

Maneesh Soni,  
Systems Manager  
Thomas Mauer,  
Systems Applications Engineer  
Pratheesh Gangadhar,  
Technical Lead  
Texas Instruments



# PROFIBUS<sup>®</sup> on Sitara<sup>™</sup> Processors

## Executive summary

PROFIBUS, one of the most used communication technologies, is installed in more than 35 million industrial nodes worldwide and is growing at a rate of approximately 10 percent each year.

Texas Instruments, Inc. (TI) has enhanced its integrated PROFIBUS<sup>®</sup> slave and master functionality on the Sitara<sup>™</sup> AM335x ARM<sup>®</sup> Cortex<sup>®</sup>-A8 processors. Other Sitara devices, such as the AM437x ARM Cortex-A9 processors, have all of the on-chip resources needed to support integrated PROFIBUS capabilities.

The integrated PROFIBUS slave on the Sitara AM335x processors has also been released with a low footprint software solution to enable further cost and system design optimizations. On the AM335x processor, the PROFIBUS Link Layer is implemented on the integrated programmable real-time unit (PRU) subsystem. This eliminates the need for a dedicated PROFIBUS ASIC or FPGA in the system. The benefits of this integration not only include lower cost but also smaller size, reduced complexity and lower power. All software and hardware components and tools required to develop PROFIBUS applications are available from TI. With industrial-grade packaging and long-term supply, the Sitara processors are a compelling choice for PROFIBUS and other industrial communications applications. In addition, TI's totally integrated PROFIBUS solution on the Sitara AM335x is certified for PROFIBUS compliance.

## Introduction to PROFIBUS

### Overview

PROFIBUS (Process Field Bus) is a standard for automation technology. It was first developed in 1989 in Germany, and today, there are over 35 million PROFIBUS nodes installed. The PROFIBUS industrial field bus is used to connect controllers to remote input/output units, sensors, actuators and inter-networking components. The applications where PROFIBUS is deployed include factory automation, drives and motion control, process automation and safety-critical applications (see Figure 1 below).

### Technology

PROFIBUS increases communication efficiency in a factory by connecting a number of nodes over a single connection. This single connection not only eliminates the need for dedicated wiring for each node, it also allows reduced complexity, reduced investment and easier deployments. PROFIBUS communication technology has multiple protocols – PROFIBUS DP and PROFIBUS<sup>®</sup> PA – that are used depending upon the application requirements. PROFIBUS protocol also defines the role of master and slave nodes to manage the communication among the PROFIBUS nodes.

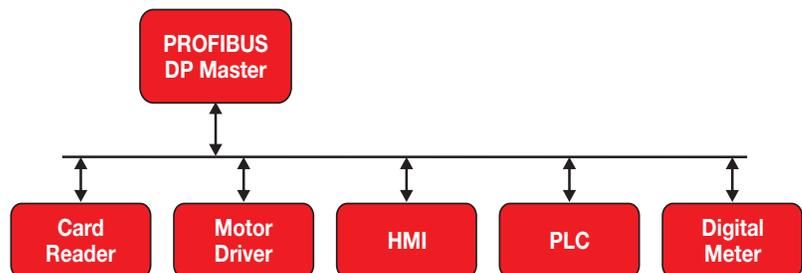


Figure 1. PROFIBUS in industrial automation

### *PROFIBUS Decentralized Periphery (DP)*

PROFIBUS DP is the most popular PROFIBUS protocol. This protocol has three versions within the application layer – DP-V0, DP-V1 and DP-V2. DP-V0 provides cyclic data exchange and diagnostic messages. DP-V1 adds acyclic data exchange and alarm handling. DP-V2 is isochronous mode and data exchange broadcast like slave-to-slave communication.

### *PROFIBUS Process Automation (PA)*

PROFIBUS PA is used in hazardous environments. Both data and power are transmitted on the same link, and a reduced power level is used to minimize the risk of explosion. PA has a fixed transmission rate at 31.25kbaud. Usually, the PROFIBUS DP-to-PROFIBUS PA coupler is used to create PROFIBUS network segments in a larger factory network. These couplers are also used to supply power to meet safety requirements.

