

## FEATURES

- 2 mA full-scale current  $\pm 20\%$ , with  $V_{REF} = \pm 10\text{ V}$
- 0.9  $\mu\text{s}$  settling time to  $\pm 0.1\%$
- 12 MHz multiplying bandwidth
- Midscale glitch of  $-1\text{ nV-sec}$
- Midscale or zero-scale reset
- 4 separate, 4-quadrant multiplying reference inputs
- SPI-compatible, 3-wire interface
- Double-buffered registers enable
- Simultaneous multichannel change
- Internal power-on reset
- Compact 28-lead SSOP

## ENHANCED PRODUCT FEATURES

- Supports defense and aerospace applications (AQEC)
- Military temperature range ( $-55^\circ\text{C}$  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

- Automatic test equipment
- Instrumentation
- Digitally controlled calibration

## GENERAL DESCRIPTION

The **AD5544-EP** quad, 16-bit, current output, digital-to-analog converter (DAC) is designed to operate from a 2.7 V to 5.5 V supply range.

The applied external reference input voltage ( $V_{REFx}$ ) determines the full-scale output current. Integrated feedback resistors ( $R_{FB}$ ) provide temperature-tracking, full-scale voltage outputs when combined with an external I-to-V precision amplifier.

A double-buffered serial data interface offers high speed, 3-wire, SPI- and microcontroller-compatible inputs using serial data in (SDI), a chip select ( $\overline{CS}$ ), and clock (CLK) signals. In addition, a serial data out pin (SDO) allows for daisy chaining when multiple

## FUNCTIONAL BLOCK DIAGRAM

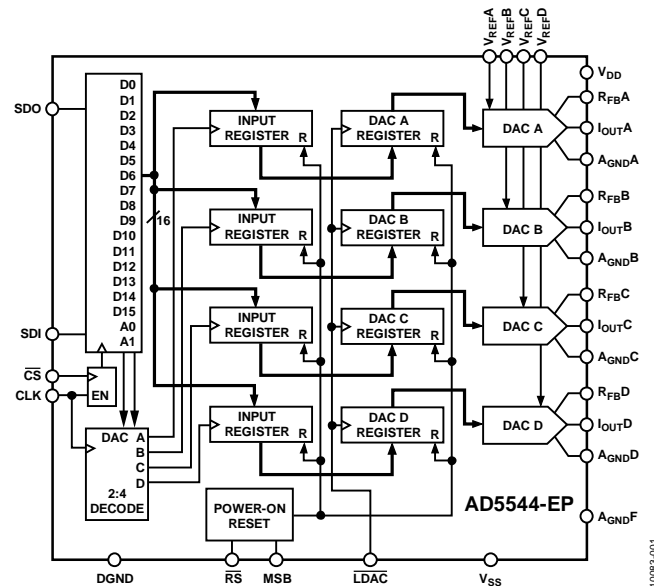


Figure 1.

packages are used. A common, level-sensitive, load DAC strobe ( $\overline{LDAC}$ ) input allows the simultaneous update of all DAC outputs from previously loaded input registers. Additionally, an internal power-on reset forces the output voltage to 0 at system turn-on. The MSB pin allows system reset assertion ( $\overline{RS}$ ) to force all registers to zero code when  $\text{MSB} = 0$  or to half-scale code when  $\text{MSB} = 1$ . The **AD5544-EP** is packaged in the compact 28-lead SSOP.

Additional application and technical information can be found in the [AD5544](#) data sheet.

### Rev. 0

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**REVISION HISTORY**

**4/12—Revision 0: Initial Version**

## SPECIFICATIONS

$V_{DD} = 2.7\text{ V to }5.5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ,  $I_{OUTX} = \text{virtual GND}$ ,  $A_{GNDX} = 0\text{ V}$ ,  $V_{REFA} = V_{REFB} = V_{REFC} = V_{REFD} = 10\text{ V}$ ,  $T_A = \text{full operating temperature range of } -55^\circ\text{C to } +125^\circ\text{C}$ , unless otherwise noted.

Table 1.

