

14-Bit 400-MSPS Digital-to-Analog Converter

FEATURES

- 400-MSPS Update Rate
- Controlled Baseline
 - One Assembly
 - One Test Site
 - One Fabrication Site
- Extended Temperature Performance of -55°C to 125°C
- Enhanced Diminishing Manufacturing Sources (DMS) Support
- Enhanced Product-Change Notification
- LVDS-Compatible Input Interface
- Spurious-Free Dynamic Range (SFDR) to Nyquist
 - 69 dBc at 70 MHz IF, 400 MSPS
- W-CDMA Adjacent Channel Power Ratio (ACPR)
 - 73 dBc at 30.72-MHz IF, 122.88 MSPS
 - 71 dBc at 61.44-MHz IF, 245.76 MSPS
- Differential Scalable Current Outputs: 2 mA to 20 mA
- On-Chip 1.2-V Reference
- Single 3.3-V Supply Operation

- Power Dissipation: 660 mW at $f_{\text{CLK}} = 400 \text{ MSPS}$, $f_{\text{OUT}} = 20 \text{ MHz}$
- Package: 48-Pin PowerPAD™ Thermally-Enhanced Thin Quad Flat Pack (HTQFP) $T_{\text{JA}} = 29.1^{\circ}\text{C/W}$

APPLICATIONS

- Cellular Base Transceiver Station Transmit Channel:
 - CDMA: WCDMA, CDMA2000, IS-95
 - TDMA: GSM, IS-136, EDGE/GPRS
 - Supports Single-Carrier and Multicarrier Applications
- Test and Measurement: Arbitrary Waveform Generation
- Military Communications

DESCRIPTION/ORDERING INFORMATION

The DAC5675 is a 14-bit resolution high-speed digital-to-analog converter (DAC). The DAC5675 is designed for high-speed digital data transmission in wired and wireless communication systems, high-frequency direct-digital synthesis (DDS), and waveform reconstruction in test and measurement applications. The DAC5675 has excellent spurious-free dynamic range (SFDR) at high intermediate frequencies, which makes it well-suited for multicarrier transmission in TDMA- and CDMA-based cellular base transceiver stations (BTSS).

The DAC5675 operates from a single-supply voltage of 3.3 V. Power dissipation is 660 mW at $f_{\text{CLK}} = 400 \text{ MSPS}$, $f_{\text{OUT}} = 20 \text{ MHz}$. The DAC5675 provides a nominal full-scale differential current output of 20 mA, supporting both single-ended and differential applications. The output current can be directly fed to the load with no additional external output buffer required. The output is referred to the analog supply voltage AV_{DD} .

The DAC5675 comprises a low-voltage differential signaling (LVDS) interface for high-speed digital data input. LVDS features a low differential voltage swing with a low constant power consumption across frequency, allowing for high-speed data transmission with low noise levels; that is, with low electromagnetic interference (EMI). LVDS is typically implemented in low-voltage digital CMOS processes, making it the ideal technology for high-speed interfacing between the DAC5675 and high-speed low-voltage CMOS ASICs or FPGAs. The DAC5675 current-source-array architecture supports update rates of up to 400 MSPS. On-chip edge-triggered input latches provide for minimum setup and hold times, thereby relaxing interface timing.



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PowerPAD is a trademark of Texas Instruments.

The DAC5675 has been specifically designed for a differential transformer-coupled output with a 50- Ω doubly-terminated load. With the 20-mA full-scale output current, both a 4:1 impedance ratio (resulting in an output power of 4 dBm) and 1:1 impedance ratio transformer (–2 dBm) is supported. The last configuration is preferred for optimum performance at high output frequencies and update rates. The outputs are terminated to AVDD and have voltage compliance ranges from $AV_{DD} - 1$ to $AV_{DD} + 0.3$ V.

An accurate on-chip 1.2-V temperature-compensated bandgap reference and control amplifier allows the user to adjust this output current from 20 mA down to 2 mA. This provides 20-dB gain range control capabilities. Alternatively, an external reference voltage may be applied. The DAC5675 features a SLEEP mode, which reduces the standby power to approximately 18 mW.

The DAC5675 is available in a 48-pin PowerPAD™ thermally-enhanced thin quad flat pack (HTQFP). This package increases thermal efficiency in a standard size IC package. The device is specified for operation over the military temperature range of –55°C to 125°C.



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

ORDERING INFORMATION⁽¹⁾

PRODUCT	PACKAGE LEAD	PACKAGE DESIGNATOR	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
DAC5675-EP	48 HTQFP	PHP	DAC5675-EP	DAC5675MPHPREP	Tape and reel, 1000
				DAC5675MPHPEP	Tray, 250

(1) For the most current package and ordering information, see the *Package Option Addendum* located at the end of this data sheet.

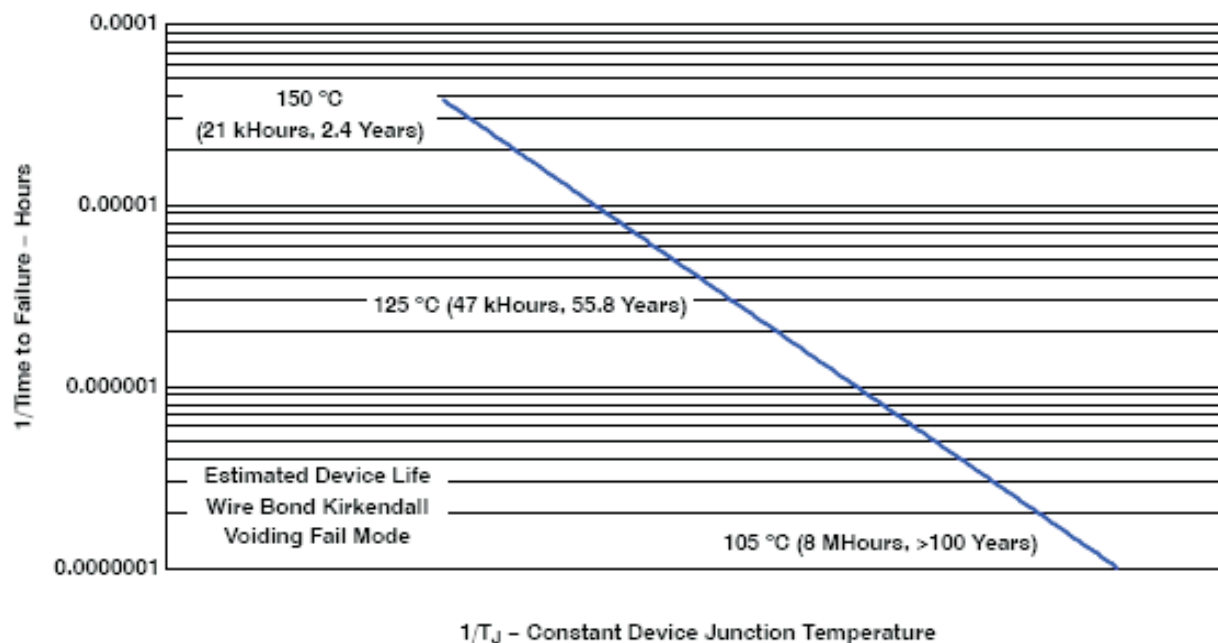
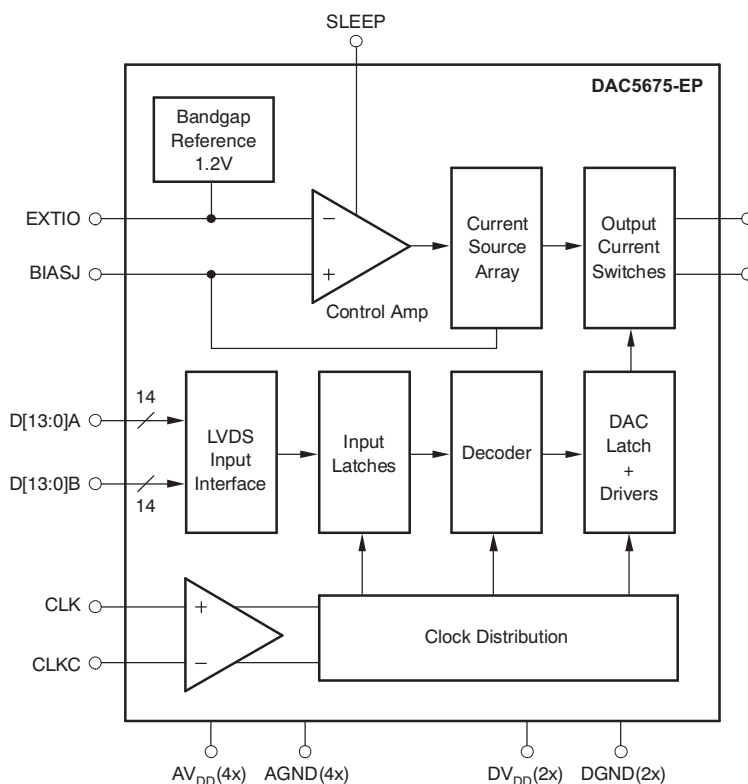
TQFP-48 PACKAGE THERMAL CHARACTERISTICS

PARAMETER	SAME PACKAGE FORM WITHOUT PowerPAD	PowerPAD CONNECTED TO PCB THERMAL PLANE ⁽¹⁾
$R_{\theta JA}$ Thermal resistance, junction to ambient ⁽¹⁾⁽²⁾	108.71°C/W	29.11°C/W
$R_{\theta JC}$ Thermal resistance, junction to case ⁽¹⁾⁽²⁾	18.18°C/W	1.14°C/W

(1) Airflow is at 0 LFM (no airflow).