PROFIBUS can be customized for end application needs by using application profiles. For some of the common applications, the PROFIBUS organization has standardized the application profiles. The PROFIsafe and PROFIdrive are two such profiles that are used in safety or in motor drives applications.

### **Components of a PROFIBUS node**

Each PROFIBUS node has three components – the electrical layer, the data link layer and an application layer. The electrical layer is implemented using RS-485, fiber-optic or Manchester Bus Power (MBP) media. The data link layer is called Fieldbus Data Link (FDL) and it implements master-slave communication. The application layer is one of DP-V0, DP-V1 and DP-V2, etc. and it supports messaging between the PROFIBUS nodes. These messages can involve data exchange, diagnosis, alarms and such. For DP-V0 and DP-V1 the PROFIBUS master is allowed to start a transmission, while the slave is only allowed to respond to a message that matches with its slave address. A maximum of 126 devices (masters and slaves) with unique addresses are permitted in a single system.

### **Compliance**

To ensure wide interoperability among devices designed with PROFIBUS interfaces, the PROFIBUS organization has a certification program which ensures that a device is in compliance with the rules and specifications of the protocols. Each new device or already-certified device but with hardware or software change needs to pass certification to claim PROFIBUS compliance and use the official PROFIBUS logo. Certification is done by authorized certification labs that follow the test procedures defined by PNO/PI. The PNO/PI website provides a list of certification labs.

### Typical PROFIBUS<sup>®</sup> solution

A typical PROFIBUS solution in use today has an architecture similar to Figure 2 below.



Figure 2. Typical PROFIBUS implementation

In such solutions, a microprocessor runs the PROFIBUS application level stack and implements the industrial application, a separate ASIC or FPGA implements the PROFIBUS protocol and an RS-485 transceiver provides the connection to the physical layer. The PROFIBUS device connects to the microprocessor over a parallel or a serial interface. At the physical layer, an RS-485 transceiver with galvanic isolation is used.

### PROFIBUS solution from Texas Instruments

TI has integrated PROFIBUS functionality into the Sitara AM335x ARM Cortex-A8 processors. These devices connect directly to the RS-485 transceiver and do not require an external PROFIBUS ASIC or FPGA. The Sitara AM437x devices are fully compatible with integrating PROFIBUS functionality.

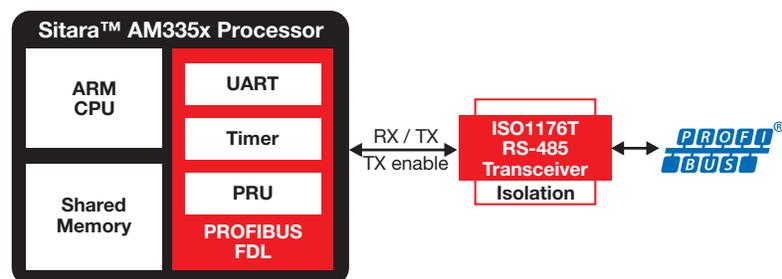


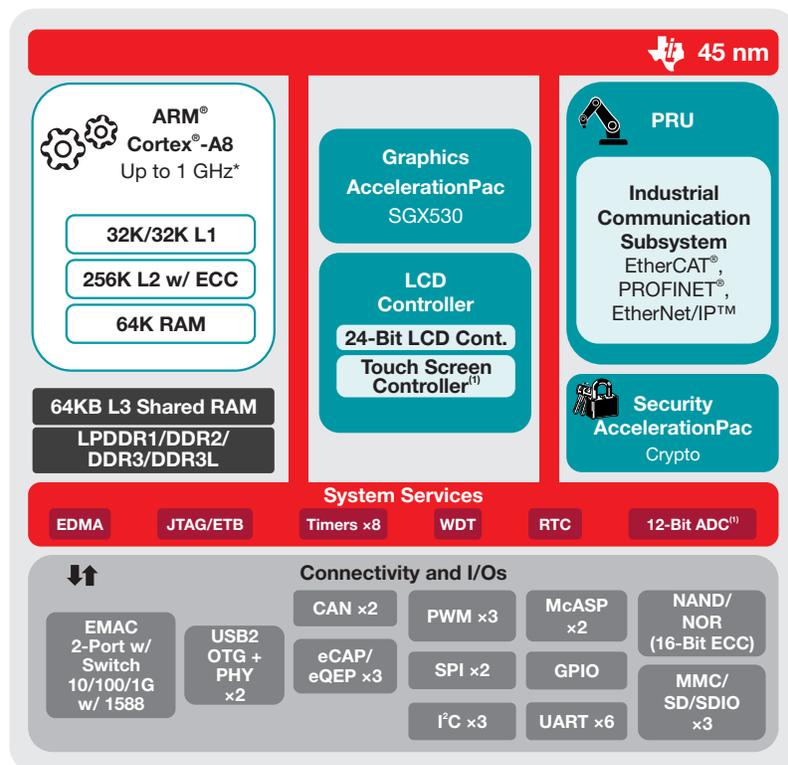
Figure 3. PROFIBUS solution from Texas Instruments

