

## IEEE 1394a THREE-PORT CABLE TRANSCEIVER/ARBITER

### FEATURES

- Fully Supports Provisions of IEEE 1394-1995 Standard for High Performance Serial Bus<sup>1</sup> and the P1394a Supplement
- Fully Interoperable With FireWire™ and i.LINK™ Implementation of IEEE Std 1394
- Fully Compliant With OpenHCI Requirements
- Provides Three P1394a Fully Compliant Cable Ports at 100/200/400 Megabits per Second (Mbits/s)
- Full P1394a Support Includes: Connection Debounce, Arbitrated Short Reset, Multispeed Concatenation, Arbitration Acceleration, Fly-By Concatenation, Port Disable/Suspend/Resume
- Extended Resume Signaling for Compatibility With Legacy DV Devices
- Power-Down Features to Conserve Energy in Battery Powered Applications Include: Automatic Device Power-Down During Suspend, Device Power-Down Terminal, Link Interface Disable via LPS, and Inactive Ports Powered Down
- Ultralow-Power Sleep Mode
- Node Power Class Information Signaling for System Power Management
- Cable Power Presence Monitoring
- Cable Ports Monitor Line Conditions for Active Connection to Remote Node
- Register Bits Give Software Control of Contender Bit, Power Class bits, Link Active Control Bit and P1394a Features
- Data Interface to Link-Layer Controller Through 2/4/8 Parallel Lines at 49.152 MHz
- Interface to Link Layer Controller Supports Low Cost TI Bus-Holder Isolation and Optional Annex J Electrical Isolation
- Interoperable With Link-Layer Controllers Using 3.3-V and 5-V Supplies
- Interoperable With Other Physical Layers (PHYs) Using 3.3-V and 5-V Supplies
- Low Cost 24.576-MHz Crystal Provides Transmit, Receive Data at 100/200/400 Mbits/s, and Link-Layer Controller Clock at 49.152 MHz
- Incoming Data Resynchronized to Local Clock
- Logic Performs System Initialization and Arbitration Functions
- Encode and Decode Functions Included for Data–Strobe Bit Level Encoding
- Separate Cable Bias (TPBIAS) for Each Port
- Single 3.3-V Supply Operation
- Low Cost High Performance 80-Pin TQFP (PFP) Thermally Enhanced Package
- Direct Drop-In Upgrade for TSB41LV03PFP

NOTE: Implements technology covered by one or more patents of Apple Computer, Incorporated and SGS Thompson, Limited.

### DESCRIPTION

The TSB41LV03A provides the digital and analog transceiver functions needed to implement a three-port node in a cable-based IEEE 1394 network. Each cable port incorporates two differential line transceivers. The transceivers include circuitry to monitor the line conditions as needed for determining connection status, for initialization and arbitration, and for packet reception and transmission. The TSB41LV03A is designed to interface with a line layer controller (LLC), such as the TSB12LV21, TSB12LV22, TSB12LV23, TSB12LV31, TSB12LV41, TSB12LV42, or TSB12LV01A.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

FireWire is a trademark of Apple Computer, Incorporated.  
i.LINK is a trademark of Sony Corporation.

The TSB41LV03A requires only an external 24.576 MHz crystal as a reference. An external clock may be provided instead of a crystal. An internal oscillator drives an internal phase-locked loop (PLL), which generates the required 393.216 MHz reference signal. This reference signal is internally divided to provide the clock signals used to control transmission of the outbound encoded strobe and data information. A 49.152 MHz clock signal is supplied to the associated LLC for synchronization of the two chips and is used for resynchronization of the received data. The power-down (PD) function, when enabled by asserting the PD terminal high, stops operation of the PLL.

The TSB41LV03A supports an optional isolation barrier between itself and its LLC. When the  $\overline{\text{ISO}}$  input terminal is tied high, the LLC interface outputs behave normally. When the  $\overline{\text{ISO}}$  terminal is tied low, internal differentiating logic is enabled, and the outputs are driven such that they can be coupled through a capacitive or transformer galvanic isolation barrier as described in Annex J of IEEE Std 1394-1995 and in the P1394a Supplement section 5.9.4) (hereafter referred to as Annex J type isolation). To operate with TI bus holder isolation, the  $\overline{\text{ISO}}$  terminal on the PHY must be high.

