

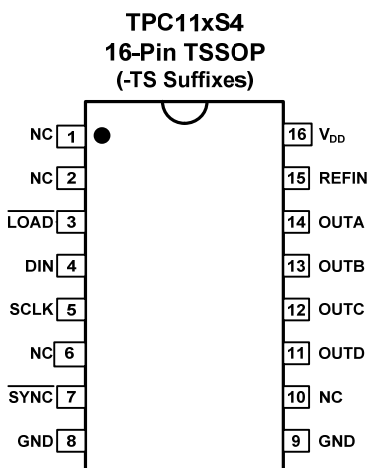
Features

- Quad, 16-/12-Bit Pin Compatible DACs
TPC116S4: 16bit
TPC112S4: 12bit
- Low Power Consumption (800µA typ)
- Differential Nonlinearity: ±1LSB(max)
- Glitch Energy: 2nV-s
- Power-On Reset to Zero
- Supply Range: 2.7V to 5.5V
- Buffered Rail-to-Rail Output Operation
- Safe Power-On Reset (POR) to Zero DAC Output
- Fast 30MHz, 3-Wire, SPI/QSPI/MICROWIRE-Compatible Serial Interface
- Schmitt-Trigger Inputs for Direct Optocoupler Interface
- SYNC Interrupt Facility
- High Performance Drop-In Compatible With TLV5614
- Available in TSSOP-16 Package

Applications

- Gain and Offset Adjustment
- Process Control and Servo Loops
- Programmable voltage and current sources
- Programmable attenuators
- Automatic Test Equipment

Package Information (Top View)



Description

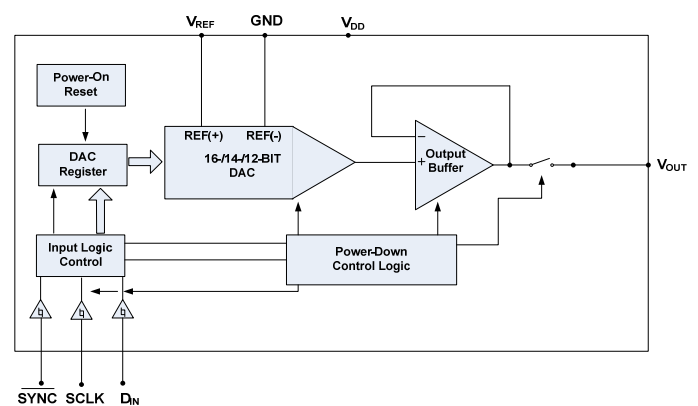
The TPC116S4/TPC112S4 are pin compatible 16-bit and 12-bit digital-to-analog converter, these series product are four channels, low power, buffered voltage-out DACs and are guaranteed monotonic by design. The devices use a precision external reference applied through the high resistance input for rail-to-rail operation and low system power consumption.

The TPC116S4/ TPC112S4 accepts a wide 2.7V to 5.5V supply voltage range. The parts incorporate a power-on reset circuit to ensure that the DAC output powers up to 0 V and remains there until a valid write takes place.

The TPC116S4/ TPC112S4 on-chip precision output amplifier allows rail-to-rail output swing to be achieved. For remote sensing applications, the output amplifier's inverting input is available to the user. The TPC116S4/ TPC112S4 use a versatile 3-wire serial interface that operates at clock rates up to 30 MHz and is compatible with standard SPI®, QSPI™, MICROWIRE™, and DSP interface standards.

The TPC116S4/ TPC112S4 are available in a small size 16-pin TSSOP package, all package are specified over the -40°C to +125°C extended industrial temperature range.

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Block diagram of one DAC

Order Information

TPC116S4/ TPC112S4

Quad 16-/12-Bit, Low Power, High Performance DACs

Model Name	Order Number	Package	Transport Media, Quantity	Marking Information
TPC112S4	TPC112S4-TR	16-Pin TSSOP	Tape and Reel, 3,000	112S4
TPC116S4*	TPC116S4-TR	16-Pin TSSOP	Tape and Reel, 3,000	116S4

* Sample is not ready, can be provided in 2 months.

Absolute Maximum Ratings Note 1

Supply Voltage: $V^+ - V^-$ <small>Note 2</small>	7.0V	Operating Temperature Range.....	-40°C to 125°C
Input Voltage.....	$V^- - 0.3$ to $V^+ + 0.3$	Maximum Junction Temperature.....	150°C
Input Current: +IN, -IN <small>Note 3</small>	±20mA	Storage Temperature Range.....	-65°C to 150°C
Output Short-Circuit Duration <small>Note 4</small>	Indefinite	Lead Temperature (Soldering, 10 sec)	260°C

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Note 2: The supplies must be established simultaneously, with, or before, the application of any input signals.