(2) Specified with the PowerPAD bond pad on the backside of the package soldered to a 2-oz CU plate PCB thermal plane

FUNCTIONAL BLOCK DIAGRAM



Absolute Maximum Ratings

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

		DAC5675-EP	UNIT
Supply voltage range	$AV_{DD}^{(2)}$	–0.3 to 3.6	V
	$DV_{DD}^{(3)}$	–0.3 to 3.6	
	AV_{DD} to DV_{DD}	–3.6 to 3.6	
Voltage between AGND and DGND		–0.3 to 0.5	V
CLK, CLKC ⁽²⁾		–0.3 to $AV_{DD} + 0.3$	V
Digital input D[13:0]A, D[13:0]B ⁽³⁾ , SLEEP, DLLOFF		–0.3 to $DV_{DD} + 0.3$	V
IOUT1, IOUT2 ⁽²⁾		–1 to $AV_{DD} + 0.3$	V
EXTIO, BIASJ ⁽²⁾		–1 to $AV_{DD} + 0.3$	V
Peak input current (any input)		20	mA
Peak total input current (all inputs)		–30	mA
Operating free-air temperature range, T_A		–55 to 125	°C
Storage temperature range		–65 to 150	°C
Lead temperature 1,6 mm (1/16 in) from the case for 10 s		260	°C

(1) Stresses above those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. Exposure to absolute maximum conditions for extended periods may degrade device reliability. 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.

(2) Measured with respect to AGND

(3) Measured with respect to DGND

DC Electrical Characteristics

over operating free-air temperature range, typical values at 25°C, $AV_{DD} = 3.3$ V, $DV_{DD} = 3.3$ V, $I_{O(FS)} = 20$ mA (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Resolution			14			Bit
DC Accuracy ⁽¹⁾						
INL	Integral nonlinearity	T _{MIN} to T _{MAX}	–4	±1.5	4.6	LSB
DNL	Differential nonlinearity		–2	±0.6	2.2	LSB
Monotonicity			Monotonic 12b Level			
Analog Output						
I _{O(FS)}	Full-scale output current		2		20	mA
Output compliance range		AV _{DD} = 3.15 V to 3.45 V, I _{O(FS)} = 20 mA	AV _{DD} – 1		AV _{DD} + 0.3	V
Offset error			0.01			%FSR
Gain error		Without internal reference	–10	5	10	%FSR
		With internal reference	–10	2.5	10	
Output resistance			300			kΩ
Output capacitance			5			pF
Reference Output						
V _(EXTIO)	Reference voltage		1.17	1.23	1.29	V
Reference output current ⁽²⁾			100			nA
Reference Input						
V _(EXTIO)	Input reference voltage		0.6	1.2	1.25	V
Input resistance			1			MΩ
Small-signal bandwidth			1.4			MHz
Input capacitance			100			pF
Temperature Coefficients						
Offset drift			12			ppm of FSR/°C
ΔV _(EXTIO)	Reference voltage drift		±50			ppm/°C
Power Supply						
AV _{DD}	Analog supply voltage		3.15	3.3	3.6	V
DV _{DD}	Digital supply voltage		3.15	3.3	3.6	V
I _(AVDD)	Analog supply current ⁽³⁾		115			mA
I _(DVDD)	Digital supply current ⁽³⁾		85			mA
P _D	Power dissipation	Sleep mode	18			mW
		AV _{DD} = 3.3 V, DV _{DD} = 3.3 V	660 900			
APSRR	Analog and digital power-supply rejection ratio	AV _{DD} = 3.15 V to 3.45 V	–0.9	±0.1	0.9	%FSR/V
DPSRR			–0.9	±0.1	0.9	

(1) Measured differential at I_{OUT1} and I_{OUT2} : 25 Ω to AV_{DD}

(2) Use an external buffer amplifier with high impedance input to drive any external load.

(3) Measured at $f_{CLK} = 400$ MSPS and $f_{OUT} = 70$ MHz

AC Electrical Characteristics

over operating free-air temperature range, typical values at 25°C, $AV_{DD} = 3.3\text{ V}$, $DV_{DD} = 3.3\text{ V}$, $I_{O(FS)} = 20\text{ mA}$, differential transformer-coupled output, 50- Ω doubly-terminated load (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Analog Output						
f _{CLK}	Output update rate			400		MSPS
t _{s(DAC)}	Output setting time to 0.1%	Transition: code x2000 to x23 _{FF}		12		ns
t _{PD}	Output propagation delay			1		ns
t _{r(IOUT)}	Output rise time, 10% to 90%			2		ns
t _{f(IOUT)}	Output fall time, 90% to 10%			2		ns
Output noise		IOUT _{FS} = 20 mA		55		pA/√Hz
		IOUT _{FS} = 2 mA		30		
AC Linearity						
THD	Total harmonic distortion	f _{CLK} = 100 MSPS, f _{OUT} = 19.9 MHz		73		dBc
		f _{CLK} = 160 MSPS, f _{OUT} = 41 MHz		72		
		f _{CLK} = 200 MSPS, f _{OUT} = 70 MHz		68		
		f _{CLK} = 400 MSPS	f _{OUT} = 20.1 MHz	72		
			f _{OUT} = 70 MHz	71		
			f _{OUT} = 140 MHz	58		
SFDR	Spurious-free dynamic range to Nyquist	f _{CLK} = 100 MSPS, f _{OUT} = 19.9 MHz		73		dBc
		f _{CLK} = 160 MSPS, f _{OUT} = 41 MHz		73		
		f _{CLK} = 200 MSPS, f _{OUT} = 70 MHz		70		
		f _{CLK} = 400 MSPS	f _{OUT} = 20.1 MHz	73		
			f _{OUT} = 70 MHz	74		
			f _{OUT} = 140 MHz	60		
SFDR	Spurious-free dynamic range within a window, 5-MHz span	f _{CLK} = 100 MSPS, f _{OUT} = 19.9 MHz		88		dBc
		f _{CLK} = 160 MSPS, f _{OUT} = 41 MHz		87		
		f _{CLK} = 200 MSPS, f _{OUT} = 70 MHz		82		
		f _{CLK} = 400 MSPS	f _{OUT} = 20.1 MHz	87		
			f _{OUT} = 70 MHz	82		
			f _{OUT} = 140 MHz	75		
ACPR	Adjacent channel power ratio WCDM A with 3.84 MHz BW, 5-MHz channel spacing	f _{CLK} = 122.88 MSPS, IF = 30.72 MHz, See Figure 9		73		dB
		f _{CLK} = 245.76 MSPS, IF = 61.44 MHz, See Figure 10		71		
		f _{CLK} = 399.32 MSPS, IF = 153.36 MHz, See Figure 12		65		
IMD	Two-tone intermodulation to Nyquist (each tone at –6 dBfs)	f _{CLK} = 400 MSPS, f _{OUT1} = 70 MHz, f _{OUT2} = 71 MHz		73		dBc
		f _{CLK} = 400 MSPS, f _{OUT1} = 140 MHz, f _{OUT2} = 141 MHz		62		
	Four-tone intermodulation, 15-MHz span, missing center tone (each tone at –16 dBfs)	f _{CLK} = 156 MSPS, f _{OUT} = 15.6, 15.8, 16.2, 16.4 MHz		82		
		f _{CLK} = 400 MSPS, f _{OUT} = 68.1, 69.3, 71.2, 72 MHz		74		

Digital Specifications

over operating free-air temperature range, typical values at 25°C, $AV_{DD} = 3.3\text{ V}$, $DV_{DD} = 3.3\text{ V}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
LVDS Interface: Nodes D[13:0]A, D[13:0]B						
V _{ITH+}	Positive-going differential input voltage threshold	See LVDS Min/Max Threshold Voltages table	100			mV
V _{ITH−}	Negative-going differential input voltage threshold		−100			mV
Z _T	Internal termination impedance		90	110	132	Ω
C _I	Input capacitance		2			pF
CMOS Interface (SLEEP)						
V _{IH}	High-level input voltage		2	3.3		V
V _{IL}	Low-level input voltage			0	0.8	V
I _{IH}	High-level input current		−100		100	μA
I _{IL}	Low-level input current		−10		10	μA
	Input capacitance		2			pF
Clock Interface (CLK, CLKC)						
CLK-CLKC	Clock differential input voltage		0.4		0.8	V _{PP}
t _{w(H)}	Clock pulse width high		1.25			ns
t _{w(L)}	Clock pulse width low		1.25			ns
	Clock duty cycle		40%		60%	
V _{CM}	Common-mode voltage range		2 ± 20%			V
	Input resistance	Node CLK, CLKC	670			Ω
	Input capacitance	Node CLK, CLKC	2			pF
	Input resistance	Differential	1.3			kΩ
	Input capacitance	Differential	1			pF
Timing						
t _{SU}	Input setup time		1.5			ns
t _H	Input hold time		0.25			ns
t _{LPH}	Input latch pulse high time		2			ns
t _{DD}	Digital delay time	DLL disabled, DLLOFF = 1	3			clk

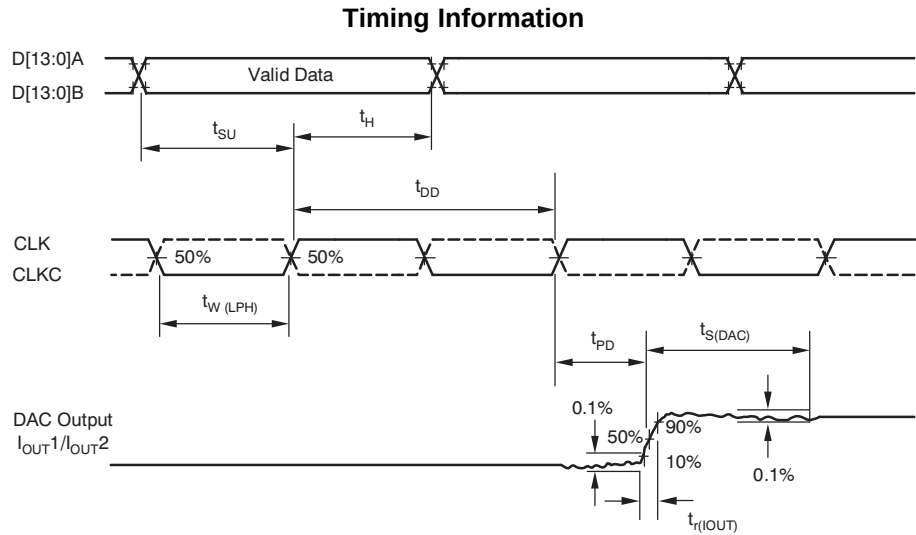


Figure 1. Timing Diagram

Electrical Characteristics⁽¹⁾

over operating free-air temperature range, $AV_{DD} = 3.3\text{ V}$, $DV_{DD} = 3.3\text{ V}$, $I_{O(FS)} = 20\text{ mA}$ (unless otherwise noted)