Parameter	Symbol	Test Condition/Comments	Min	Typ	Max	Unit
<b>STATIC PERFORMANCE<sup>1</sup></b>						
Resolution	N	1 LSB = $V_{REFX}/2^{16} = 153\ \mu\text{V}$ when $V_{REF} = 10\text{ V}$			16	Bits
Relative Accuracy	INL				$\pm 1.5$	LSB
Differential Nonlinearity	DNL				$\pm 1.5$	LSB
Output Leakage Current	$I_{OUTX}$	Data = 0x0000, $T_A = 25^\circ\text{C}$ Data = 0x0000, $T_A = 85^\circ\text{C}$			10 20	nA nA
Full-Scale Gain Error	$G_{FSE}$	Data = 0xFFFF		$\pm 0.75$	$\pm 4$	mV
Full-Scale Tempco <sup>2</sup>	$TCV_{FS}$			1		ppm/ $^\circ\text{C}$
Feedback Resistor	$R_{FBX}$	$V_{DD} = 5\text{ V}$	4	6	8	k $\Omega$
<b>REFERENCE INPUT</b>						
$V_{REFX}$ Range	$V_{REFX}$		-15		+15	V
Input Resistance	$R_{REFX}$		4	6	8	k $\Omega$
Input Resistance Match	$R_{REFX}$	Channel-to-channel		0.35		%
Input Capacitance <sup>2</sup>	$C_{REFX}$			5		pF
<b>ANALOG OUTPUT</b>						
Output Current	$I_{OUTX}$	Data = 0xFFFF	1.25		2.5	mA
Output Capacitance <sup>2</sup>	$C_{OUTX}$	Code dependent		35		pF
<b>LOGIC INPUT AND OUTPUT</b>						
Logic Input Low Voltage	$V_{IL}$				0.8	V
Logic Input High Voltage	$V_{IH}$		2.4			V
Input Leakage Current	$I_{IL}$				1	$\mu\text{A}$
Input Capacitance <sup>2</sup>	$C_{IL}$				10	pF
Logic Output Low Voltage	$V_{OL}$	$I_{OL} = 1.6\text{ mA}$			0.4	V
Logic Output High Voltage	$V_{OH}$	$I_{OH} = 100\ \mu\text{A}$	4			V
<b>INTERFACE TIMING<sup>2, 3</sup></b>						
Clock Width High	$t_{CH}$		25			ns
Clock Width Low	$t_{CL}$		25			ns
$\overline{\text{CS}}$ to Clock Setup	$t_{CSS}$		0			ns
Clock to $\overline{\text{CS}}$ Hold	$t_{CSH}$		25			ns
Clock to SDO Propagation Delay	$t_{PD}$		2		20	ns
Load DAC Pulse Width	$t_{LDAC}$		25			ns
Data Setup	$t_{DS}$		20			ns
Data Hold	$t_{DH}$		20			ns
Load Setup	$t_{LDS}$		5			ns
Load Hold	$t_{LDH}$		25			ns
<b>SUPPLY CHARACTERISTICS</b>						
Power Supply Range	$V_{DD\text{ RANGE}}$		2.7		5.5	V
Positive Supply Current	$I_{DD}$	Logic inputs = 0 V			5	$\mu\text{A}$
Negative Supply Current	$I_{SS}$	Logic inputs = 0 V, $V_{SS} = -5\text{ V}$		0.001	9	$\mu\text{A}$
Power Dissipation	$P_{DISS}$	Logic inputs = 0 V			1.25	mW
Power Supply Sensitivity	PSS	$\Delta V_{DD} = \pm 5\%$			0.006	%/%

