

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 $\pm 10V$ 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: 10 μ W 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.

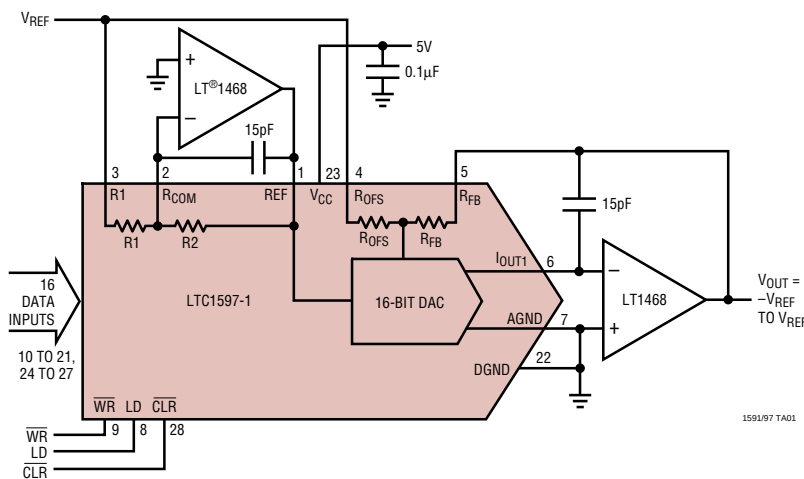
The LTC1591/LTC1597 are available in 28-pin SSOP and PDIP packages and are specified over the industrial temperature range.

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

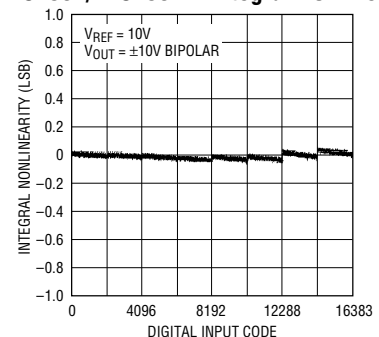
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TYPICAL APPLICATION

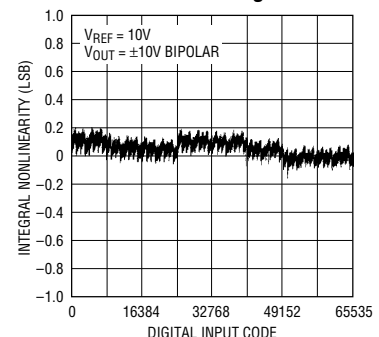
16-Bit, 4-Quadrant Multiplying DAC with a Minimum of External Components



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
G PACKAGE 28-LEAD PLASTIC SSOP N PACKAGE 28-LEAD NARROW PDIP $T_{JMAX} = 125^{\circ}C$, $\theta_{JA} = 95^{\circ}C/W$ (G) $T_{JMAX} = 125^{\circ}C$, $\theta_{JA} = 70^{\circ}C/W$ (N)	LTC1591CG LTC1591CN LTC1591IG LTC1591IN LTC1591-1CG LTC1591-1CN LTC1591-1IG LTC1591-1IN	G PACKAGE 28-LEAD PLASTIC SSOP N PACKAGE 28-LEAD NARROW PDIP $T_{JMAX} = 125^{\circ}C$, $\theta_{JA} = 95^{\circ}C/W$ (G) $T_{JMAX} = 125^{\circ}C$, $\theta_{JA} = 70^{\circ}C/W$ (N)	LTC1597ACG LTC1597ACN LTC1597BCG LTC1597BCN LTC1597-1ACG LTC1597-1ACN LTC1597-1BCG LTC1597-1BCN LTC1597AIG LTC1597AIN LTC1597BIG LTC1597BIN LTC1597-1AIG LTC1597-1AIN LTC1597-1BIG LTC1597-1BIN

Consult factory for Military grade parts.

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°C T _{MIN} to T _{MAX}	●	±1 ±1		±2 ±2		±0.25 ±0.35		±1 ±1		LSB LSB
DNL	Differential Nonlinearity	T _A = 25°C T _{MIN} to T _{MAX}	●	±1 ±1		±1 ±1		±0.2 ±0.2		±1 ±1		LSB LSB
GE	Gain Error	Unipolar Mode (Note 3) T _A = 25°C T _{MIN} to T _{MAX}	●	±4 ±6		±16 ±24		2 3		±16 ±16		LSB LSB
		Bipolar Mode (Note 3) T _A = 25°C T _{MIN} to T _{MAX}	●	±4 ±6		±16 ±24		2 3		±16 ±16		LSB LSB
	Gain Temperature Coefficient	(Note 4) ΔGain/ΔTemperature	●	1	2	1	2	1	2			ppm/°C
	Bipolar Zero-Scale Error	T _A = 25°C T _{MIN} to T _{MAX}	●	±3 ±5		±10 ±16		±5 ±8				LSB LSB
I _{LKG}	OUT1 Leakage Current	(Note 5) T _A = 25°C T _{MIN} to T _{MAX}	●	±5 ±15		±5 ±15		±5 ±15				nA nA
PSRR	Power Supply Rejection Ratio	V _{CC} = 5V ±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	kΩ
R1/R2	R1/R2 Resistance (Bipolar)	(Notes 6, 13)	●	9	12	20	kΩ
R _{OFS} , R _{FB}	Feedback and Offset Resistances	(Note 6)	●	9	12	20	kΩ

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

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 = 100 Ω 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).

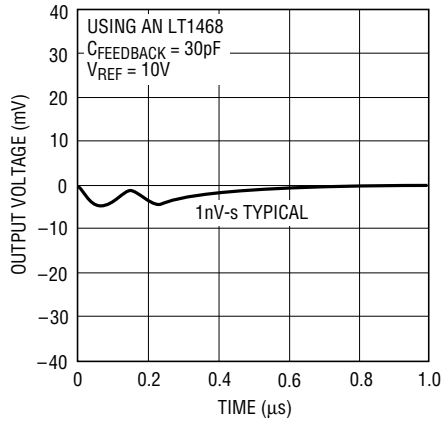
Note 12: Midscale transition code: 01 1111 1111 1111 to 10 0000 0000 0000 for the LTC1591/LTC1591-1 and 0111 1111 1111 1111 to 1000 0000 0000 0000 for the LTC1597/LTC1597-1.

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, $V_{REF} = 5V$, $T_A = 25^\circ C$.

