

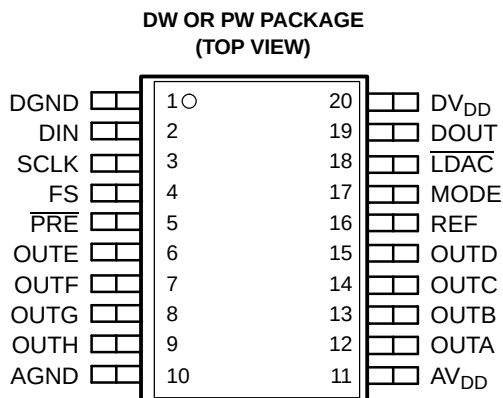
8-CHANNEL, 12-/10-/8-BIT, 2.7-V TO 5.5-V LOW POWER DIGITAL-TO-ANALOG CONVERTER WITH POWER DOWN

FEATURES

- Eight Voltage Output DACs in One Package
 - TLV5610 . . . 12-Bit
 - TLV5608 . . . 10-Bit
 - TLV5629 . . . 8-Bit
- Programmable Settling Time vs Power Consumption
 - 1 μ s In Fast Mode
 - 3 μ s In Slow Mode
- Compatible With TMS320 and SPI™ Serial Ports
- Monotonic Over Temperature
- Low Power Consumption:
 - 18 mW In Slow Mode at 3-V
 - 48 mW In Fast Mode at 3-V
- Reference Input Buffers
- Power-Down Mode
- Buffered, High Impedance Reference Inputs
- Data Output for Daisy-Chaining

APPLICATIONS

- Digital Servo Control Loops
- Digital Offset and Gain Adjustment
- Industrial Process Control
- Machine and Motion Control Devices
- Mass Storage Devices



DESCRIPTION

The TLV5610, TLV5608, and TLV5629 are pin-compatible, eight-channel, 12-/10-/8-bit voltage output DACs each with a flexible serial interface. The serial interface allows glueless interface to TMS320 and SPI, QSPI, and Microwire serial ports. It is programmed with a 16-bit serial string containing 4 control and 12 data bits.

Additional features are a power-down mode, an LDAC input for simultaneous update of all eight DAC outputs, and a data output which can be used to cascade multiple devices.

The resistor string output voltage is buffered by a rail-to-rail output amplifier with a programmable settling time to allow the designer to optimize speed vs power dissipation. The buffered, high-impedance reference input can be connected to the supply voltage.

Implemented with a CMOS process, the DACs are designed for single-supply operation from 2.7 V to 5.5 V. The devices are available in 20-pin SOIC and TSSOP packages.

AVAILABLE OPTIONS

T _A	PACKAGE		
	SMALL OUTLINE (DW)	TSSOP (PW)	RESOLUTION
-40°C to 85°C	TLV5610IDW	TLV5610IPW	12
	TLV5608IDW	TLV5608IPW	10
	TLV5629IDW	TLV5629IPW	8



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ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

	UNIT
Supply voltage (AV _{DD} , DV _{DD} to GND)	7 V
Reference input voltage	- 0.3 V to AV _{DD} + 0.3 V
Digital input voltage range	- 0.3 V to DV _{DD} + 0.3 V
Operating free-air temperature range, T _A	-40°C to 85°C
Storage temperature range, T _{stg}	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C

- (1) Stresses beyond those listed under *absolute maximum ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *recommended operating conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

		MIN	NOM	MAX	UNIT
Supply voltage, AV _{DD} , DV _{DD}	5-V operation	4.5	5	5.5	V
	3-V operation	2.7	3	3.3	V
High-level digital input voltage, V _{IH}	DV _{DD} = 2.7 V	2			V
	DV _{DD} = 5.5 V	2.4			
Low-level digital input voltage, V _{IL}	DV _{DD} = 2.7 V			0.6	V
	DV _{DD} = 5.5 V			1	
Reference voltage, V _{ref}	AV _{DD} = 5 V	GND	4.096	AV _{DD}	V
	AV _{DD} = 3 V	GND	2.048	AV _{DD}	V
Load resistance, R _L		2			kΩ
Load capacitance, C _L				100	pF
Clock frequency, f _{CLK}				30	MHz
Operating free-air temperature, T _A		-40		85	°C

ELECTRICAL CHARACTERISTICS

over recommended operating free-air temperature range, supply voltages, and reference voltages (unless otherwise noted)

POWER SUPPLY					
PARAMETER	TEST CONDITIONS		MIN	TYP	MAX
I _{DD} Power supply current	No load, V _{ref} = 4.096 V, All inputs = DV _{DD} or GND	Fast		16	21
		Slow		6	8
Power down supply current				0.1	
POR Power on threshold				2	
PSRR Power supply rejection ratio	Full scale ⁽¹⁾			-60	

- (1) Power supply rejection ratio at full scale is measured by varying AV_{DD} and is given by:
PSRR = 20 log [(E_G(AV_{DD}max) - E_G(AV_{DD}min))/V_{DD}max]

ELECTRICAL CHARACTERISTICS (CONTINUED)

over recommended operating free-air temperature range, supply voltages, and reference voltages (unless otherwise noted)