Parameter	Symbol	Test Condition/Comments	Min	Typ	Max	Unit
AC CHARACTERISTICS <sup>4</sup>						
Output Voltage Settling Time	$t_s$	To $\pm 0.1\%$ of full scale, data = 0x0000 to 0xFFFF to 0x0000		0.9		$\mu\text{s}$
Reference Multiplying Bandwidth (BW)	BW – 3 dB	$V_{\text{REF}X} = 5\text{ V p-p}$ , data = 0xFFFF, $C_{\text{FB}} = 2.0\text{ pF}$ ,		12		MHz
DAC Glitch Impulse	Q	$V_{\text{REF}X} = 8\text{ V}$ , data = 0x0000 to 0x8000 to 0x0000		-1		nV-sec
Feedthrough Error	$V_{\text{OUT}X}/V_{\text{REF}X}$	Data = 0x0000, $V_{\text{REF}X} = 100\text{ mV rms}$ , $f = 100\text{ kHz}$		-65		dB
Crosstalk Error	$V_{\text{OUT}A}/V_{\text{REF}B}$	Data = 0x0000, $V_{\text{REF}B} = 100\text{ mV rms}$ , adjacent channel, $f = 100\text{ kHz}$		-90		dB
Digital Feedthrough	Q	$\overline{\text{CS}} = 1$ , $f_{\text{CLK}} = 1\text{ MHz}$		0.6		nV-sec
Total Harmonic Distortion	THD	$V_{\text{REF}X} = 5\text{ V p-p}$ , data = 0xFFFF, $f = 1\text{ kHz}$		-98		dB
Output Spot Noise Voltage	$e_N$	$f = 1\text{ kHz}$ , BW = 1 Hz		7		$\text{nV}/\sqrt{\text{Hz}}$

<sup>1</sup> All static performance tests (except  $I_{\text{OUT}X}$ ) are performed in a closed-loop system using an external precision OP177 I-to-V converter amplifier. The AD5544  $R_{\text{FB}}$  terminal is tied to the amplifier output. Typical values represent average readings measured at 25°C.

<sup>2</sup> These parameters are guaranteed by design and not subject to production testing.

<sup>3</sup> All input control signals are specified with  $t_r = t_f = 2.5\text{ ns}$  (10% to 90% of 3 V) and timed from a voltage level of 1.5 V.

<sup>4</sup> All ac characteristic tests are performed in a closed-loop system using an AD8038 I-to-V converter amplifier.

**TIMING DIAGRAMS**

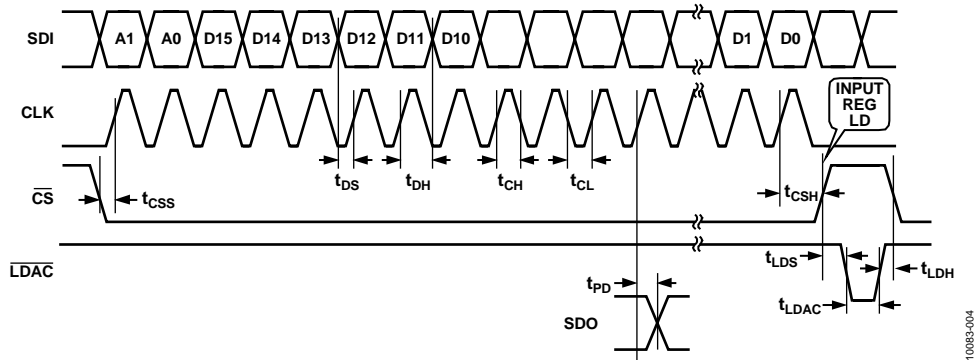


Figure 2. Timing Diagram

10083-004

## ABSOLUTE MAXIMUM RATINGS

Table 2.

Parameter	Rating
$V_{DD}$ to GND	-0.3 V, +8 V
$V_{SS}$ to GND	+0.3 V, -7 V
$V_{REFX}$ to GND	-18 V, +18 V
Logic Input and Output to GND	-0.3 V, +8 V
$V(I_{OUTX})$ to GND	-0.3 V, $V_{DD} + 0.3$ V
$A_{GNDX}$ to DGND	-0.3 V, +0.3 V
Input Current to Any Pin Except Supplies	±50 mA
Package Power Dissipation	$(T_J \text{ max} - T_A)/\theta_{JA}$
Thermal Resistance	$\theta_{JA}$
28-Lead SSOP	100°C/W
32-Lead LFCSP	32.5°C/W
Maximum Junction Temperature ( $T_J$ Max)	150°C
Operating Temperature Range, Enhanced Product (EP Version)	-55°C to +125°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature	
Vapor Phase, 60 Sec	215°C
Infrared, 15 Sec	220°C