APPLIED VOLTAGES		RESULTING DIFFERENTIAL INPUT VOLTAGE	RESULTING COMMON-MODE INPUT VOLTAGE	LOGICAL BIT BINARY EQUIVALENT	COMMENT
$V_A\text{ (V)}$	$V_B\text{ (V)}$	$V_{A,B}\text{ (mV)}$	$V_{COM}\text{ (V)}$		
1.25	1.15	100	1.2	1	Operation with minimum differential voltage ($\pm 100\text{ mV}$) applied to the complementary inputs versus common-mode range
1.15	1.25	-100	1.2	0	
2.4	2.3	100	2.35	1	
2.3	2.4	-100	2.35	0	
0.1	0	100	0.05	1	
0	0.1	-100	0.05	0	
1.5	0.9	600	1.2	1	Operation with maximum differential voltage ($\pm 600\text{ mV}$) applied to the complementary inputs versus common-mode range
0.9	1.5	-600	1.2	0	
2.4	1.8	600	2.1	1	
1.8	2.4	-600	2.1	0	
0.6	0	600	0.3	1	
0	0.6	-600	0.3	0	

(1) Specifications subject to change.

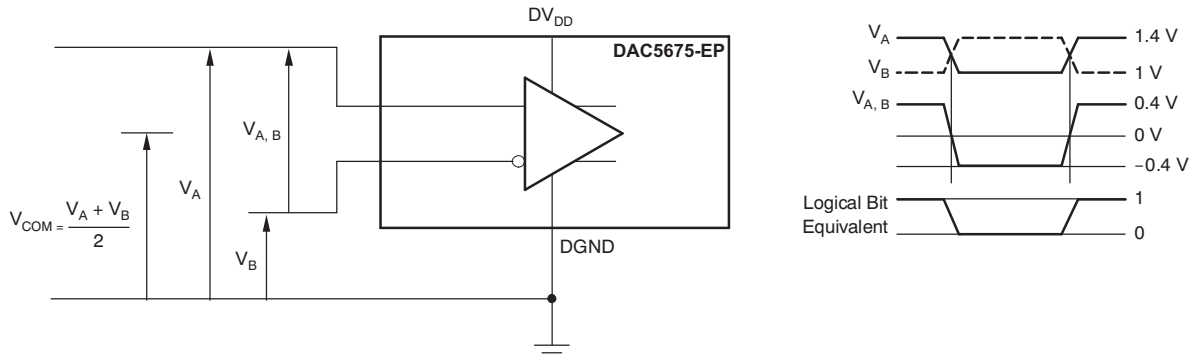
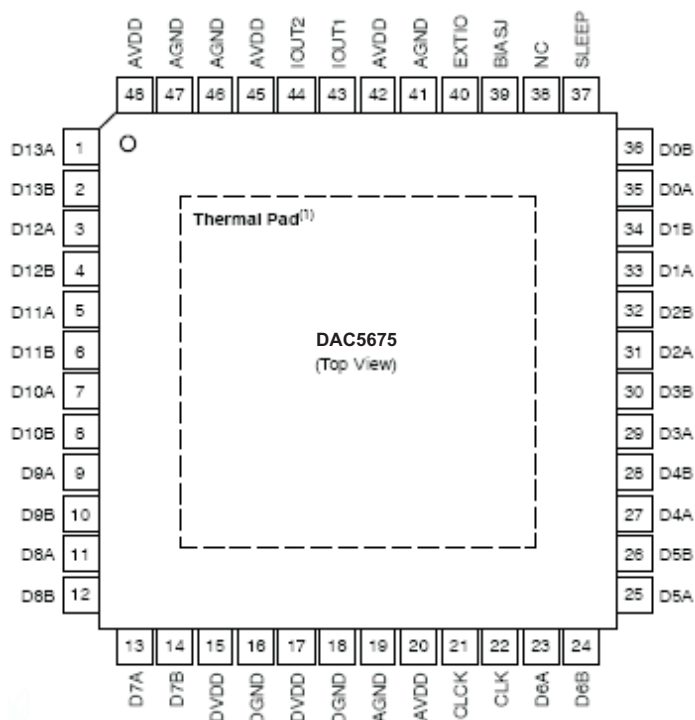


Figure 2. LVDS Timing Test Circuit and Input Test Levels

DEVICE INFORMATION

PHP PACKAGE (TOP VIEW)



- A. Thermal pad size: 4,5mm × 4,5mm (min), 5,5mm × 5,5mm (max)

DEVICE INFORMATION (continued)

TERMINAL FUNCTIONS

TERMINAL		I/O	DESCRIPTION
NAME	NO.		
AGND	19, 41, 46, 47	I	Analog negative supply voltage (ground). Pin 47 is internally connected to the heat slug.
AV _{DD}	20, 42, 45, 48	I	Analog positive supply voltage
BIASJ	39	O	Full-scale output current bias
CLK	22	I	External clock input
CLKC	21	I	Complementary external clock
D[13:0]A	1, 3, 5, 7, 9, 11, 13, 23, 25, 27, 29, 31, 33, 35	I	LVDS positive input, data bits 13–0. D13A is the most significant data bit (MSB). D0A is the least significant data bit (LSB).
D[13:0]B	2, 4, 6, 8, 10, 12, 14, 24, 26, 28, 30, 32, 34, 36	I	LVDS negative input, data bits 13–0.. D13B is the most significant data bit (MSB). D0B is the least significant data bit (LSB).
DGND	16, 18	I	Digital negative supply voltage (ground)
DV _{DD}	15, 17	I	Digital positive supply voltage
EXTIO	40	I/O	Internal reference output or external reference input. Requires a 0.1-μF decoupling capacitor to AGND when used as reference output.
IOUT1	43	O	DAC current output. Full-scale when all input bits are set 1. Connect the reference side of the DAC load resistors to AV _{DD} .
IOUT2	44	O	DAC complementary current output. Full-scale when all input bits are 0. Connect the reference side of the DAC load resistors to AV _{DD} .
NC	38		Not connected in chip. Can be high or low.
SLEEP	37	I	Asynchronous hardware power-down input. Active high. Internal pulldown.

TYPICAL CHARACTERISTICS

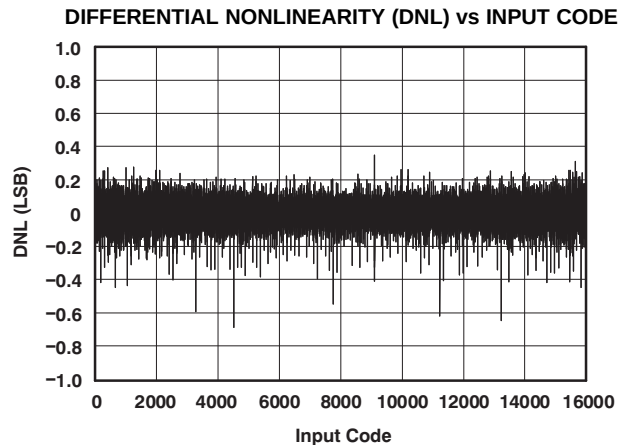


Figure 3.

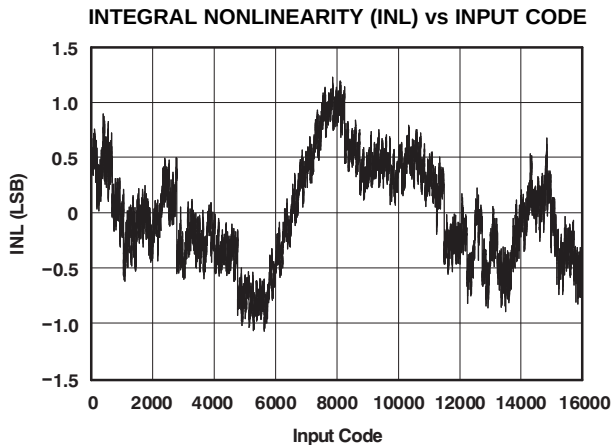


Figure 4.

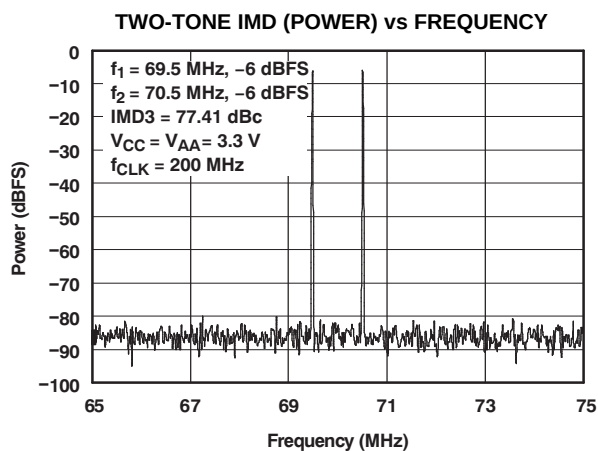


Figure 5.

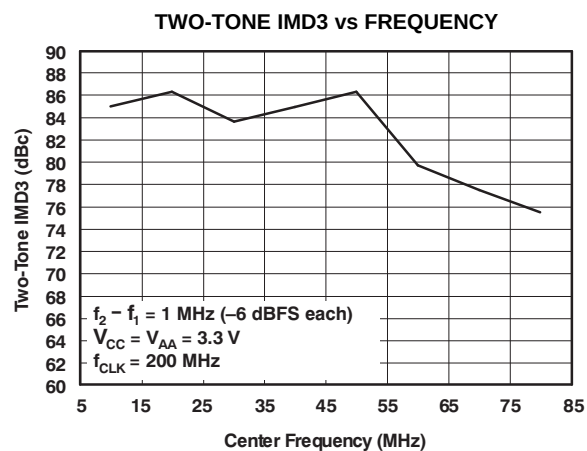


Figure 6.

