TRIPLE 10-BIT 180-MSPS GRAPHICS AND VIDEO DAC

FEATURES

- **Triple 10-Bit Digital-to-Analog Converters (DACs)**
- **180-MSPS Operation**
- **Direct Drive of Double-Terminated 75-Ω Load Into Standard Video Levels**
- **Bi-Level Sync and Blank Level Generation**
- **Internal Voltage Reference**
- **Low-Power Operation From 3.3-V Analog and 1.8-V Digital Supply Levels**
- **1.8-V Compatible Inputs**

APPLICATIONS

- **Graphics and Video Generation**
- **High-Resolution Image Processing**
- **Generic Triple D/A Converter**

DESCRIPTION

The THS8136 is a general-purpose triple high-speed digital-to-analog (D/A) converter optimized for use in video/graphics applications. The device operates from 3.3-V analog and 1.8-V digital supplies with D/A converter performance assured at sampling rates up to 180 MHz. The THS8136 consists of three 10-bit D/A converters and additional circuitry for bi-level sync and blanking level generation. The current-steering DACs have been specifically designed to produce standard video output levels when directly connected to a single-ended double-terminated 75-Ω coaxial cable.

By providing a dc offset in sync insertion mode, the THS8136 can generate a bi-level sync on the AG DAC output without sacrificing DAC resolution. Support is also provided for insertion of RGB or YPbPr reference or blanking levels, irrespective of the the DAC input codes. A generic DAC mode is provided for applications not requiring sync generation. All digital inputs are 1.8-V compatible.

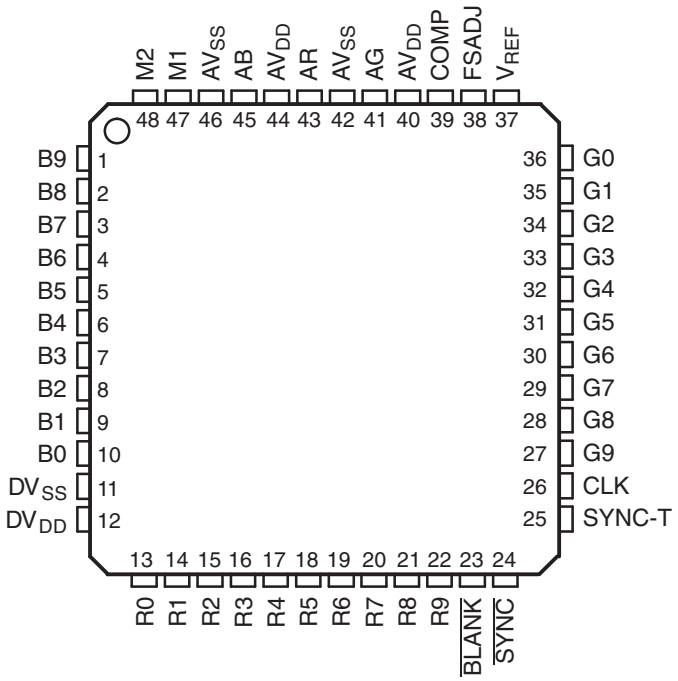
ORDERING INFORMATION(1)

T_A	PACKAGE(2)		ORDERABLE PART NUMBER
0°C to 70°C	PowerPAD™ TQFP-48 – PHP	Tray	THS8136PHP
		Tape and reel	THS8136PHPR
–40°C to 85°C	PowerPAD™ TQFP-48 – PHP	Tray	THS8136IPHP
		Tape and reel	THS8136IPHPR

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.

(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

PHP (TQFP-48) PowerPAD PACKAGE
(TOP VIEW)



TERMINAL FUNCTIONS

TERMINAL		I/O	DESCRIPTION
NAME	NO.		
AB	45	O	Analog blue current output, capable of directly driving a double terminated 75-Ω coaxial cable
AG	41	O	Analog green current output, capable of directly driving a double terminated 75-Ω coaxial cable
AR	43	O	Analog red current output, capable of directly driving a double terminated 75-Ω coaxial cable
AV_{DD}	40, 44	I	Analog power supply (3.3 V). All AV_{DD} pins must be connected.
AV_{SS}	42, 46	I	Analog ground
$\overline{SYNC}$	24	I	Sync insertion input. Active low. When asserted, the G output is forced to the bottom sync tip level.
SYNC-T	25	I	Connect to DV_{SS} (GND) or logic low to enable bi-level sync insertion. Connect to DV_{DD} (1.8 V) or logic high for generic DAC applications not requiring sync insertion.
M2	48	I	Connect to DV_{SS} (GND) or logic 0 for RGB blanking level operation. Connect to the $\overline{SYNC}$ control input for YPbPr video operation.
M1	47	I	Must be tied to DV_{SS} (GND) or logic 0 for normal operation.
B0 B1 B2 B3 B4 B5 B6 B7 B8 B9	10 9 8 7 6 5 4 3 2 1	I	Blue or (Pb) pixel data input. Signals with index 0 denote the least significant bit. Unused inputs should be connected to DV_{SS}(GND).
$\overline{BLANK}$	23	I	Blanking control input, active low. A rising edge on CLK latches BLANK. When asserted, the AR, AG, and AB outputs are driven to the reference blanking level, regardless of the value on the data inputs.
CLK	26	I	Clock input. A rising edge on CLK latches R0–R9, G0–G9, B0–B9, and BLANK.
COMP	39	O	Compensation terminal. A 0.1-µF capacitor must be connected between COMP and AV_{DD}.
DV_{DD}	12	I	Digital power supply (1.8 V)
DV_{SS}	11	I	Digital ground
FSADJ	38	I	Full-scale adjust control. The full-scale current drive on each of the output channels is determined by the value of a resistor R_{FS} connected between this terminal and AV_{SS}. Figure 3 shows the relationship between full-scale output voltage compliance and R_{FS} for the nominal DAC termination of 37.5 Ω.
G0 G1 G2 G3 G4 G5 G6 G7 G8 G9	36 35 34 33 32 31 30 29 28 27	I	Green (or Y) pixel data input. Signals with index 0 denote the least significant bit. Unused inputs should be connected to DV_{SS}(GND).
R0 R1 R2 R3 R4 R5 R6 R7 R8 R9	13 14 15 16 17 18 19 20 21 22	I	Red (or Pr) pixel data input. Signals with index 0 denote the least significant bit. Unused inputs should be connected to DV_{SS}(GND).