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

### 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

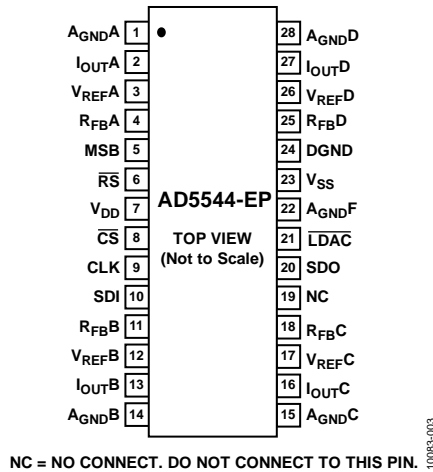


Figure 3. Pin Configuration

Table 3. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	A <sub>GND</sub> A	DAC A Analog Ground.
2	I <sub>OUT</sub> A	DAC A Current Output.
3	V <sub>REF</sub> A	DAC A Reference Voltage Input Terminal. Establishes DAC A full-scale output voltage. This pin can be tied to the V <sub>DD</sub> pin.
4	R <sub>FB</sub> A	Establish the voltage output for DAC A by connecting to an external amplifier output.
5	MSB	MSB Pin. Set pin during a reset pulse ( $\overline{RS}$ ) or at system power-on if tied to ground or V <sub>DD</sub> .
6	$\overline{RS}$	Reset Pin, Active Low Input. Input registers and DAC registers are set to all 0s or half-scale code, determined by the voltage on the MSB pin. Register data = 0x0000 when MSB = 0.
7	V <sub>DD</sub>	Positive Power Supply Input. Specified range of operation: 5 V ± 10%.
8	$\overline{CS}$	Chip Select, Active Low Input. Disables shift register loading when high. Transfers serial register data to the input register when $\overline{CS}$ /LDAC returns high. Does not affect LDAC operation.
9	CLK	Clock Input. Positive edge clocks data into the shift register.
10	SDI	Serial Data Input. Input data loads directly into the shift register.
11	R <sub>FB</sub> B	Establish the voltage output for DAC B by connecting to an external amplifier output.
12	V <sub>REF</sub> B	DAC B Reference Voltage Input Terminal. Establishes DAC B full-scale output voltage. This pin can be tied to the V <sub>DD</sub> pin.
13	I <sub>OUT</sub> B	DAC B Current Output.
14	A <sub>GND</sub> B	DAC B Analog Ground.
15	A <sub>GND</sub> C	DAC C Analog Ground.
16	I <sub>OUT</sub> C	DAC C Current Output.
17	V <sub>REF</sub> C	DAC C Reference Voltage Input Terminal. Establishes DAC C full-scale output voltage. This pin can be tied to the V <sub>DD</sub> pin.
18	R <sub>FB</sub> C	Establish the voltage output for DAC C by connecting to an external amplifier output.
19	NC	No Connect. Do not connect to this pin.
20	SDO	Serial Data Output. Input data loads directly into the shift register. Data appears at SDO at 19 clock pulses for the AD5544-EP after input at the SDI pin.
21	$\overline{LDAC}$	Load DAC Register Strobe, Level Sensitive Active Low. Transfers all input register data to DAC registers. Asynchronous active low input.
22	A <sub>GND</sub> F	High Current Analog Force Ground.
23	V <sub>SS</sub>	Negative Bias Power Supply Input. Specified range of operation: -5.5 V to +0.3 V.
24	DGND	Digital Ground Pin.
25	R <sub>FB</sub> D	Establish the voltage output for DAC D by connecting to an external amplifier output.