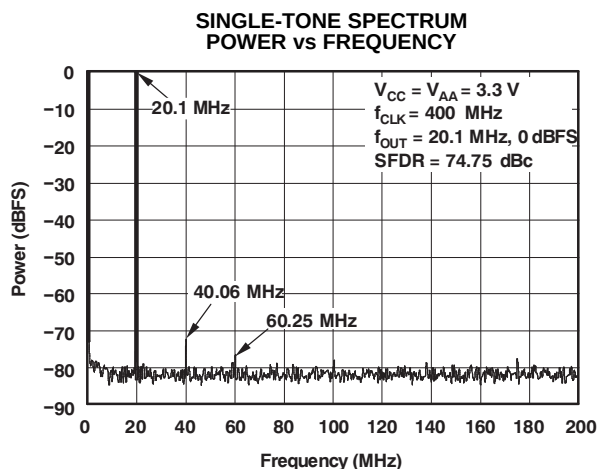


Figure 7.

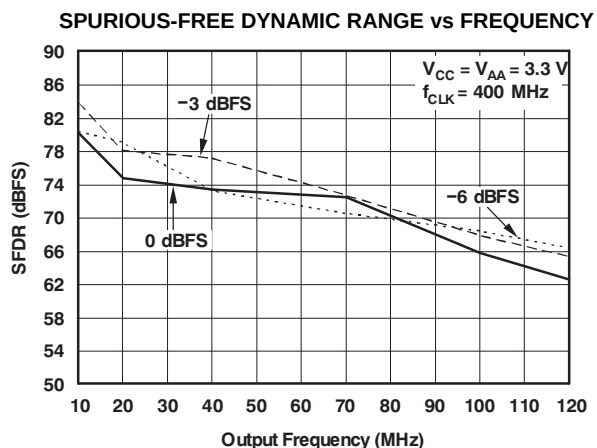


Figure 8.

TYPICAL CHARACTERISTICS (continued)

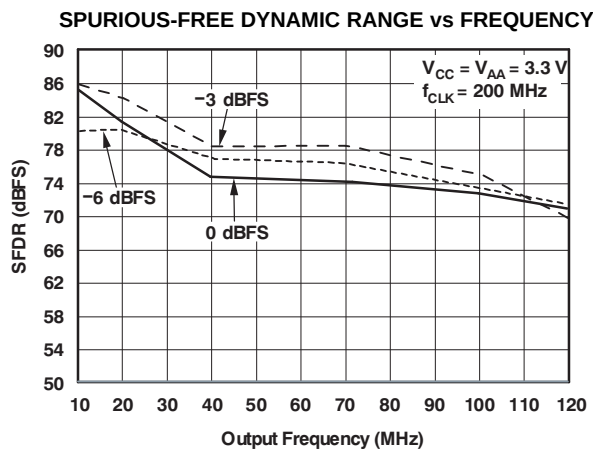


Figure 9.

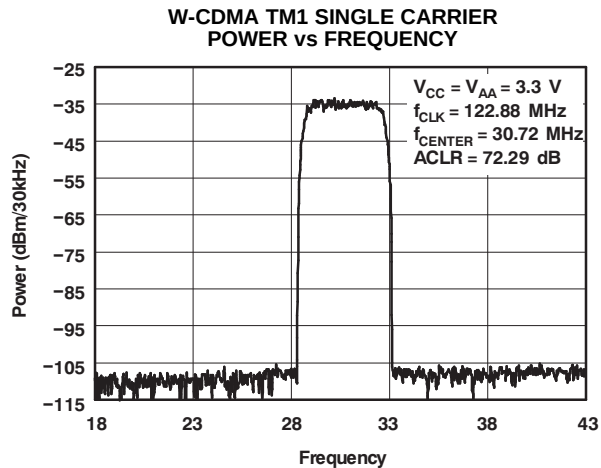


Figure 10.

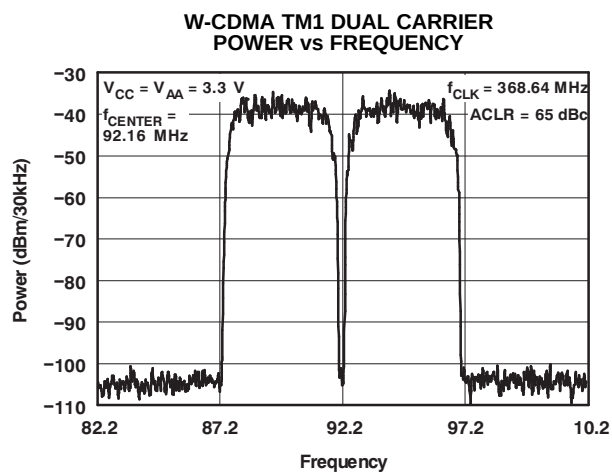


Figure 11.

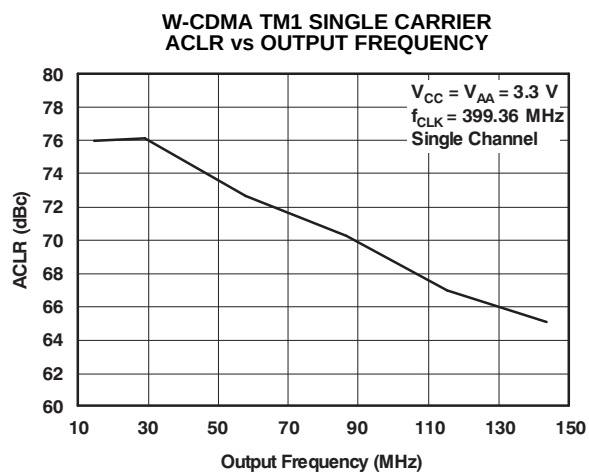


Figure 12.

APPLICATION INFORMATION

Detailed Description

Figure 13 shows a simplified block diagram of the current steering DAC5675. The DAC5675 consists of a segmented array of NPN-transistor current sources, capable of delivering a full-scale output current up to 20 mA. Differential current switches direct the current of each current source to either one of the complementary output nodes IOUT1 or IOUT2. The complementary current output enables differential operation, canceling out common-mode noise sources (digital feedthrough, on-chip, and PCB noise), dc offsets, and even-order distortion components, and doubling signal output power.

The full-scale output current is set using an external resistor (R_{BIAS}) in combination with an on-chip bandgap voltage reference source (1.2 V) and control amplifier. The current (I_{BIAS}) through resistor R_{BIAS} is mirrored internally to provide a full-scale output current equal to 16 times I_{BIAS} . The full-scale current is adjustable from 20 mA down to 2 mA by using the appropriate bias resistor value.

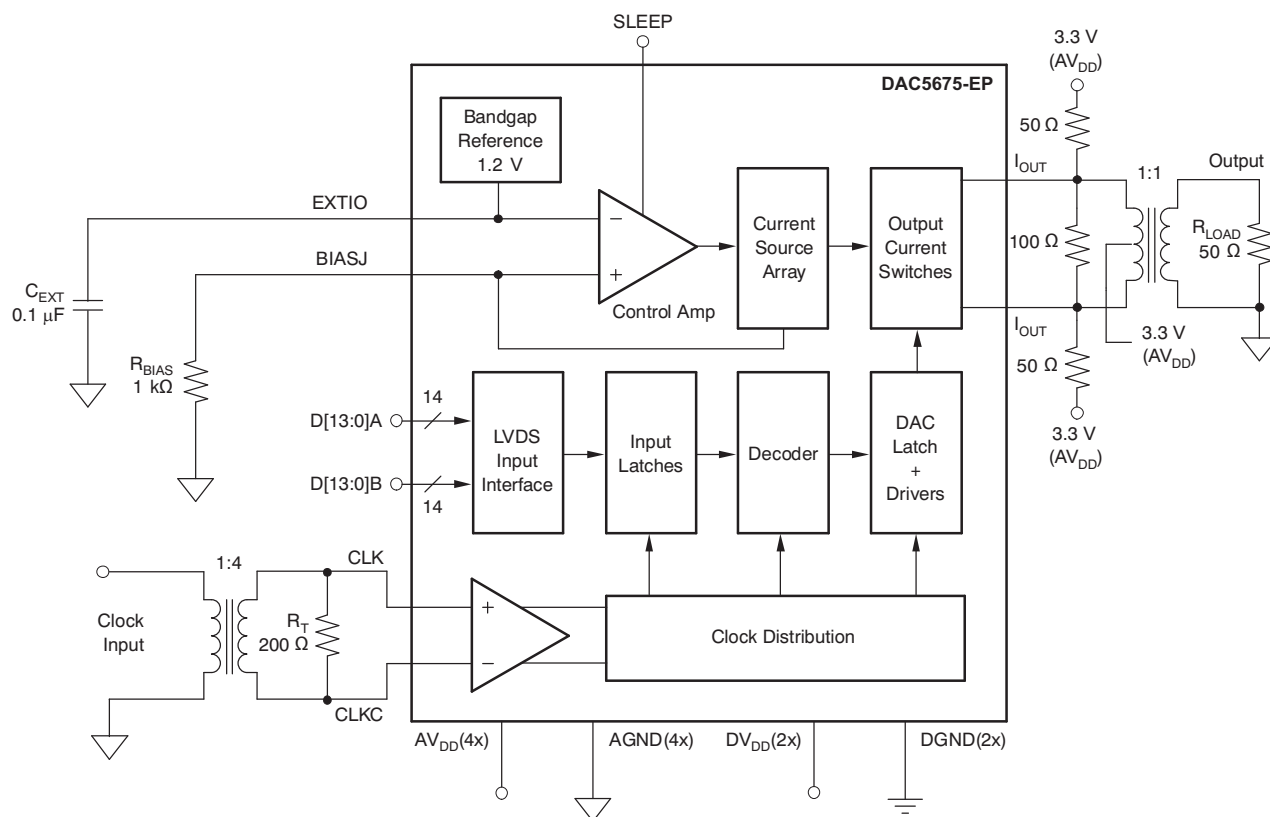


Figure 13. Application Schematic

APPLICATION INFORMATION (continued)

Digital Inputs

The DAC5675 uses a low-voltage differential signaling (LVDS) bus input interface. The LVDS features a low differential voltage swing with low constant power consumption (4 mA per complementary data input) across frequency. The differential characteristic of LVDS allows for high-speed data transmission with low electromagnetic interference (EMI) levels. The LVDS input minimum and maximum input threshold table lists the LVDS input levels. Figure 14 shows the equivalent complementary digital input interface for the DAC5675, valid for pins D[13:0]A and D[13:0]B. Note that the LVDS interface features internal 110- Ω resistors for proper termination. Figure 2 shows the LVDS input timing measurement circuit and waveforms. A common-mode level of 1.2 V and a differential input swing of 0.8 V_{PP} is applied to the inputs.

