



Multiple Range, 16-Bit, Bipolar/Unipolar Voltage Output DAC with 7 ppm/°C Reference

Enhanced Product

AD5761R-EP

FEATURES

- 8 software-programmable output ranges: 0 V to 5 V, 0 V to 10 V, 0 V to 16 V, 0 V to 20 V, -2.5 V to +7.5 V, ± 3 V, ± 5 V, and ± 10 V; 5% overrange
- Low drift 2.5 V reference: ± 7 ppm/°C typical
- TUE: $\pm 0.1\%$ FSR maximum
- 16-bit relative accuracy (INL): ± 8 LSB maximum
- Guaranteed monotonicity (DNL): ± 1 LSB maximum
- Single channel, 16-bit DAC
- Output voltage settling time
 - 7.5 μ s typical, 10 V step to 1 LSB at 16-bit resolution
- Integrated reference buffers
- Low noise: 35 nV/ $\sqrt{\text{Hz}}$ (± 3 V range)
- Low glitch: 1 nV-sec (0 V to 5 V range)
- 1.7 V to 5.5 V digital supply range (DV_{CC})
- Asynchronous updating via $\overline{\text{LDAC}}$
- Asynchronous $\overline{\text{RESET}}$ to zero scale/midscale
- DSP-/microcontroller-compatible serial interface
- Robust 4 kV HBM ESD rating
- 16-lead TSSOP package
- Operating temperature range: -55°C to $+125^\circ\text{C}$

ENHANCED PRODUCT FEATURES

- Supports defense and aerospace applications (AQEC standard)
- Military temperature range: -55°C to $+125^\circ\text{C}$
- Controlled manufacturing baseline
- 1 assembly/test site
- 1 fabrication site
- Enhanced product change notification
- Qualification data available on request

APPLICATIONS

- Industrial automation
- Instrumentation, data acquisition
- Open-/closed-loop servo control, process control
- Programmable logic controllers

GENERAL DESCRIPTION

The **AD5761R-EP** is a single-channel, 16-bit serial input, voltage output, digital-to-analog converter (DAC). It operates from single-supply voltages from 4.75 V to 30 V V_{DD} or dual supply voltages from -16.5 V to 0 V V_{SS} and 4.75 V to 16.5 V V_{DD} . The integrated output amplifier, reference buffer, and reference provide an easy to use, universal solution.

The device offers guaranteed monotonicity, integral nonlinearity (INL) of ± 8 LSB maximum, 35 nV/ $\sqrt{\text{Hz}}$ noise, and a 7.5 μ s settling time on selected ranges.

The **AD5761R-EP** uses a serial interface that operates at clock rates of up to 50 MHz and is compatible with digital signal processor (DSP) and microcontroller interface standards. Double buffering allows the asynchronous updating of the DAC output. The input coding is user selectable, twos complement or straight binary. The asynchronous reset function resets all registers to their default state. The output range is user selectable via the $\text{RA}[2:0]$ bits in the control register.

The device is available in a 16-lead TSSOP package, and it offers guaranteed specifications over the -55°C to $+125^\circ\text{C}$ military temperature range.

Additional application and technical information can be found in the **AD5761R** data sheet.

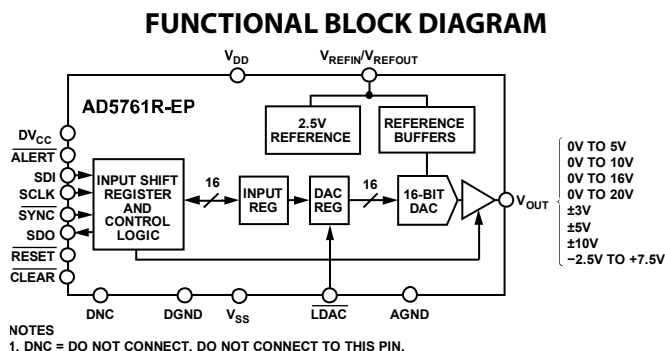


Figure 1.

