miniPMU with 3 DC/DC Converters for Application Processors

Check for Samples: TPS650380

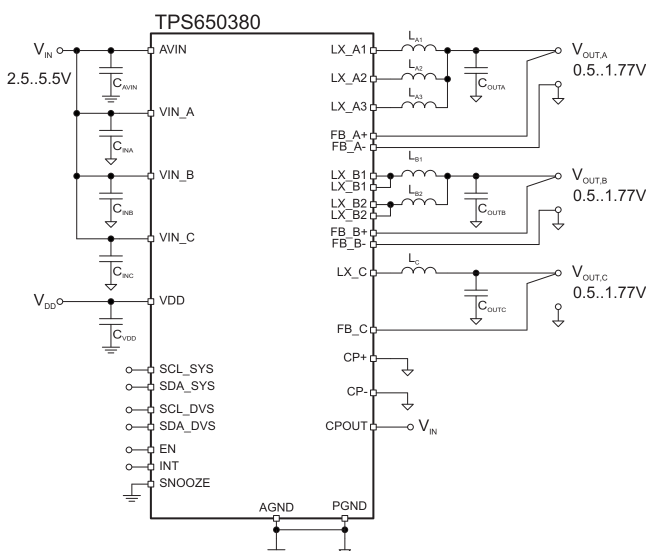
FEATURES

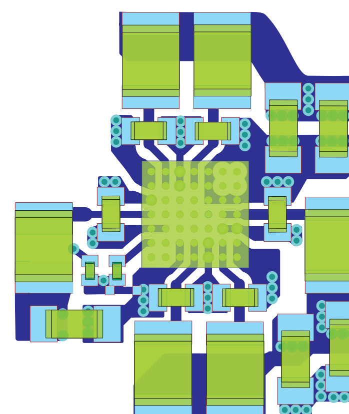
- 3 Step-Down Converters
  - 3-Phase Step-Down Converter
  - 2-Phase Step-Down Converter
  - 1-Phase Step-Down Converter
- Highest Efficiency:
  - Reduced Inductor and On-Chip Losses by Multi Phase Design
  - Low $R_{DS,on}$ Switches and Active Rectifiers
  - Automatic Multi-to-Single Phase Operation Transition (Phase Shedding)
  - Power Save Mode for Light Load Efficiency
- Two I^2C High Speed Compatible Interfaces
  - Digital Voltage Scaling
  - Monitoring, Software Control
- Excellent DC and AC Output Voltage Regulation
  - Differential Load Sensing
  - Precise DC Output Voltage Accuracy
  - Multiplied Regulation Bandwidth by Multi Phase Design
  - Reduced Output Voltage Ripple by Phase Shifted Operation
  - Low Battery Voltage Drop by Phase Shifted Operation
- Multiple Dedicated Features:
  - Soft Start
  - Power Good Indication
  - Programmable Slew Rate at Voltage Transition
  - Over Temperature Monitoring and Protection with Multiple Thresholds
  - Input Under Voltage Detection and Lockout
  - Output Current Limit and Protection
  - Interrupt Signal for Exception Handling
  - Built-in, programmable Output Rail Sequencer
- Available in 49-Bump, 3.25 x 3.25 mm^2 NanoFree™ Package
- Low External Device Count: down to 65 mm^2 Solution Size

APPLICATIONS

- Application Processor, DSP, ASIC and FPGA power
- Dynamic Voltage Scale Compliant Processors and DSPs
- Industrial Application
- Infotainment and Telematics Applications
- Smart Phones, Tablets, Ultrabooks

PRODUCT PREVIEW





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.

NanoFree, Smart Reflex are trademarks of Texas Instruments.

PRODUCT PREVIEW information concerns products in the formative or design phase of development. Characteristic data and other specifications are design goals. Texas Instruments reserves the right to change or discontinue these products without notice.