Pin No.	Mnemonic	Description
26	$V_{REFD}$	DAC D Reference Voltage Input Terminal. Establishes DAC D full-scale output voltage. This pin can be tied to the $V_{DD}$ pin.
27	$I_{OUTD}$	DAC D Current Output.
28	$A_{GND D}$	DAC D Analog Ground.

TYPICAL PERFORMANCE CHARACTERISTICS

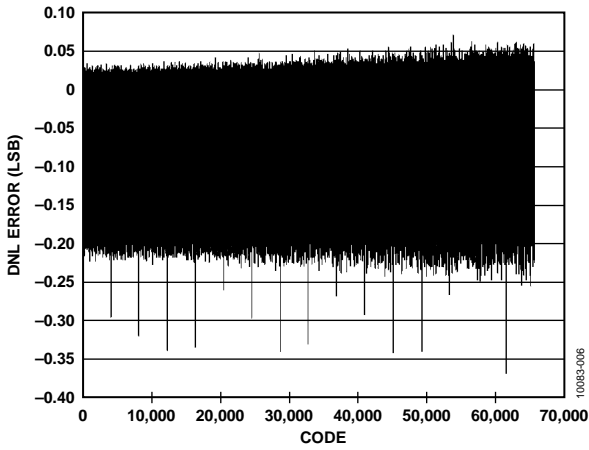


Figure 4. DNL Error vs. Code,  $T_A = 25^\circ\text{C}$

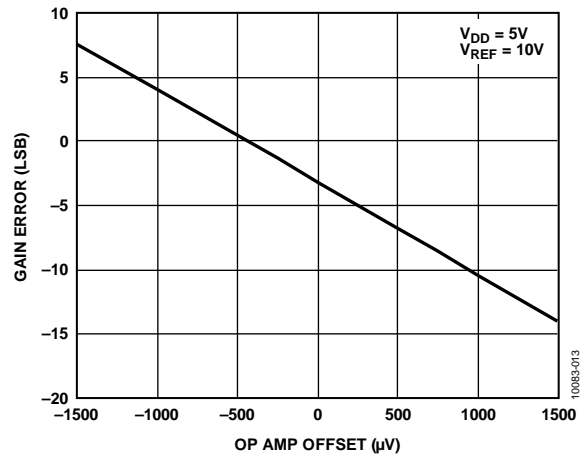


Figure 7. Gain Error vs. Op Amp Offset

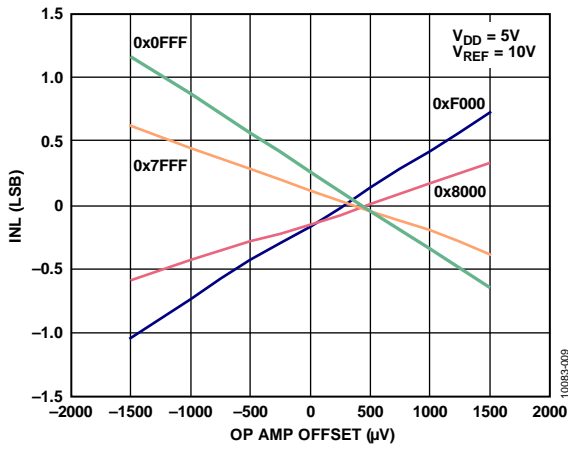


Figure 5. INL Error vs. Op Amp Offset

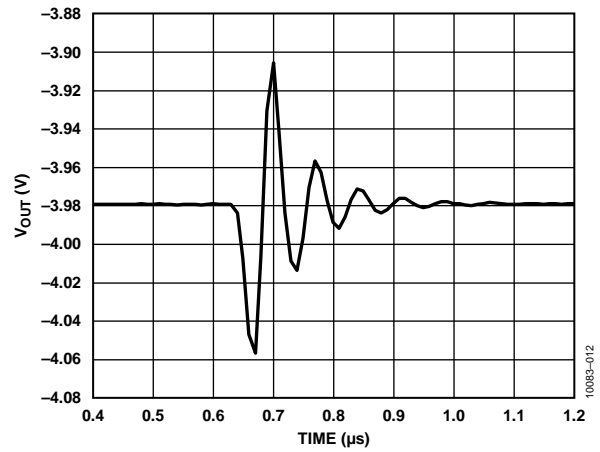


Figure 8. Midscale Transition

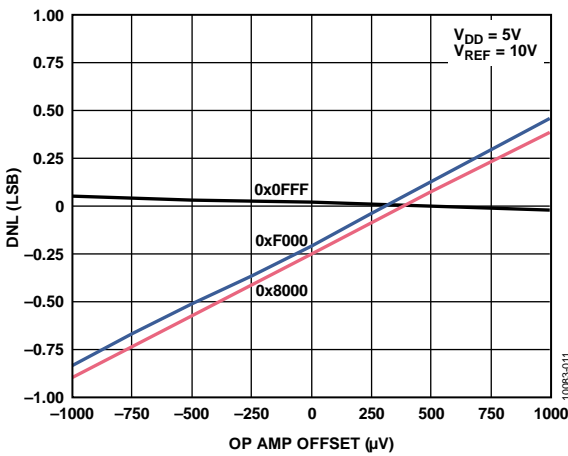