Data bits to be transmitted through the cable ports are received from the LLC on two, four, or eight parallel paths (depending on the requested transmission speed). They are latched internally in the TSB41LV03A in synchronization with the 49.152-MHz system clock. These bits are combined serially, encoded, and transmitted at 98.304, 196.608, or 392.216 Mbits/s (referred to as S100, S200, and S400 speed respectively) as the outbound data-strobe information stream. During transmission, the encoded data information is transmitted differentially on the TPB cable pair(s), and the encoded strobe information is transmitted differentially on the TPA cable pair(s).

During packet reception the TPA and TPB transmitters of the receiving cable port are disabled, and the receivers for that port are enabled. The encoded data information is received on the TPA cable pair, and the encoded strobe information is received on the TPB cable pair. The received data-strobe information is decoded to recover the receive clock signal and the serial data bits. The serial data bits are split into two-, four-, or eight-bit parallel streams (depending upon the indicated receive speed), resynchronized to the local 49.152-MHz system clock and sent to the associated LLC. The received data is also transmitted (repeated) on the other active (connected) cable ports.

Both the TPA and TPB cable interfaces incorporate differential comparators to monitor the line states during initialization and arbitration. The outputs of these comparators are used by the internal logic to determine the arbitration status. The TPA channel monitors the incoming cable common-mode voltage. The value of this common-mode voltage is used during arbitration to set the speed of the next packet transmission. In addition, the TPB channel monitors the incoming cable common-mode voltage on the TPB pair for the presence of the remotely supplied twisted-pair bias voltage.

The TSB41LV03A provides a 1.86-V nominal bias voltage at the TPBIAS terminal for port termination. The PHY contains three independent TPBIAS circuits. This bias voltage, when seen through a cable by a remote receiver, indicates the presence of an active connection. This bias voltage source must be stabilized by an external filter capacitor of 1  $\mu\text{F}$ .

The line drivers in the TSB41LV03A, operating in a high-impedance current mode, are designed to work with external 112- $\Omega$  line-termination resistor networks in order to match the 110- $\Omega$  cable impedance. One network is provided at each end of a twisted-pair cable. Each network is composed of a pair of series-connected 56- $\Omega$  resistors. The midpoint of the pair of resistors that is directly connected to the twisted-pair A terminals is connected to its corresponding TPBIAS voltage terminal. The midpoint of the pair of resistors that is directly connected to the twisted-pair B terminals is coupled to ground through a parallel R-C network with recommended values of 5 k $\Omega$  and 220 pF. The values of the external line-termination resistors are designed to meet the standard specifications when connected in parallel with the internal receiver circuits. An external resistor connected between the R0 and R1 terminals sets the driver output current, along with other internal operating currents. This current setting resistor has a value of 6.3 k $\Omega \pm 1\%$ . This may be accomplished by placing a 6.34-k $\Omega \pm 1\%$  resistor in parallel with a 1-M $\Omega$  resistor.

When the power supply of the TSB41LV03A is off while the twisted-pair cables are connected, the TSB41LV03A transmitter and receiver circuitry presents a high-impedance signal to the cable and does not load the TPBIAS voltage at the other end of the cable.

When the TSB41LV03A is used with one or more of the ports not brought out to a connector, the twisted-pair terminals of the unused ports must be terminated for reliable operation. For each unused port, the TPB+ and TPB– terminals can be tied together and then pulled to ground, or the TPB+ and TPB– terminals can be connected to the suggested termination network. The TPA+ and TPA– and TPBIAS terminals of an unused port can be left unconnected. The TPBias terminal can be connected to a 1- $\mu$ F capacitor to ground or left floating.

The TESTM, SE, and SM terminals are used to set up various manufacturing test conditions. For normal operation, the TESTM terminal should be connected to  $V_{DD}$ , SE should be tied to ground through a 1-k $\Omega$  resistor, while SM should be connected directly to ground.

Four package terminals are used as inputs to set the default value for four configuration status bits in the self-ID packet, are hardwired high or low as a function of the equipment design. The PC0–PC2 terminals are used to indicate the default power-class status for the node (the need for power from the cable or the ability to supply power to the cable). The C/LKON terminal is used as an input to indicate that the node is a contender for either isochronous resource manager (IRM) or for bus manager (BM).