STATIC DAC SPECIFICATIONS							
PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Resolution	TLV5610			12		Bits	
	TLV5608			10			
	TLV5629			8			
Integral nonlinearity (INL)	TLV5610	V _{ref} = 2 V, 4V	Code 40 to 4095	±2	±6	LSB	
	TLV5608		Code 20 to 1023	±0.5	±2		
	TLV5629		Code 6 to 255	±0.3	±1		
Differential nonlinearity (DNL)	TLV5610	V _{ref} = 2 V, 4V	Code 40 to 4095	±0.5	±1	LSB	
	TLV5608		Code 20 to 1023	±0.1	±1		
	TLV5629		Code 6 to 255	±0.1	±1		
E _{ZS}	Zero-scale error (offset error at zero scale)				±30	mV	
E _{ZS} TC	Zero-scale-error temperature coefficient				30	μV/°C	
E _G	Gain error				±0.6	% of FS voltage	
E _G TC	Gain error temperature coefficient				10	ppm/°C	
OUTPUT SPECIFICATIONS							
PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V _O	Voltage output range	R _L = 10 kΩ		0	AV _{DD} -0.4		V
Output load regulation accuracy		R _L = 2 kΩ vs 10 kΩ				±0.3	% of FS voltage
REFERENCE INPUT							
PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V _I	Reference input voltage			0	AV _{DD}		V
R _i	Reference input resistance			100			kΩ
C _i	Reference input capacitance			5			pF
Reference input bandwidth	V _{ref} = 0.4 V _{pp} + 2.048 V dc, Input code = 0x800	Fast	2.2		MHz		
		Slow	1.9				
Reference feedthrough	V _{ref} = 2 V _{pp} at 1 kHz + 2.048 V dc ⁽¹⁾				-84	dB	
DIGITAL INPUT							
I _{IH}	High-level digital input current	V _I = V _{DD}		1		μA	
I _{IL}	Low-level digital input current	V _I = 0 V		-1		μA	
C _i	Input capacitance			8		pF	
DIGITAL OUTPUT							
V _{OH}	High-level digital output voltage	R _L = 10 kΩ		2.6		V	
V _{OL}	Low-level digital output voltage	R _L = 10 kΩ		0.4		V	
Output voltage rise time		R _L = 10 kΩ, C _L = 20 pF, Includes propogation delay		7 20		ns	

(1) Reference feedthrough is measured at the DAC output with an input code = 0x000.

ELECTRICAL CHARACTERISTICS (CONTINUED)

over recommended operating free-air temperature range, supply voltages, and reference voltages (unless otherwise noted)

ANALOG OUTPUT DYNAMIC PERFORMANCE							
PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
t _{s(FS)}	Output settling time (full scale)	R _L = 10 kΩ, C _L = 100 pF ⁽¹⁾	Fast	1		3	μs
			Slow	3		7	
t _{s(CC)}	Output settling time, code to code	R _L = 10 kΩ, C _L = 100 pF ⁽²⁾	Fast	0.5		1	μs
			Slow	1		2	
SR	Slew rate	R _L = 10 kΩ, C _L = 100 pF ⁽³⁾	Fast	4	10		V/μs
			Slow	1	3		
Glitch energy		See note ⁽⁴⁾		4			nV-s
Channel crosstalk		10 kHz sine, 4 V _{PP}		-90			dB

- (1) Settling time is the time for the output signal to remain within +0.5 LSB of the final measured value for a digital input code change of 0x80 to 0xFFF and 0xFFF to 0x080, respectively. Assured by design; not tested.
- (2) Settling time is the time for the output signal to remain within +0.5 LSB of the final measured value for a digital input code change of one count. The max time applies to code changes near zero scale or full scale. Assured by design; not tested.
- (3) Slew rate determines the time it takes for a change of the DAC output from 10% to 90% full scale voltage.
- (4) Code transition: TLV5610 - 0x7FF to 0x800, TLV5608 - 0x7FC to 0x800, TLV5629 - 0x7F0 to 0x800

TIMING REQUIREMENTS

DIGITAL INPUTS				
		MIN	NOM	MAX
$t_{su(FS-CK)}$	Setup time, FS low before next negative SCLK edge	8		
$t_{su(C16-FS)}$	Setup time, 16 th negative edge after FS low on which bit D0 is sampled before rising edge of FS. μC mode only	10		
$t_{su(FS-C17)}$	μC mode, setup time, FS high before 17 th positive SCLK.	10		
$t_{su(CK-FS)}$	DSP mode, setup time, SCLK low before FS low.	5		
$t_{WL(LDAC)}$	$\overline{\text{LDAC}}$ duration low	10		
t_{WH}	SCLK pulse duration high	16		
t_{WL}	SCLK pulse duration low	16		
$t_{su(D)}$	Setup time, data ready before SCLK falling edge	8		
$t_{h(D)}$	Hold time, data held valid after SCLK falling edge	5		
$t_{WH(FS)}$	FS duration high	10		
$t_{WL(FS)}$	FS duration low	10		
t_s	Settling time	See AC specs		