DETAILED DESCRIPTION

The THS8136 is a fast well-matched triple DAC with current outputs optimized for graphics and video applications without sacrificing is usefulness as a generic DAC. The DAC output stages are designed to provide direct drive of doubly-terminated 75-Ω loads (37.5 Ω). The full-scale output current of all three DACs is determined by a single resistor connecting the FSADJ pin to AV_{SS} (GND). A 3.8-kΩ resistor is suitable for most applications requiring 700-mV output levels. Additional circuitry and digital input controls for analog sync and blank level generation are provided for both RGB and YPbPr color spaces. A generic mode of operation is provided for applications not requiring sync insertion. Figure 1 shows a block diagram of the device.

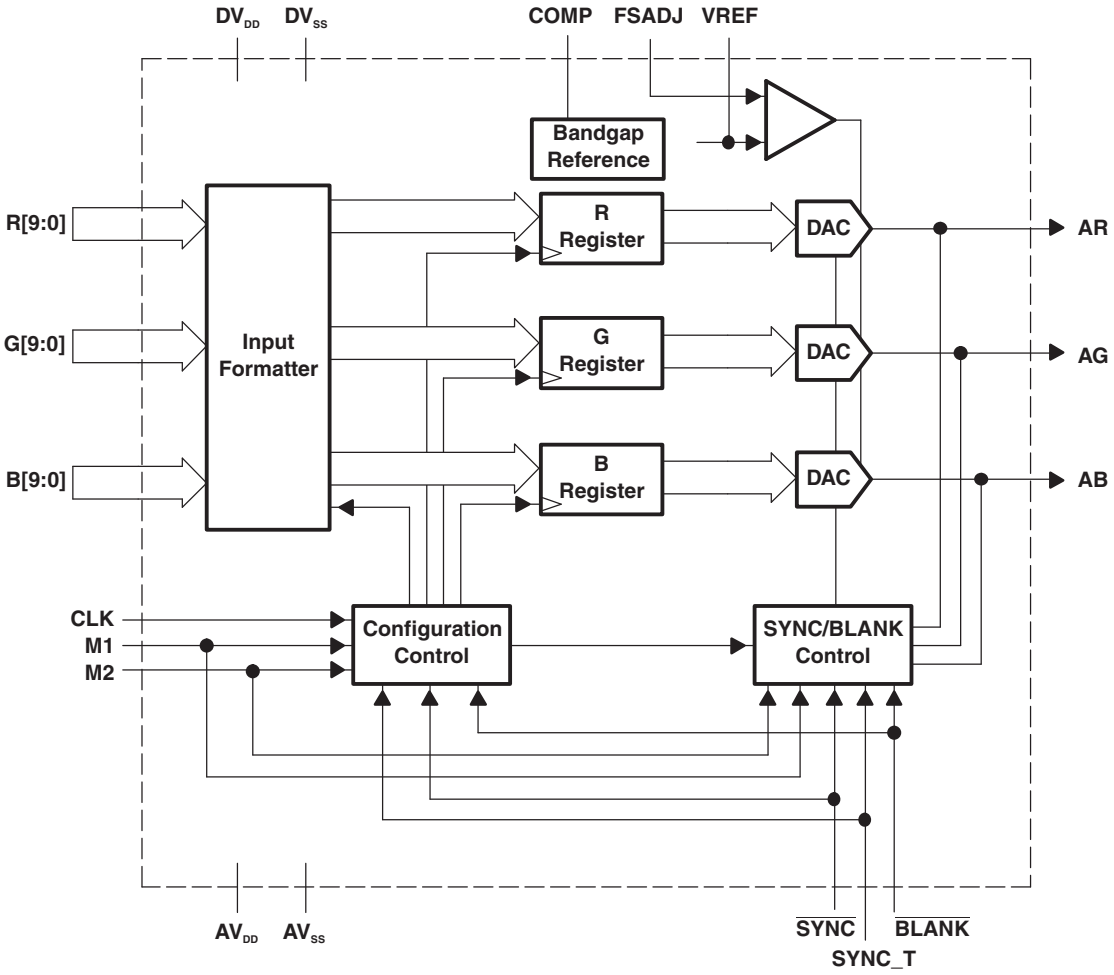


Figure 1. Functional Block Diagram

Generic DAC Mode Versus Sync Insertion Mode

When configured for sync insertion, the THS8136 provides additional dc bias on the DAC outputs to provide headroom for negative bi-level sync insertion. Such bias might be undesirable in applications where no analog sync insertion is required, since it results in additional power consumption and might prevent dc coupling of the DAC outputs. In such cases, only triple DAC operation without dc bias (i.e., DAC input code 0 corresponding to 0-V output) might be preferred. Generic DAC mode is easily selected by connecting the SYNC and SYNC_T pins to DV_{DD} (or logic 1) and the M1 and M2 pins to DV_{SS} (or logic 0). $\overline{\text{BLANK}}$ is functional in both generic mode and sync insertion mode.

Blanking Generation

The $\overline{\text{BLANK}}$ control input forces the output amplitude on all channels to the blanking or reference level, irrespective of the value on the data input ports. The output blanking level on each channel and its relation to active video varies depending on the mode of operation. In generic DAC mode, the output blank level for each DAC is at 0 V and corresponds to a DAC input code of 0. When sync insertion is enabled a 350-mV dc bias (R_{FS} selected for 700-mV output) is applied to provide room for bi-level sync insertion. When RGB sync insertion is enabled, the output blank level of each DAC will be at 350 mV and will correspond to a DAC input code of 0. In YPbPr video mode, the blank level of each DAC is 350 mV, but the AR and AB blank levels correspond to a DAC input code of 512 to accommodate mid-level UV blank levels. A video to blank level amplitude ratio of 2:1 is maintained for various R_{FS} values, provided the maximum DAC output compliance is not exceeded.

Sync Generation

The $\overline{\text{SYNC}}$ and SYNC_T control inputs can be used to enable the superposition of a bi-level sync on the AG DAC output. Correctly timed assertion of the $\overline{\text{SYNC}}$ input (active low) allows insertion of an analog composite sync on the AG DAC output consisting of horizontal sync and vertical sync. The video to sync amplitude ratio is 7:3 providing a 300 mV sync tip, when FSADJ is selected to provide 700 mV full-scale graphics or video. This 7:3 video to sync amplitude ratio is maintained for various R_{FS} values, provided the maximum DAC output compliance is not exceeded. The SYNC-T input pin must be connected to DV_{SS} (or logic low) to enable sync insertion.