The TSB41LV03A supports suspend/resume as defined in the IEEE P1394a specification. The suspend mechanism allows pairs of directly-connected ports to be placed into a low-power conservation state (suspended state) while maintaining a port-to-port connection between 1394 bus segments. While in the suspended state, a port is unable to transmit or receive data transaction packets. However, a port in the suspended state is capable of detecting connection status changes and detecting incoming TPBias. When all three ports of the TSB41LV03A are suspended, all circuits except the bandgap reference generator and bias detection circuits are powered down, resulting in significant power savings. For additional details of suspend/resume operation refer to the P1394a specification. The use of suspend/resume is recommended for new designs.

The port transmitter and receiver circuitry is disabled during power down (when the PD input terminal is asserted high), during reset (when the RESET input terminal is asserted low), when no active cable is connected to the port, or when controlled by the internal arbitration logic. The TPBias output is disabled during power-down, during reset, or when the port is disabled as commanded by the LLC.

The CNA (cable-not-active) terminal provides a high when there are no twisted-pair cable ports receiving incoming bias (i.e., they are either disconnected or suspended), and can be used along with LPS to determine when to power down the TSB41LV03A. The CNA output is not debounced. When the PD terminal is asserted high, the CNA detection circuitry is enabled (regardless of the previous state of the ports) and a pulldown is activated on the RESET terminal so as to force a reset of the TSB41LV03A internal logic.

The LPS (link power status) terminal works with the C/LKON terminal to manage the power usage in the node. The LPS signal from the LLC is used in conjunction with the LCtrl bit to indicate the active/power status of the LLC. The LPS signal is also used to reset, disable, and initialize the PHY-LLC interface (the state of the PHY-LCC interface is controlled solely by the LPS input, regardless of the state of the LCtrl bit).

The LPS input is considered inactive if it remains low for more than 2.6  $\mu$ s and is considered active otherwise. When the TSB41LV03A detects that LPS is inactive, it places the PHY-LLC interface into a low-power reset state in which the CTL and D outputs are held in the logic zero state and the LREQ input is ignored; however, the SYSCLK output remains active. If the LPS input remains low for more than 26  $\mu$ s, the PHY-LLC interface is put into a low-power disabled state in which the SYSCLK output is also held inactive. The PHY-LLC interface is also held in the disabled state during hardware reset. The TSB41LV03A continues the necessary repeater functions required for normal network operation regardless of the state of the PHY-LLC interface. When the interface is in the reset or disabled state and LPS is again observed active, the PHY initializes the interface and returns it to normal operation.

When the PHY-LLC interface in the low-power disabled state, the TSB41LV03A automatically enters a low-power mode if all ports are inactive (disconnected, disabled, or suspended). In this low-power mode, the TSB41LV03A disables its internal clock generators and also disables various voltage and current reference circuits depending on the state of the ports (some reference circuitry must remain active in order to detect new cable connections, disconnections, or incoming TPBias, for example). The lowest power consumption (the *ultralow-power sleep mode*) is attained when all ports are either disconnected, or disabled with the port's interrupt enable bit cleared. The TSB41LV03A exits the low-power mode when the LPS input is asserted high or when a port event occurs which requires that the TSB41LV03A become active in order to respond to the event or to notify the LLC of the event (e.g., incoming bias is detected on a suspended port, a disconnection is detected on a suspended port, a new connection is detected on a nondisabled port, etc.). The SYSCLK output becomes active (and the PHY-LLC interface is initialized and becomes operative) within 7.3 ms after LPS is asserted high when the TSB41LV03A is in the low-power mode.

The PHY uses the C/LKON terminal to notify the LLC to power up and become active. When activated, the C/LKON signal is a square wave of approximately 163 ns period. The PHY activates the C/LKON output when the LLC is inactive and a wake-up event occurs. The LLC is considered inactive when either the LPS input is inactive, as described above, or the LCtrl bit is cleared to 0. A wake-up event occurs when a link-on PHY packet addressed to this node is received, or conditionally when a PHY interrupt occurs. The PHY deasserts the C/LKON output when the LLC becomes active (both LPS active and the LCtrl bit set to 1). The PHY also deasserts the C/LKON output when a bus-reset occurs unless a PHY interrupt condition exists which would otherwise cause C/LKON to be active.

**NOTE:**

This product is for high-volume applications only. For a complete datasheet or more information contact [support@ti.com](mailto:support@ti.com).