Figure 15 shows a schematic of the equivalent CMOS/TTL-compatible digital inputs of the DAC5675, valid for the SLEEP pin.

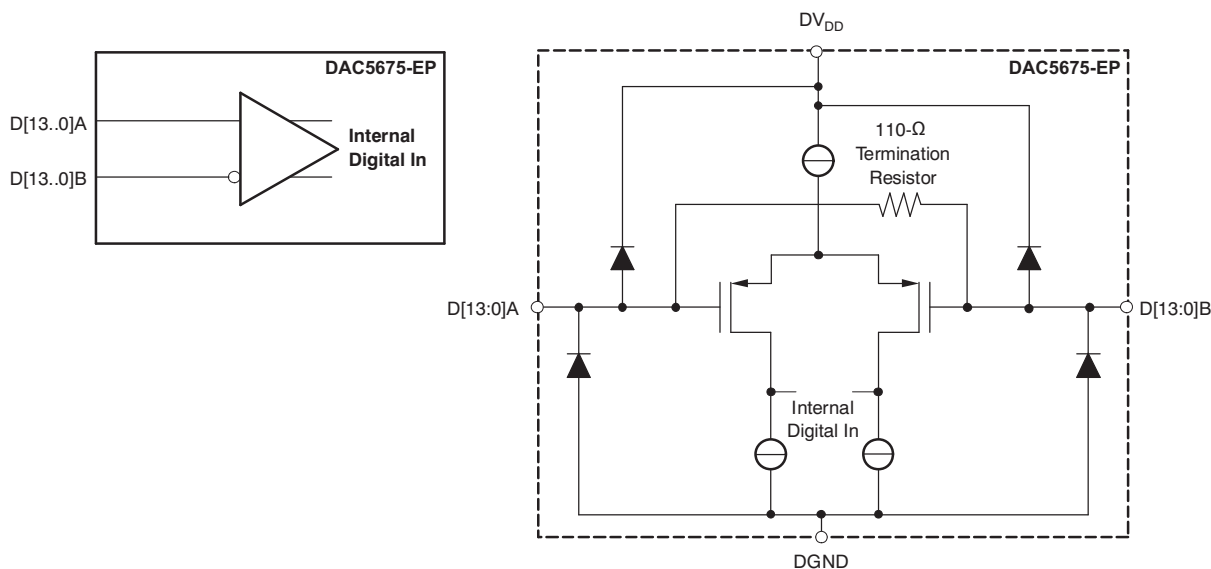


Figure 14. LVDS Digital Equivalent Input

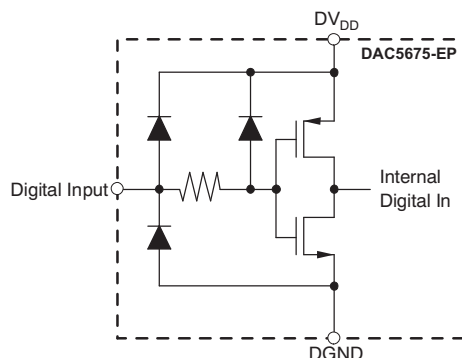


Figure 15. CMOS/TTL Digital Equivalent Input

Clock Input

The DAC5675 features differential LVPECL-compatible clock inputs (CLK, CLKC). Figure 16 shows the equivalent schematic of the clock input buffer. The internal biasing resistors set the input common-mode voltage to approximately 2 V, while the input resistance is typically 670 Ω . A variety of clock sources can be ac-coupled to the device, including a sine-wave source (see Figure 17).

APPLICATION INFORMATION (continued)

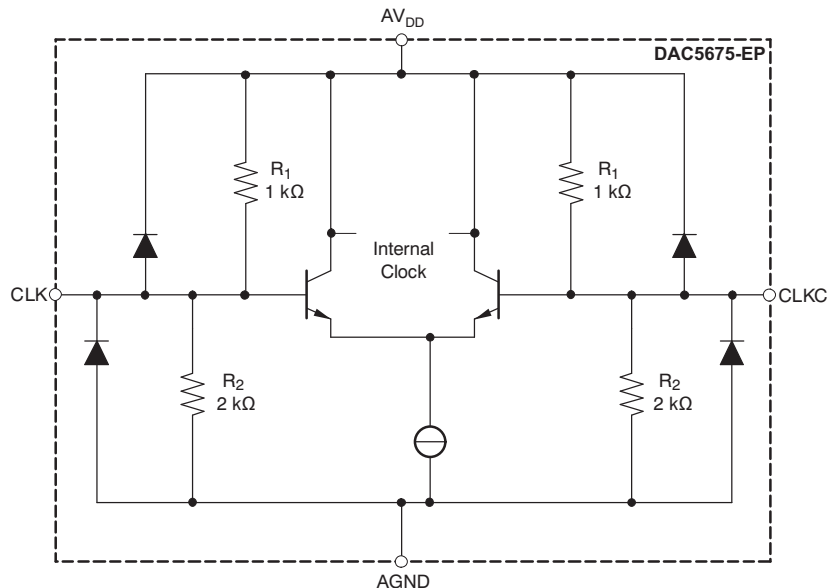


Figure 16. Clock Equivalent Input

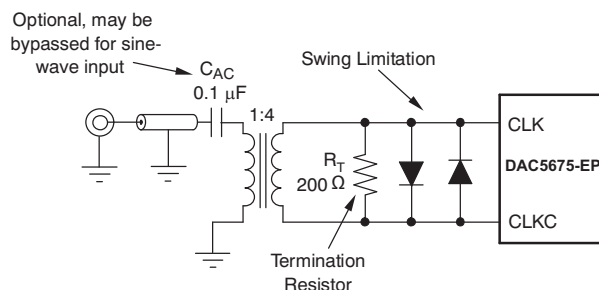


Figure 17. Driving the DAC5675 With a Single-Ended Clock Source Using a Transformer

To obtain best ac performance, the DAC5675 clock input should be driven with a differential LVPECL or sine-wave source as shown in [Figure 18](#) and [Figure 19](#). Here, the potential of V_{TT} should be set to the termination voltage required by the driver along with the proper termination resistors (R_T). The DAC5675 clock input can also be driven single ended; this is shown in [Figure 20](#).

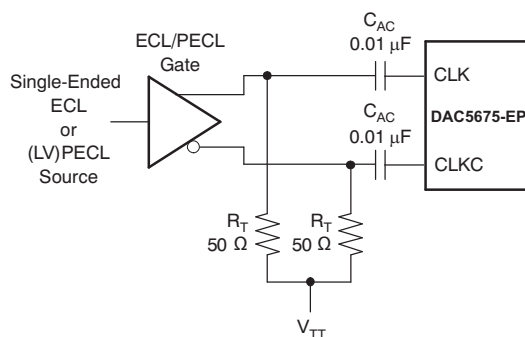
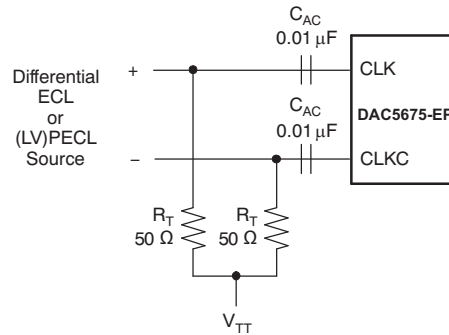
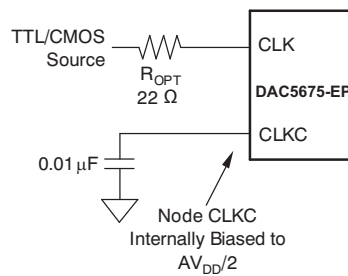


Figure 18. Driving the DAC5675 With a Single-Ended ECL/PECL Clock Source

APPLICATION INFORMATION (continued)**Figure 19. Driving the DAC5675 With a Differential ECL/PECL Clock Source****Figure 20. Driving the DAC5675 With a Single-Ended TTL/CMOS Clock Source****Supply Inputs**

The DAC5675 comprises separate analog and digital supplies, that is AV_{DD} and DV_{DD} , respectively. These supply inputs can be set independently from 3.6 V down to 3.15 V.