Device Configuration

The THS8136 operating mode is determined from the state of the $\overline{\text{SYNC}}$, SYNC-T, M1, and M2 control terminals. Generic DAC mode is easily selected by connecting $\overline{\text{SYNC}}$ and SYNC_T to DV_{DD} (or logic high) and M1 and M2 to DV_{SS} (logic low). To enable sync insertion, the SYNC_T terminal must be connected to DVSS (or logic low). YPbPr video mode can be selected for support of mid-level PbPr blanking by connecting the sync control input to both the $\overline{\text{SYNC}}$ and M2 input terminals. The M1 terminal must be connected to DV_{SS} (logic 0) for all operating modes. See Table 1 and Figure 4, Figure 5, and Figure 6 for additional information on configuring the THS8136.

Table 1. Table 1. Device Configuration

OPERATING MODE	M1	M2	SYNC_T	$\overline{\text{SYNC}}$	DESCRIPTION
Generic DAC	0	0	1	1	Sync insertion disabled. The blank level on all DAC outputs corresponds to 0-V and DAC input code 0.
RGB Sync Insertion	0	0	0	$\overline{\text{SYNC}}$	DC bias and sync insertion enabled. The blank level on all DAC outputs corresponds to DAC input code 0.
YPbPr Sync Insertion	0	$\overline{\text{SYNC}}$	0	$\overline{\text{SYNC}}$	DC bias and sync insertion enabled. AB and AR mid-level blanking corresponds to DAC input code 512.

DAC Operation

The DAC output drivers generate a current with a drive level that can be user-modified by choosing an appropriate resistor value R_{FS} connected between the FSADJ terminal and AV_{SS} (GND). All current source amplitudes (graphics/video, blanking, and sync on AG) are derived from R_{FS} and an internal voltage reference such that the relative amplitudes of sync, blank, and graphics/video are always equal to their nominal relationships. The relative amplitudes of these current drivers are maintained without regard to the value of R_{FS}, as long as the maximum current drive capability is not exceeded. Figure 3 shows the relationship between R_{FS} and the current drive level on each channel for full-range DAC input. The voltage compliance outputs in Figure 3 assume termination with a 37.5-Ω resistor. When sync insertion is enabled, an additional current source is enabled providing a DC bias and head-room for negative sync insertion. A fixed R_{FS} value of 3.8 kΩ ($R_{FS(nom)}$) is suitable for most applications requiring 700-mV output levels.

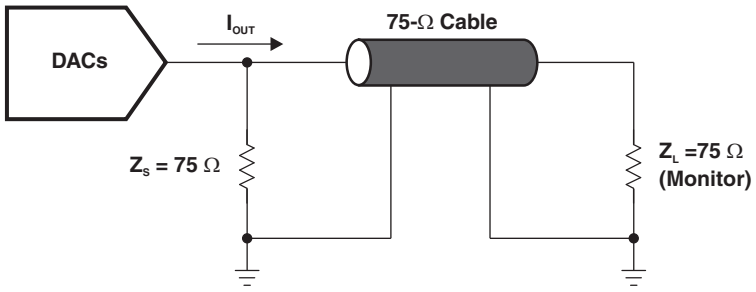


Figure 2. DAC Output Termination

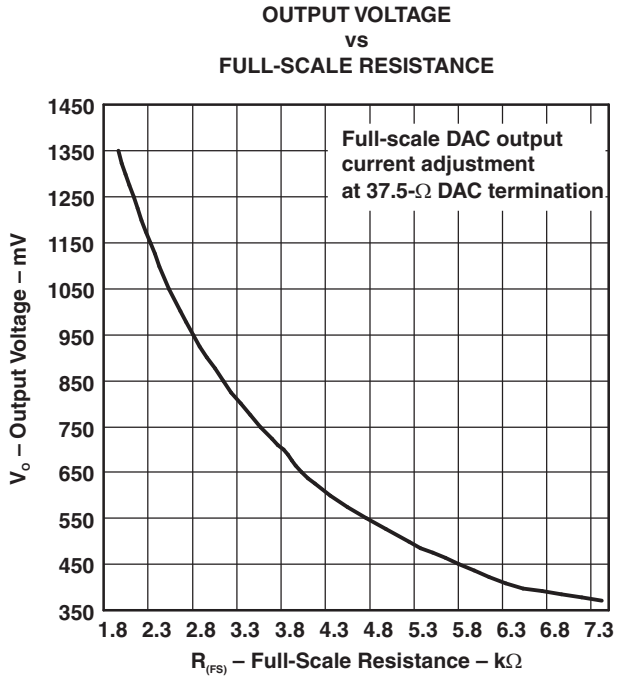
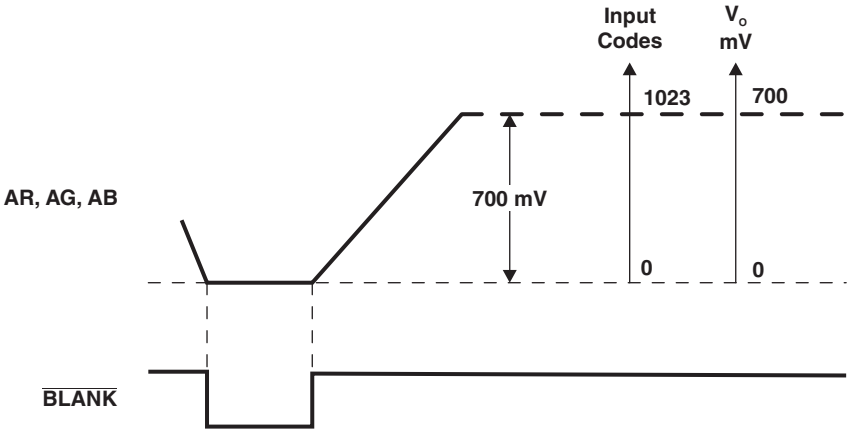