Copyright © 2012, Texas Instruments Incorporated

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

DEVICE INFORMATION

Figure 1. Block Diagram and Pin Functions

PRODUCT PREVIEW

Copyright © 2012, Texas Instruments Incorporated

DESCRIPTION

The TPS650380 device is a high-frequency synchronous 3-rail mini PMIC solution for processors optimized for smallest solution size and battery-powered portable applications. With an input voltage range of 2.5V to 5.5V, 3.3V and 5V system rails as well as common and future battery technologies are supported.

The device's rails provide 6.8A / 3.7A / 1.8A load current, operating at 4MHz typical switching frequency to enable smallest inductors. The 6.8A rated rail is a 3-phase step down converter, the 2.9A rail is a 2-phase step down converter and the 1.5A rail operates as 1-phase step down converter.

All rails support an output voltage range of 0.5V to 1.77V. Programmable via I^2C interface in 10mV steps, the TPS650380 supports low-voltage DSPs, ASICs, FPGAs and application processor including latest submicron processes and their retention modes, addressing digital voltage scaling technologies (DVS) such as Smart Reflex™. High efficiency conversion, accurate output voltage in the static and dynamic domain and a dedicated feature set address these applications.

Output Voltages and Modes can be fully programmed via I^2C. Safe operation is supported by a comprehensive monitoring and exception handling feature set.

The 3.25 x 3.25 mm^2 package and the low number of required external components lead to a tiny solution size of approximately 65 mm^2.

OPERATION

High Efficiency Step Down Conversion

The device is equipped with a comprehensive set of built-in features to support high efficiency conversion over the complete output current and input voltage range. At highest output currents, the multi-phase rails operate in parallel. Thereby, the effective $R_{DS,ON}$ is significantly reduced leading to lowest on-chip losses. In addition, the external inductor losses are significantly lowered with an effective DCR being divided by 2 for the 2-phase rail (DCDC_B) and being divided by 3 for the 3-phase rail (DCDC_A). By reducing the on-chip and inductor losses, not only is efficiency improved; the device and PCB are kept cooler by reducing on-chip and external losses.

In order to maintain high efficiency conversion, the multi-phase rails automatically transition to single phase operation when required to maintain high efficiency conversion at medium load currents (phase shedding).

As the load current decreases further, the converter enters Power Save Mode to sustain high efficiency down to light loads. The transition from PWM to Power Save Mode is seamless and avoids output voltage transients.

Static Output Voltage Accuracy

The TPS650380 regulates the output voltage with a high accuracy voltage mode control. For the 3-phase (DCDC_A) and 2-phase (DCDC_B) rails, differential output voltage sensing (remote sense) is embedded which measures the output voltage at the point of load. With the differential and remote sensing, the TPS650380 compensates supply rail and ground shifts caused by non-ideal PCB traces.

The 1-phase output (DCDC_C) uses single-ended output voltage sensing due to its lower output current.

The multi-phase architecture reduces input and output voltage ripple to a minimum by operating the phases with a constant phase shift of 180° for the 2-phase rail and 120° for the 3-phase rail. A high precision clock keeps the phase shift constant while the duty cycle is altered to distribute the current equally to all phases (phase balancing).

Dynamic Output Voltage Accuracy

The current consumption profile of processors can be volatile due to sudden load changes which are caused by power gating, clock changes, etc. The TPS650380 addresses the sudden load changes by nearly instantaneously adjusting the output voltage to keep it in regulation. The multi-phase architecture helps further with a increased effective regulation bandwidth.

PRODUCT PREVIEW

Copyright © 2012, Texas Instruments Incorporated

PRODUCT PREVIEW

APPLICATION SPECIFIC FEATURES

The TPS650380 is equipped with application specific features. These features are accessible by software via I^2C interface resulting in highest flexibility.

- The built-in, programmable output rail sequencer combined with a fast output rail start-up time allows precise sequencing of the output rail.
- The output voltage can be programmed with 10mV steps. A transition between different voltage levels is performed with a controlled, linear output voltage ramp. The slew rates can be programmed to both match timing requirements and provide predictability.
- An all integrated feature set to enable safe, most reliable operation and easy system integration addresses application specific requirements. These features can be controlled and monitored by I^2C. In addition, a dedicated pin for exception handling is provided. The feature list includes output current monitoring with programmable electronic fuse, temperature monitoring / protection and individual power good indication for each output.