Rev. 0

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REVISION HISTORY

3/2017—Revision 0: Initial Version

SPECIFICATIONS

$V_{DD}^1 = 4.75 \text{ V to } 30 \text{ V}$, $V_{SS}^1 = -16.5 \text{ V to } 0 \text{ V}$, $AGND = DGND = 0 \text{ V}$, $V_{REFIN}/V_{REFOUT} = 2.5 \text{ V external}$, $DV_{CC} = 1.7 \text{ V to } 5.5 \text{ V}$, $R_{LOAD} = 1 \text{ k}\Omega$ for all ranges except $0 \text{ V to } 16 \text{ V}$ and $0 \text{ V to } 20 \text{ V}$ for which $R_{LOAD} = 2 \text{ k}\Omega$, $C_{LOAD} = 200 \text{ pF}$, and all specifications T_{MIN} to T_{MAX} , unless otherwise noted. Temperature range: -55°C to $+125^\circ\text{C}$, typical at $+25^\circ\text{C}$.

Table 1.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
STATIC PERFORMANCE					
Programmable Output Ranges	0		5	V	External reference ² and internal reference, outputs unloaded
	0		10	V	
	0		16	V	
	0		20	V	
	-2.5		+7.5	V	
	-3		+3	V	
	-5		+5	V	
	-10		+10	V	
Resolution	16			Bits	
Relative Accuracy (INL)	-8		+8	LSB	External reference ² and internal reference
Differential Nonlinearity (DNL)	-1		+1	LSB	
Zero-Scale Error	-6		+6	mV	All ranges except $\pm 10 \text{ V}$ and $0 \text{ V to } 20 \text{ V}$, external reference ²
	-10		+10	mV	$0 \text{ V to } 20 \text{ V}$, $\pm 10 \text{ V}$ ranges, external reference ²
	-6		+6	mV	All ranges except $\pm 5 \text{ V}$, $\pm 10 \text{ V}$, and $0 \text{ V to } 20 \text{ V}$, internal reference
	-8		+8	mV	$\pm 5 \text{ V}$ range, internal reference
	-9		+9	mV	$0 \text{ V to } 20 \text{ V}$ range, internal reference
	-13		+13	mV	$\pm 10 \text{ V}$ range, internal reference
		± 5		$\mu\text{V}/^\circ\text{C}$	Unipolar ranges, external reference ² and internal reference
		± 15		$\mu\text{V}/^\circ\text{C}$	Bipolar ranges, external reference ² and internal reference
Bipolar Zero Error	-5		+5	mV	All bipolar ranges except $\pm 10 \text{ V}$
	-7		+7	mV	$\pm 10 \text{ V}$ output range
Bipolar Zero TC ³		± 2		$\mu\text{V}/^\circ\text{C}$	$\pm 3 \text{ V}$ range, external reference ² and internal reference
		± 5		$\mu\text{V}/^\circ\text{C}$	All bipolar ranges except $\pm 3 \text{ V}$ range, external reference ² and internal reference
Offset Error	-6		+6	mV	All ranges except $\pm 10 \text{ V}$ and $0 \text{ V to } 20 \text{ V}$, external reference ²
	-10		+10	mV	$0 \text{ V to } 20 \text{ V}$, $\pm 10 \text{ V}$ ranges, external reference ²
	-6		+6	mV	All ranges except $\pm 5 \text{ V}$, $\pm 10 \text{ V}$, and $0 \text{ V to } 20 \text{ V}$; internal reference
	-8		+8	mV	$\pm 5 \text{ V}$ range, internal reference
	-9		+9	mV	$0 \text{ V to } 20 \text{ V}$ range, internal reference
	-18		+18	mV	$\pm 10 \text{ V}$ range, internal reference
		± 5		$\mu\text{V}/^\circ\text{C}$	Unipolar ranges, external reference ² and internal reference
		± 15		$\mu\text{V}/^\circ\text{C}$	Bipolar ranges, external reference ² and internal reference
Gain Error	-0.1		+0.1	% FSR	External reference ²
	-0.15		+0.15	% FSR	Internal reference
Gain Error TC ³		± 1.5		ppm FSR/ $^\circ\text{C}$	External reference ² and internal reference
Total Unadjusted Error (TUE)	-0.1		+0.1	% FSR	External reference ²
	-0.15		+0.15	% FSR	Internal reference