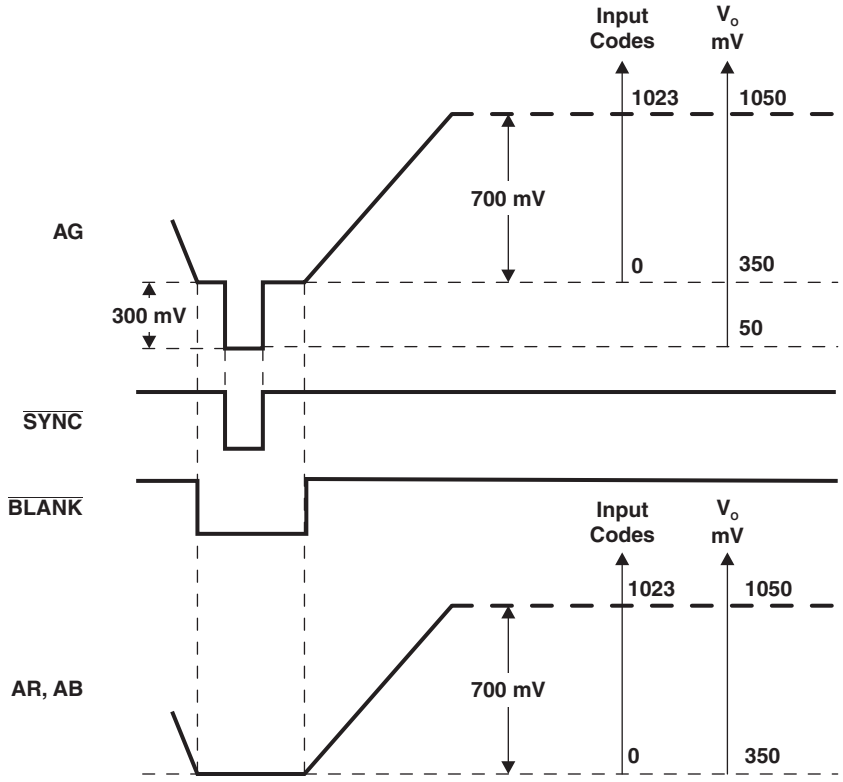
Figure 3. Output Voltage vs Full-Scale Resistance

The user is free to connect another resistor value, but care should be taken not to exceed the maximum current level on each of the DAC outputs as shown in the specifications section. Additionally, DAC output linearity will degrade if the 1.2-V maximum output compliance is exceeded.



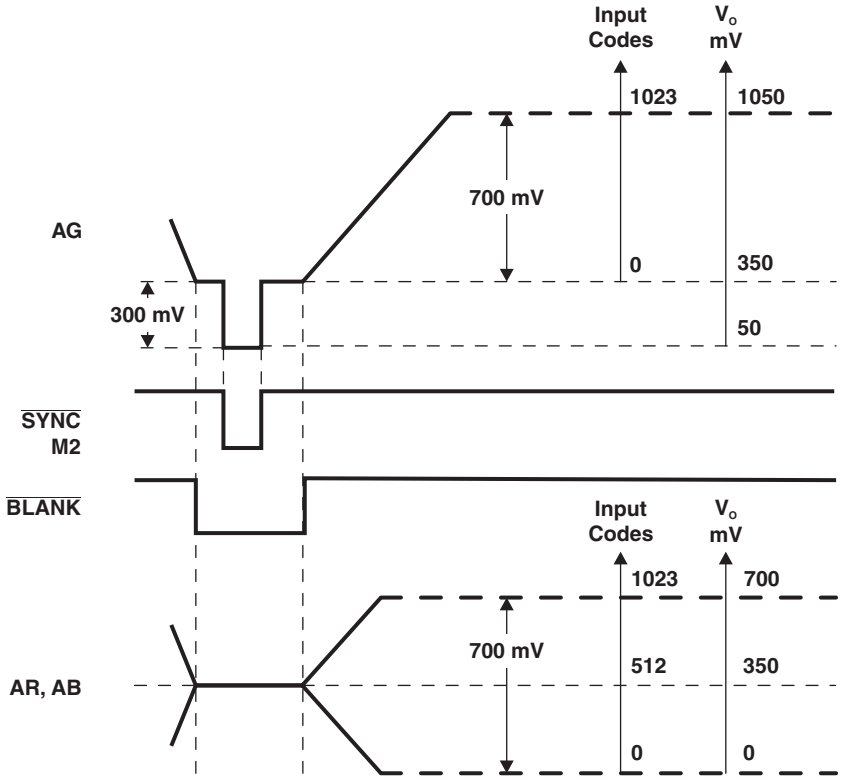
NOTE: $\overline{\text{BLANK}}$ = High in applications not requiring a forced blank level.
R_{FS} chosen for 700-mV output.
R_{LOAD} = 37.5 Ω

Figure 4. Generic DAC Mode (M1 = Low, M2 = Low, $\overline{\text{SYNC}}$ = High, SYNC_T = High)



NOTE: R_{FS} chosen for 700-mV output.
R_{LOAD} = 37.5 Ω

Figure 5. RGB Sync-on-G (M1 = Low, M2 = Low, SYNC_T = Low)



NOTE: R_{FS} chosen for 700-mV output.
R_{LOAD} = 37.5 Ω

Figure 6. YPbPr Sync-on-Y (M1 = Low, M2 = $\overline{\text{SYNC}}$, SYNC_T = Low)

ABSOLUTE MAXIMUM RATINGS(1)

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

	Supply voltage	AV_{DD} to AV_{SS}	–0.5 V to 3.6 V
		DV_{DD} to DV_{SS}	–0.5 V to 1.95 V
		AV_{SS} to DV_{SS}	–0.5 to 0.5 V
	Digital input voltage range to DV_{SS}		–0.5 V to (DV_{DD} + 0.5) V
T_A	Operating free-air temperature range		–40°C to 85°C
T_{stg}	Storage temperature range		–55°C to 150°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.

POWER DISSIPATION RATINGS(1)

BOARD	PACKAGE	$R_{\theta JC}$	$R_{\theta JA}$	$T_A \le 25°C$ POWER RATING	$T_A = 85°C$ POWER RATING
Low-K(2)	TQFP-48-PHP	33.0°C/W	67.60°C/W	1.18 W	0.296 W
High-K(3)	TQFP-48-PHP	33.0°C/W	29.04°C/W	2.75 W	0.689 W

(1) Specified with 105°C maximum junction temperature (T_J).
(2) Specified with thermal pad not soldered to the PCB
(3) Specified with thermal pad soldered to 2-oz Cu plate PCB thermal plane.

RECOMMENDED OPERATING CONDITIONS

		MIN	NOM	MAX	UNIT
Power Supply					
AV_{DD}		3	3.3	3.6	V
DV_{DD}		1.65	1.8	1.95	V
Digital and Reference Inputs					
V_{IH}	High-level input voltage	1.2		DV_{DD}	V
V_{IL}	Low-level input voltage	DV_{SS}		0.7	V
f_{CLK}	Clock frequency	0		180	MHz
$t_{w(CLKH)}$	Pulse duration, clock high	40%		60%	CLK period
$t_{w(CLKL)}$	Pulse duration, clock low	40%		60%	CLK period
$R_{FS(nom)}$	FSADJ resistor(1)		3.8		kΩ

(1) R_{FS} should be chosen such that the maximum full-scale DAC output current (I_{FS}) does not exceed the maximum stated level. This yields the nominal output voltage compliance at the nominal load termination of 37.5 Ω.