PARAMETER MEASUREMENT INFORMATION

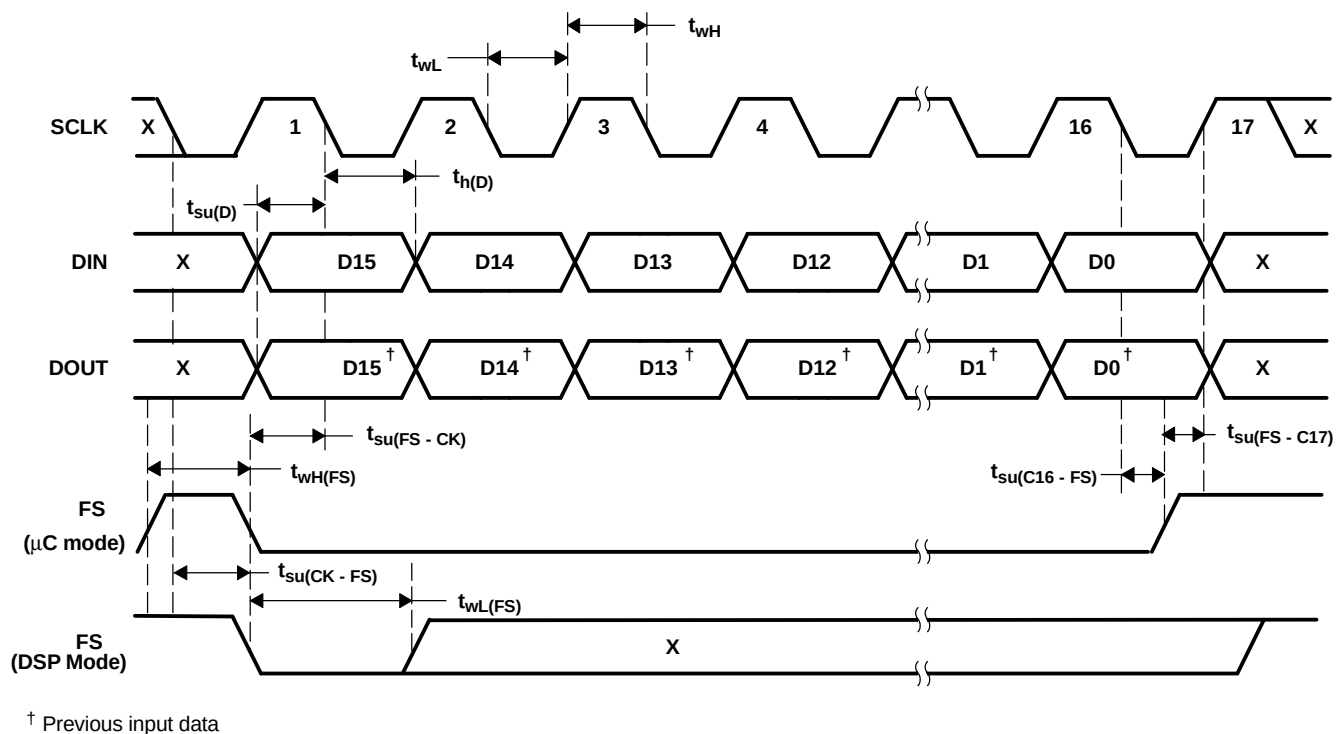


Figure 1. Serial Interface Timing

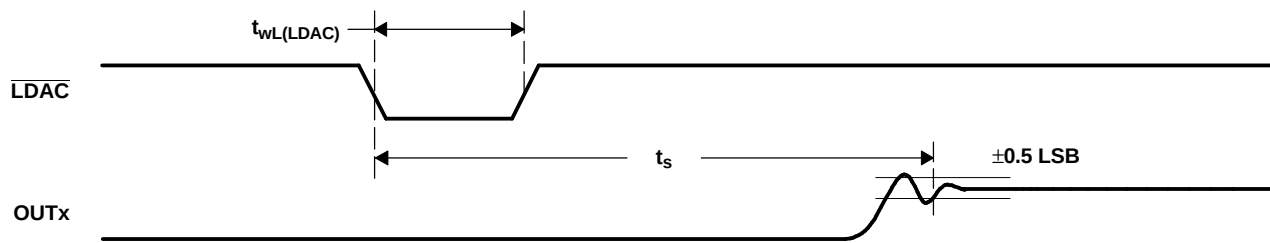


Figure 2. Output Timing

TYPICAL CHARACTERISTICS

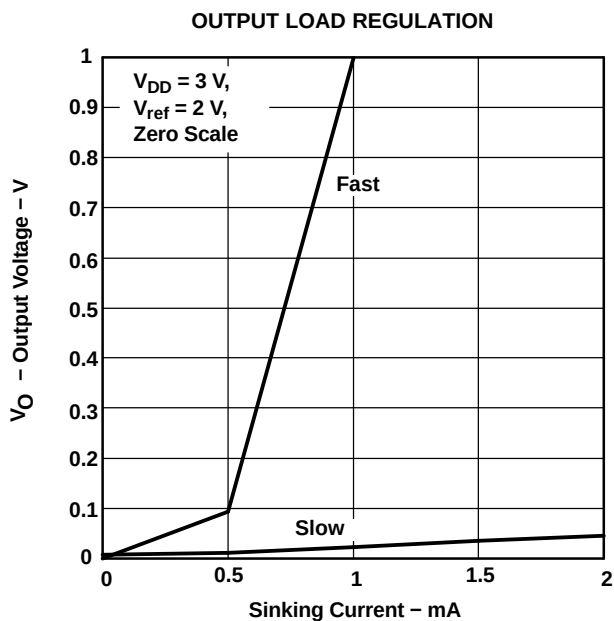


Figure 3.

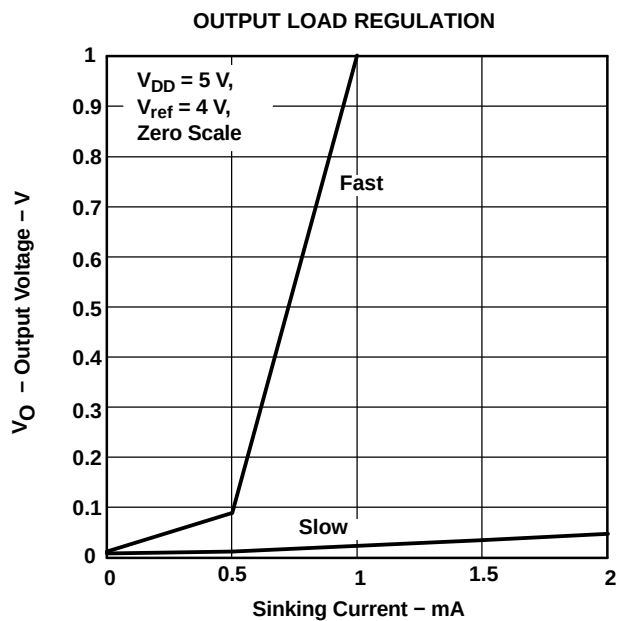


Figure 4.