Note 3: The inputs are protected by ESD protection diodes to each power supply. If the input extends more than 500mV beyond the power supply, the input current should be limited to less than 10mA.

Note 4: A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001	8	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002	2	kV

Thermal Resistance

Package Type	θ_{JA}	θ_{JC}	Unit
16-Pin TSSOP	180	35	°C/W

Quad 16-/12-Bit, Low Power, High Performance DACs

Electrical Characteristics

($V_{DD} = 5V$, $V_{REF} = 5V$, $C_L = 100pF$, $R_L = 10k\Omega$, $T_A = -40^\circ C$ to $+105^\circ C$, unless otherwise noted. Typical values are at $T_A = +25^\circ C$.)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
STATIC ACCURACY (Note 5)						
N	Resolution	TPC112S4	12			Bits
		TPC116S4	16			
INL	Integral Nonlinearity	TPC112S4 (12-bit) (Note 6)	-2	± 0.25	2	LSB
		TPC116S4 (16-bit) (Note 6)	-16	± 8	16	
DNL	Differential Nonlinearity	TPC112S4 (12-bit) (Note 6)	-1	± 0.05	1	LSB
		TPC116S4 (16-bit) (Note 6)	-1	± 0.5	1	
OE	Zero Offset Error			6.5	30	mV
	Full-Scale Offset Error		-30	0	30	mV
	Offset-Error Drift			± 1		$\mu V/^\circ C$
GE	Gain Error		-0.3	± 0.13	0.3	%FS
	Gain Temperature Coefficient			± 2		ppmFS/ $^\circ C$
REFERENCE INPUT						
V_{REF}	Reference-Input Voltage Range		0.5		V_{DD}	V
R_{REF}	Reference-Input Impedance			333		k Ω
DAC OUTPUT						
	Output Voltage Range	No load (typical)			V_{REF}	V
		10 k Ω load	0.2		$V_{REF}-0.1$	
	DC Output Impedance			0.1		Ω
C_L	Capacitive Load (Note 8)	Series resistance = 0 Ω			0.1	nF
		Series resistance = 1k Ω			15	μF
R_L	Resistive Load (Note 8)		5			k Ω
	Short-Circuit Current	$V_{DD} = 5.5V$		35		mA
	Power-Up Time	From power-down mode		25		μs
DIGITAL INPUTS (SCLK, DIN, SYNC)						
V_{IH}	Input High Voltage	$V_{DD} = 5V$	2			V
		$V_{DD} = 3.3V$	1.5			V
V_{IL}	Input Low Voltage	$V_{DD} = 5V$			0.6	V
		$V_{DD} = 3.3V$			0.4	V
I_{IN}	Input Leakage Current	$V_{IN} = 0V$ or V_{DD}		± 5	± 10	μA
C_{IN}	Input Capacitance			1		pF

Electrical Characteristics(continued)

($V_{DD} = 5V$, $V_{REF} = 5V$, $C_L = 100pF$, $R_L = 10k\Omega$, $T_A = -40^\circ C$ to $+105^\circ C$, unless otherwise noted. Typical values are at $T_A = +25^\circ C$.)

TPC116S4/ TPC112S4

Quad 16-/12-Bit, Low Power, High Performance DACs

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V _{HYS}	Hysteresis Voltage			0.15		V
DYNAMIC PERFORMANCE (Note 8)						
SR	Voltage-Output Slew Rate	Positive and negative		1		V/μs
BW	Voltage-Output Settling Time	1/4 scale to 3/4 scale, to ≤ 0.5 LSB, 12-bit		14		μs
	Reference -3dB Bandwidth	Hex code = 800 (TPC112S4), Hex code = 8000 (TPC116S4)		100		kHz
	Digital Feedthrough	Code = 0, all digital inputs from 0V to V _{DD} , SCLK < 50MHz		0.5		nV · s
	DAC Glitch Impulse	Major code transition		2		nV · s
	Output Noise	10kHz		90		nV/√Hz
	Integrated Output Noise	0.1Hz to 10Hz		25		μV _{P-P}
POWER REQUIREMENTS						
V _{DD}	Supply Voltage		2.7		5.5	V
I _{DD}	Supply Current	V _{DD} = 5V, No load; all digital inputs at 0V or V _{DD} , supply current only; excludes reference input current, midscale		0.8	1.5	mA
I _{DD}	Supply Current	V _{DD} = 3.3V, No load; all digital inputs at 0V or V _{DD} , supply current only; excludes reference input current, midscale		0.5	1	mA
	Power-Down Supply Current	No load, all digital inputs at 0V or V _{DD}			500	μA

Note 5: Linearity is tested within 20mV of GND and V_{DD}.

Note 6: Gain and offset is tested within 100mV of GND and V_{DD}.

Note 7: Guaranteed by design; not production tested.