POWER SUPPLY ELECTRICAL CHARACTERISTICS

over recommended operating conditions, f_{CLK} = 180 MHz, use of internal reference voltage V_{REF}, R_{FS} = $R_{FS(nom)}$, 37.5-Ω load termination (unless otherwise noted)

PARAMETER		TEST CONDITIONS[1]		MIN	TYP[2]	MAX[3]	UNIT
I_{AVDD}	Operating supply current, analog	CLK = 80 MSPS	Generic (700 mV)		65	72	mA
		CLK = 180 MSPS			65	72	
		CLK = 80 MSPS	Generic (1.2 mV)		110	112	
		CLK = 180 MSPS			110	112	
		CLK = 80 MSPS	Sync Insertion (700 mV + Sync)		94	102	
		CLK = 180 MSPS			94	103	
I_{DVDD}	Operating supply current, digital	CLK = 80 MSPS	Generic (700 mV)		13	16	mA
		CLK = 180 MSPS			31	36	
		CLK = 80 MSPS	Generic (1.2 mV)		14	16	
		CLK = 180 MSPS			31	37	
		CLK = 80 MSPS	Sync Insertion (700 mV + Sync)		13	16	
		CLK = 180 MSPS			31	36	
P_D	Power dissipation	CLK = 80 MSPS	Generic (700 mV)		238	290	mW
		CLK = 180 MSPS			270	329	
		CLK = 80 MSPS	Generic (1.2 mV)		388	434	
		CLK = 180 MSPS			419	475	
		CLK = 80 MSPS	Sync Insertion (700 mV + Sync)		334	398	
		CLK = 180 MSPS			366	441	

(1) A multiburst RGB input test pattern was used in all cases.
(2) TYP current and P_D measured at AV_{DD} = 3.3 V and DV_{DD} = 1.8 V.
(3) MAX current and P_D measured at AV_{DD} = 3.6 V and DV_{DD} = 1.95 V.

DIGITAL INPUTS – DC ELECTRICAL CHARACTERISTICS

over recommended operating conditions, f_{CLK} = 180 MHz, use of internal reference voltage V_{REF}, R_{FS} = $R_{FS(nom)}$, 37.5-Ω load termination (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{IH}	High-level input current	AV_{DD} = 3.3 V, DV_{DD} = 1.8 V, Digital inputs at 1.95 V			1	µA
I_{IL}	Low-level input current	AV_{DD} = 3.3 V, DV_{DD} = 1.8 V, Digital inputs at 0 V			–1	µA
$I_{IH(CLK)}$	High-level input current, CLK	AV_{DD} = 3.3 V, DV_{DD} = 1.8 V, CLK at 1.95 V	–1		1	µA
$I_{IL(CLK)}$	Low-level input current, CLK	AV_{DD} = 3.3 V, DV_{DD} = 1.8 V, CLK at 0 V	–1		1	µA
C_I	Input capacitance	T_A = 25°C		5		pF
t_s	Setup time, data and control inputs		1.5			ns
t_h	Hold time, data and control inputs		500			ps
$t_{d(D)}$	Digital process delay time from first registered color component of pixel[1]			7.5		CLK periods

(1) This parameter is specified by design. The digital process delay is defined as the number of CLK cycles required for the first registered color component of a pixel, starting from the time of registering it on the input bus, to propagate through all processing and appear at the DAC output drivers. The remaining delay through the IC is the analog delay $t_{d(A)}$ of the analog output drivers.

ANALOG (DAC) OUTPUTS ELECTRICAL CHARACTERISTICS

over recommended operating conditions, f_{CLK} = 180 MHz, use of internal reference voltage V_{REF}, $R_{FS} = R_{FS(nom)}$, 37.5-Ω load termination (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
	DAC resolution			10		Bits
INL	Integral nonlinearity	Static, best fit, RGB with sync insertion (700 + sync)		-1/1	–2.5/1.5	LSB
		Static, best fit, generic mode, 1.2 V output range		–1/1		
DNL	Differential nonlinearity	Static, RGB with sync insertion (700 + sync)		–0.4/0.4	±1	LSB
		Static, generic mode, 1.2 V output range		-0.4/0.4		
PSRR	Power supply ripple rejection ratio of DAC output (full scale)	f = DC (1)		38.5		dB
V_{refo}	Voltage reference output		1.12	1.16	1.20	V
R_R	V_{REF} output resistance			284		Ω
K_{IMBAL}	Imbalance between DACs (2)	CLK = 80 MSPS, video mode	–2	1.8	2	%
V_{OC}	DAC output compliance voltage			0.7	1.2	V
I_{FS}	Generic DAC mode	CLK = 80 MSPS (3)	18	18.67	19.5	mA
	RGB with sync insertion enabled	CLK = 80 MSPS (3)	27	28	29.3	
t_{RDAC}	DAC output current rise time	CLK = 80 MSPS, 10 to 90% of full scale (4)	2.8	3.3	3.6	ns
t_{FDAC}	DAC output current fall time	CLK = 80 MSPS, 10 to 90% of full scale (4)	2.8	3.3	3.6	ns
$t_{d(A)}$	Analog output delay	Measured from CLK = $V_{IH(min)}$ to 50% of full-scale transition (5)		4.5		ns
t_S	Analog output settling time	Measured from 50% of full scale transition on output to output settling, within 2% (4)		15		ns

(1) PSRR is measured with a 0.1-µF capacitor between the COMP and AV_{DD} pins and with a 0.1-µF capacitor connected between the V_{REF} and AV_{SS} pins. The ripple amplitude is within the range 100 mVp-p to 500 mVp-p with the DAC output set to full scale and a double-terminated 75 Ω (= 37.5 Ω) load. PSRR is defined as 20 × log(ripple voltage at DAC output/ripple voltage at AV_{DD} input). Limits are from characterization only.
(2) The imbalance between DACs applies to all possible pairs of the three DACs.
(3) Values at $R_{FS} = R_{FS(nom)}$
(4) From characterization only. Measured on the AG channel with $R_{FS} = R_{FS(nom)}$.
(5) This value excludes the digital process delay, $t_{D(D)}$. Limit are from characterization only.