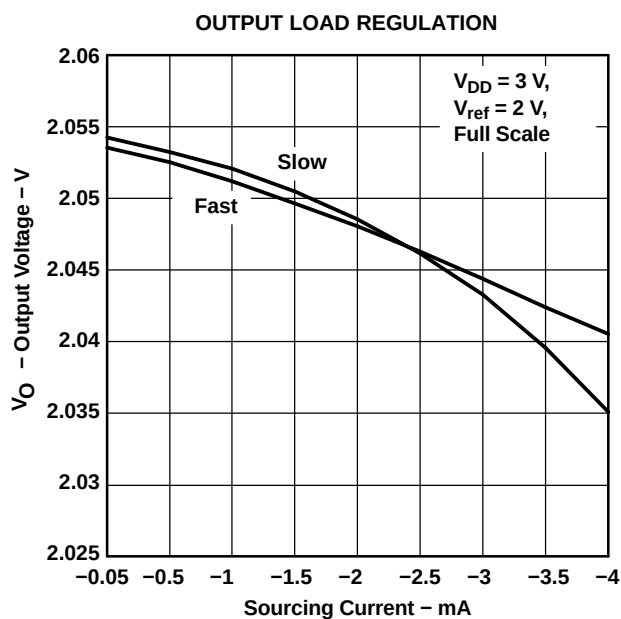


Figure 5.

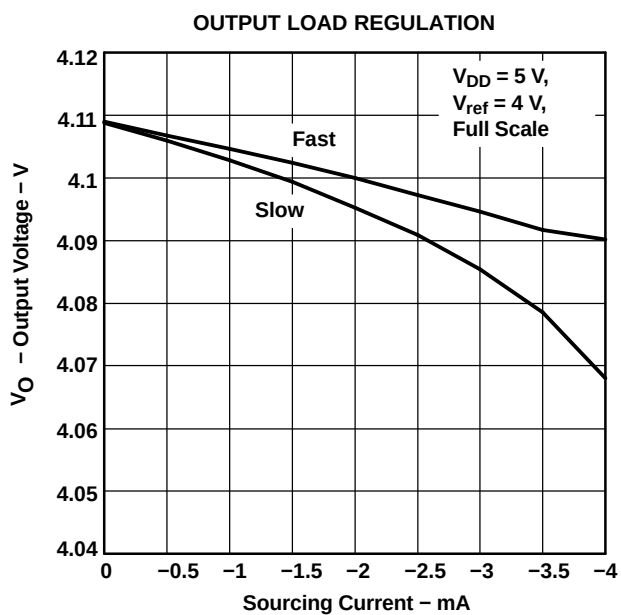
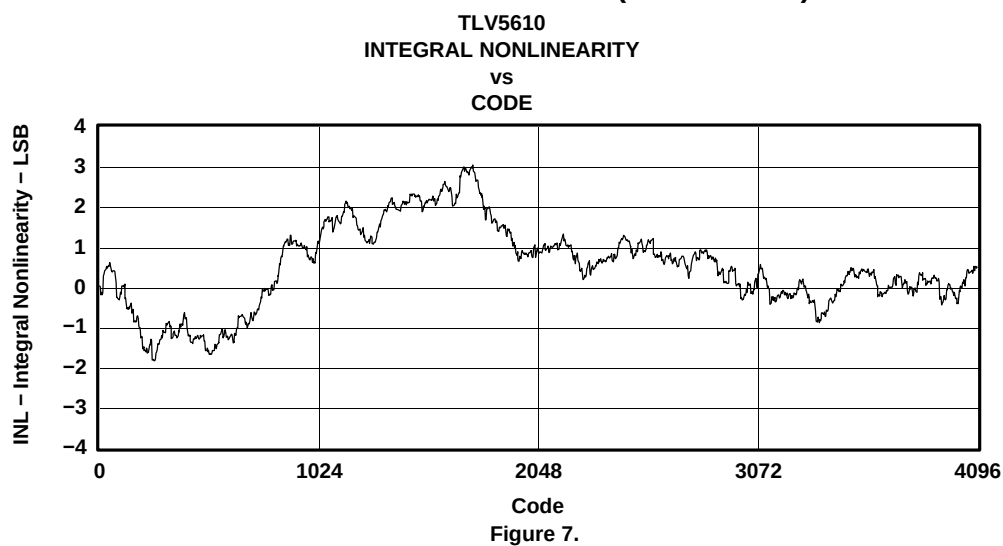