Note 8: All timing specifications measured with V_{IL} = V_{GND}, V_{IH} = V_{DD}.

Quad 16-/12-Bit, Low Power, High Performance DACs

Serial Write Operation

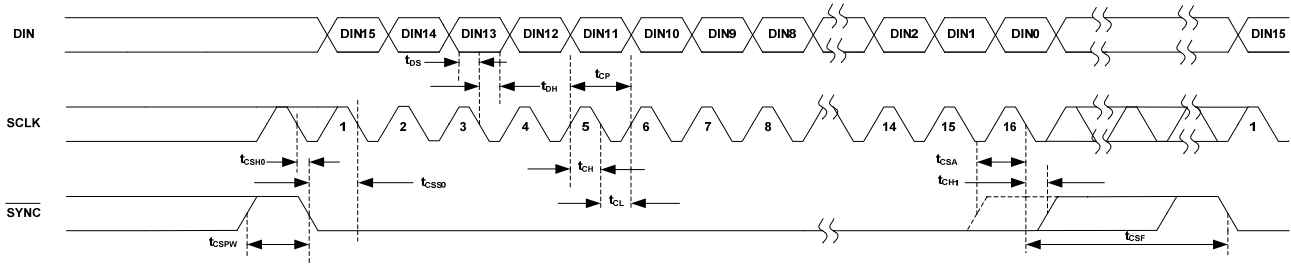


Figure 1. 16-Bit Serial-Interface Timing Diagram (TPC112S4)

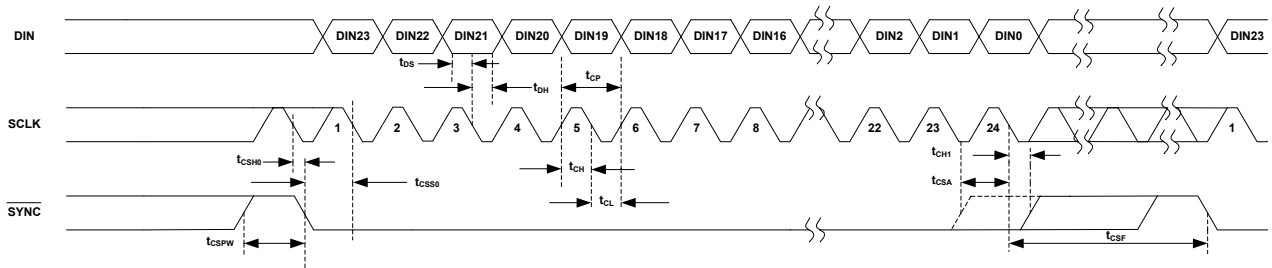


Figure 2. 24-Bit Serial-Interface Timing Diagram (TPC116S4)

TIMING CHARACTERISTICS (Figures 1,2 and 3)						
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
f_{SCLK}	Serial Clock Frequency		0		30	MHz
t_{CH}	SCLK Pulse-Width High		8			ns
t_{CL}	SCLK Pulse-Width Low		8			ns
t_{CSS0}	SYNC Fall to SCLK Fall Setup Time		8			ns
t_{CSH0}	SYNC Fall to SCLK Fall Hold Time		0			ns
t_{CSH1}	SYNC Rise to SCLK Fall Hold Time		0			ns
t_{CSA}	SYNC Rise to SCLK Fall				12	ns
t_{CSF}	SCLK Fall to SYNC Fall		100			ns
t_{DS}	DIN to SCLK Fall Setup Time		5			ns
t_{DH}	DIN to SCLK Fall Hold Time		4.5			ns
t_{CP}	DIN to SCLK Fall Capture Time					ns
t_{CSPW}	SYNC Pulse-Width High		20			ns
t_{CLPW}	SYNC Pulse-Width Low		20			ns
t_{CSC}	SYNC Rise to SYNC Fall		20			ns

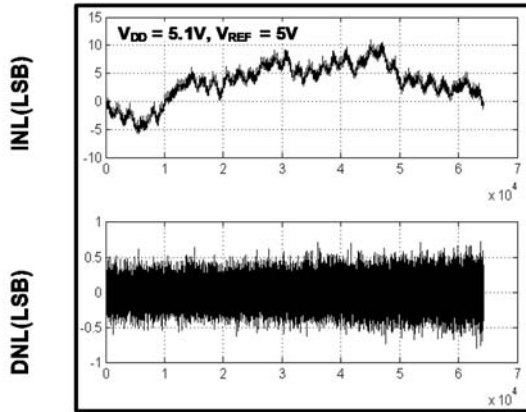
TPC116S4/ TPC112S4

Quad 16-/12-Bit, Low Power, High Performance DACs

Typical Performance Characteristics

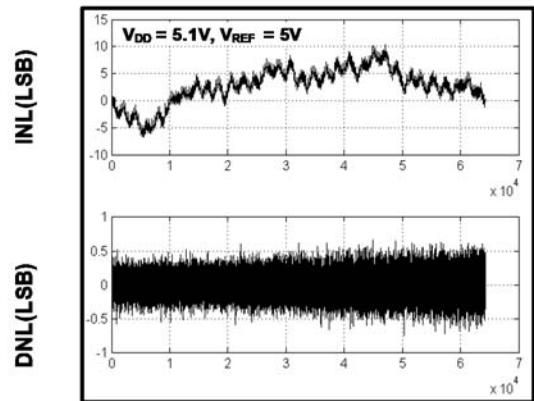
$V_S = 5V$, At $T_A = +25^\circ C$, unless otherwise specified