TYPICAL CHARACTERISTICS

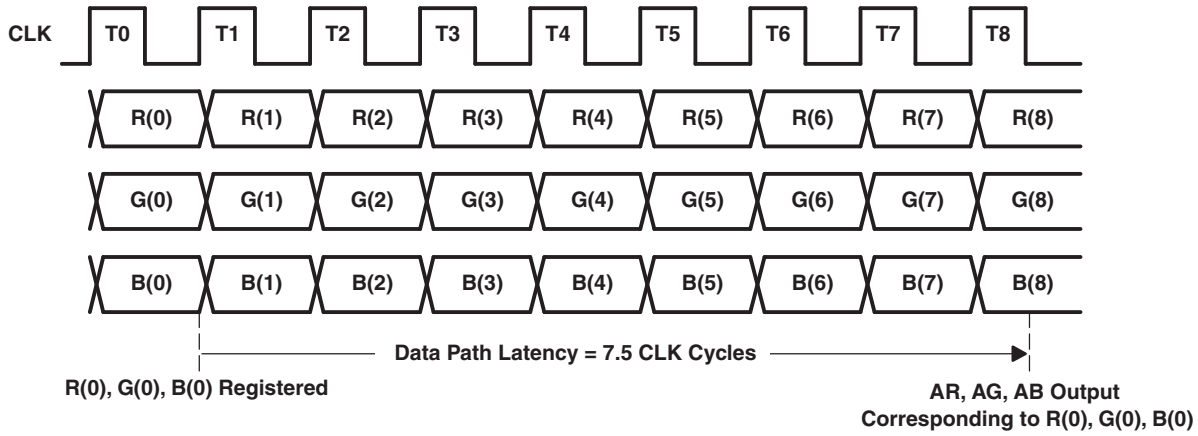


Figure 7. Input Data Internally Latched on Rising Edge of CLK (Data Path Latency is 7.5 CLK Cycles)

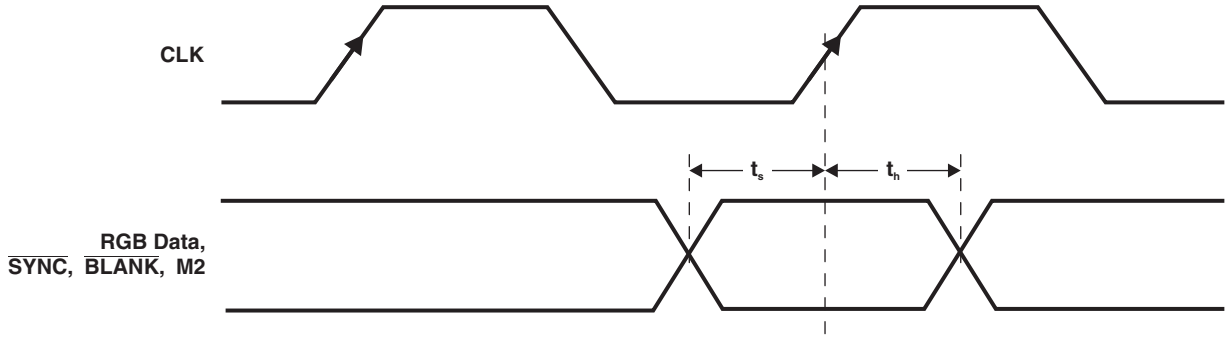


Figure 8. Input Data Registered on Rising Edge of CLK

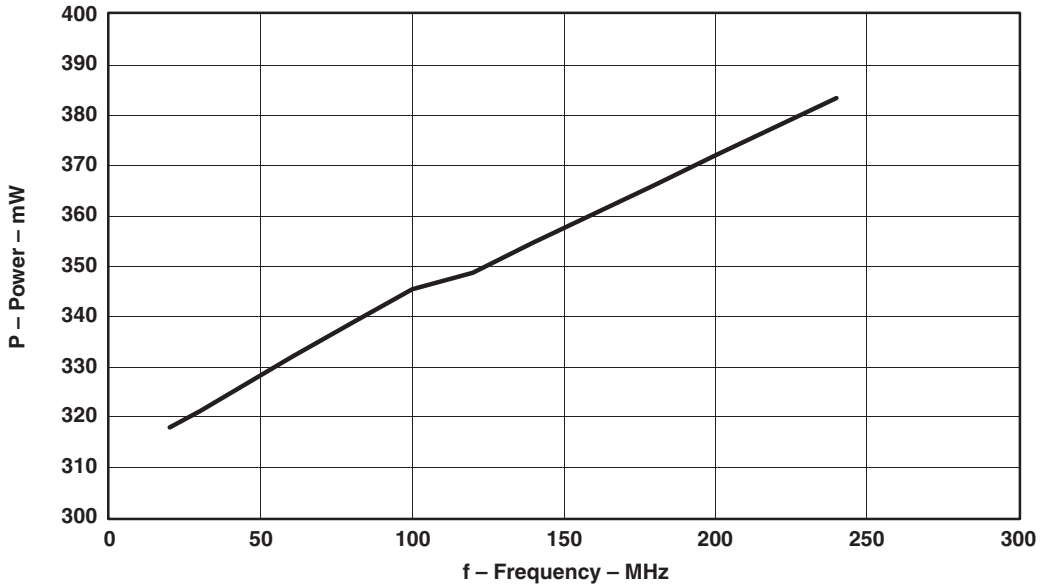


Figure 9. Power vs Clock Frequency, RGB sync insertion, 1-MHz Input Tone on All Channels