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
REFERENCE INPUT (EXTERNAL) ³					
Reference Input Voltage (V_{REF})		2.5		V	±1% for specified performance
Input Current	−2	±0.5	+2	μA	
Reference Range	2		3	V	
REFERENCE OUTPUT (INTERNAL) ³					
Output Voltage		2.5		V	±3 mV, at ambient temperature
Voltage Reference TC		7	25	ppm/°C	
Output Impedance		25		kΩ	
Output Voltage Noise		6		μV p-p	0.1 Hz to 10 Hz
Noise Spectral Density		10		nV/√Hz	At ambient; f = 10 kHz
Line Regulation		6		μV/V	At ambient
Thermal Hysteresis		±80		ppm	First temperature cycle
Start-Up Time		3.5		ms	Coming out of power-down mode with a 10 nF capacitor on the V_{REFIN}/V_{REFOUT} pin improves noise performance; outputs unloaded
OUTPUT CHARACTERISTICS ³					
Output Voltage Range	− V_{OUT}		+ V_{OUT}		See the AD5761R data sheet for the different output voltage ranges available
	−10		+10	V	$V_{DD}/V_{SS} = \pm 11$ V, ±10 V output range
	−10.5		+10.5	V	$V_{DD}/V_{SS} = \pm 11$ V, ±10 V output range with 5% overrange
Capacitive Load Stability			1	nF	
Headroom		0.5	1	V	$R_{LOAD} = 1$ kΩ for all ranges except 0 V to 16 V and 0 V to 20 V ranges ($R_{LOAD} = 2$ kΩ)
Output Voltage TC		±3		ppm FSR/°C	±10 V range, external reference
Short-Circuit Current		25		mA	Short on the V_{OUT} pin
Resistive Load			1	kΩ	All ranges except 0 V to 16 V and 0 V to 20 V
			2	kΩ	0 V to 16 V, 0 V to 20 V ranges
Load Regulation		0.3		mV/mA	Outputs unloaded
DC Output Impedance		0.5		Ω	Outputs unloaded
LOGIC INPUTS ³					$DV_{CC} = 1.7$ V to 5.5 V, JEDEC compliant
Input Voltage					
High (V_{IH})	$0.7 \times DV_{CC}$			V	
Low (V_{IL})			$0.3 \times DV_{CC}$	V	
Input Current					
Leakage Current	−1		+1	μA	$\overline{SDI}$, $\overline{SCLK}$, $\overline{SYNC}$
	−1		+1	μA	$\overline{LDAC}$, $\overline{CLEAR}$, $\overline{RESET}$ pins held high
	−55			μA	$\overline{LDAC}$, $\overline{CLEAR}$, $\overline{RESET}$ pins held low
Pin Capacitance		5		pF	Per pin, outputs unloaded
LOGIC OUTPUTS (SDO, ALERT) ³					
Output Voltage					
Low (V_{OL})			0.4	V	$DV_{CC} = 1.7$ V to 5.5 V, sinking 200 μA
High (V_{OH})	$DV_{CC} - 0.5$			V	$DV_{CC} = 1.7$ V to 5.5 V, sourcing 200 μA
High Impedance, SDO Pin					
Leakage Current	−1		+1	μA	
Pin Capacitance		5		pF	
POWER REQUIREMENTS					
Single Supply					
V_{DD}	4.75		30	V	
V_{SS}		0		V	
Dual Supply					
V_{DD}	4.75		16.5	V	
V_{SS}	−16.5		0	V	

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
DV _{CC}	1.7		5.5	V	
I _{DD}		5.1	6.5	mA	Outputs unloaded, external reference
I _{SS}		1	3	mA	Outputs unloaded
DI _{CC}		0.005	1	μA	V _{IH} = DV _{CC} , V _{IL} = DGND
Power Dissipation		67.1		mW	±11 V operation, outputs unloaded
DC Power Supply Rejection Ratio (PSRR) ³		0.1		mV/V	V _{DD} ± 10%, V _{SS} = −15 V
AC PSRR ³		0.1		mV/V	V _{SS} ±10%, V _{DD} = +15 V
		65		dB	V _{DD} ±200 mV, 50 Hz/60 Hz, V _{SS} = −15 V, internal reference, C _{LOAD} = 100 nF
		65		dB	V _{SS} ±200 mV, 50 Hz/60 Hz, V _{DD} = +15 V, internal reference, C _{LOAD} = 100 nF
		80		dB	V _{DD} ±200 mV, 50 Hz/60 Hz, V _{SS} = −15 V, external reference, C _{LOAD} = unloaded
		80		dB	V _{SS} ±200 mV, 50 Hz/60 Hz, V _{DD} = +15 V, external reference, C _{LOAD} = unloaded

¹ For specified performance, headroom requirement is 1 V. V_{DD} = 4.75 V to 30 V and V_{SS} = 0 V for single-supply operation, and V_{DD} = 4.75 V to 16.5 V and V_{SS} = −16.5 V to 0 V for dual-supply operation.