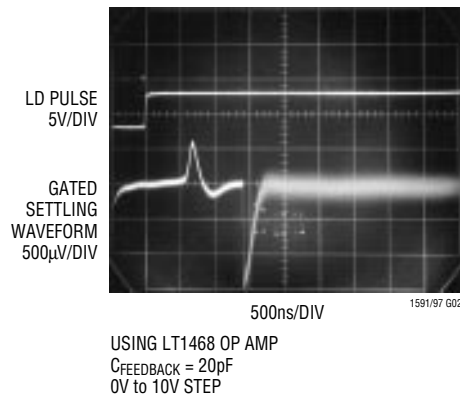
TYPICAL PERFORMANCE CHARACTERISTICS (LTC1591/LTC1597)

Midscale Glitch Impulse



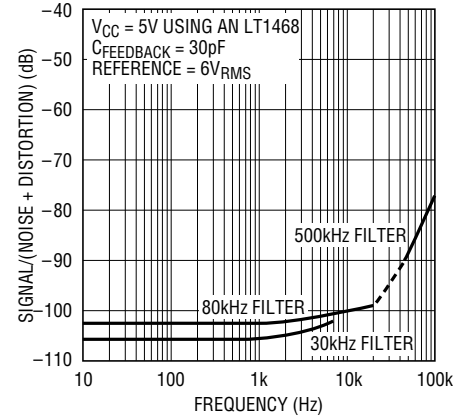
1591/97 G01

Full-Scale Settling Waveform



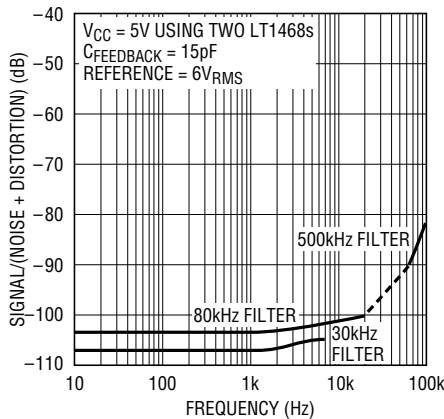
1591/97 G02

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



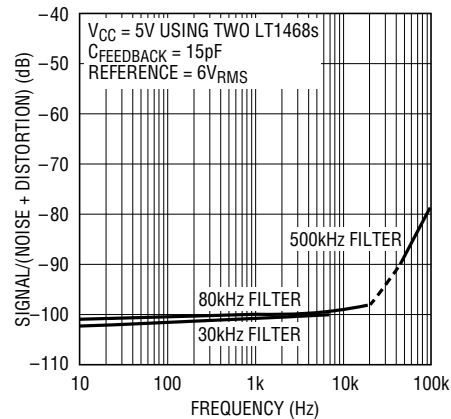
1591/97 G03

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



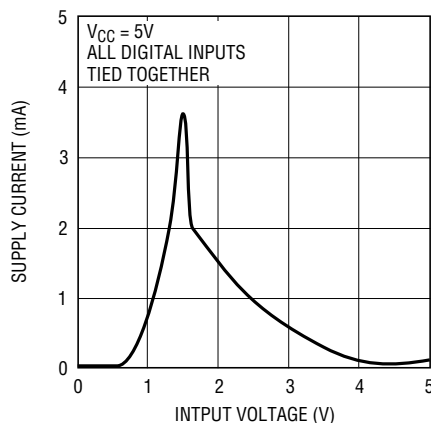
1591/97 G04

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



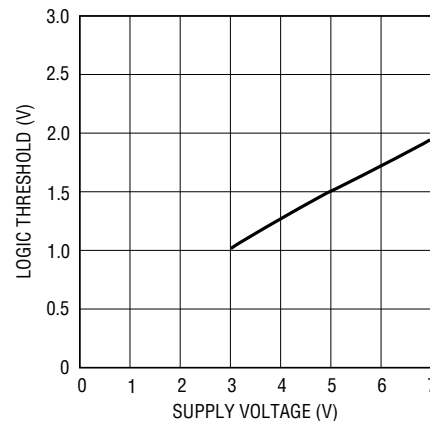
1591/97 G05

Supply Current vs Input Voltage



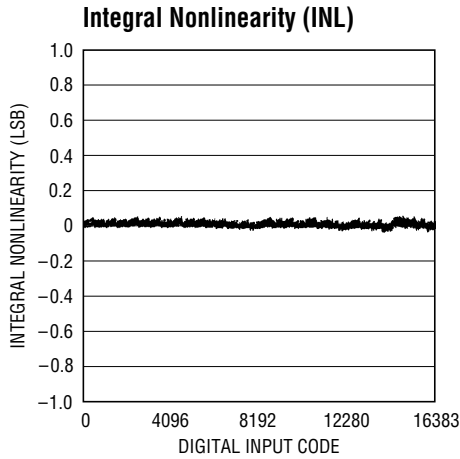
1591/97 G06

Logic Threshold vs Supply Voltage

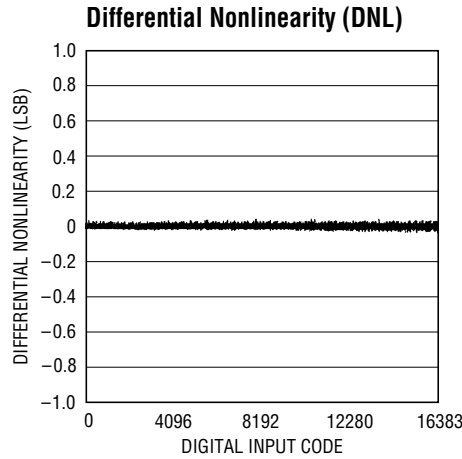


1591/97 G07

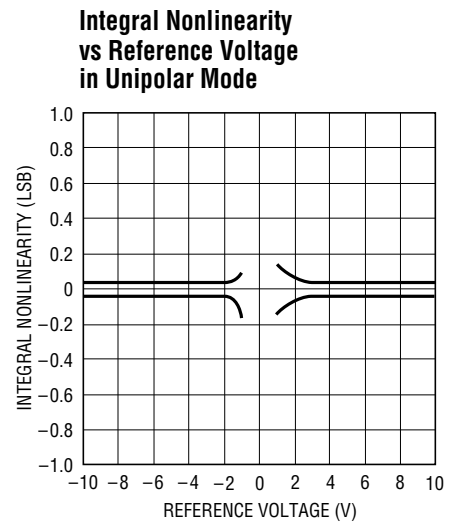
TYPICAL PERFORMANCE CHARACTERISTICS (LTC1591)