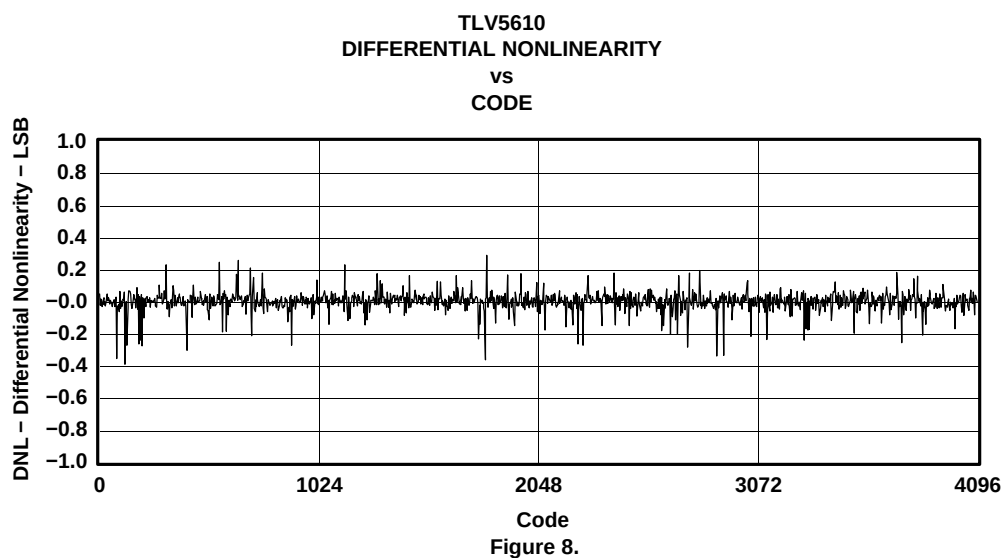
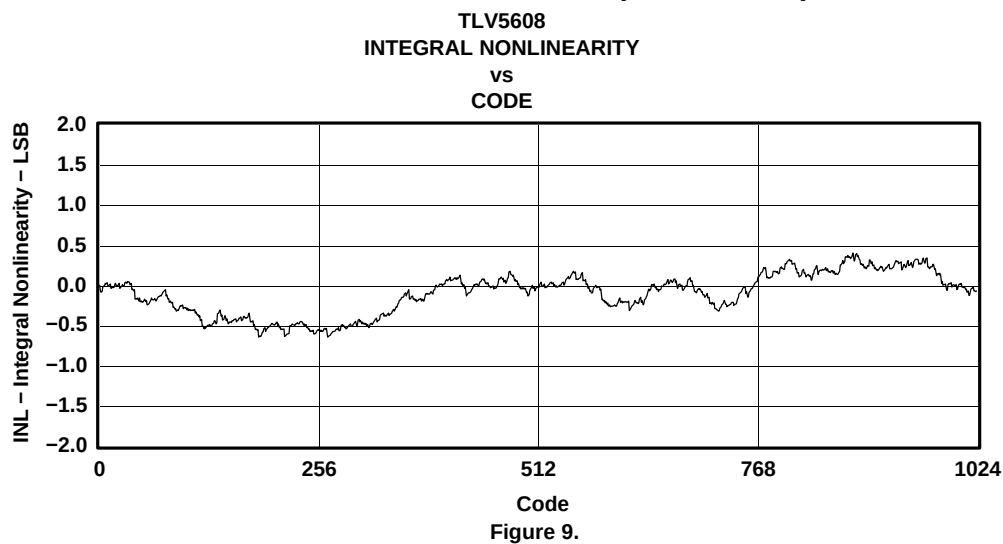
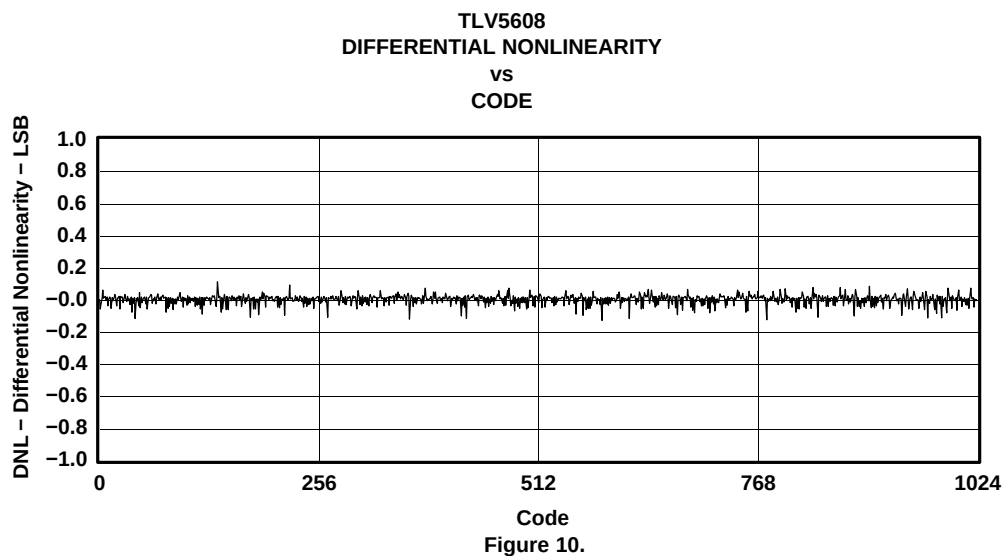