² External reference is 2 V to 2.85 V with overrange and 2 V to 3 V without overrange.

³ Guaranteed by design and characterization, not production tested.

AC PERFORMANCE CHARACTERISTICS

$V_{DD}^1 = 4.75\text{ V to }30\text{ V}$, $V_{SS}^1 = -16.5\text{ V to }0\text{ V}$, $AGND = DGND = 0\text{ V}$, $V_{REFIN}/V_{REFOUT} = 2.5\text{ V external}$, $DV_{CC} = 1.7\text{ V to }5.5\text{ V}$, $R_{LOAD} = 1\text{ k}\Omega$ for all ranges except $0\text{ V to }16\text{ V}$ and $0\text{ V to }20\text{ V}$ for which $R_{LOAD} = 2\text{ k}\Omega$, $C_{LOAD} = 200\text{ pF}$, all specifications T_{MIN} to T_{MAX} , unless otherwise noted. Temperature range: $-55^\circ\text{C to }+125^\circ\text{C}$, typical at $+25^\circ\text{C}$. Guaranteed by design and characterization, not production tested.

Table 2.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
DYNAMIC PERFORMANCE					
Output Voltage Settling Time	9	12.5		μs	20 V step to 1 LSB at 16-bit resolution
	7.5	8.5		μs	10 V step to 1 LSB at 16-bit resolution
		5		μs	512 LSB step to 1 LSB at 16-bit resolution
Digital-to-Analog Glitch Impulse	8			nV-sec	$\pm 10\text{ V range}$
	1			nV-sec	0 V to 5 V range
Glitch Impulse Peak Amplitude	15			mV	$\pm 10\text{ V range}$
	10			mV	0 V to 5 V range
Power-On Glitch	100			mV p-p	
Digital Feedthrough	0.6			nV-sec	
Output Noise					
0.1 Hz to 10 Hz Bandwidth	15			$\mu\text{V p-p}$	
100 kHz Bandwidth	45			$\mu\text{V rms}$	0 V to 20 V and 0 V to 16 V ranges, 2.5 V external reference
	35			$\mu\text{V rms}$	0 V to 10 V, $\pm 10\text{ V}$, and $-2.5\text{ V to }+7.5\text{ V}$ ranges, 2.5 V external reference
	25			$\mu\text{V rms}$	$\pm 5\text{ V range}$, 2.5 V external reference
	15			$\mu\text{V rms}$	0 V to 5 V and $\pm 3\text{ V ranges}$, 2.5 V external reference
	80			nV/ $\sqrt{\text{Hz}}$	$\pm 10\text{ V range}$, 2.5 V external reference
Output Noise Spectral Density, at 10 kHz	35			nV/ $\sqrt{\text{Hz}}$	$\pm 3\text{ V range}$, 2.5 V external reference
	70			nV/ $\sqrt{\text{Hz}}$	$\pm 5\text{ V}$, 0 V to 10 V, and $-2.5\text{ V to }+7.5\text{ V ranges}$, 2.5 V external reference
	110			nV/ $\sqrt{\text{Hz}}$	0 V to 20 V range, 2.5 V external reference
	90			nV/ $\sqrt{\text{Hz}}$	0 V to 16 V range, 2.5 V external reference
	45			nV/ $\sqrt{\text{Hz}}$	0 V to 5 V range, 2.5 V external reference
Total Harmonic Distortion (THD) ²	-87			dB	2.5 V external reference, 1 kHz tone
Signal-to-Noise Ratio (SNR)	92			dB	At ambient, 2.5 V external reference, bandwidth (BW) = 20 kHz, $f_{OUT} = 1\text{ kHz}$
Peak Harmonic or Spurious Noise (SFDR)	92			dB	At ambient, 2.5 V external reference, BW = 20 kHz, $f_{OUT} = 1\text{ kHz}$
Signal-to-Noise-and-Distortion (SINAD) Ratio	85			dB	At ambient, 2.5 V external reference, BW = 20 kHz, $f_{OUT} = 1\text{ kHz}$

¹ For specified performance, headroom requirement is 1 V. $V_{DD} = 4.75\text{ V to }30\text{ V}$ and $V_{SS} = 0\text{ V}$ for single-supply operation, and $V_{DD} = 4.75\text{ V to }16.5\text{ V}$ and $V_{SS} = -16.5\text{ V to }0\text{ V}$ for dual-supply operation.