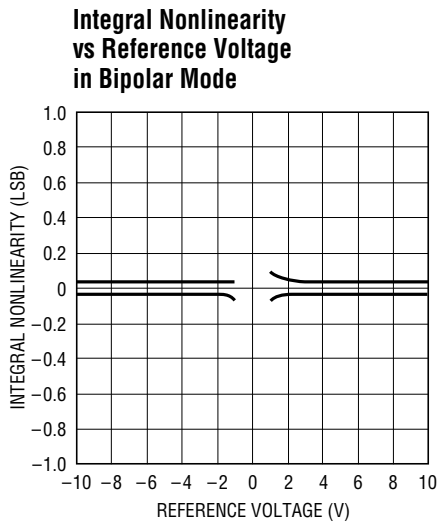
1591 G01



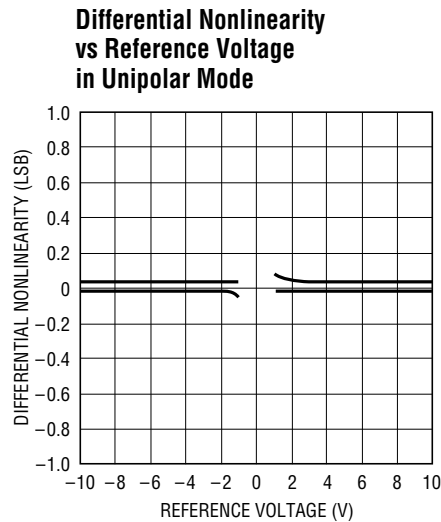
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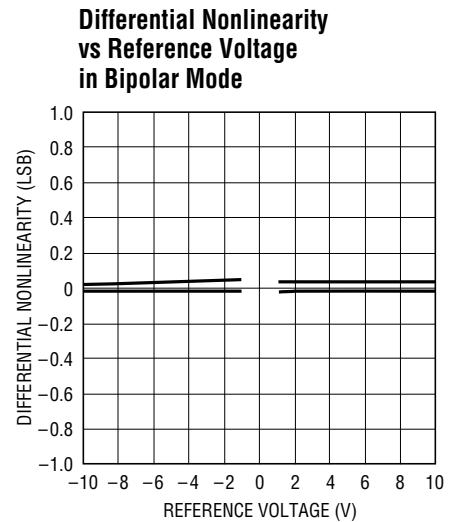
1591 G03



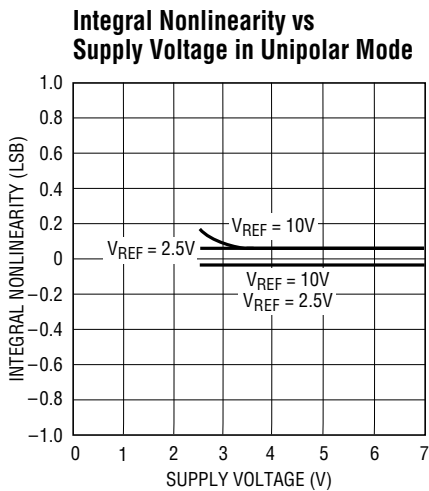
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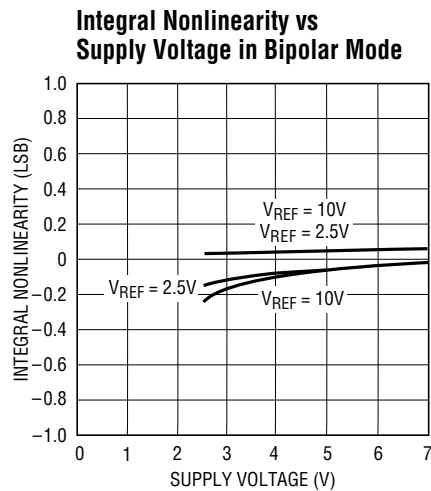
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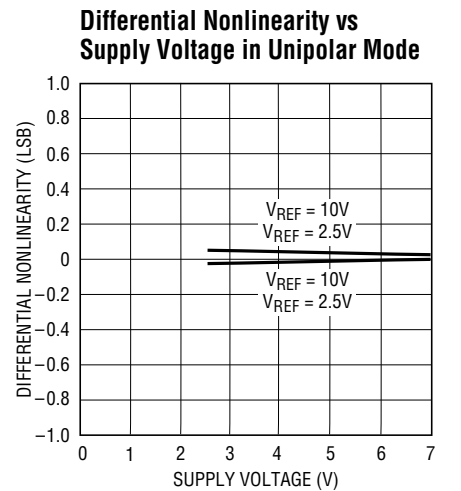
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1591 G07



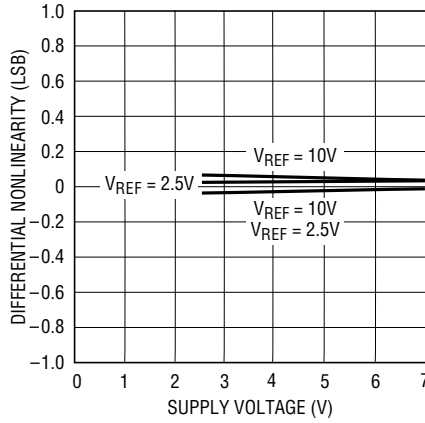
1591 G08



1591 G09

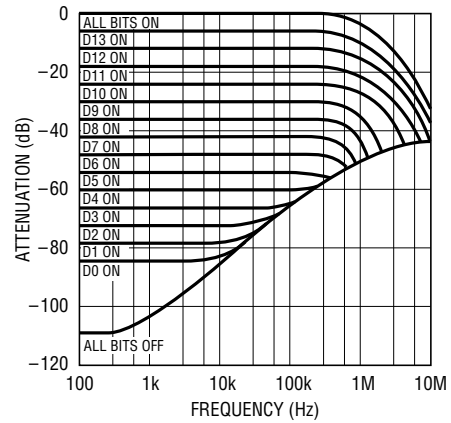
TYPICAL PERFORMANCE CHARACTERISTICS (LTC1591)

Differential Nonlinearity vs Supply Voltage in Bipolar Mode

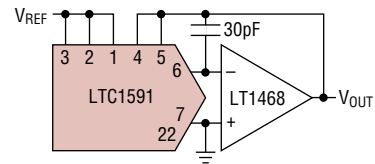


1591 G10

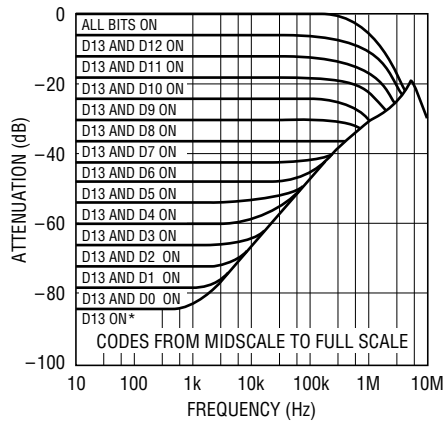
Unipolar Multiplying Mode Frequency Response vs Digital Code