The PROFIBUS real-time frame handler (Fieldbus Data Link or FDL) is encapsulated in the Sitara AM335x's programmable real-time unit (PRU) subsystem, which is integrated into all Sitara processors, including the AM437x processor.

In each variant of the PRU subsystem, the PRUs implement real-time PROFIBUS message transmission, frame validation and communication with the ARM processor. Interrupts are used to communicate with the ARM where the PROFIBUS stack (Layer 7, DP-Protocol) and the industrial application are run. All process data handling like cyclic, acyclic and service access point (SAP) between the PROFIBUS stack on ARM and the PRU is through the internal memory. One of the PRUs controls the integrated on-chip universal asynchronous receiver/transmitter (UART) that is designated for PROFIBUS communication at up to 12Mbaud data rate. The industrial application and the PROFIBUS DP-Protocol (Layer 7) are operated on the ARM. The solution can be completed with an RS-485 transceiver suitable for harsh environments, such as TI's ISO 1176T PROFIBUS transceiver.

## Sitara™ processors block diagram

The Sitara AM335x and AM437x processors are low-power devices based on the ARM Cortex-A8 and ARM Cortex-A9 RISC cores, respectively. Both processors feature a broad range of integrated peripherals. For industrial applications, the Sitara processors support multiple operating frequency ranges from 300 MHz for simple applications up to 1 GHz for complex applications that require high performance, such as industrial drives. Both the AM335x and AM437x processors at any performance level can implement PROFIBUS. The AM335x processor is configured with one PRU coprocessor (two real-time cores) while the AM437x processor features two PRUs with a total of four real-time cores. The block diagrams of the Sitara AM335x and AM437x are shown in Figure 4 below and Figure 5 on the following page. Additional information about both devices, their on-chip peripherals and features is available at [www.ti.com/am335x](http://www.ti.com/am335x) or [www.ti.com/am437x](http://www.ti.com/am437x).



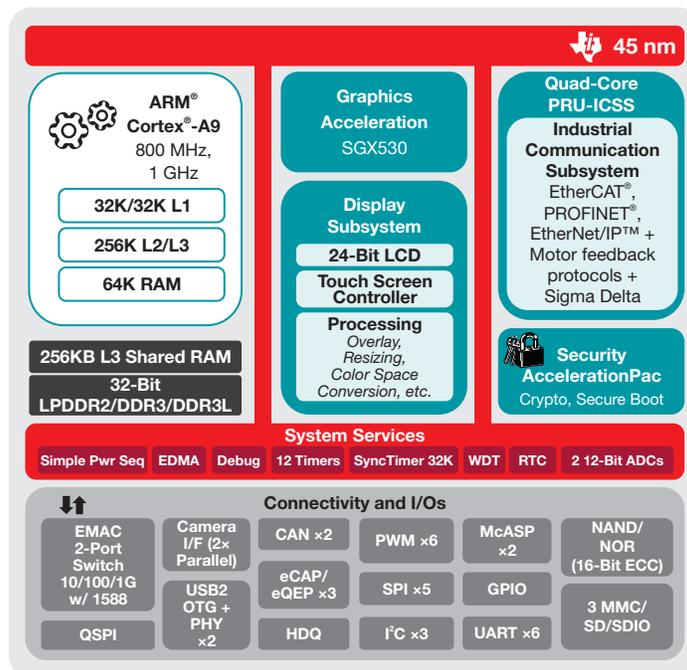
\* 800 MHz / 1 GHz only available on 15×15 package. 13×13 package supports up to 600 MHz.