² Digitally generated sine wave at 1 kHz.

ABSOLUTE MAXIMUM RATINGS

$T_A = 25^\circ\text{C}$, unless otherwise noted. Transient currents of up to 200 mA do not cause silicon controlled rectifier (SCR) latch-up.

Table 3.

Parameter	Rating
V_{DD} to AGND	−0.3 V to +34 V
V_{SS} to AGND	+0.3 V to −17 V
V_{DD} to V_{SS}	−0.3 V to +34 V
DV_{CC} to DGND	−0.3 V to +7 V
Digital Inputs to DGND	−0.3 V to $DV_{CC} + 0.3$ V or 7 V (whichever is less)
Digital Outputs to DGND	−0.3 V to $DV_{CC} + 0.3$ V or 7 V (whichever is less)
V_{REFIN}/V_{REFOUT} to DGND	−0.3 V to +7 V
V_{OUT} to AGND	V_{SS} to V_{DD}
AGND to DGND	−0.3 V to +0.3 V
Military Temperature Range	−55°C to +125°C
Storage Temperature Range	−65°C to +150°C
Junction Temperature, T_{JMAX}	150°C
θ_{JA} Thermal Impedance	113°C/W ¹
Power Dissipation	See Figure 2
Lead Temperature	JEDEC industry standard
Soldering	J-STD-020
ESD (Human Body Model)	4 kV

¹ JEDEC 2S2P test board, still air (0 m/sec airflow).