1591G11

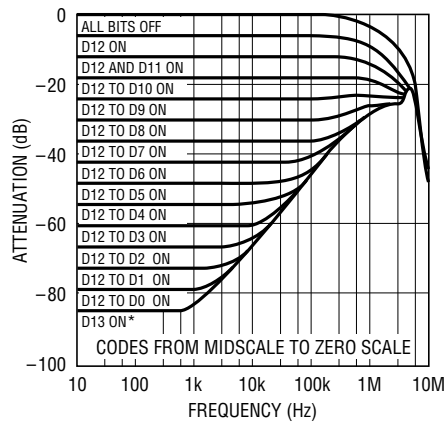


Bipolar Multiplying Mode Frequency Response vs Digital Code



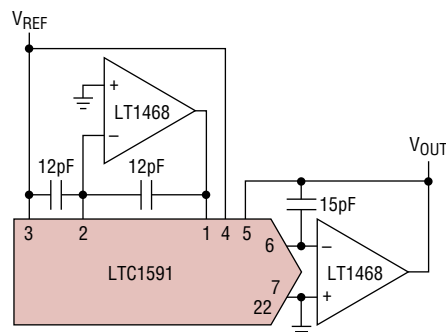
1591 G12

Bipolar Multiplying Mode Frequency Response vs Digital Code

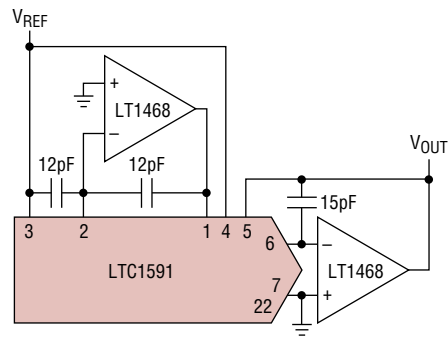


1591G13

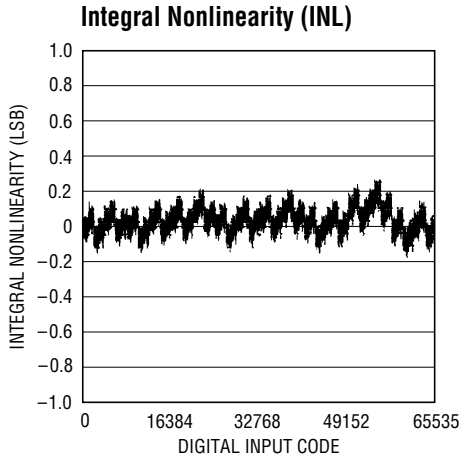
*DAC ZERO VOLTAGE OUTPUT LIMITED BY BIPOLAR ZERO ERROR TO -84dB TYPICAL (-70dB MAX)



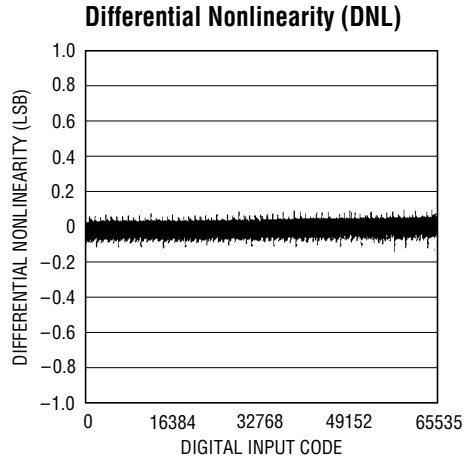
*DAC ZERO VOLTAGE OUTPUT LIMITED BY BIPOLAR ZERO ERROR TO -84dB TYPICAL (-70dB MAX)



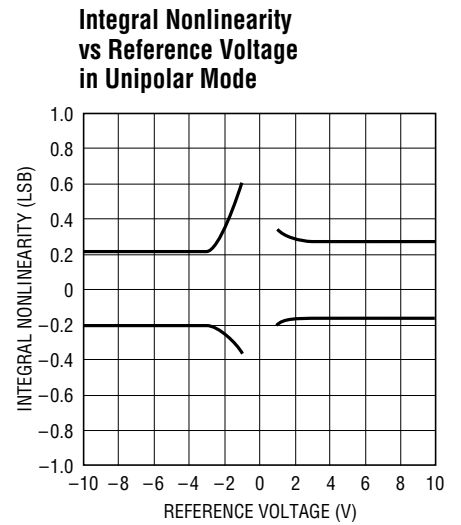
TYPICAL PERFORMANCE CHARACTERISTICS (LTC1597)