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/ Ball Finish	MSL Peak Temp <sup>(3)</sup>	Samples (Requires Login)
TSB41LV03AIPFP	OBSOLETE	HTQFP	PFP	80		TBD	Call TI	Call TI	
TSB41LV03APFP	ACTIVE	HTQFP	PFP	80	96	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	
TSB41LV03APFPG4	ACTIVE	HTQFP	PFP	80	96	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

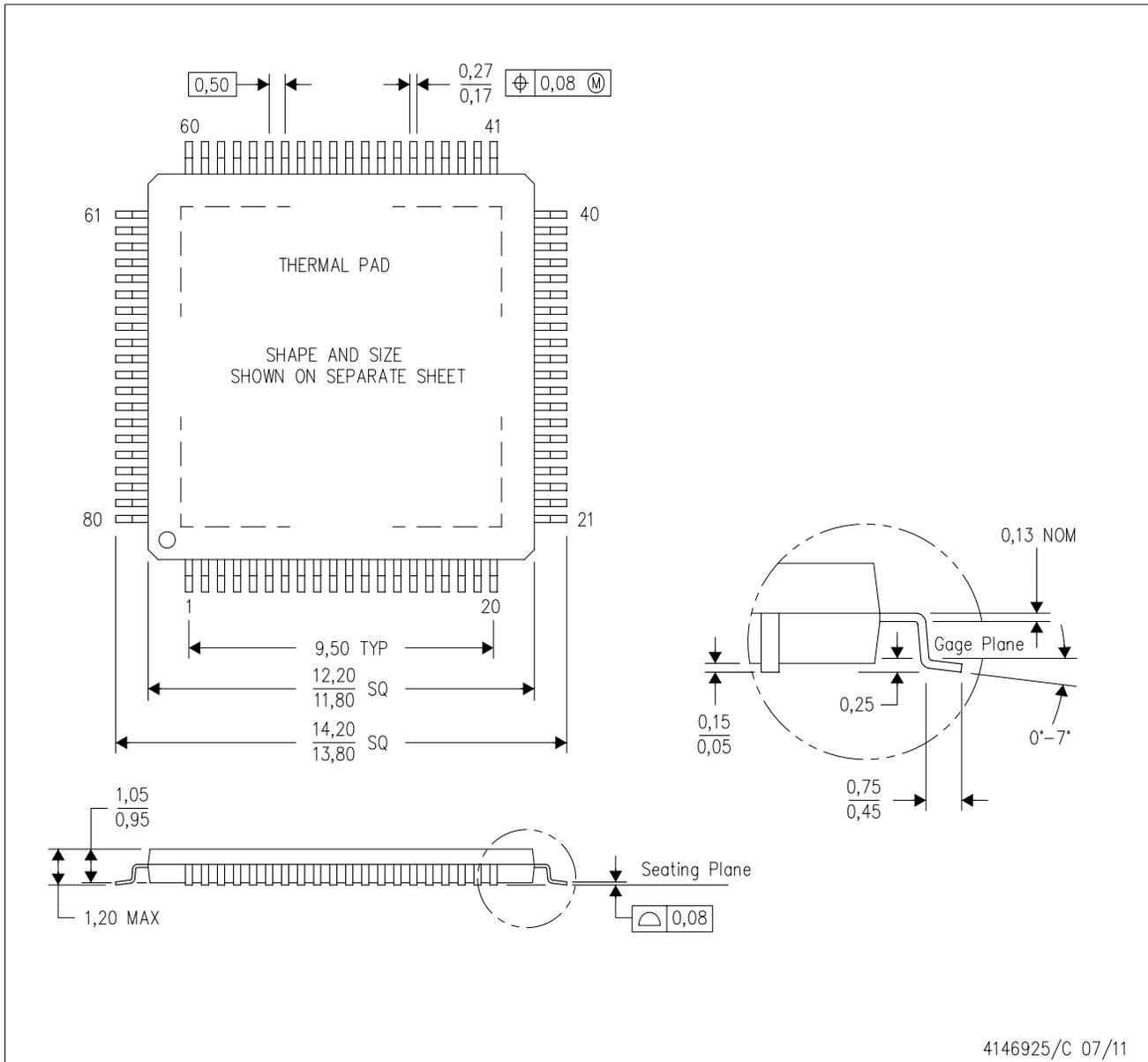
**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

# MECHANICAL DATA

PFP (S-PQFP-G80)

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) <<http://www.ti.com>>.
  - E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
  - F. Falls within JEDEC MS-026

PowerPAD is a trademark of Texas Instruments.