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

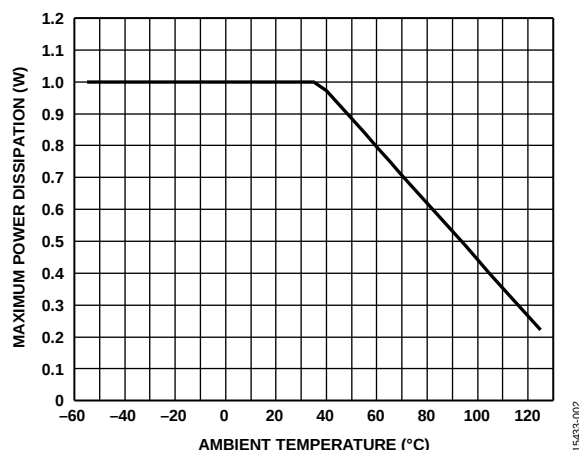


Figure 2. Maximum Power Dissipation vs. Ambient Temperature

ESD CAUTION



ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

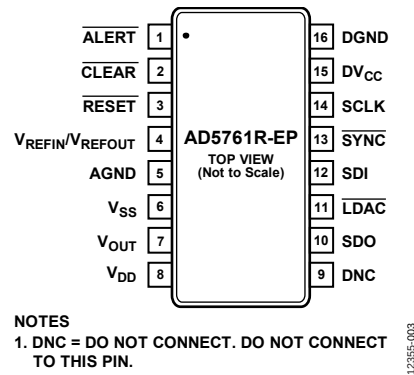


Figure 3. Pin Configuration

Table 4. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	<u>ALERT</u>	Active Low Alert. This pin is asserted low when the die temperature exceeds approximately 150°C, or when an output short circuit or a brownout occurs. This pin is also asserted low during power-up, a full software reset, or a hardware reset for which a write to the control register asserts the pin high.
2	<u>CLEAR</u>	Falling Edge Clear Input. Asserting this pin sets the DAC register to zero-scale, midscale, or full-scale code (user selectable) and updates the DAC output. This pin can be left floating because there is an internal pull-up resistor.
3	<u>RESET</u>	Active Low Reset Input. Asserting this pin returns the AD5761R-EP to its default power-on status where the output is clamped to ground, and the output buffer is powered down. This pin can be left floating because there is an internal pull-up resistor.
4	V _{REFIN} /V _{REFOUT}	Internal Reference Voltage Output and External Reference Voltage Input. For specified performance, V _{REFIN} /V _{REFOUT} = 2.5 V. Connect a 10 nF capacitor with the internal reference to minimize the noise.
5	AGND	Ground Reference Pin for Analog Circuitry.
6	V _{SS}	Negative Analog Supply Connection. A voltage in the range of –16.5 V to 0 V can be connected to this pin. For unipolar output ranges, connect this pin to 0 V. V _{SS} must be decoupled to AGND.
7	V _{OUT}	Analog Output Voltage of the DAC. The output amplifier is capable of directly driving a 2 kΩ, 1 nF load.
8	V _{DD}	Positive Analog Supply Connection. A voltage in the range of 4.75 V to 30 V can be connected to this pin for unipolar output ranges. Bipolar output ranges accept a voltage in the range of 4.75 V to 16.5 V. V _{DD} must be decoupled to AGND.
9	DNC	Do Not Connect. Do not connect to this pin.
10	SDO	Serial Data Output. This pin clocks data from the serial register in daisy-chain or readback mode. Data is clocked out on the rising edge of SCLK and is valid on the falling edge of SCLK.
11	<u>LDAC</u>	Load DAC. This logic input updates the DAC register and, consequently, the analog output. When tied permanently low, the DAC register is updated when the input register is updated. If <u>LDAC</u> is held high during the write to the input register, the DAC output register is not updated, and the DAC output update is held off until the falling edge of <u>LDAC</u> . This pin can be left floating because there is an internal pull-up resistor.
12	SDI	Serial Data Input. Data must be valid on the falling edge of SCLK.
13	<u>SYNC</u>	Active Low Synchronization Input. This pin is the frame synchronization signal for the serial interface. While <u>SYNC</u> is low, data is transferred in on the falling edge of SCLK. Data is latched on the rising edge of <u>SYNC</u> .
14	SCLK	Serial Clock Input. Data is clocked into the input shift register on the falling edge of SCLK. This pin operates at clock speeds of up to 50 MHz.
15	DV _{CC}	Digital Supply. The voltage range is from 1.7 V to 5.5 V. The applied voltage sets the voltage at which the digital interface operates.
16	DGND	Digital Ground.