INL and DNL vs. Digital Input Code(+25°C TPC116S4)



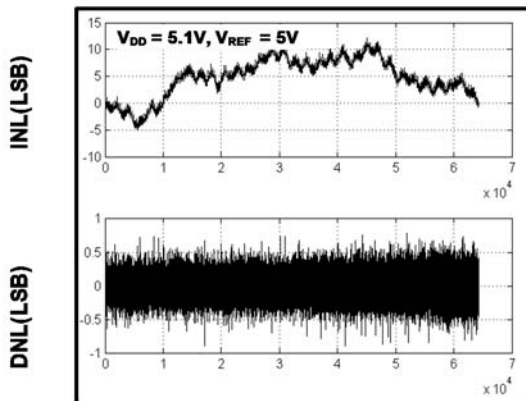
Digital Input Code

INL and DNL vs. Digital Input Code(-40°C TPC116S4)



Digital Input Code

INL and DNL vs. Digital Input Code(+105°C TPC116S4)



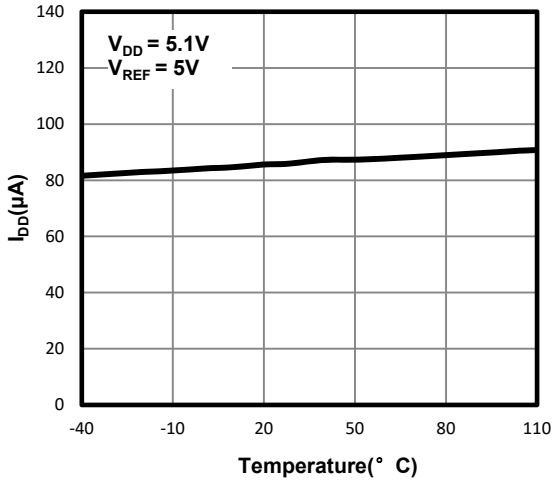
Digital Input Code

Quad 16-/12-Bit, Low Power, High Performance DACs

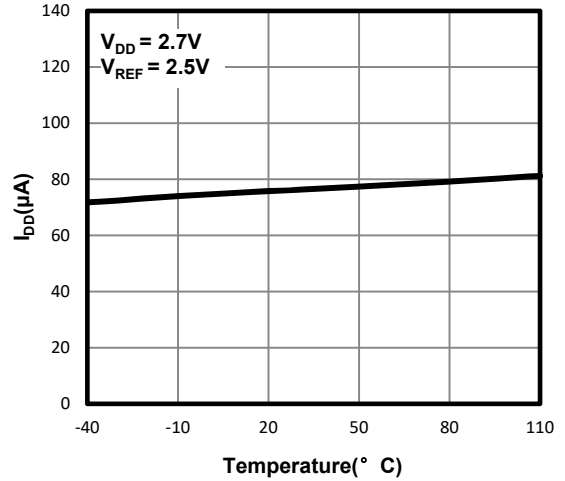
Typical Performance Characteristics

$V_S = 5V$, At $T_A = +25^\circ C$, unless otherwise specified

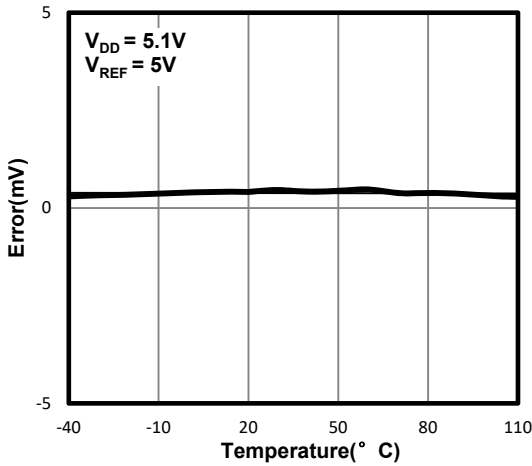
Power-Supply Current vs. Temperature(TPC116S4)