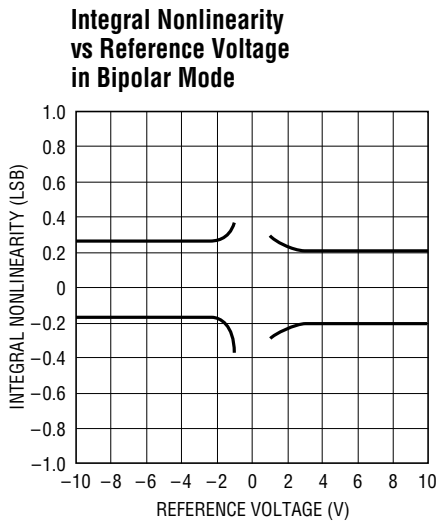
1597 G01



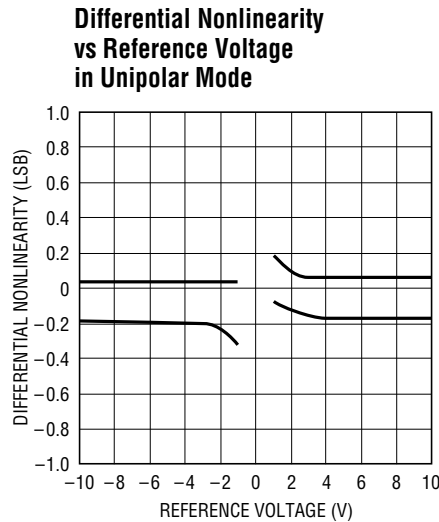
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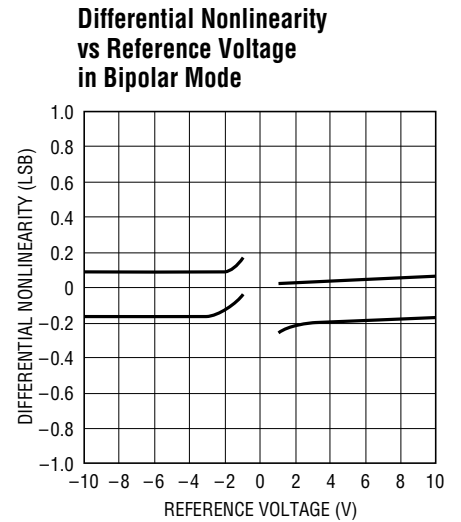
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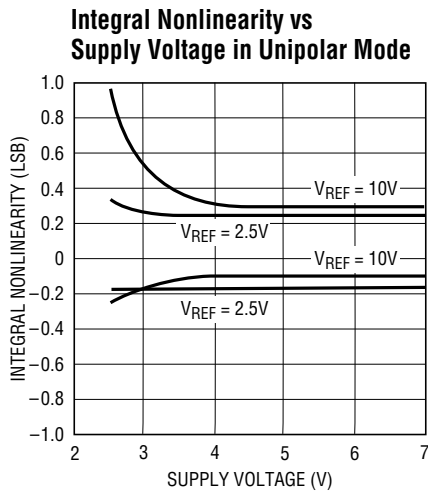
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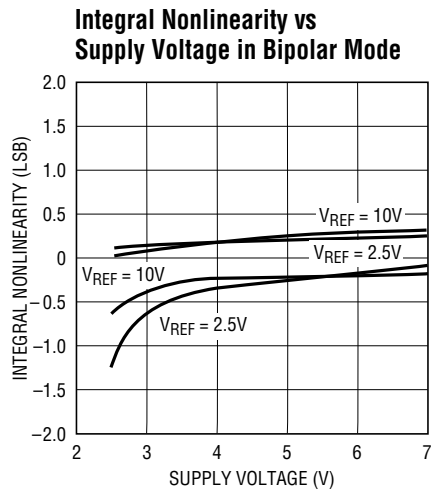
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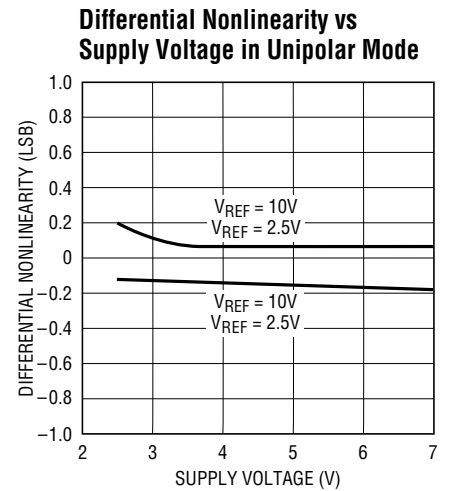
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1597 G07



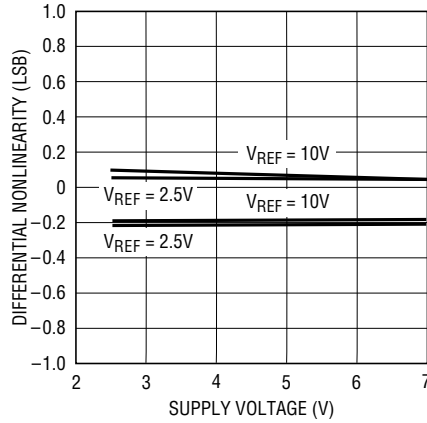
1597 G08



1597 G09

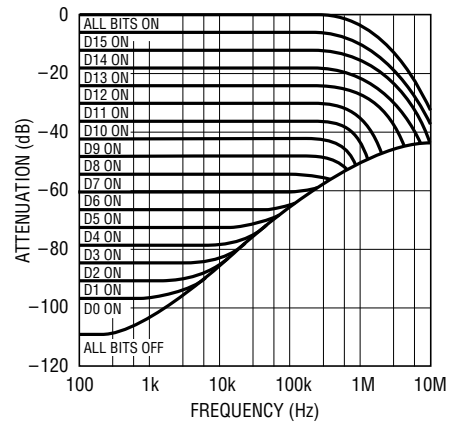
TYPICAL PERFORMANCE CHARACTERISTICS (LTC1597)

Differential Nonlinearity vs Supply Voltage in Bipolar Mode

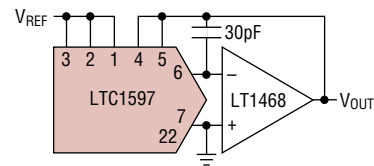


1597 G10

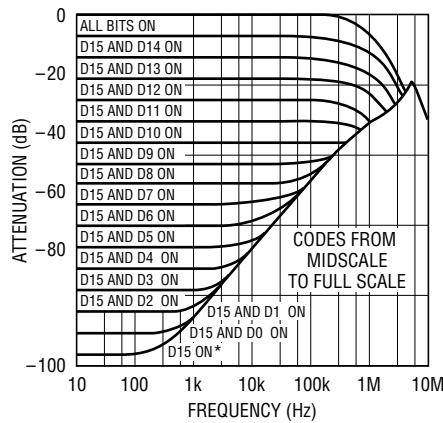
Unipolar Multiplying Mode Frequency Response vs Digital Code



1597 G11

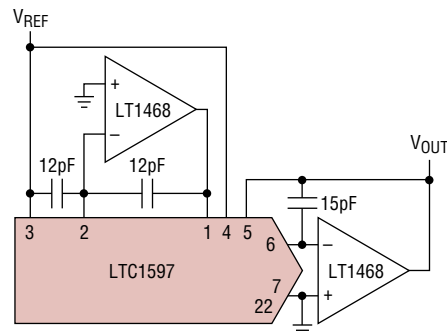


Bipolar Multiplying Mode Frequency Response vs Digital Code

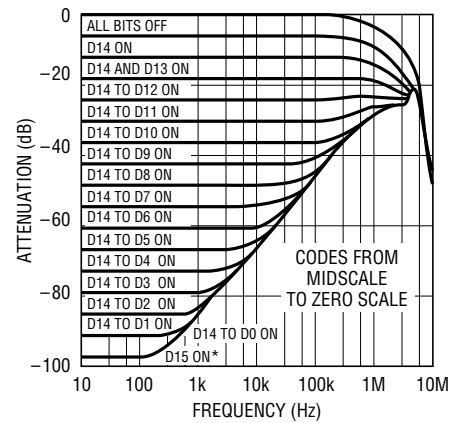


1597 G12

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

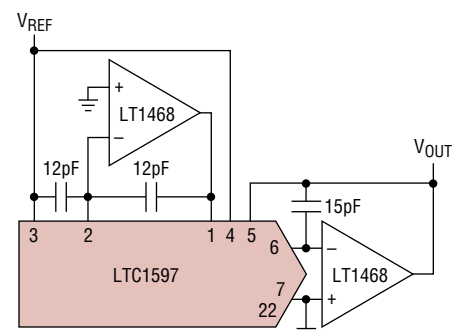


Bipolar Multiplying Mode Frequency Response vs Digital Code



1597 G13

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



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_{OFFS} (Pin 4).

R_{OFFS} (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.

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_{OFFS} (Pin 4).

R_{OFFS} (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 16-bit wide input register.

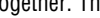
DB15 to D4 (Pins 10 to 21): Digital Input Data Bits.