Figure 6.

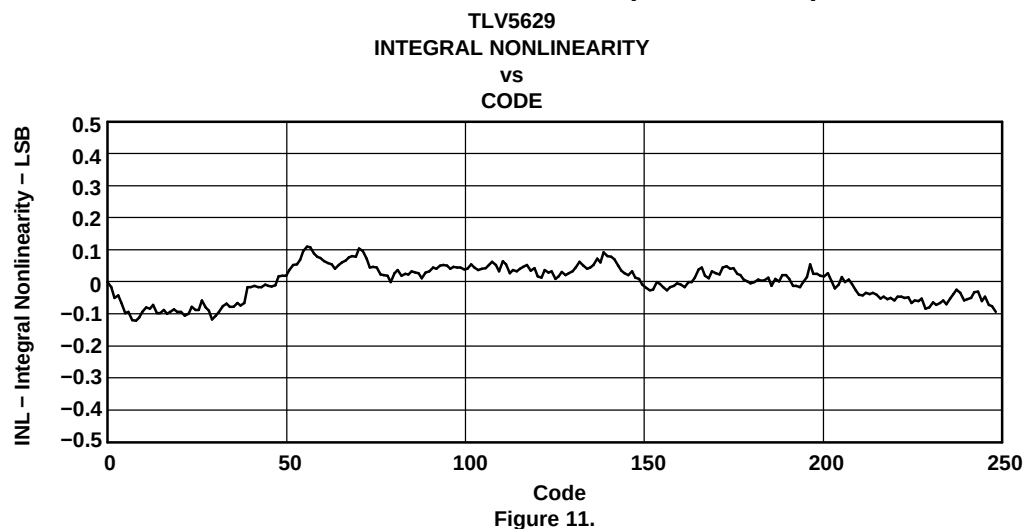
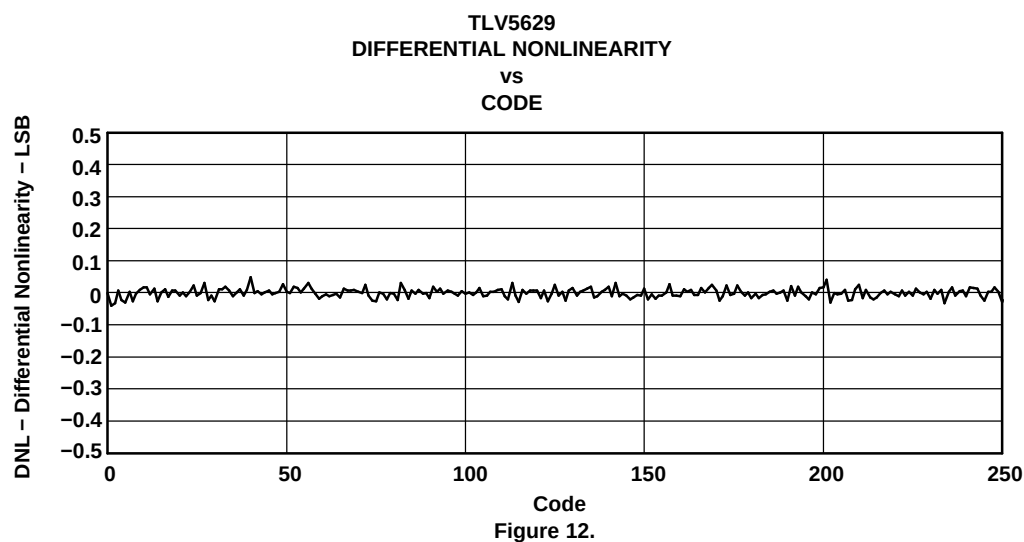
TYPICAL CHARACTERISTICS (CONTINUED)



TYPICAL CHARACTERISTICS (CONTINUED)



TYPICAL CHARACTERISTICS (CONTINUED)



APPLICATION INFORMATION

GENERAL FUNCTION

The TLV5610, TLV5608, and TLV5629 are 8-channel, 12-bit, single-supply DACs, based on a resistor string architecture. They consist of a serial interface, a speed and power-down control logic, a reference input buffer, a resistor string, and a rail-to-rail output buffer.

The output voltage (full scale determined by external reference) for each channel is given by:

$$V_{REF} \frac{CODE}{0x1000} [V] \quad (1)$$

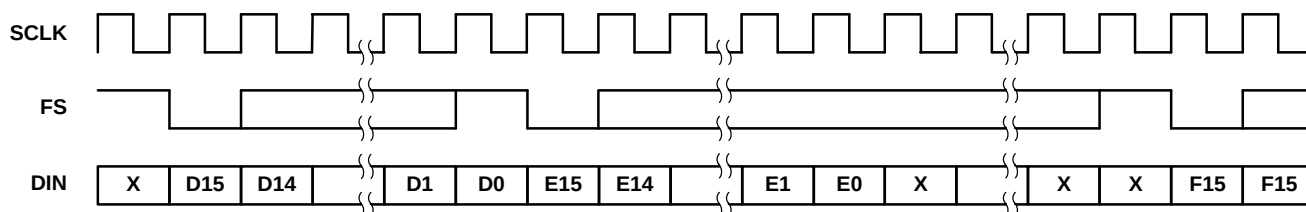
where REF is the reference voltage and CODE is the digital input value. The input range is 0x000 to 0xFFFF for the TLV5610, 0x000 to 0xFFC for the TLV5608, and 0x000 to 0xFF0 for the TLV5629. A power-on-reset initially puts the internal latches to a defined state (all bits zero).

SERIAL INTERFACE

A falling edge of FS starts shifting the data on DIN starting with the MSB to the internal register on the falling edges of SCLK. After 16 bits have been transferred, the content of the shift register is moved to one of the DAC holding registers, depending on the address bits within the data word. A logic 0 on the $\overline{LDAC}$ pin is required to transfer the content of the DAC holding register to the DAC latch and to update the DAC outputs. $\overline{LDAC}$ is an asynchronous input. It can be held low if a simultaneous update of all eight channels is not needed.

For daisy-chaining, DOUT provides the data sampled on DIN with a delay of 16 clock cycles.

DSP Mode:



μC Mode:

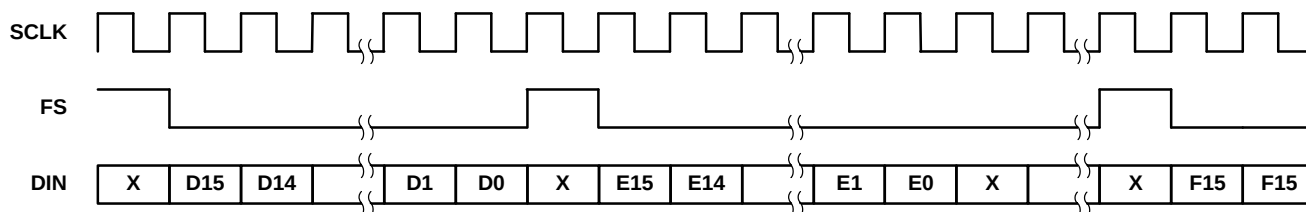


Figure 13. Data Sampled on DIN

Difference between DSP mode (MODE = N.C. or 0) and μC (MODE = 1) mode:

- In μC mode, FS needs to be held low until all 16 data bits have been transferred. If FS is driven high before the 16th falling clock edge, the data transfer is cancelled. The DAC is updated after a rising edge on FS.
- In DSP mode, FS needs to stay low for 20 ns and can go high before the 16th falling clock edge.
- In DSP mode there needs to be one falling SCLK edge before FS goes low to start the write (DIN) cycle. This extra falling SCLK edge has to happen at least 5 ns before FS goes low, $t_{su(CK-FS)} \geq 5$ ns.
- In μC mode, the extra falling SCLK edge is not necessary. However, if it does happen, the extra negative SCLK edge is not allowed to occur within 10 ns after FS goes HIGH to finish the WRITE cycle ($t_{su(FS-C17)}$).