APPLICATION INFORMATION

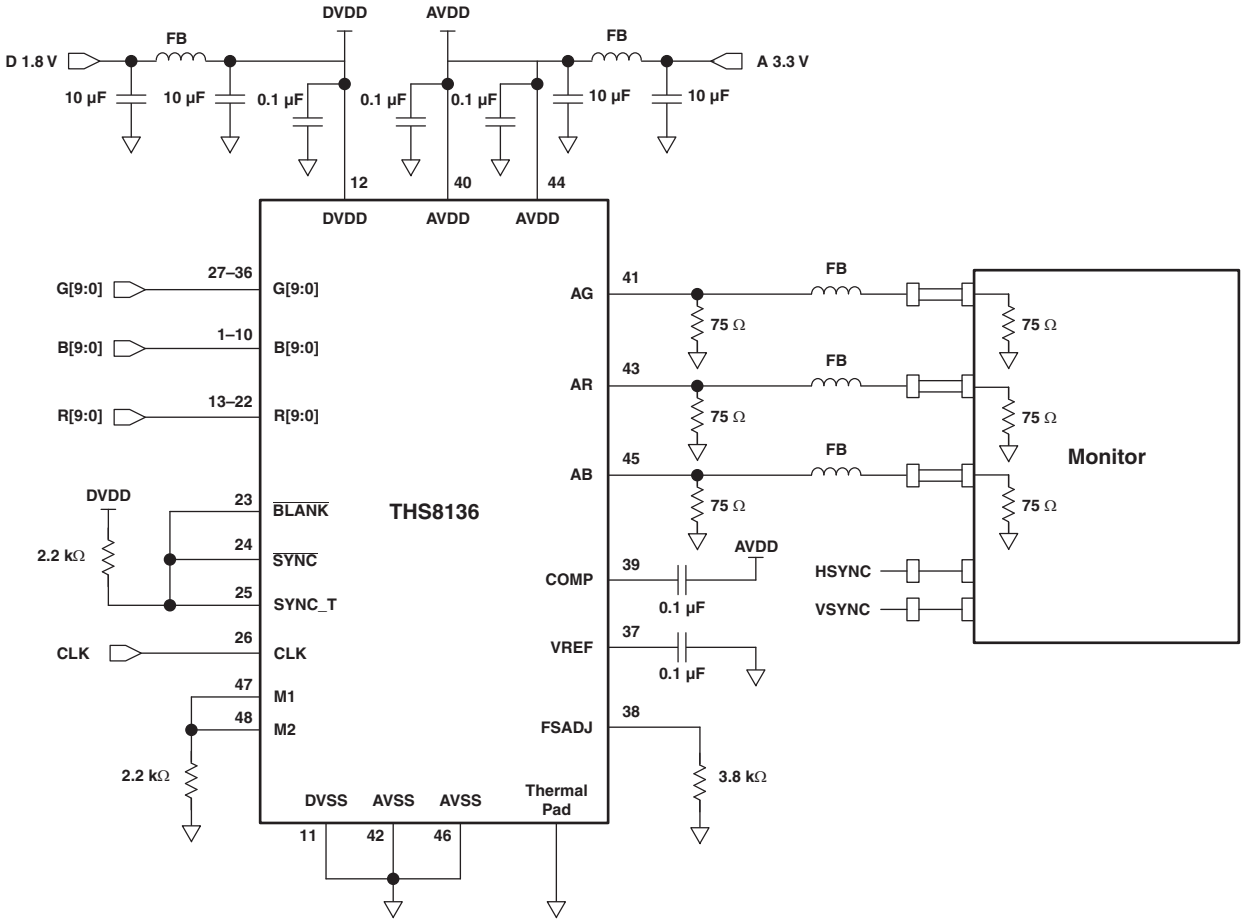
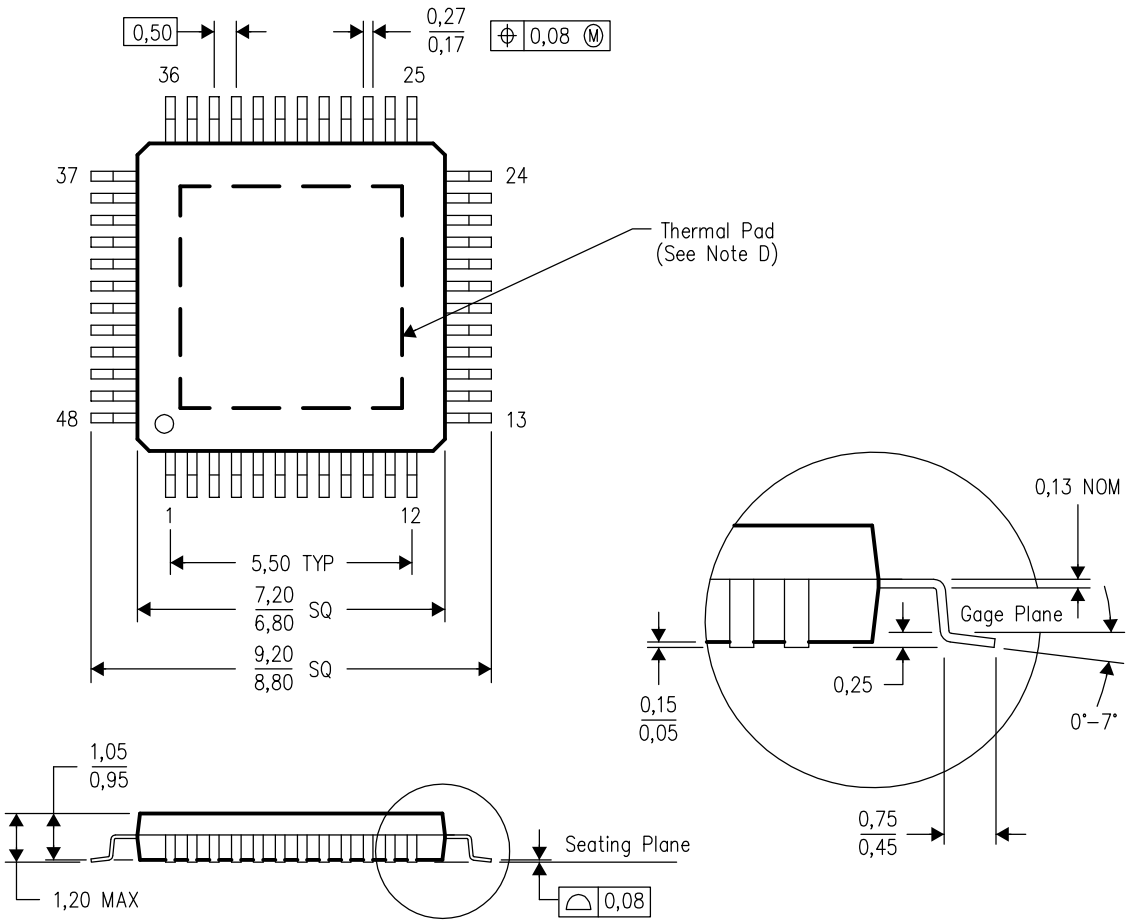