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.

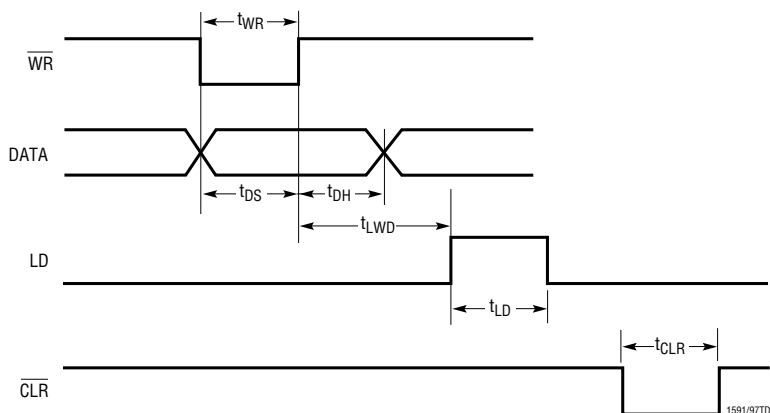
CLR (Pin 28): Digital Clear Control Function for the DAC. When $\overline{CLR}$ is taken to a logic low, it sets the DAC output and all internal registers to zero code for the LTC1597 and midscale code for the LTC1597-1.

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

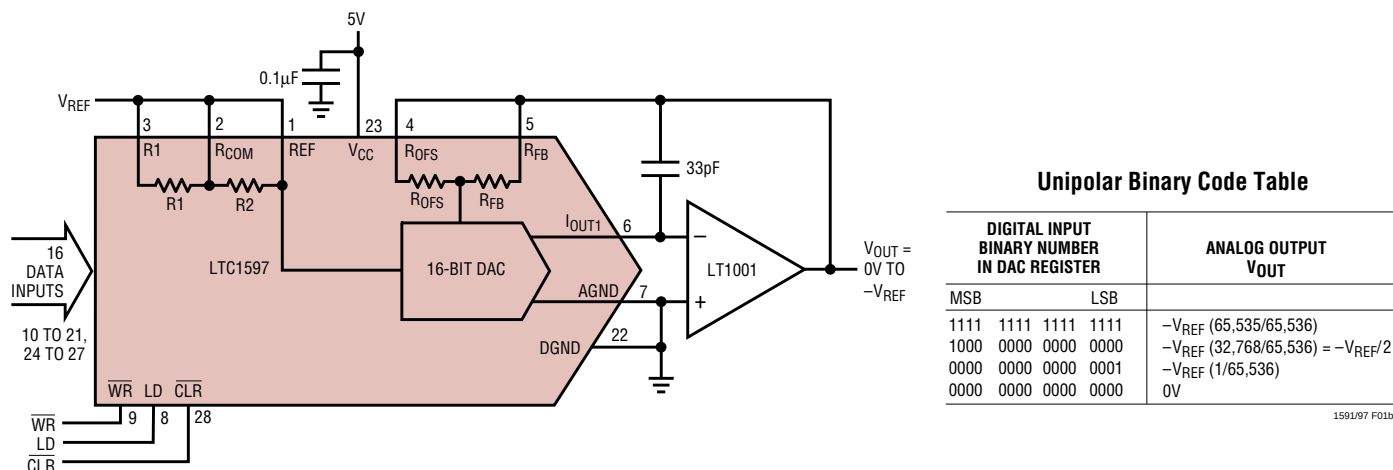
BLOCK DIAGRAMS



TIMING DIAGRAM



APPLICATIONS INFORMATION

Figure 1b. Unipolar Operation (2-Quadrant Multiplication) V_{OUT} = 0V to -V_{REF}**Bipolar Mode****(4-Quadrant Multiplying, V_{OUT} = -V_{REF} to V_{REF})**

The LTC1591/LTC1597 contain on chip all the 4-quadrant resistors necessary for bipolar operation. 4-quadrant multiplying operation can be achieved with a minimum of external components, a capacitor and a dual op amp, as shown in Figure 2. With a fixed 10V reference, the circuit shown gives a precision bipolar -10V to 10V output swing.

Op Amp Selection

Because of the extremely high accuracy of the 14-/16-bit LTC1591/LTC1597, thought should be given to op amp selection in order to achieve the exceptional performance of which the part is capable. Fortunately, the sensitivity of INL and DNL to op amp offset has been greatly reduced compared to previous generations of multiplying DACs.

Op amp offset will contribute mostly to output offset and gain and will have minimal effect on INL and DNL. For the LTC1597, a 500µV op amp offset will cause about 0.55LSB INL degradation and 0.15LSB DNL degradation with a 10V full-scale range. The main effects of op amp offset will be a degradation of zero-scale error equal to the op amp

offset, and a degradation of full-scale error equal to twice the op amp offset. For the LTC1597, the same 500µV op amp offset (2mV offset for LTC1591) will cause a 3.3LSB zero-scale error and a 6.5LSB full-scale error with a 10V full-scale range.

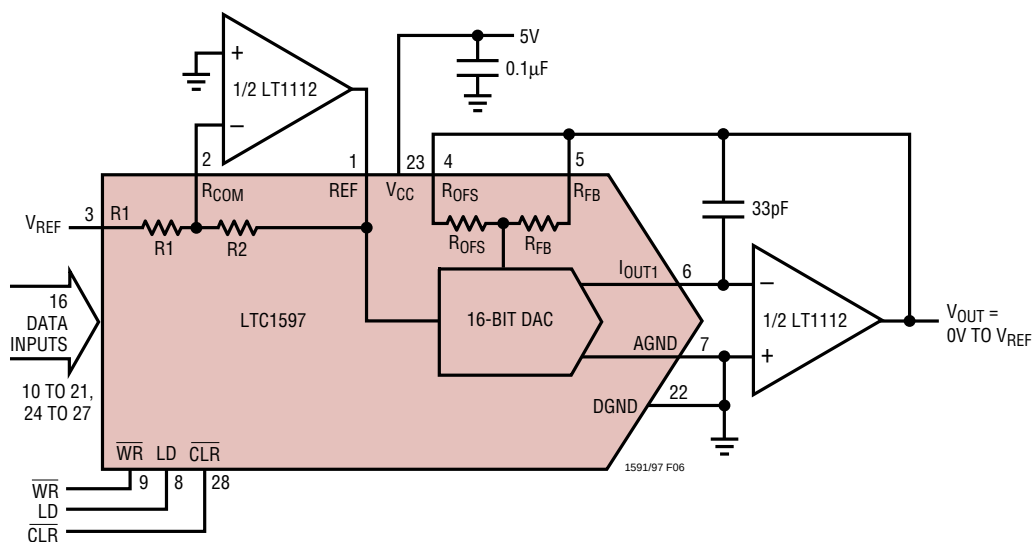
Op amp input bias current (I_{BIAS}) contributes only a zero-scale error equal to I_{BIAS}(R_{FB}/R_{OFS}) = I_{BIAS}(6k). For a thorough discussion of 16-bit DAC settling time and op amp selection, refer to Application Note 74, "Component and Measurement Advances Ensure 16-Bit DAC Settling Time."