APPLICATION INFORMATION (continued)

SERIAL CLOCK FREQUENCY AND UPDATE RATE

The maximum serial clock frequency is given by:

$$f_{\text{sclkmax}} = \frac{1}{t_{\text{whmin}} + t_{\text{wlmin}}} = 30 \text{ MHz} \quad (2)$$

The maximum update rate is:

$$f_{\text{updatemax}} = \frac{1}{16(t_{\text{whmin}} + t_{\text{wlmin}})} = 1.95 \text{ MHz} \quad (3)$$

Note, that the maximum update rate is just a theoretical value for the serial interface, as the settling time of the DAC has to be considered also.

DATA FORMAT

The 16-bit data word consists of two parts:

- Address bits (D15D12)
- Data bits (D11D0)

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
A3	A2	A1	A0	DATA											

Register Map

A3	A2	A1	A0	FUNCTION
0	0	0	0	DAC A
0	0	0	1	DAC B
0	0	1	0	DAC C
0	0	1	1	DAC D
0	1	0	0	DAC E
0	1	0	1	DAC F
0	1	1	0	DAC G
0	1	1	1	DAC H
1	0	0	0	CTRL0
1	0	0	1	CTRL1
1	0	1	0	Preset
1	0	1	1	Reserved
1	1	0	0	DAC A and $\overline{B}$
1	1	0	1	DAC C and $\overline{D}$
1	1	1	0	DAC E and $\overline{F}$
1	1	1	1	DAC G and $\overline{H}$

DAC A-H AND TWO-CHANNEL REGISTERS

Writing to DAC A-H sets the output voltage of channel A-H. It is possible to automatically generate the complement of one channel by writing to one of the four two-channel registers (DAC A and B etc.).

The TLV5610 decodes all 12 data bits. The TLV5608 decodes D11 to D2 (D1 and D0 are ignored). The TLV5629 decodes D11 to D4 (D3 to D0 are ignored).

PRESET

The outputs of all DAC channels can be driven to a predefined value stored in the Preset register by driving the PRE input low. The PRE input is asynchronous to the clock.

CTRL0

D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
X	X	X	X	X	X	X	PD	DO	X	X	IM

PD : Full device power down 0 = normal 1 = power down
DO : Digital output enable 0 = disable 1 = enable
IM : Input mode 0 = straight binary 1 = twos complement
X : Reserved

If DOUT is enabled, the data input on DIN is output on DOUT with a 16-cycle delay. That makes it possible to daisy-chain multiple DACs on one serial bus.

CTRL1

D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
X	X	X	X	P _{GH}	P _{EF}	P _{CD}	P _{AB}	S _{GH}	S _{EF}	S _{CD}	S _{AB}

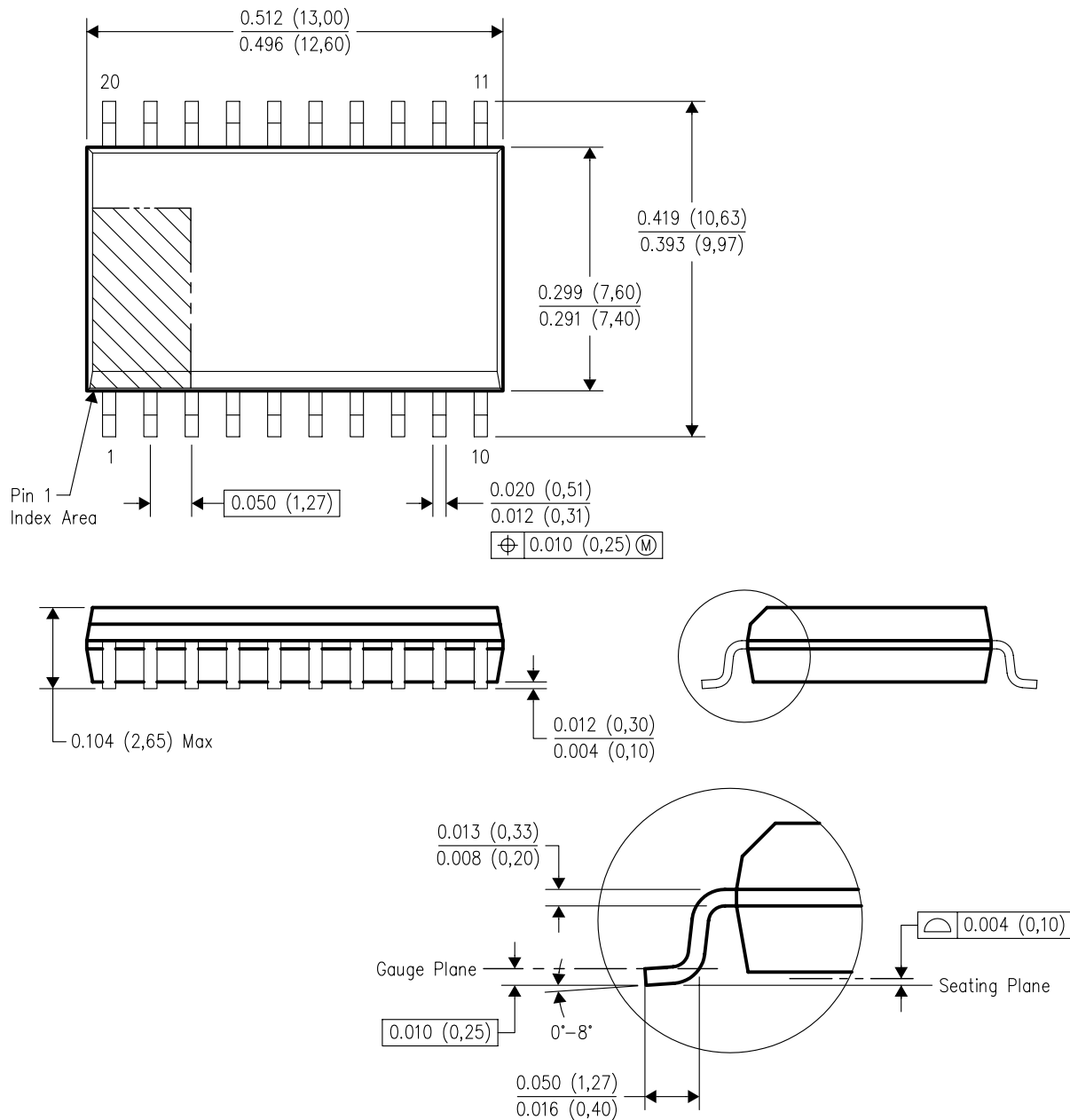
P_{XY} : Power down DAC_{XY} 0 = normal 1 = power down
S_{XY} : Speed DAC_{XY} 0 = slow 1 = fast
XY : DAC pair AB, CD, EF, or GH

