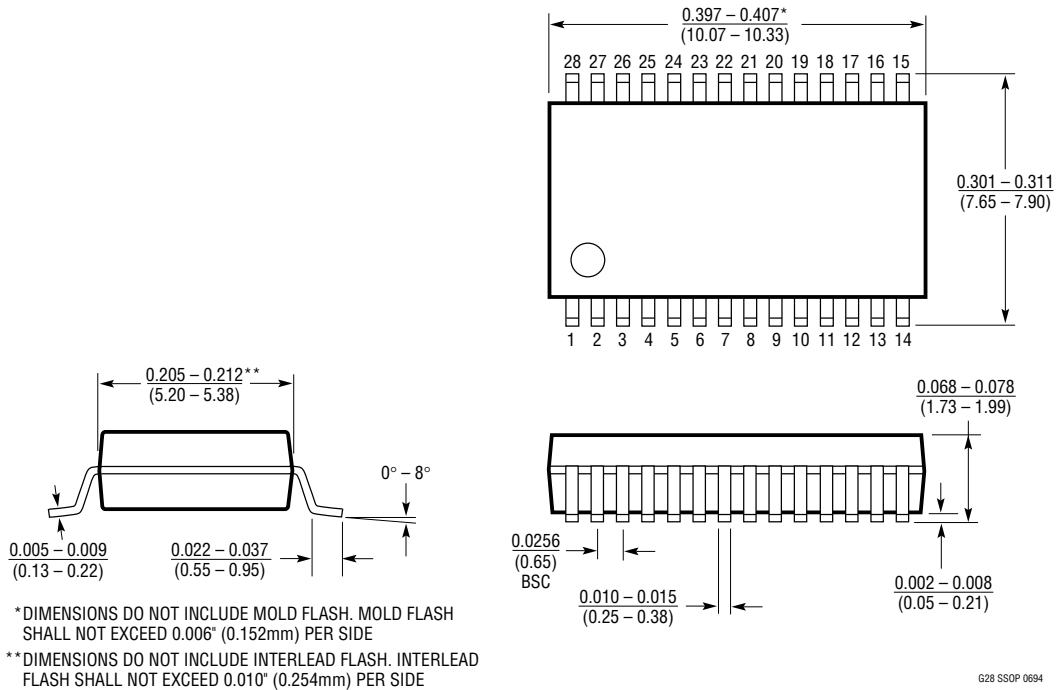
16-Bit V_{OUT} DAC Programmable Unipolar/Bipolar Configuration



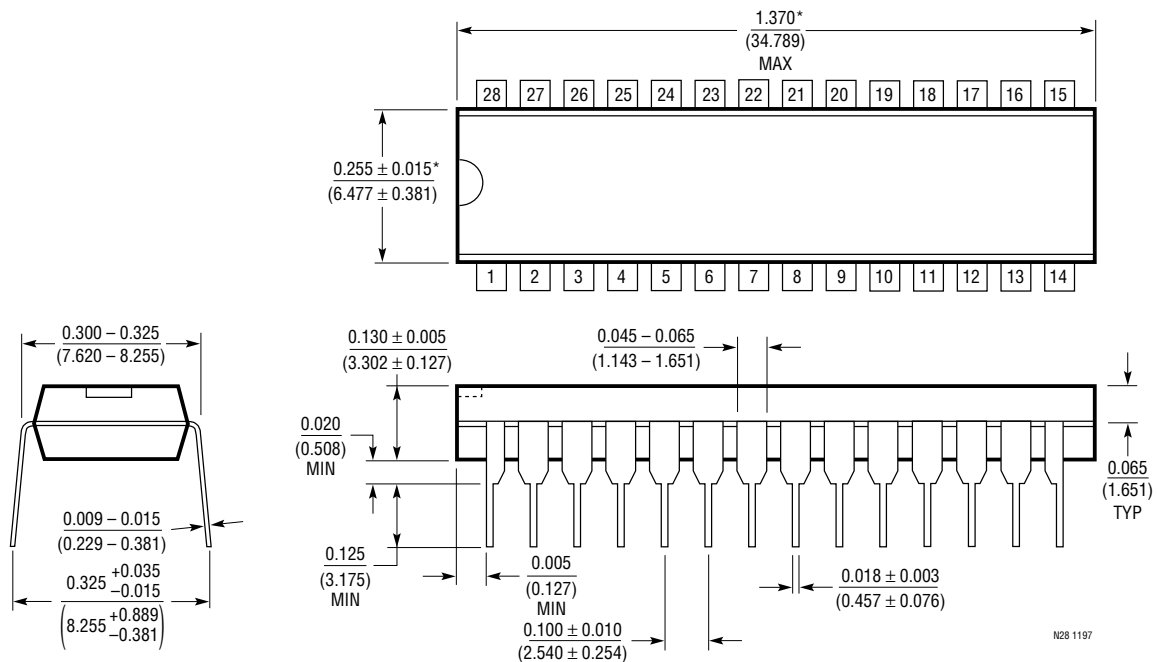
PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

G Package
28-Lead Plastic SSOP (0.209)
 (LTC DWG # 05-08-1640)