PACKAGE SUMMARY

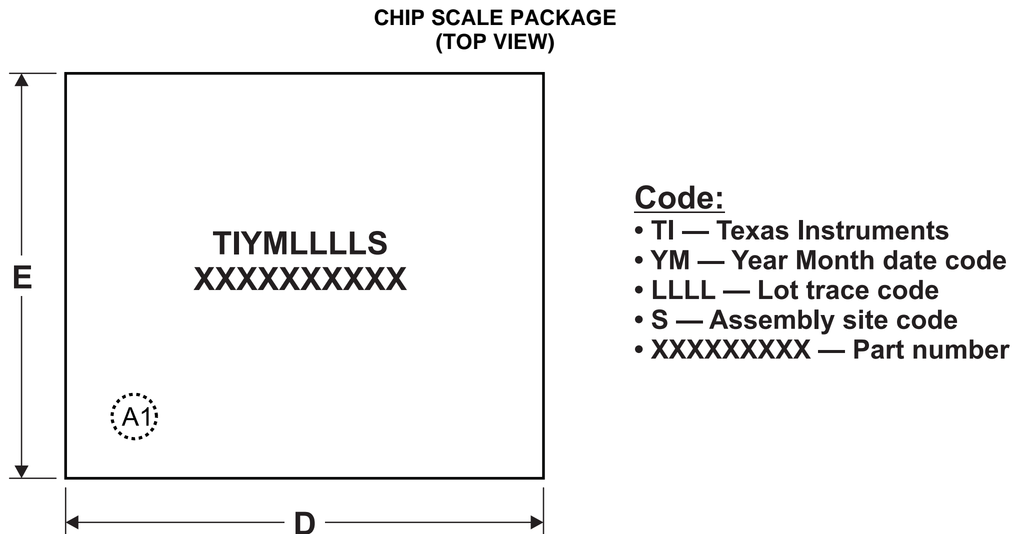


Figure 2. Package Marking and Dimensions

Package Marking

Table 1. Package Marking

Device	Marking
TPS650380	TPS650380

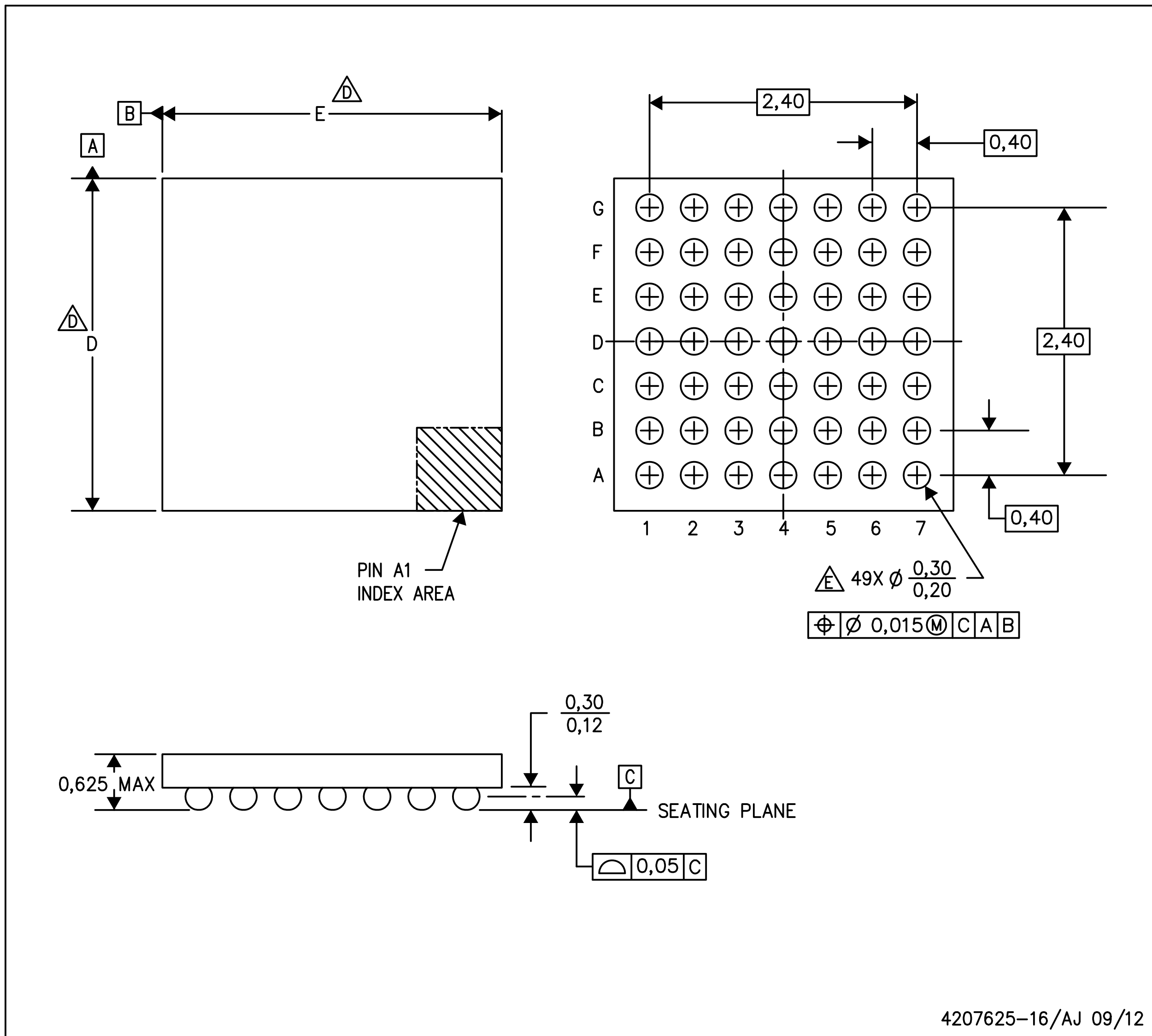
Chip Scale Package Dimensions

The TPS650380 devices are available in a 49-bump chip scale package (YFF, NanoFree™). The package dimensions are given as:

- D = 3.25mm (+/- 0.03mm)
- E = 3.25mm (+/- 0.03mm)

Copyright © 2012, Texas Instruments Incorporated

YFF (R–XBGA–N49) DIE–SIZE BALL GRID ARRAY



4207625–16/AJ 09/12

NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
B. This drawing is subject to change without notice.
C. NanoFree™ package configuration.
D. The package size (Dimension D and E) of a particular device is specified in the device Product Data Sheet version of this drawing, in case it cannot be found in the product data sheet please contact a local TI representative.
E. Reference Product Data Sheet for array population.
7 x 7 matrix pattern is shown for illustration only.
F. This package contains Pb–free balls.

NanoFree is a trademark of Texas Instruments

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Samples (Requires Login)
TPS650380YFFR	PREVIEW	DSBGA	YFF	49		TBD	Call TI	Call TI	
TPS650380YFFT	PREVIEW	DSBGA	YFF	49		TBD	Call TI	Call TI	

(1) 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.