DAC Transfer Function

The DAC5675 delivers complementary output currents I_{OUT1} and I_{OUT2} . The DAC supports straight binary coding, with D13 being the MSB and D0 the LSB. (For ease of notation, we denote D13–D0 as the logical bit equivalent of the complementary LVDS inputs D[13:0]A and D[13:0]B). Output current I_{OUT1} equals the approximate full-scale output current when all input bits are set high, when the binary input word has the decimal representation 16383. Full-scale output current flows through terminal I_{OUT2} when all input bits are set low (mode 0, straight binary input). The relation between I_{OUT1} and I_{OUT2} can thus be expressed as:

$$I_{OUT1} = I_{O(FS)} - I_{OUT2} \quad (1)$$

where $I_{O(FS)}$ is the full-scale output current. The output currents can be expressed as:

$$I_{OUT1} = \frac{I_{O(FS)} \times \text{CODE}}{16384} \quad (2)$$

$$I_{OUT2} = \frac{I_{O(FS)} \times (16383 - \text{CODE})}{16384} \quad (3)$$

where CODE is the decimal representation of the DAC data input word. Output currents I_{OUT1} and I_{OUT2} drive a load R_L . R_L is the combined impedance for the termination resistance and/or transformer load resistance, R_{LOAD} (see [Figure 22](#) and [Figure 23](#)). This would translate into single-ended voltages V_{OUT1} and V_{OUT2} at terminal I_{OUT1} and I_{OUT2} , respectively, of [Equation 4](#) and [Equation 5](#):

APPLICATION INFORMATION (continued)

$$V_{OUT1} = I_{OUT1} \times R_L = \frac{(\text{CODE} \times I_{O(FS)} \times R_L)}{16384} \quad (4)$$

$$V_{OUT2} = I_{OUT2} \times R_L = \frac{(16383 - \text{CODE}) \times I_{O(FS)} \times R_L}{16384} \quad (5)$$

Thus, the differential output voltage $V_{OUT(DIFF)}$ can be expressed as:

$$V_{OUT(DIFF)} = V_{OUT1} - V_{OUT2} = \frac{(2\text{CODE} - 16383) \times I_{O(FS)} \times R_L}{16384} \quad (6)$$

Equation 6 shows that applying the differential output results in doubling the signal power delivered to the load. Since the output currents I_{OUT1} and I_{OUT2} are complementary, they become additive when processed differentially. Care should be taken not to exceed the compliance voltages at nodes I_{OUT1} and I_{OUT2} , which leads to increased signal distortion.

Reference Operation

The DAC5675 has a bandgap reference and control amplifier for biasing the full-scale output current. The full-scale output current is set by applying an external resistor R_{BIAS} . The bias current I_{BIAS} through resistor R_{BIAS} is defined by the on-chip bandgap reference voltage and control amplifier. The full-scale output current equals 16 times this bias current. The full-scale output current $I_{O(FS)}$ is thus expressed as [Equation 7](#):

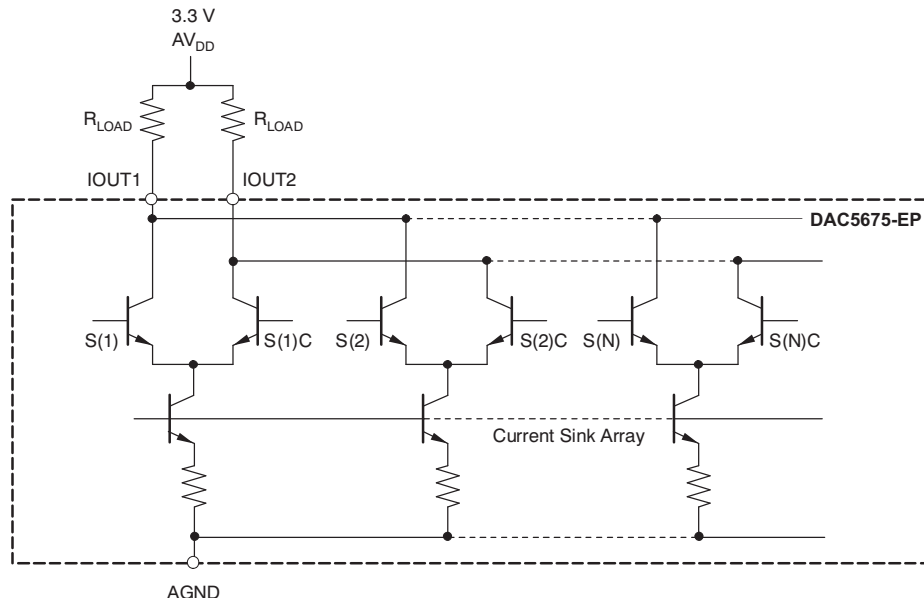
$$I_{O(FS)} = 16 \times I_{BIAS} = \frac{16 \times V_{EXTIO}}{R_{BIAS}} \quad (7)$$

where V_{EXTIO} is the voltage at terminal $EXTIO$. The bandgap reference voltage delivers a stable voltage of 1.2 V. This reference can be overridden by applying an external voltage to terminal $EXTIO$. The bandgap reference can additionally be used for external reference operation. In such a case, an external buffer amplifier with high impedance input should be selected in order to limit the bandgap load current to less than 100 nA. The capacitor C_{EXT} may be omitted. Terminal $EXTIO$ serves as either an input or output node. The full-scale output current is adjustable from 20 mA down to 2 mA by varying resistor R_{BIAS} .

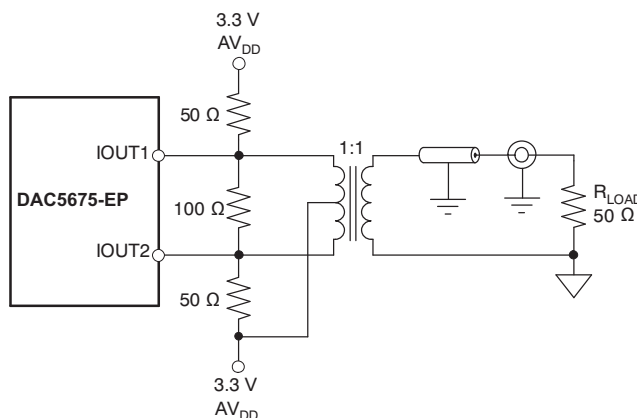
Analog Current Outputs

[Figure 21](#) shows a simplified schematic of the current source array output with corresponding switches. Differential NPN switches direct the current of each individual NPN current source to either the positive output node I_{OUT1} or its complementary negative output node I_{OUT2} . The output impedance is determined by the stack of the current sources and differential switches and is $>300 \text{ k}\Omega$ in parallel with an output capacitance of 5 pF.

The external output resistors are referred to the positive supply AV_{DD} .

APPLICATION INFORMATION (continued)**Figure 21. Equivalent Analog Current Output**

The DAC5675 can easily be configured to drive a doubly-terminated 50-Ω cable using a properly selected transformer. Figure 22 and Figure 23 show the 1:1 and 4:1 impedance ratio configuration, respectively. These configurations provide maximum rejection of common-mode noise sources and even-order distortion components, thereby doubling the power of the DAC to the output. The center tap on the primary side of the transformer is terminated to AV_{DD} , enabling a dc-current flow for both IOUT1 and IOUT2. Note that the ac performance of the DAC5675 is optimum and specified using a 1:1 differential transformer-coupled output.

**Figure 22. Driving a Doubly-Terminated 50-Ω Cable Using a 1:1 Impedance Ratio Transformer**

APPLICATION INFORMATION (continued)

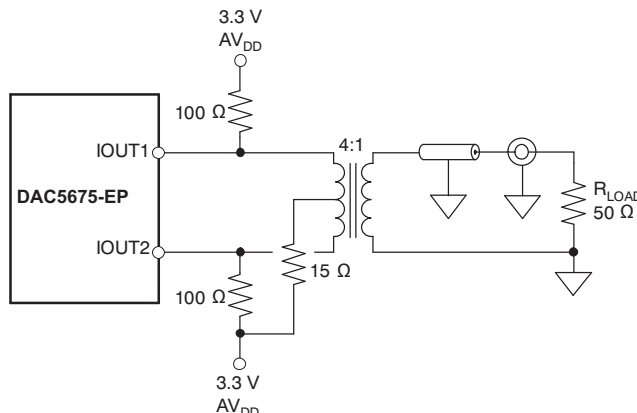


Figure 23. Driving a Doubly-Terminated 50-Ω Cable Using a 4:1 Impedance Ratio Transformer

Figure 24(a) shows the typical differential output configuration with two external matched resistor loads. The nominal resistor load of 25 Ω gives a differential output swing of 1 V_{PP} (0.5 V_{PP} single ended) when applying a 20-mA full-scale output current. The output impedance of the DAC5675 slightly depends on the output voltage at nodes IOUT1 and IOUT2. Consequently, for optimum dc-integral nonlinearity, the configuration of Figure 24(b) should be chosen. In this current/voltage (I-V) configuration, terminal IOUT1 is kept at AV_{DD} by the inverting operational amplifier. The complementary output should be connected to AV_{DD} to provide a dc-current path for the current sources switched to IOUT1. The amplifier maximum output swing and the full-scale output current of the DAC determine the value of the feedback resistor R_{FB}. The capacitor C_{FB} filters the steep edges of the DAC5675 current output, thereby reducing the operational amplifier slew-rate requirements. In this configuration, the operational amplifier should operate at a supply voltage higher than the resistor output reference voltage AV_{DD} as a result of its positive and negative output swing around AV_{DD}. Node IOUT1 should be selected if a single-ended unipolar output is desired.

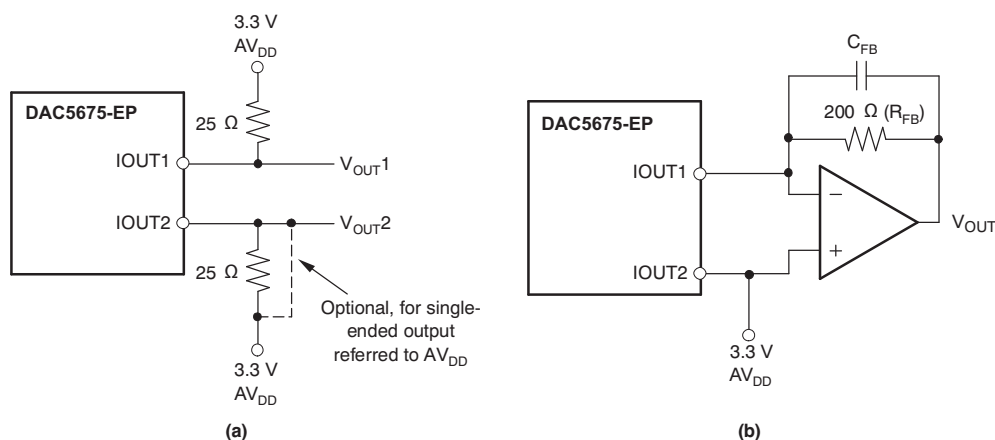


Figure 24. Output Configurations

Sleep Mode

The DAC5675 features a power-down mode that turns off the output current and reduces the supply current to approximately 6 mA. The power-down mode is activated by applying a logic level one to the SLEEP pin, pulled down internally.