## THERMAL PAD MECHANICAL DATA

PFP (S-PQFP-G80)

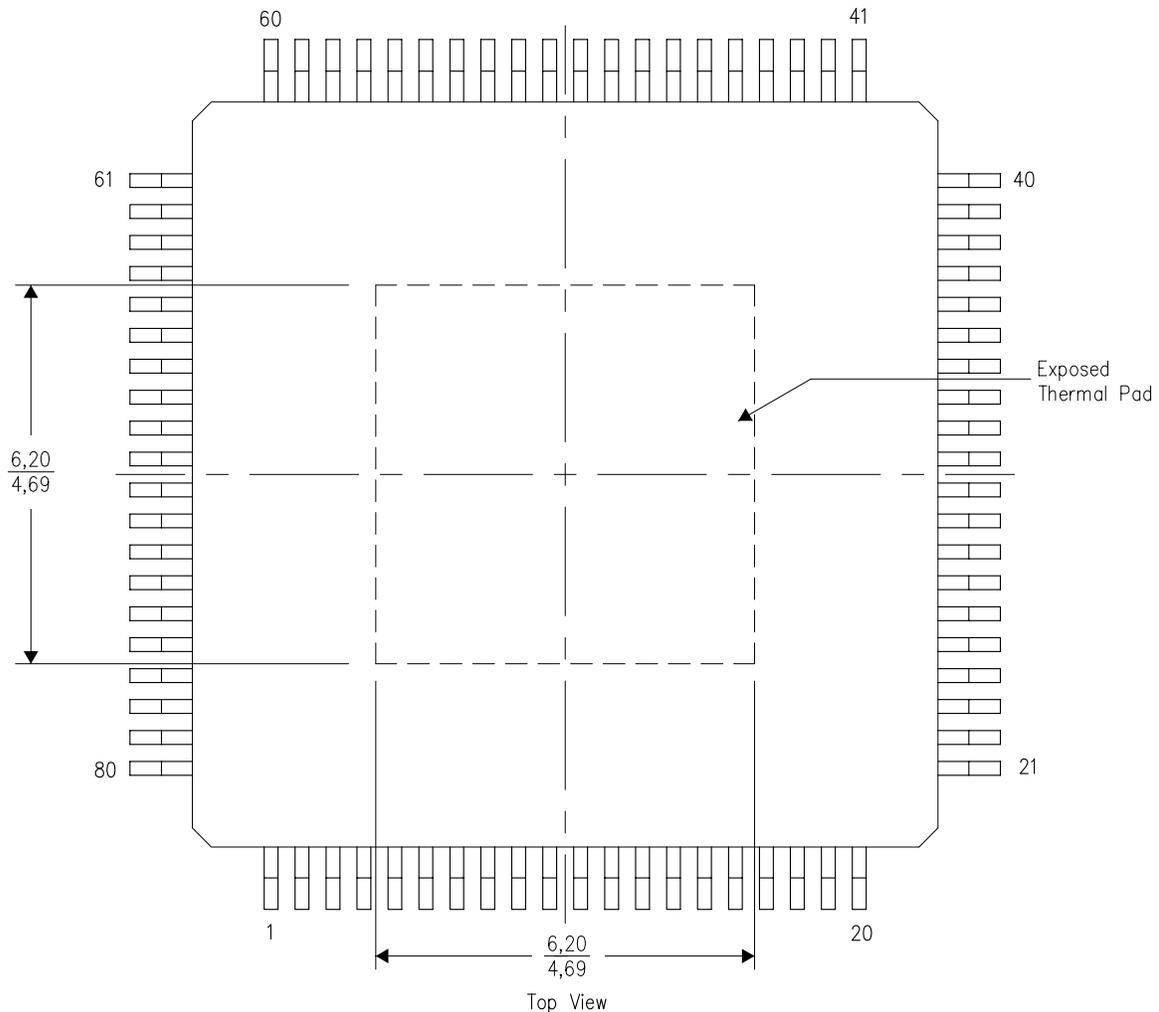
PowerPAD™ PLASTIC QUAD FLATPACK

### 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](http://www.ti.com).

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



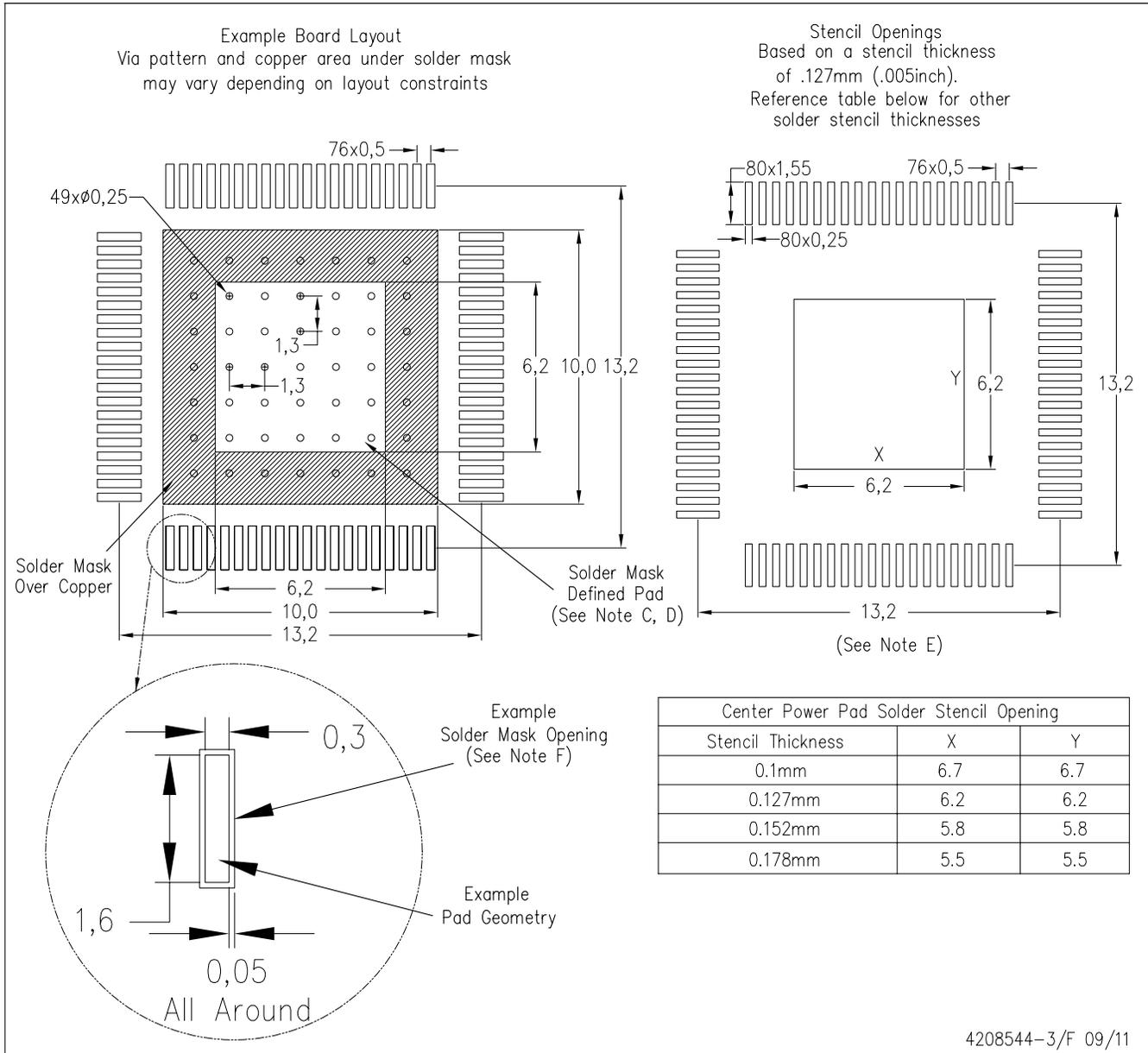
4206327-3/N 09/11

NOTE: A. All linear dimensions are in millimeters

PowerPAD is a trademark of Texas Instruments

PFP (S-PQFP-G80)

PowerPAD™ PLASTIC QUAD FLATPACK



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
  - 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) <<http://www.ti.com>>. Publication IPC-7351 is recommended for alternate designs.
  - 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. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.
  - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

PowerPAD is a trademark of Texas Instruments.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Mobile Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Transportation and Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

TI E2E Community Home Page

[e2e.ti.com](http://e2e.ti.com)

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2011, Texas Instruments Incorporated