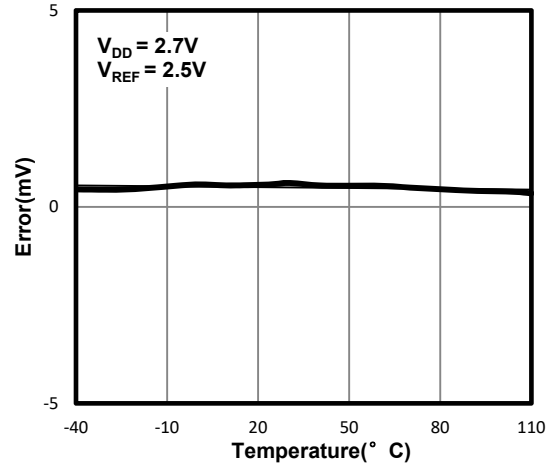
Power-Supply Current vs. Temperature(TPC116S4)



Zero-Scale Error vs. Temperature(TPC116S4)



Zero-Scale Error vs. Temperature(TPC116S4)

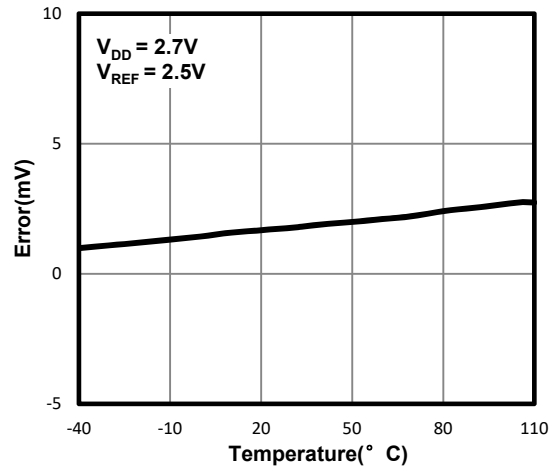
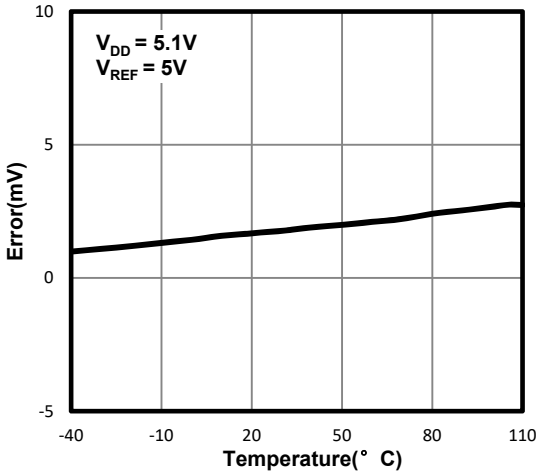


Full-Scale Error vs. Temperature(TPC116S4)

Full-Scale Error vs. Temperature(TPC116S4)

TPC116S4/ TPC112S4

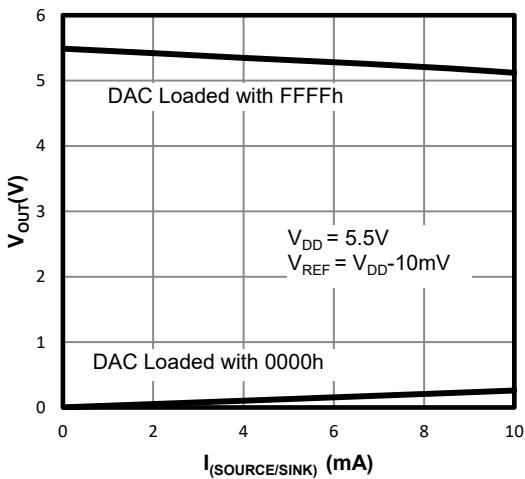
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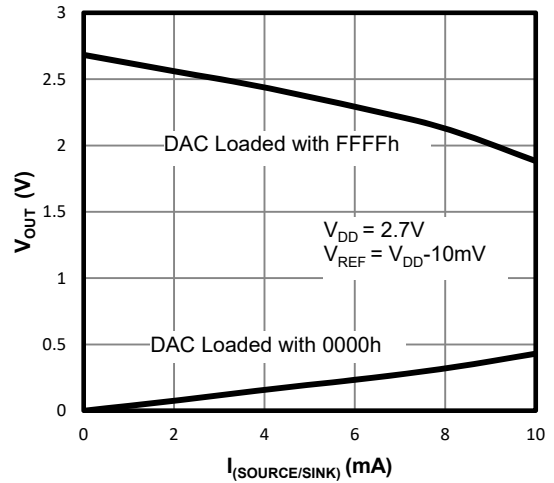
Typical Performance Characteristics