DEFINITIONS

Definitions of Specifications and Terminology

Gain error is defined as the percentage error in the ratio between the measured full-scale output current and the value of $16 \times V_{(\text{EXTIO})}/R_{\text{BIAS}}$. A $V_{(\text{EXTIO})}$ of 1.25 V is used to measure the gain error with an external reference voltage applied. With an internal reference, this error includes the deviation of $V_{(\text{EXTIO})}$ (internal bandgap reference voltage) from the typical value of 1.25 V.

Offset error is defined as the percentage error in the ratio of the differential output current (IOUT1-IOUT2) and the half of the full-scale output current for input code 8192.

THD is the ratio of the rms sum of the first six harmonic components to the rms value of the fundamental output signal.

SNR is the ratio of the rms value of the fundamental output signal to the rms sum of all other spectral components below the Nyquist frequency, including noise, but excluding the first six harmonics and dc.

SINAD is the ratio of the rms value of the fundamental output signal to the rms sum of all other spectral components below the Nyquist frequency, including noise and harmonics, but excluding dc.

ACPR or adjacent channel power ratio is defined for a 3.84-Mcps 3GPP W-CDMA input signal measured in a 3.84-MHz bandwidth at a 5-MHz offset from the carrier with a 12-dB peak-to-average ratio.

APSSR or analog power supply ratio is the percentage variation of full-scale output current versus a 5% variation of the analog power supply AV_{DD} from the nominal. This is a dc measurement.

DPSSR or digital power supply ratio is the percentage variation of full-scale output current versus a 5% variation of the digital power supply DV_{DD} from the nominal. This is a dc measurement.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
DAC5675MPHPEP	Active	Production	HTQFP (PHP) 48	250 JEDEC TRAY (10+1)	Yes	NIPDAU	Level-3-260C-168 HR	-55 to 125	DC5675MEP
DAC5675MPHPREP	Active	Production	HTQFP (PHP) 48	1000 LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-55 to 125	DC5675MEP
V62/05619-01XE	Active	Production	HTQFP (PHP) 48	1000 LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-55 to 125	DC5675MEP
V62/05619-02XE	Active	Production	HTQFP (PHP) 48	250 JEDEC TRAY (10+1)	Yes	NIPDAU	Level-3-260C-168 HR	-55 to 125	DC5675MEP

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

⁽⁴⁾ **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "--" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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OTHER QUALIFIED VERSIONS OF DAC5675-EP :

- Catalog : [DAC5675](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
DAC5675MPHPREP	HTQFP	PHP	48	1000	330.0	16.4	9.6	9.6	1.5	12.0	16.0	Q2

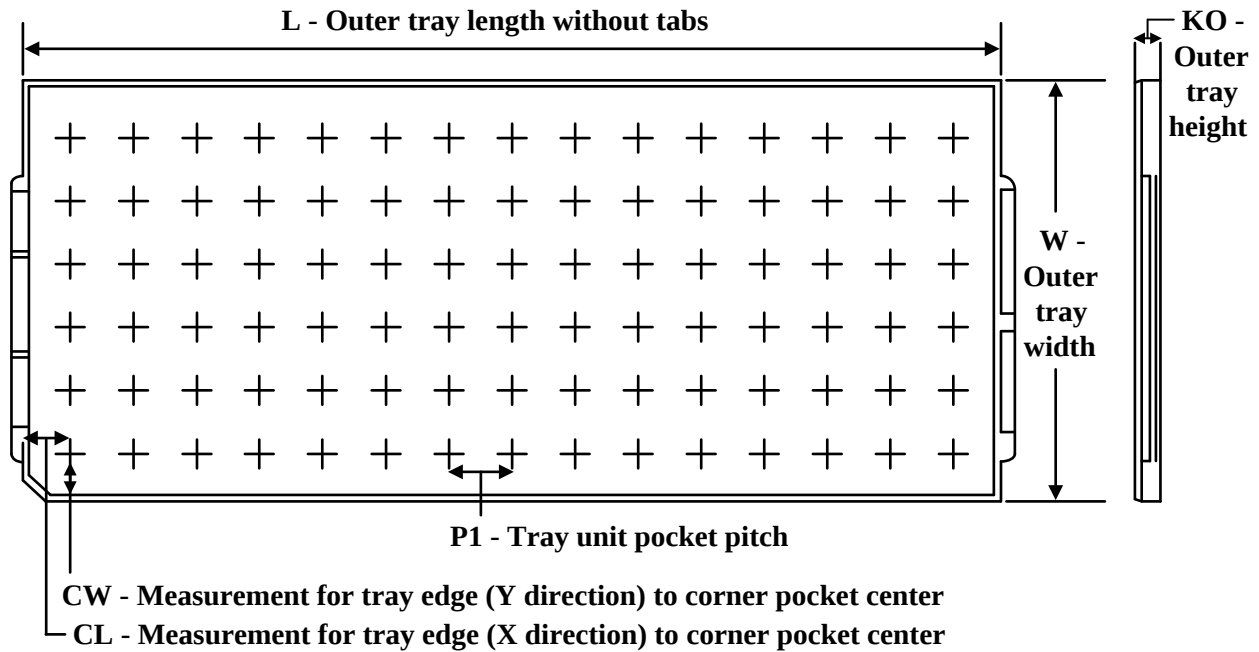
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DAC5675MPHPREP	HTQFP	PHP	48	1000	350.0	350.0	43.0

TRAY



Chamfer on Tray corner indicates Pin 1 orientation of packed units.

*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	Unit array matrix	Max temperature (°C)	L (mm)	W (mm)	K0 (µm)	P1 (mm)	CL (mm)	CW (mm)
DAC5675MPHPEP	PHP	HTQFP	48	250	10 x 25	150	315	135.9	7620	12.2	11.1	11.25
V62/05619-02XE	PHP	HTQFP	48	250	10 x 25	150	315	135.9	7620	12.2	11.1	11.25