Figure 10. Typical Generic DAC Application Circuit

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

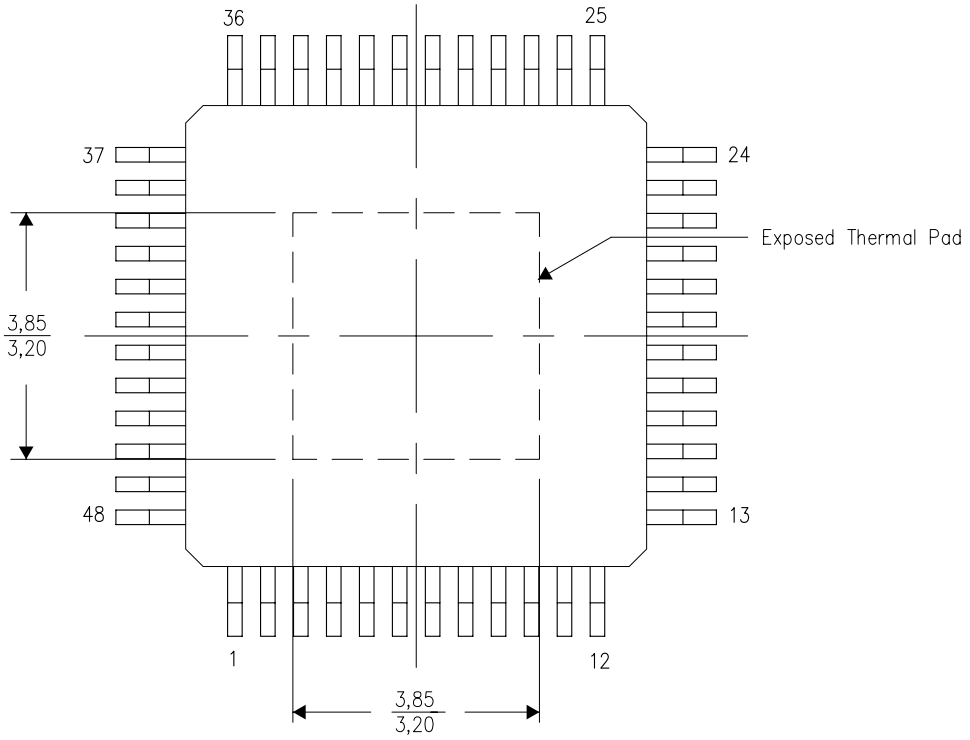
PHP (S–PQFP–G48)

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.

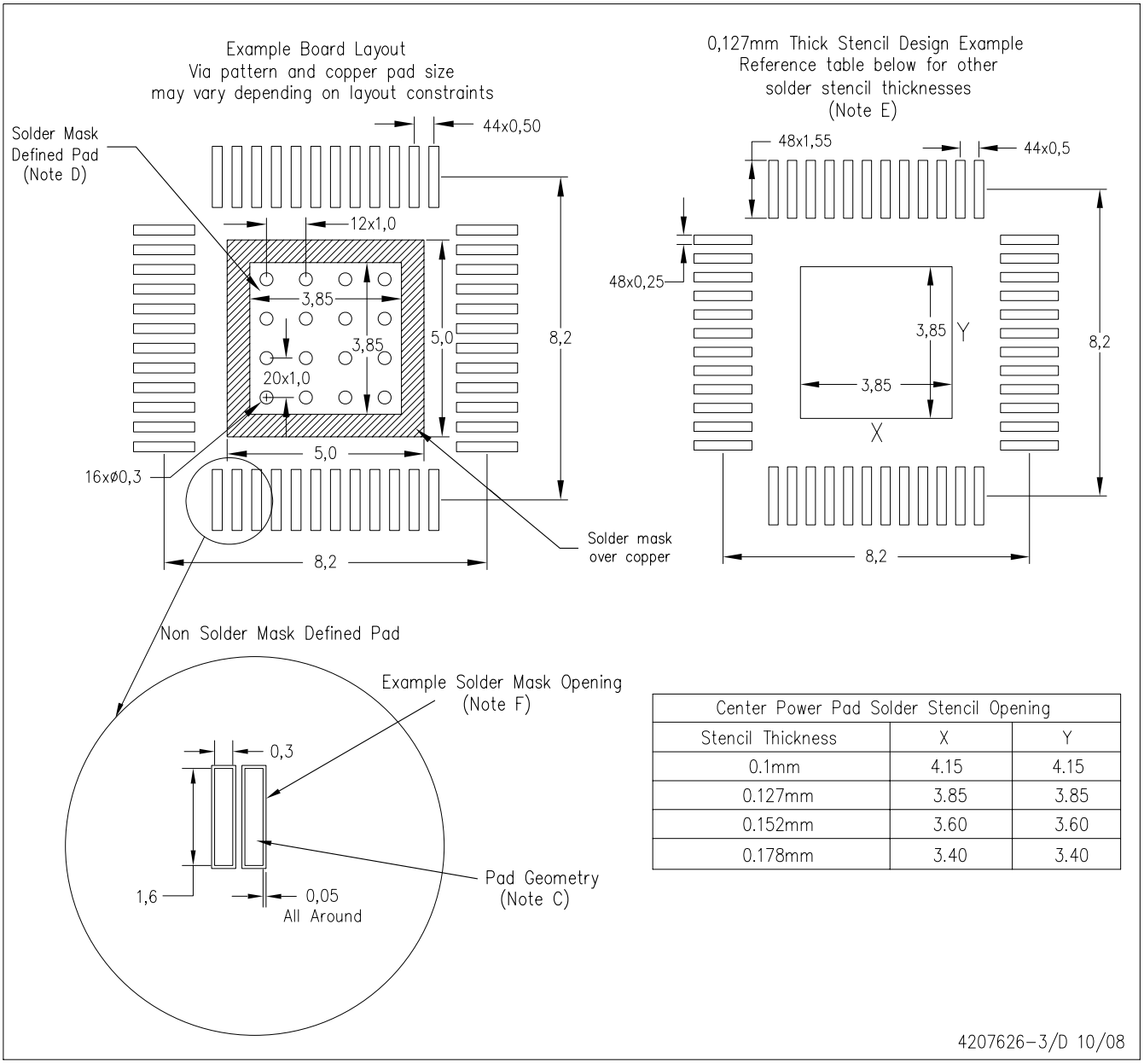


Top View

NOTE: All linear dimensions are in millimeters

Exposed Thermal Pad Dimensions

PHP (R–PDSO–G48) PowerPAD™



Center Power Pad Solder Stencil Opening		
Stencil Thickness	X	Y
0.1mm	4.15	4.15
0.127mm	3.85	3.85
0.152mm	3.60	3.60
0.178mm	3.40	3.40

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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