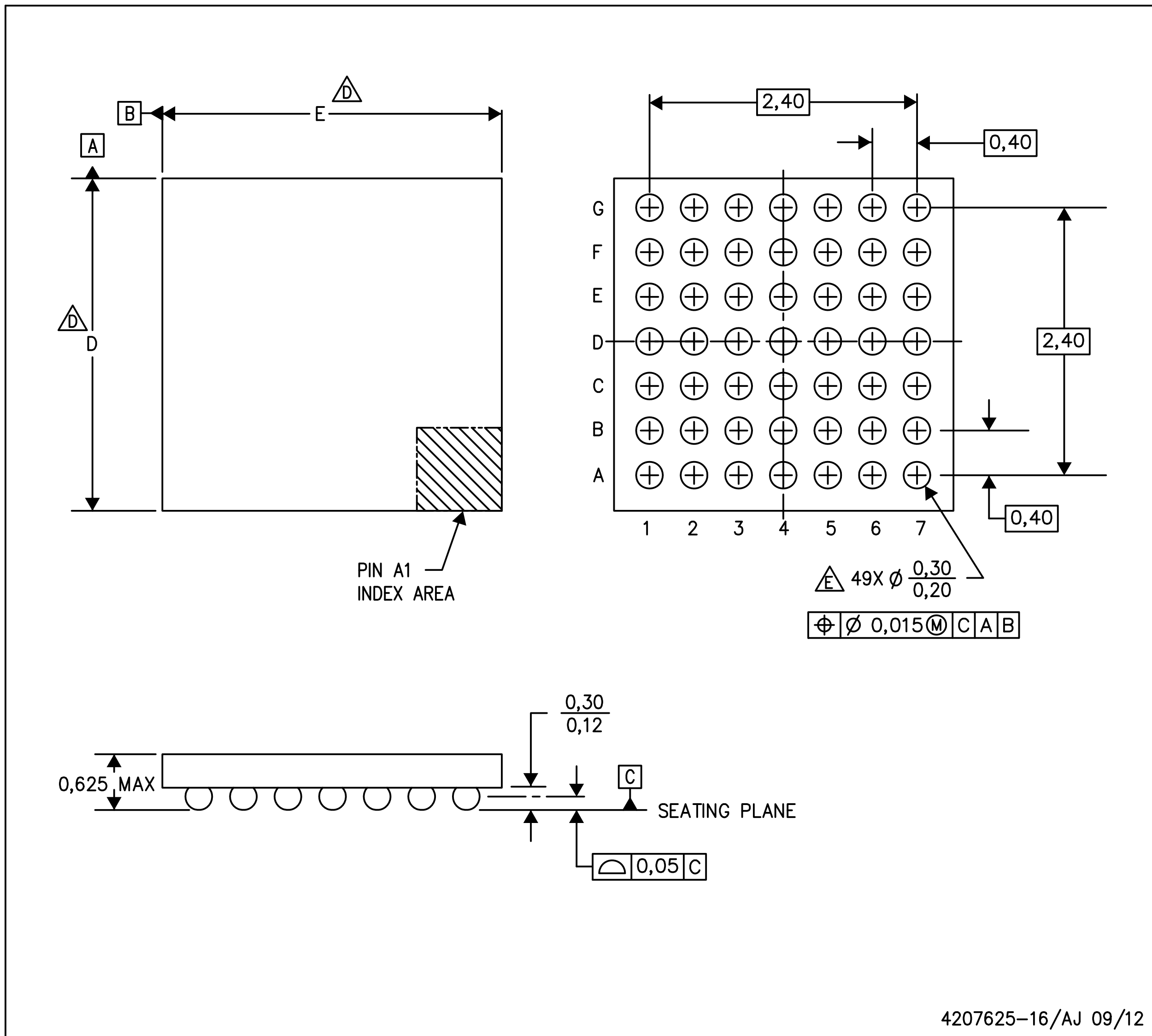
(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been 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)

(3) 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.

YFF (R–XBGA–N49) DIE–SIZE BALL GRID ARRAY



NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
- B. This drawing is subject to change without notice.
- C. NanoFree™ package configuration.
- D. The package size (Dimension D and E) of a particular device is specified in the device Product Data Sheet version of this drawing, in case it cannot be found in the product data sheet please contact a local TI representative.
- E. Reference Product Data Sheet for array population. 7 x 7 matrix pattern is shown for illustration only.
- F. This package contains Pb–free balls.

NanoFree is a trademark of Texas Instruments

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

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

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

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license 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 significant portions 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. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2012, Texas Instruments Incorporated