TYPICAL PERFORMANCE CHARACTERISTICS

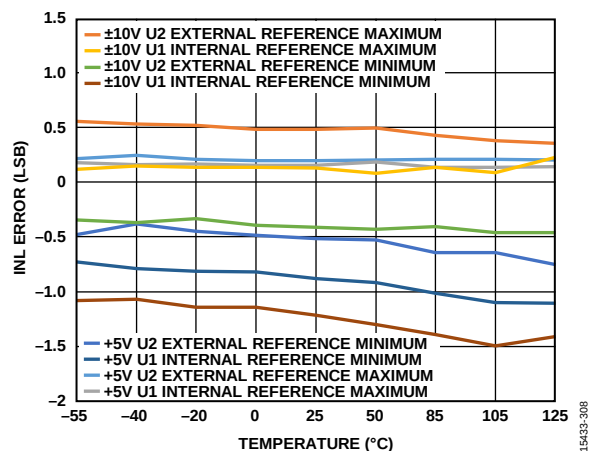


Figure 4. INL Error vs. Temperature

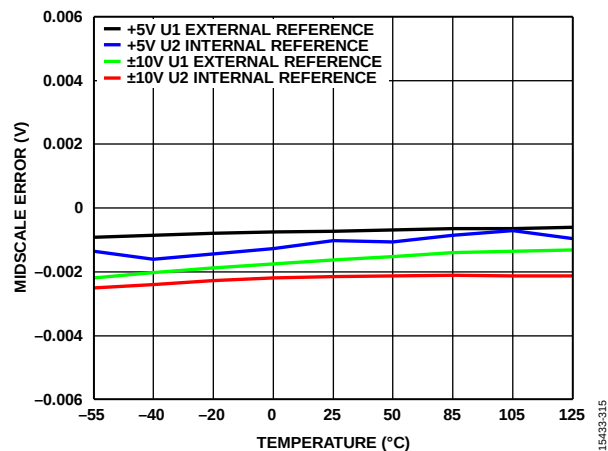


Figure 7. Midscale Error vs. Temperature

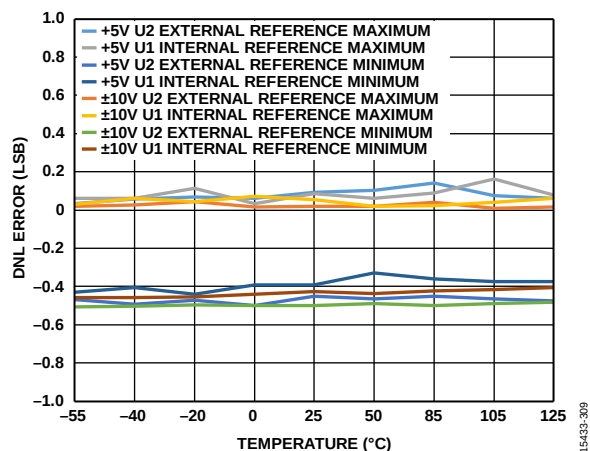


Figure 5. DNL Error vs. Temperature

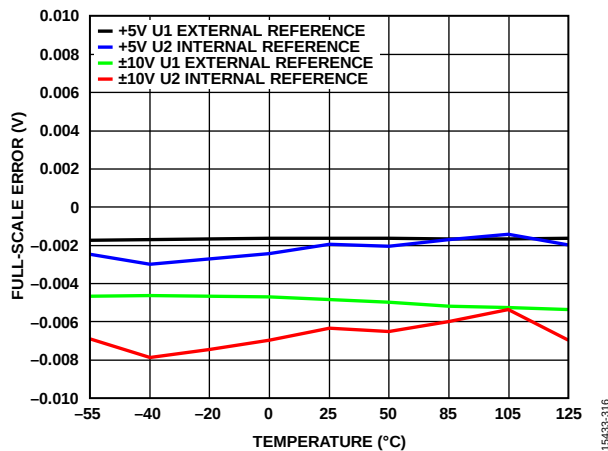


Figure 8. Full-Scale Error vs. Temperature

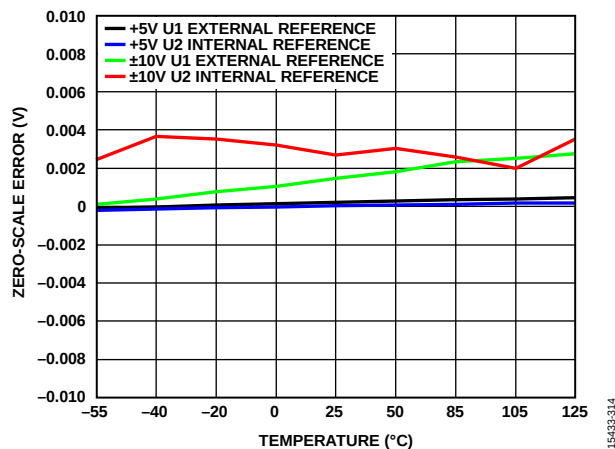


Figure 6. Zero-Scale Error vs. Temperature

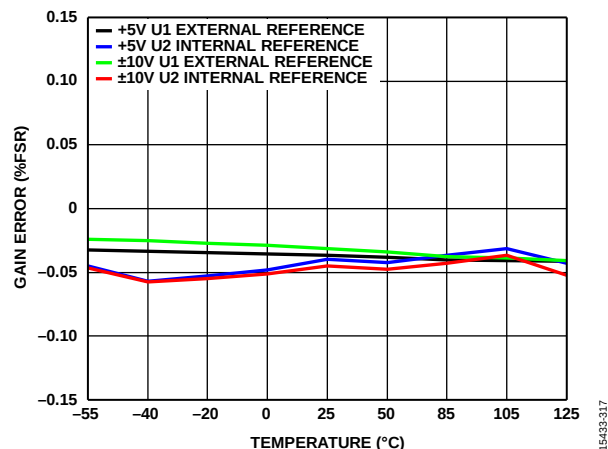


Figure 9. Gain Error vs. Temperature

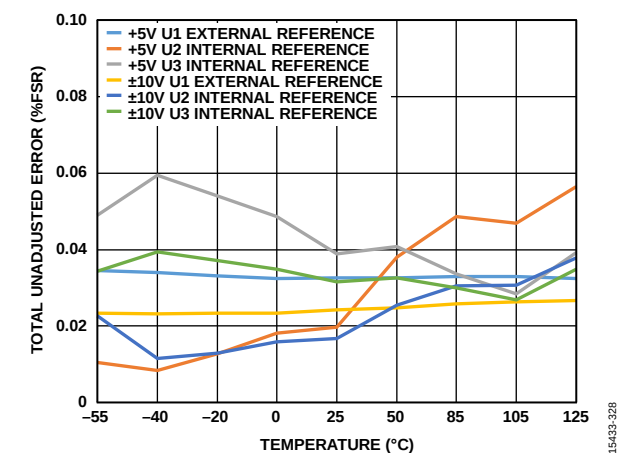


Figure 10. Total Unadjusted Error (TUE) vs. Temperature