$V_S = 5V$, At $T_A = +25^\circ C$, unless otherwise specified

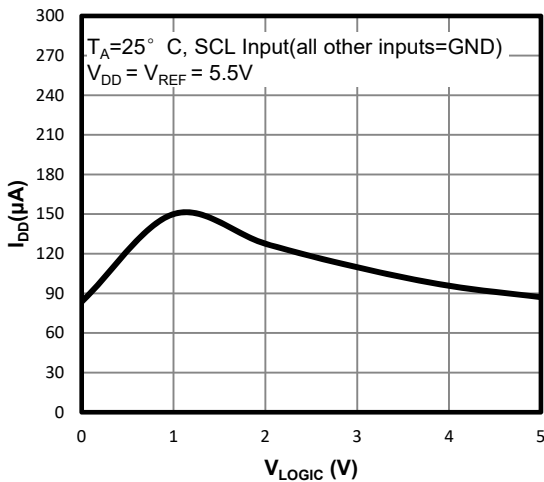
Source and Sink Current Capability(TPC116S4)



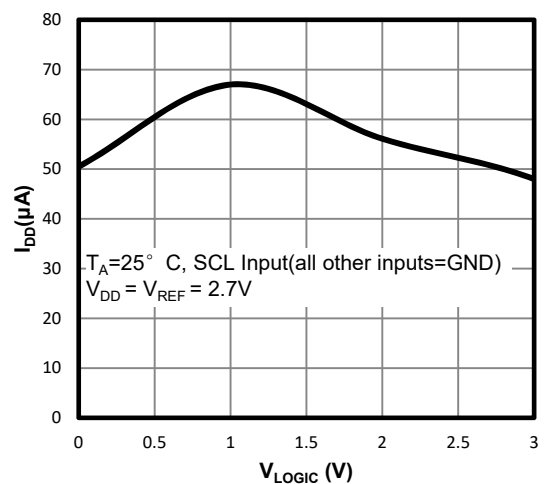
Source and Sink Current Capability(TPC116S4)



Supply Current vs. Logic Input Voltage(TPC116S4)

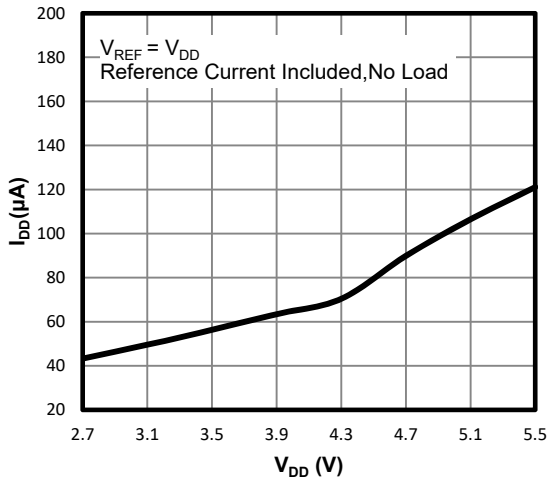


Supply Current vs. Logic Input Voltage(TPC116S4)

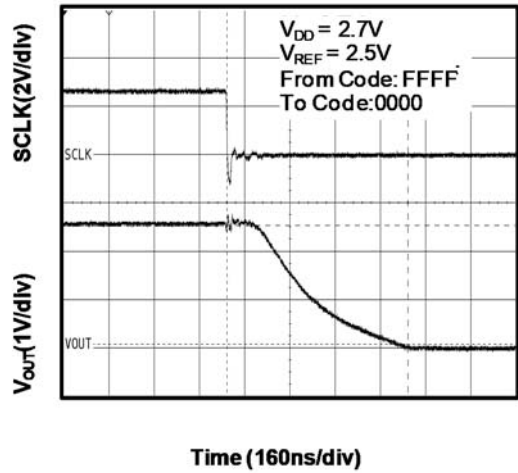


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Supply Current vs. Supply Voltage(TPC116S4)



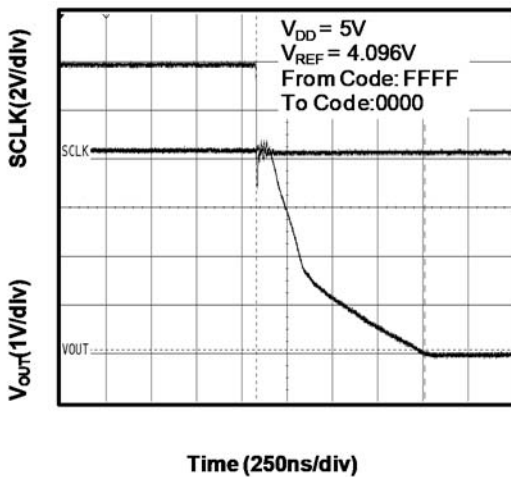
Full-Scale Settling Time(2.7V Falling Edge)