Reference Input and Grounding

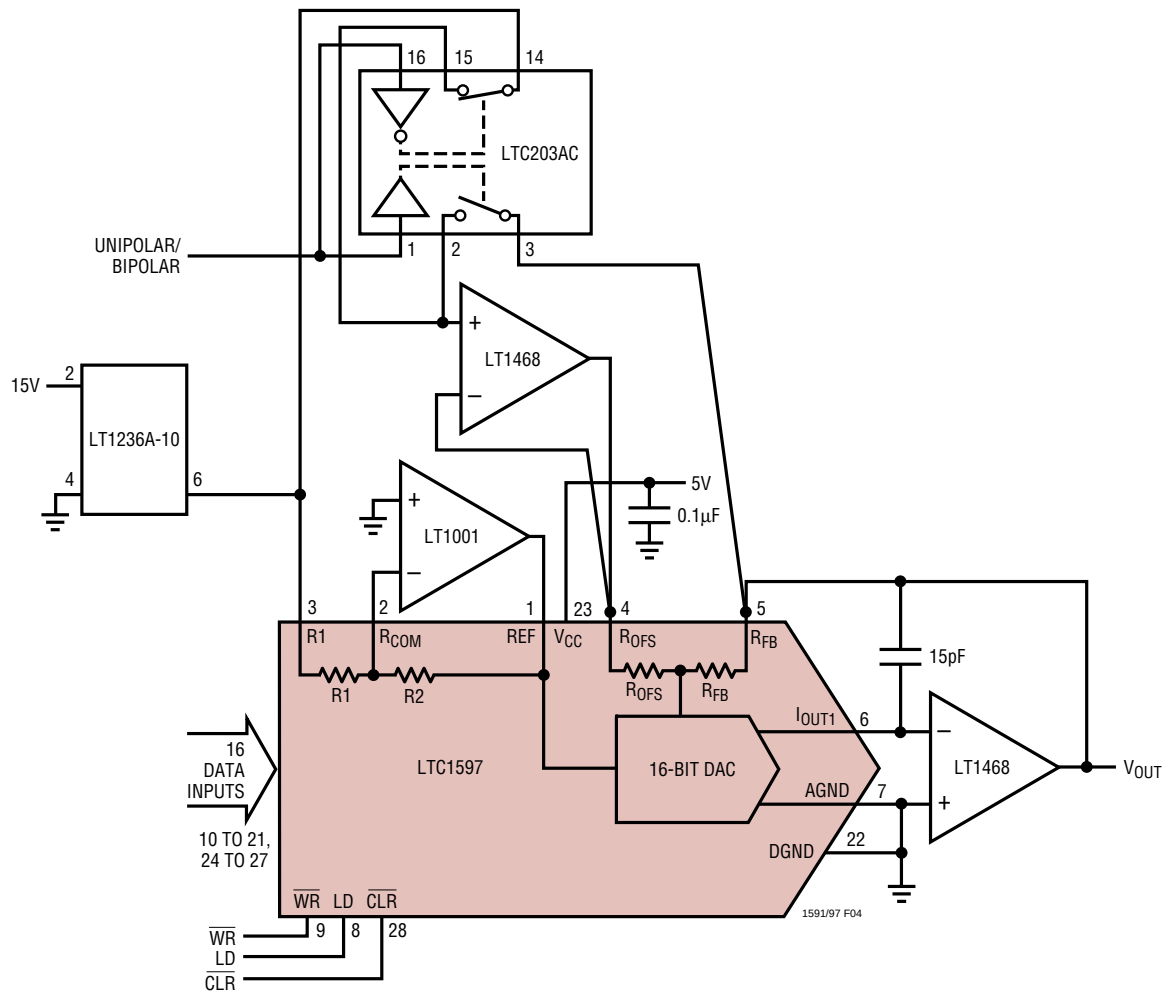
For optimum performance the reference input of the LTC1597 should be driven by a source impedance of less than 1kΩ. However, these DACs have been designed to minimize source impedance effects. An 8kΩ source impedance degrades both INL and DNL by 0.2LSB.

As with any high resolution converter, clean grounding is important. A low impedance analog ground plane and star grounding should be used. AGND must be tied to the star ground with as low a resistance as possible.

TYPICAL APPLICATIONS

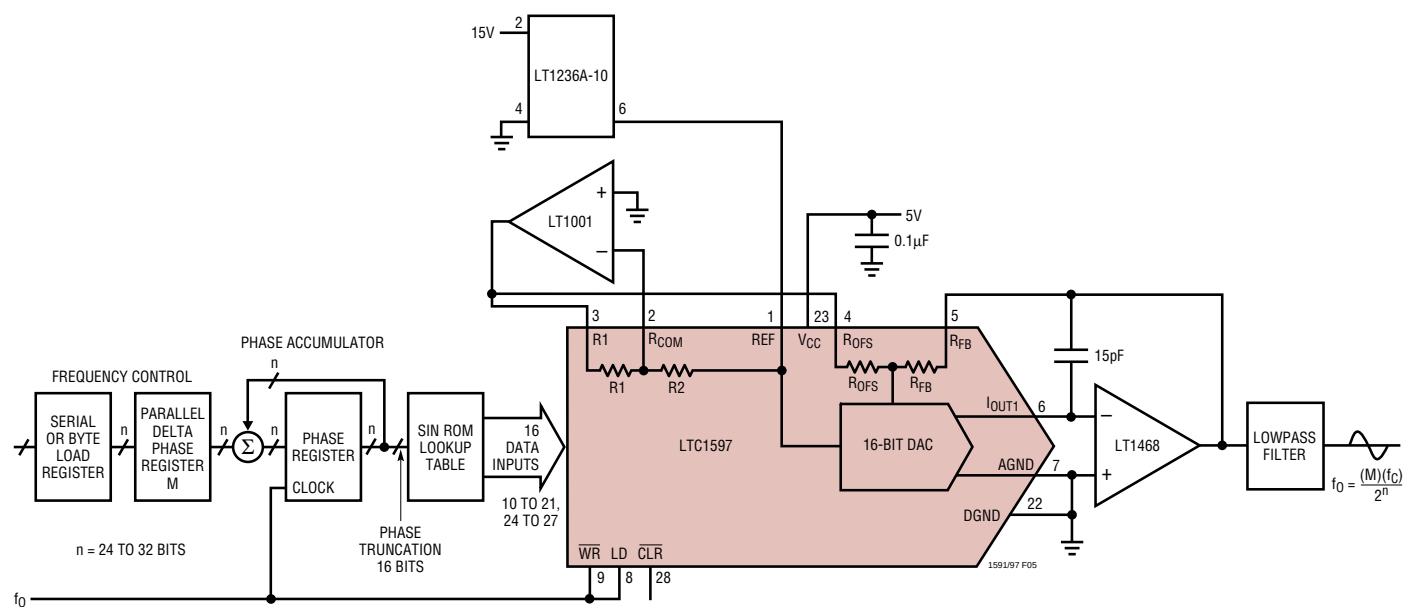
Noninverting Unipolar Operation (2-Quadrant Multiplication) $V_{OUT} = 0V$ to V_{REF} 