In power-down mode, the amplifiers of the selected DAC pair within the device are disabled and the total power consumption of the device is significantly reduced. Power-down mode of a specific DAC pair can be selected by setting the PXY bit within the data word to 1.

There are two settling time modes: fast and slow. Fast mode of a DAC pair is selected by setting S_{XY} to 1 and slow mode is selected by setting S_{XY} to 0.

DW (R-PDSO-G20)

PLASTIC SMALL-OUTLINE PACKAGE



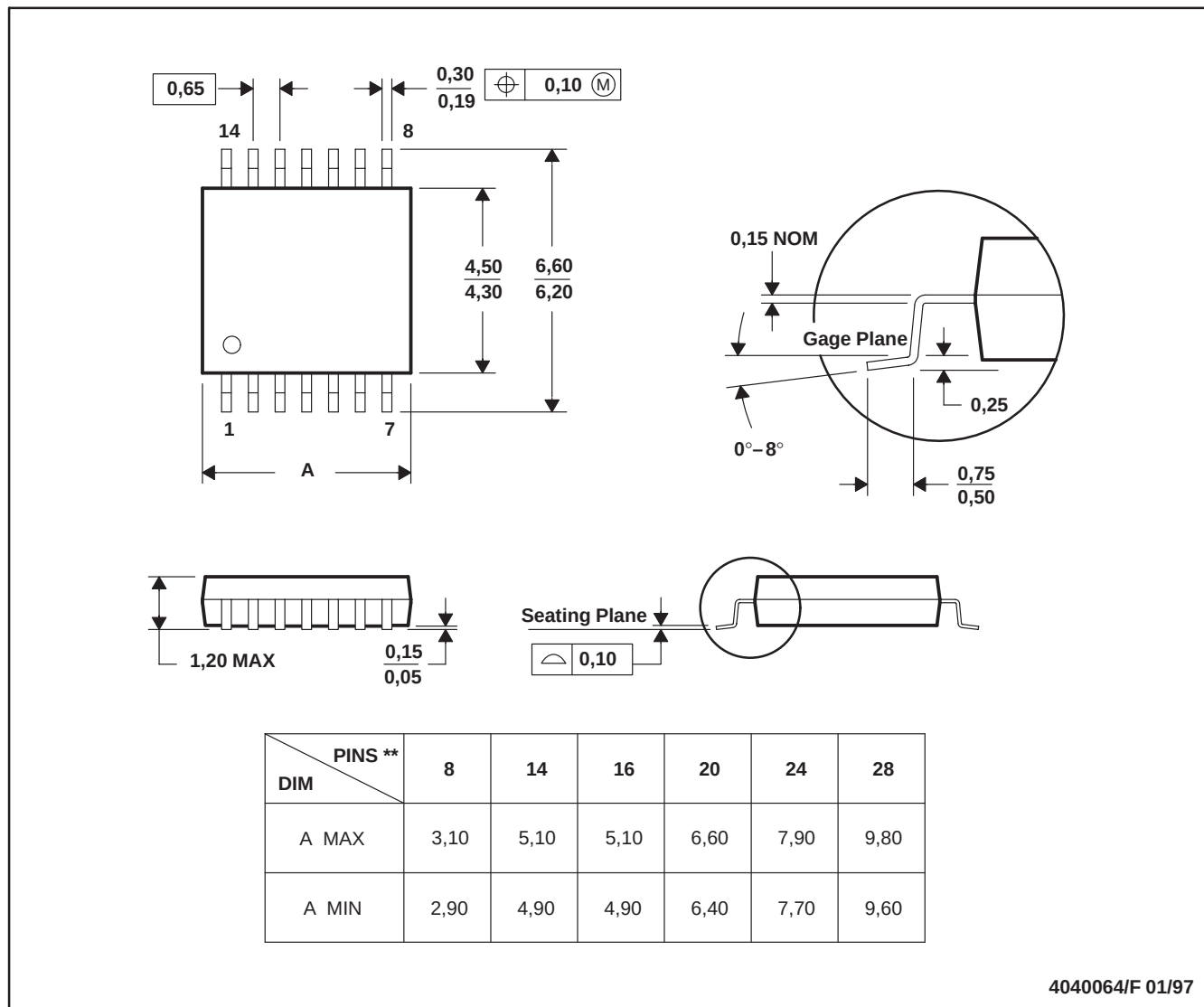
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- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
 - D. Falls within JEDEC MS-013 variation AC.

PW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
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