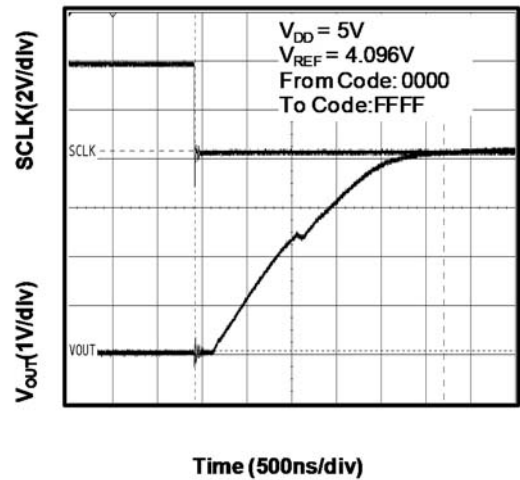
Typical Performance Characteristics

V_S = 5V, At T_A = +25°C, unless otherwise specified

Full-Scale Settling Time(5V Falling Edge)



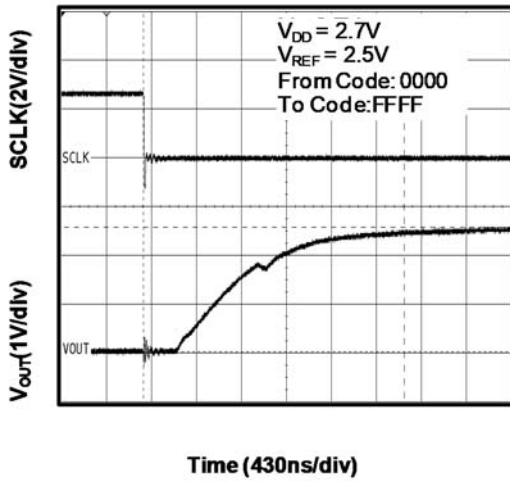
Full-Scale Settling Time(5V Rising Edge)



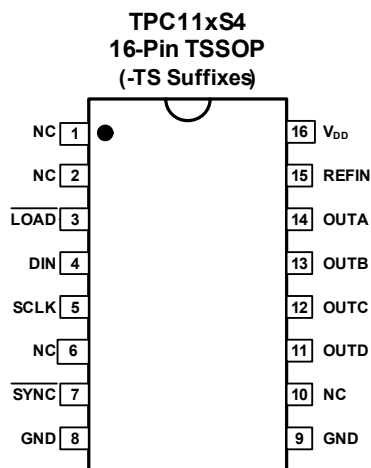
Full-Scale Settling Time(2.7V Rising Edge)

TPC116S4/ TPC112S4

Quad 16-/12-Bit, Low Power, High Performance DACs



Pin Functions



PIN number	PIN name	Function
1	NC	Not connect
2	NC	Not connect
3	LOAD	Load DAC. When the LOAD signal is high, no DAC output updates occur when the input

Quad 16-/12-Bit, Low Power, High Performance DACs

		digital data is read into the serial interface. The DAC outputs are only updated when LDAC is low.
4	DIN	Serial data input. Data is clocked into the 16-/24-bit input shift register on each falling edge of the serial clock input. Schmitt-Trigger logic input.
5	SCLK	Serial clock input. Data can be transferred at rates up to 30MHz. Schmitt-Trigger logic input.
6	NC	Not connect
7	$\overline{\text{SYNC}}$	Level-triggered control input (active LOW). This is the frame synchronization signal for the input data. When $\overline{\text{SYNC}}$ goes LOW, it enables the input shift register and data is transferred in on the falling edges of the following clocks.
8	GND	Ground reference point for all circuitry on the part.
9	GND	Ground reference point for all circuitry on the part.
10	NC	Not connect
11	OUTD	DACD output
12	OUTC	DACC output
13	OUTB	DACB output
14	OUTA	DACA output
15	REFIN	Reference voltage input
16	VDD	Power supply input, 2.7V to 5.5V

TPC116S4/ TPC112S4

Quad 16-/12-Bit, Low Power, High Performance DACs

Detailed Description

The TPC116S4/TPC112S4 are pin-compatible and software-compatible 12-bit and 16-bit DACs. The TPC116S4/TPC112S4 are 4-channels, low-power, high-reference input resistance, and buffered voltage-output DACs. The TPC116S4/TPC112S4 minimize the digital noise feed through from their inputs to their outputs by powering down the SCLK and DIN input buffers after completion of each data frame. The data frames are 16-bit for the TPC112S4 and 24-bit for the TPC116S4. On power-up, the TPC116S4/TPC112S4 reset the DAC output to zero, providing additional safety for applications that drive valves or other transducers which need to be off on power-up. The TPC116S4/TPC112S4 contain a segmented resistor string-type DAC, a serial-in/parallel-out shift register, a DAC register, power-on-reset (POR) circuit, and control logic. On the falling edge of the clock (SCLK) pulse, the serial input (DIN) data is shifted into the device, MSB first.