TYPICAL APPLICATIONS

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

TYPICAL APPLICATIONS

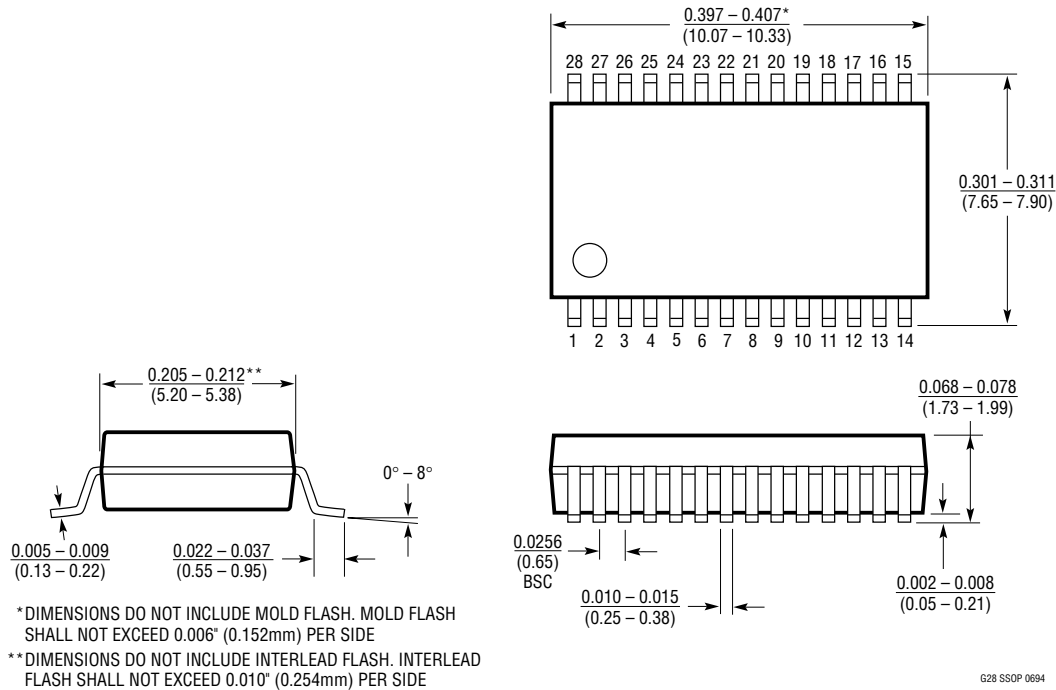
Digital Waveform Generator



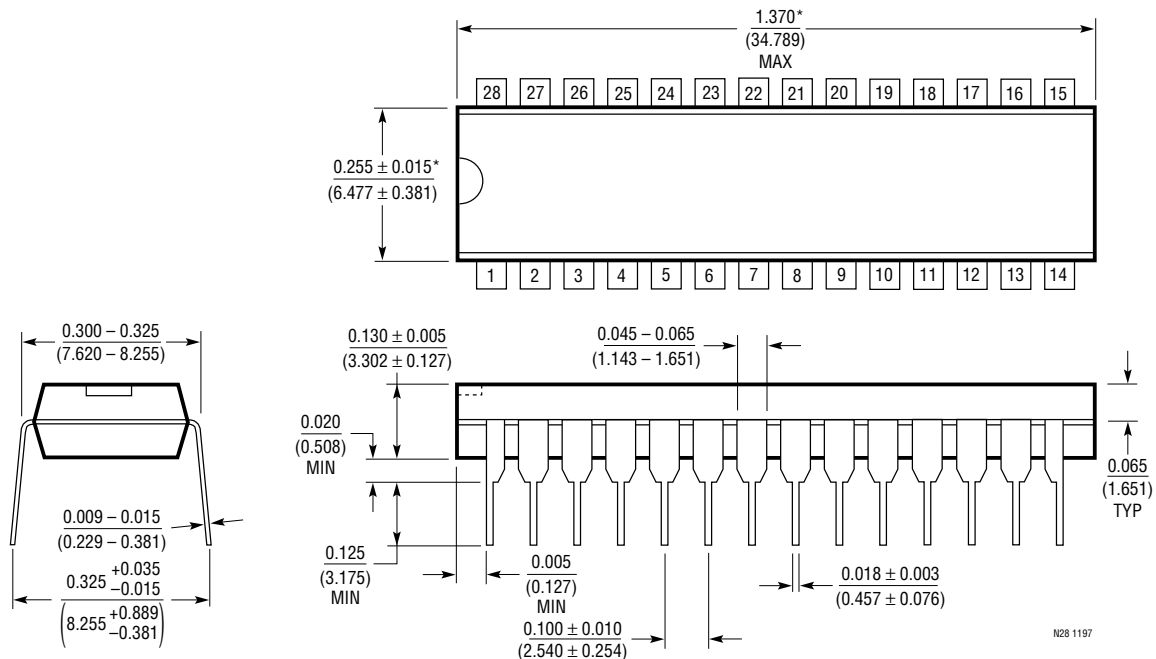
PACKAGE DESCRIPTION

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)



The schematic diagram illustrates the internal components and connections of the LTC1591/97 F03 evaluation board. Key components include:

- LT1236A-10**: A voltage detector connected to a 15V supply and ground.
- LTC203AC**: A comparator with inputs connected to the voltage detector and a 5V supply.
- LT1468**: An operational amplifier used as a buffer, connected to the comparator's output and a 15pF capacitor.
- LTC1597**: The main DAC chip, featuring a 16-bit DAC and a 15pF capacitor.
- Resistors**: Various resistors (R1, R2, RCOM, R0FS, RFB) are used for signal conditioning and feedback.
- Capacitors**: A 20pF capacitor is used for timing and signal filtering.
- Power Supply**: A 5V supply is connected to the board's VCC pin.
- Grounding**: The board includes AGND (Analog Ground) and DGND (Digital Ground) pins.

The output of the DAC is labeled **VOUT**.

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%