GENERIC PACKAGE VIEW

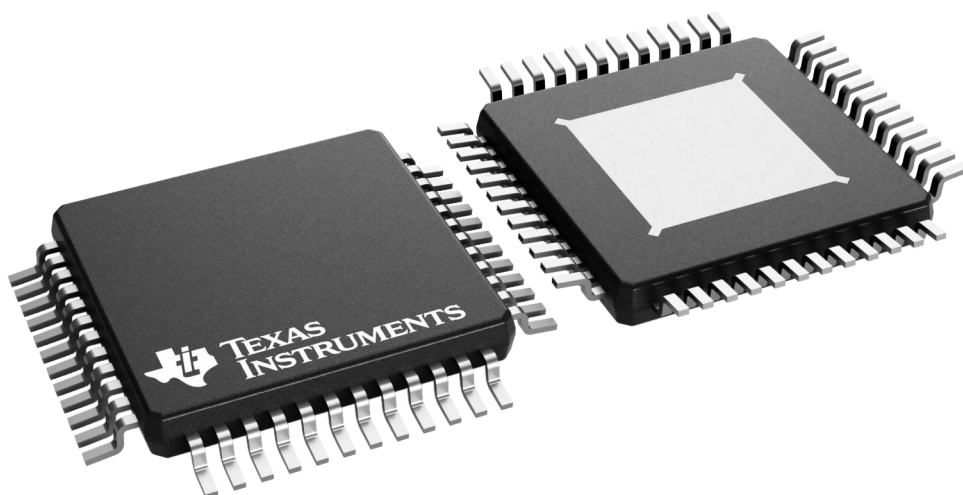
PHP 48

TQFP - 1.2 mm max height

7 x 7, 0.5 mm pitch

QUAD FLATPACK

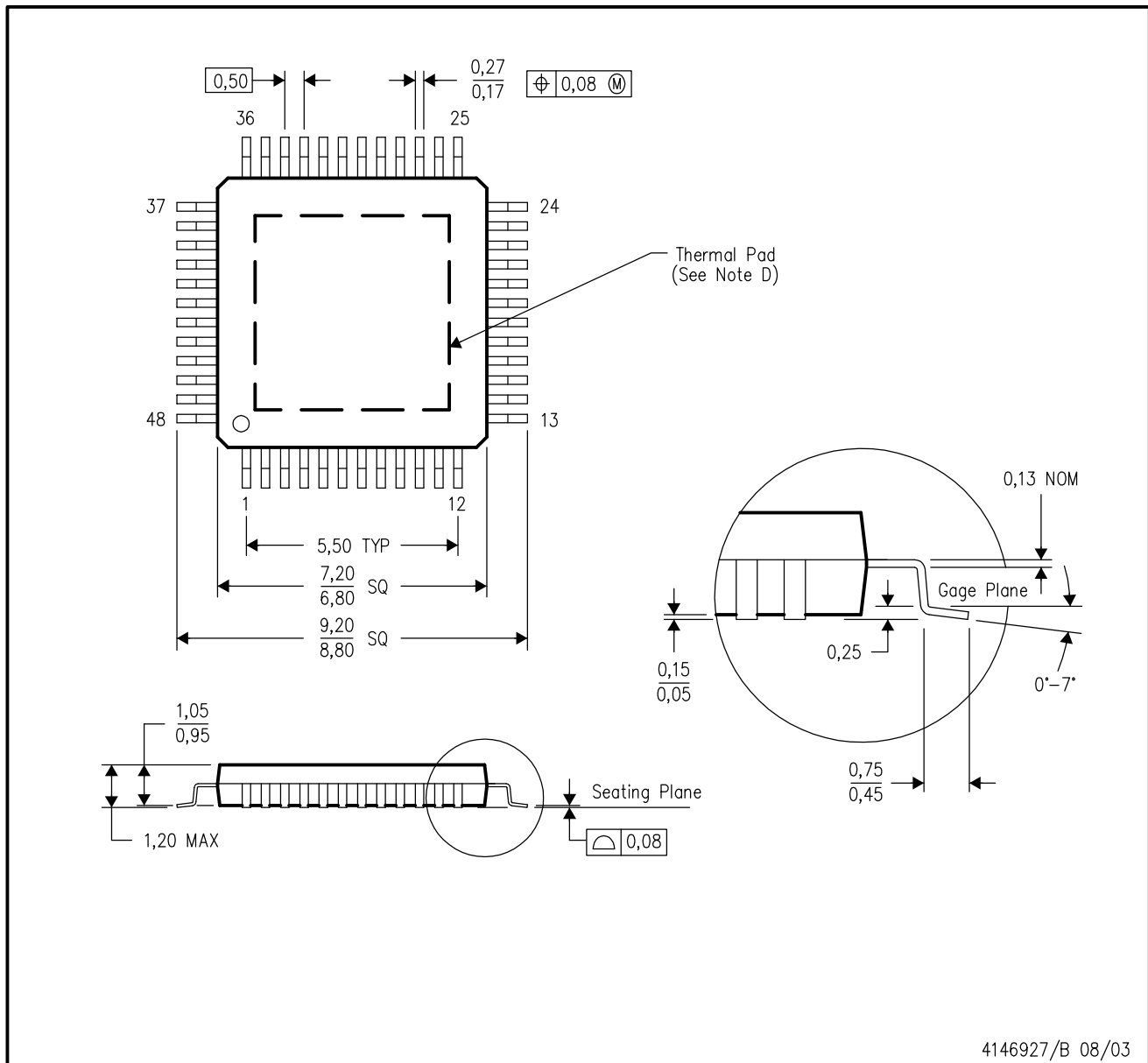
This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



4226443/A

PHP (S-PQFP-G48)

PowerPAD™ PLASTIC QUAD FLATPACK



- 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
 - D. This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 for information regarding recommended board layout. This document is available at www.ti.com <<http://www.ti.com>>.
 - E. Falls within JEDEC MS-026

PowerPAD is a trademark of Texas Instruments.

THERMAL PAD MECHANICAL DATA

PHP (S-PQFP-G48)

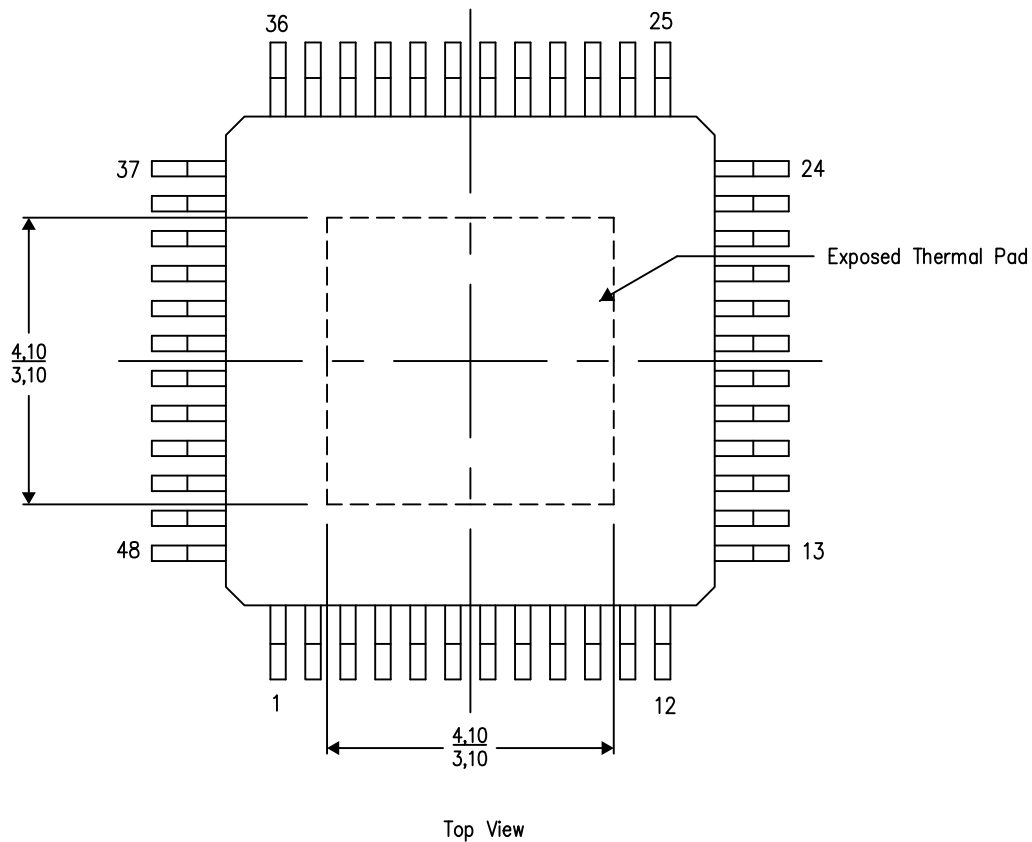
PowerPAD™ PLASTIC QUAD FLATPACK

THERMAL INFORMATION

This PowerPAD™ package incorporates an exposed thermal pad that is designed to be attached to a printed circuit board (PCB). The thermal pad must be soldered directly to the PCB. After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For additional information on the PowerPAD package and how to take advantage of its heat dissipating abilities, refer to Technical Brief, PowerPAD Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 and Application Brief, PowerPAD Made Easy, Texas Instruments Literature No. SLMA004. Both documents are available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.

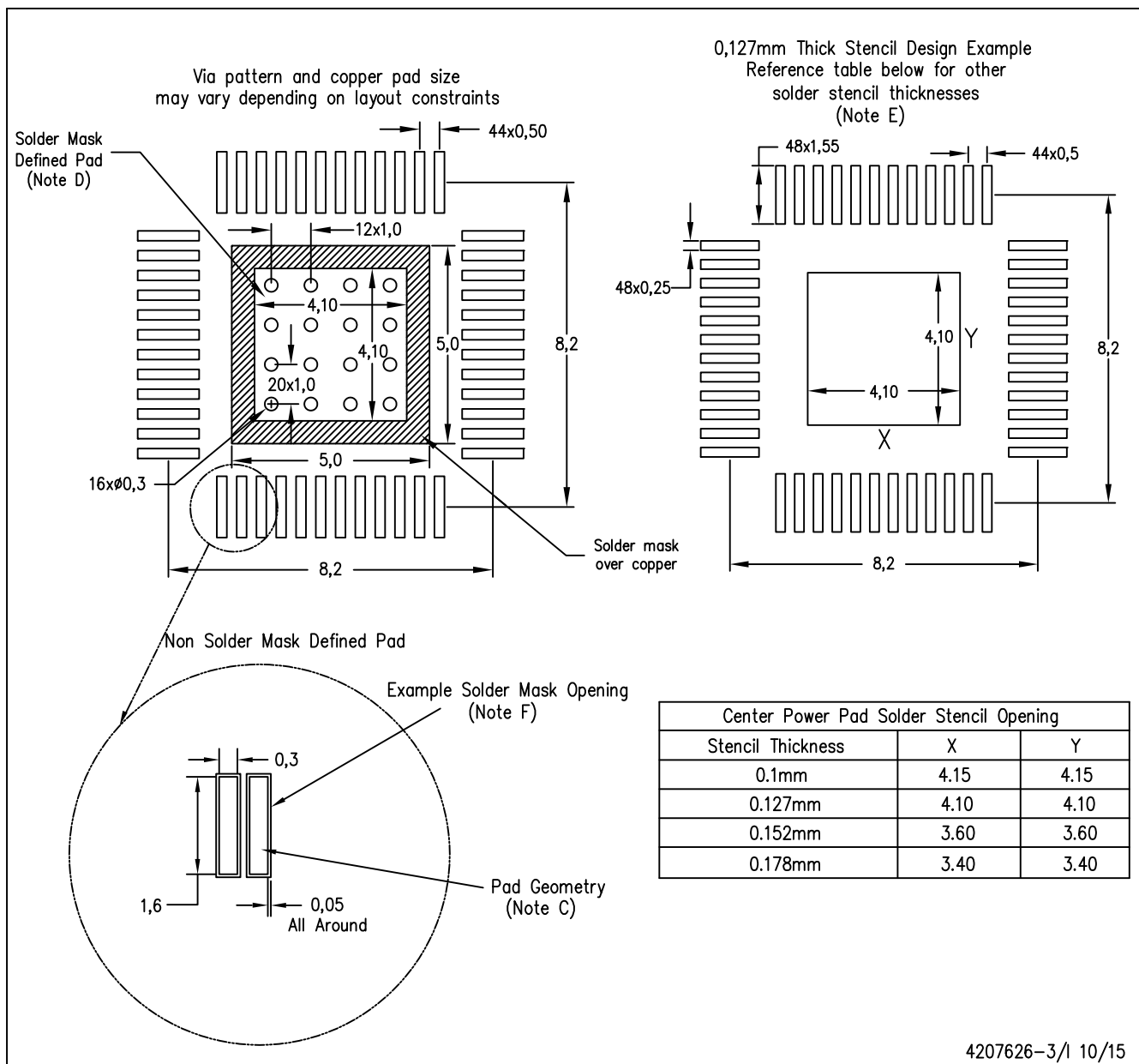


Exposed Thermal Pad Dimensions

4206329-3/P 03/15

NOTE: A. All linear dimensions are in millimeters

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- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Publication IPC-7351 is recommended for alternate designs.
 - D. This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002, SLMA004, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <<http://www.ti.com>>.
 - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
 - F. Customers should contact their board fabrication site for recommended solder mask tolerances and via tenting options for vias placed in the thermal pad.

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