Applications Information

DAC Reference (REF)

The external reference input features a typical input impedance of 333kΩ and accepts an input voltage from +2V to VDD. Connect an external voltage supply between REF and GND to apply an external reference.

Serial Interface

The TPC116S4/TPC112S4 3-wire serial interface is compatible with MICROWIRE, SPI, QSPI, and DSP. The interface provides three inputs: SCLK, SYNC, and DIN. The chip-select input (SYNC) frames the serial data loading at DIN. Following a chip-select input high-to-low transition, the data is shifted synchronously and latched into the input register on each falling edge of the serial-clock input (SCLK). Each serial word is 16-bit for the TPC112S4 and 24-bit for the TPC116S4. The first 3 bits are the control bits followed by 1 power-down bit as well as 12 data bits (MSB first) for the TPC112S4 and 22 data bits (MSB first) for the TPC116S4 as shown in Tables 1 and 2. The serial input register transfers its contents to the input registers after loading 16/24 bits of data and updates the DAC output immediately after the data is received on the 16-/24-bit falling edge of the clock. To initiate a new data transfer, drive SYNC high and keep SYNC high for a minimum of 20ns before the next write sequence. The SCLK can be either high or low between SYNC write pulses. Figures 1 and 2 show the timing diagram for the complete 3-wire serial interface transmission. The TPC116S4 DAC code is unipolar binary with $V_{OUT} = (\text{code}/65,536) \times V_{REF}$. The TPC112S4 DAC code is unipolar binary with $V_{OUT} = (\text{code}/4096) \times V_{REF}$.

16-BIT WORD																Function
A2	A1	A0	PD	DAC Data Bit												
D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	
1	0	0	0	X	X	X	X	X	X	X	X	X	X	X	X	Update DAC A Data
1	0	1	0	X	X	X	X	X	X	X	X	X	X	X	X	Update DAC B Data
1	1	0	0	X	X	X	X	X	X	X	X	X	X	X	X	Update DAC C Data
1	1	1	0	X	X	X	X	X	X	X	X	X	X	X	X	Update DAC D Data
X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	Power down

Table 1. Operating Mode Truth Table (TPC112S4)

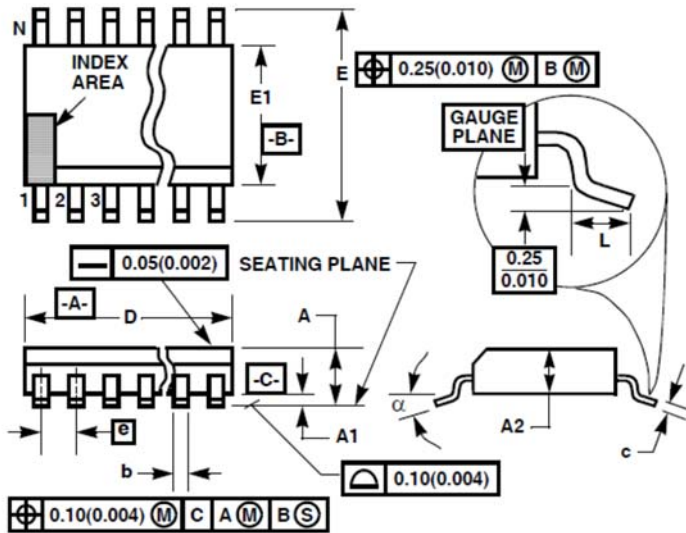
Quad 16-/12-Bit, Low Power, High Performance DACs

24-BIT WORD																	Function	
				A2	A1	A0	PD	DAC Data Bit										
D2 3	D2 2	D2 1	D2 0	D1 9	D1 8	D1 7	D1 6	D1 5	D1 4	D1 3	D1 2	D1 1	D1 0	D 9	D 8	D7~ D0		
X	X	X	X	1	0	0	0	X	X	X	X	X	X	X	X	X	Update DAC A Data	
X	X	X	X	1	0	1	0	X	X	X	X	X	X	X	X	X	Update DAC B Data	
X	X	X	X	1	1	0	0	X	X	X	X	X	X	X	X	X	Update DAC C Data	
X	X	X	X	1	1	1	0	X	X	X	X	X	X	X	X	X	Update DAC D Data	
X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	Power down	

Table 2. Operating Mode Truth Table (TPC116S4)

Package Outline Dimensions

TSSOP-16



Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	-	0.55	1.10
A1	0.05	0.10	0.15
A2	0.85	0.90	0.95
b	0.19	0.25	0.30
c	0.09	0.15	0.20
D	4.90	5.00	5.10
E1	4.30	4.40	4.50
E	6.25	6.38	6.5
L	0.50	0.60	0.70
N	16		
e	0.65 BSC		
α	0°	4°	8°