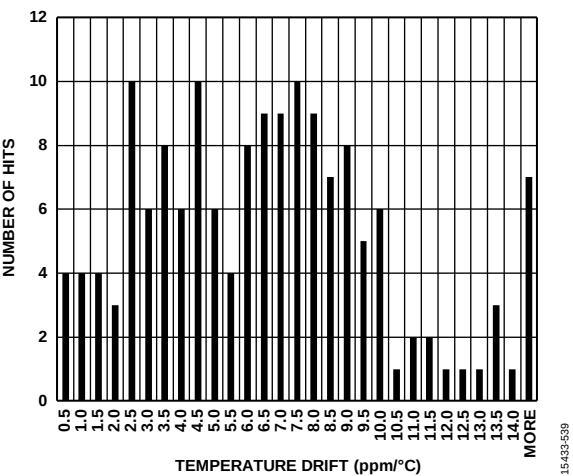


Figure 12. Reference Output TC

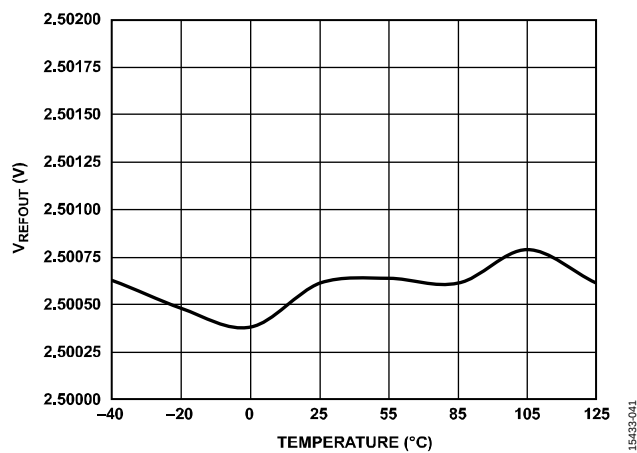


Figure 11. Reference Output Voltage vs. Temperature

OUTLINE DIMENSIONS

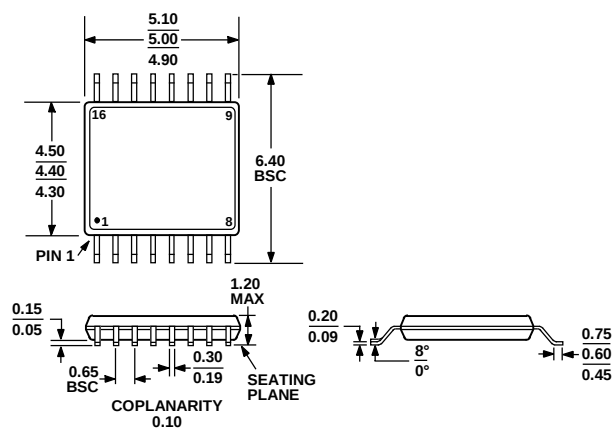


Figure 13. 16-Lead Thin Shrink Small Outline Package [TSSOP]
(RU-16)

Dimensions shown in millimeters

ORDERING GUIDE

Model ¹	Resolution (Bits)	Internal Reference (V)	Temperature Range	INL (LSB)	Package Description	Package Option
AD5761RTRUZ-EP	16	2.5	−55°C to +125°C	±8	16-Lead TSSOP	RU-16
AD5761RTRUZ-EP-RL7	16	2.5	−55°C to +125°C	±8	16-Lead TSSOP	RU-16

¹ Z = RoHS Compliant Part.