Figure 6. DNL Error vs. Op Amp Offset

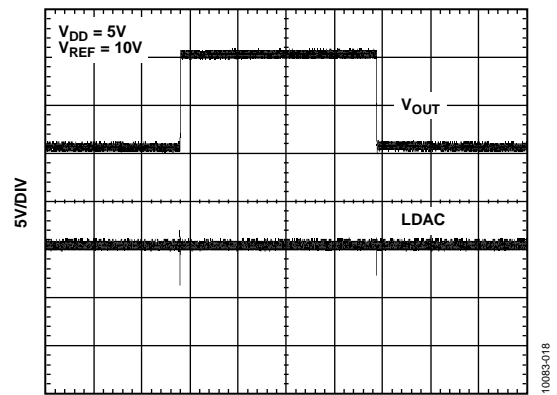


Figure 9. Large Signal Settling Time



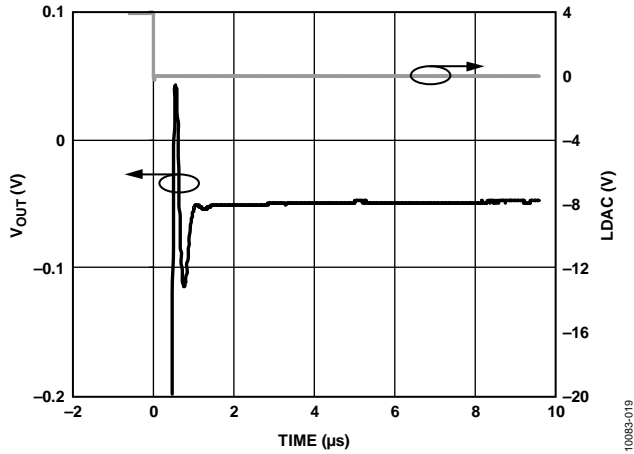


Figure 10. Small Signal Settling Time

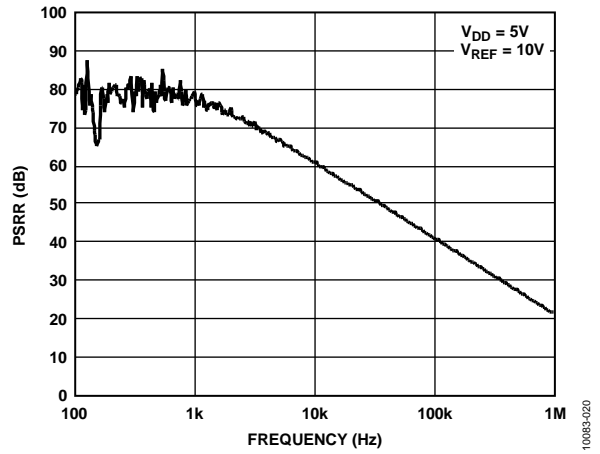


Figure 12. Power Supply Rejection vs. Frequency

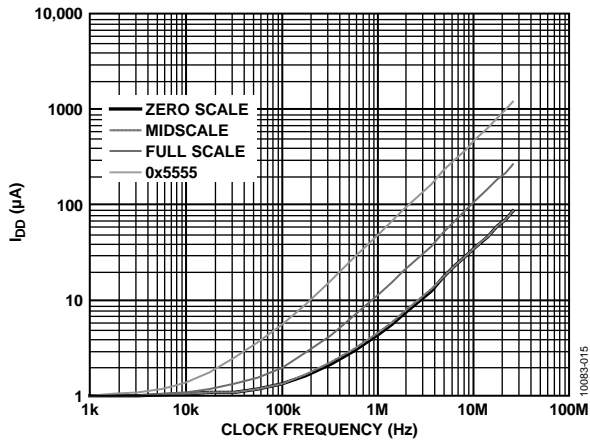


Figure 11. Power Supply Current vs. Clock Frequency

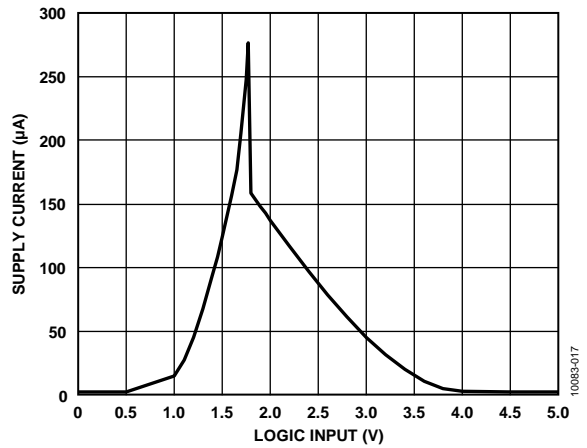
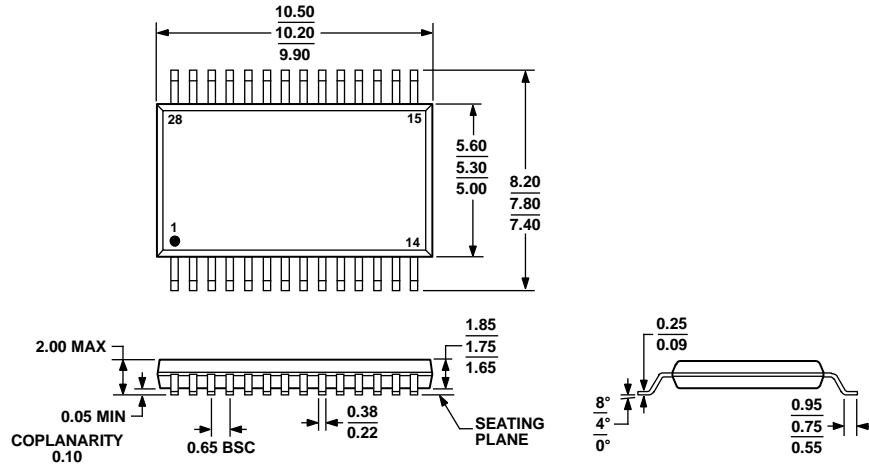


Figure 13. Power Supply Current vs. Logic Input Voltage

OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MO-150-AH

Figure 4. 28-Lead Shrink Small Outline Package [SSOP] (RS-28)

Dimensions shown in millimeters

060106-A

ORDERING GUIDE

Model	Resolution (Bits)	INL LSB	DNL LSB	Temperature Range	Package Description	Package Option
AD5544SRS-EP	16	±1.5	±1.5	-55°C to +125°C	28-Lead Shrink Small Outline Package [SSOP]	RS-28

**NOTES**

**NOTES**

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- Техническую поддержку проекта.
- Защиту от снятия компонента с производства.
- Оценку стоимости проекта по компонентам.
- Изготовление тестовой платы монтаж и пусконаладочные работы.



Тел: +7 (812) 336 43 04 (многоканальный)

Email: [org@lifeelectronics.ru](mailto:org@lifeelectronics.ru)