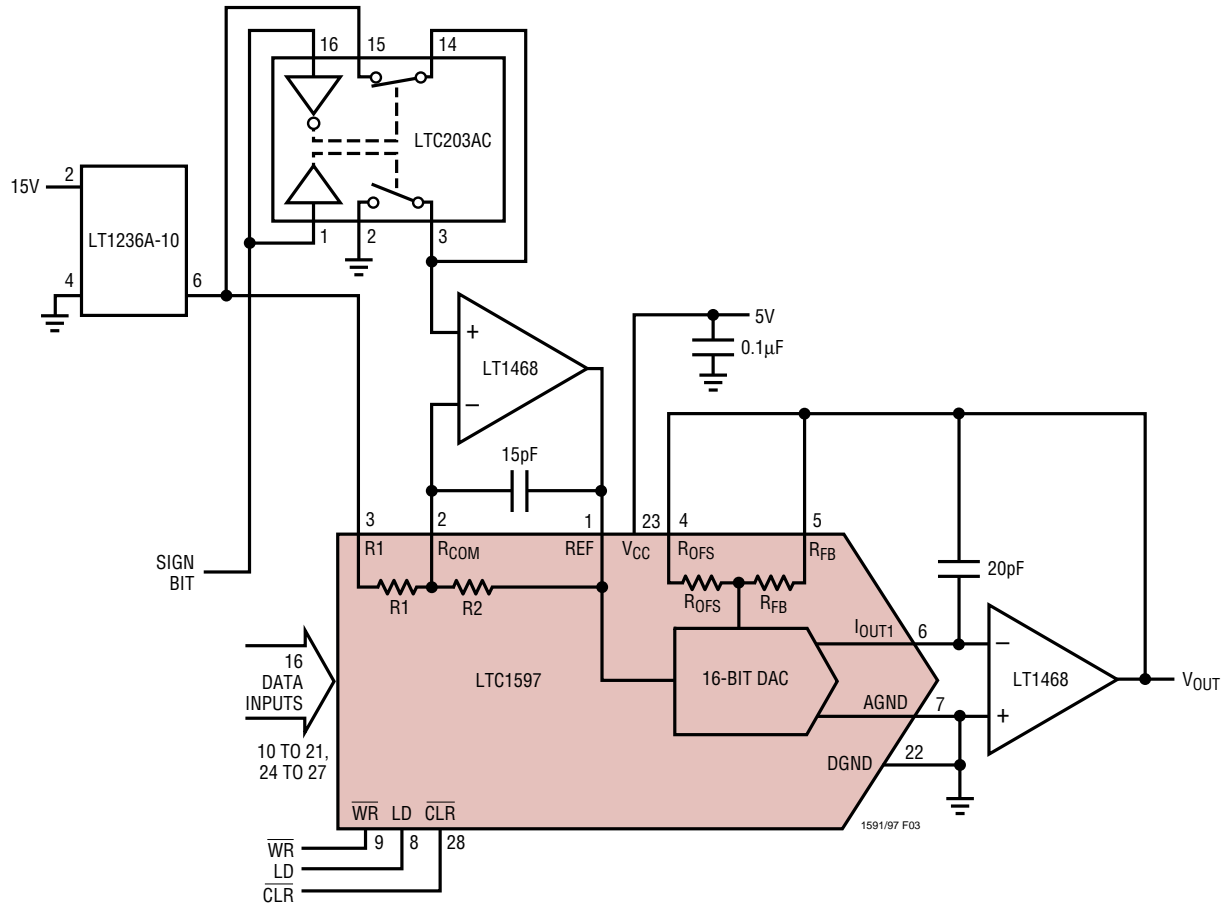
N Package
28-Lead PDIP (Narrow 0.300)
 (LTC DWG # 05-08-1510)



LTC1591/LTC1597

TYPICAL APPLICATION

17-Bit Sign Magnitude DAC with Bipolar Zero Error of $140\mu\text{V}$ (0.92LSB at 17 Bits) at 25°C



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS	
Op Amps	LT1001	Precision Operational Amplifier	Low Offset, Low Drift
	LT1112	Dual Low Power, Precision Picoamp Input Op Amp	Low Offset, Low Drift
	LT1468	90MHz, 22V/µs, 16-Bit Accurate Op Amp	Precise, 1µs Settling to 0.0015%
DACs	LTC1595/LTC1596	Serial 16-Bit Current Output DACs	Low Glitch, ±1LSB Maximum INL, DNL
	LTC1650	Serial 16-Bit Voltage Output DAC	Low Noise and Glitch Rail-to-Rail VOUT
	LTC1658	Serial 14-Bit Voltage Output DAC	Low Power, 8-Lead MSOP Rail-to-Rail VOUT
ADCs	LTC1418	14-Bit, 200ksps 5V Sampling ADC	16mW Dissipation, Serial and Parallel Outputs
	LTC1604	16-Bit, 333ksps Sampling ADC	±2.5V Input, SINAD = 90dB, THD = 100dB
	LTC1605	Single 5V, 16-Bit 100ksps ADC	Low Power, ±10V Inputs
References	LT1236	Precision Reference	Ultralow Drift, 5ppm/°C, High Accuracy 0.05%