<sup>(1)</sup> Use of TSC will limit available ADC channels.

Figure 4. Sitara™ AM335x ARM® Cortex®-A8 processor block diagram

## PROFIBUS® software architecture

Three software components comprise the integrated PROFIBUS solution on the Sitara AM335x processors. The first is the micro code that implements FDL functionality in the PRU, the second is the PROFIBUS-DP protocol that runs on the ARM MPU and third is an industrial application that is dependent on the end equipment in which this solution is used.



<sup>(1)</sup>Use of TSC will limit availability of channels on one ADC.

<sup>(2)</sup>Max clock: LPDDR2=266 MHz; DDR3=400 MHz.

Figure 5. Sitara™ AM437x ARM® Cortex® -A9 block diagram

All of TI's Sitara processors for PROFIBUS support both high-level operating systems (OS) such as Linux™ as well as applications with no operating system. In either architecture, the software structure is consistent.

Note that the Sitara devices for PROFIBUS are agnostic to the OS and the PROFIBUS DP stack, increasing flexibility in choosing an OS and PROFIBUS-DP protocol stack.

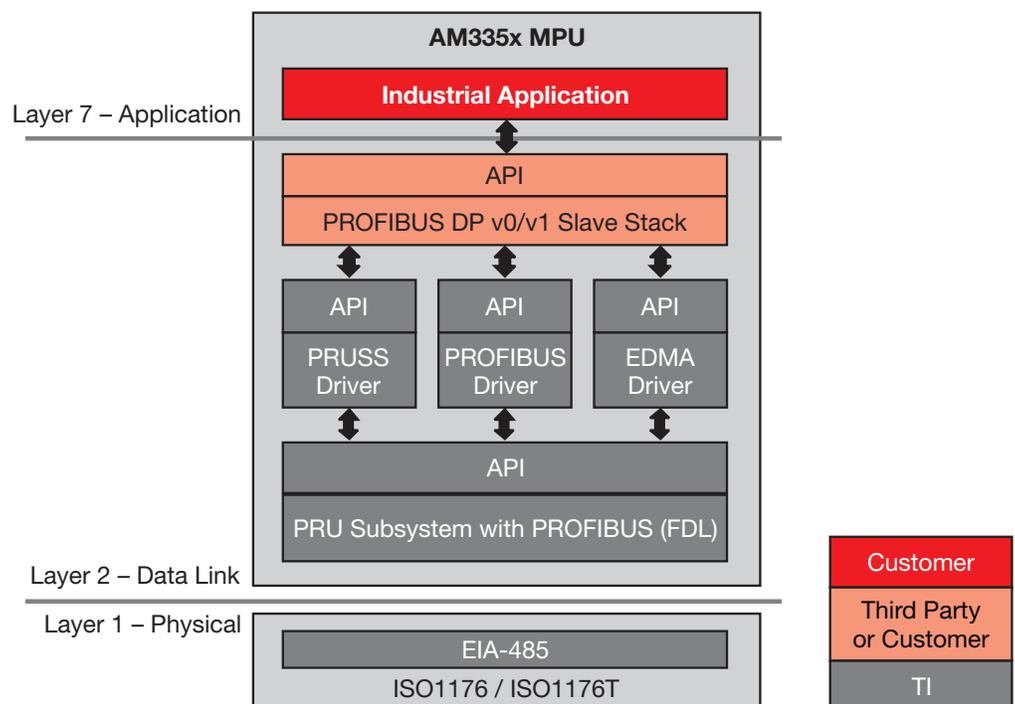


Figure 6. Software architecture for PROFIBUS-DP

## Key PROFIBUS parameters

The key parameters for the PROFIBUS solutions are tabulated below.

### *PROFIBUS slave*

Feature	AM437x Processor	AM335x Processor
ARM frequency	Up to 1 GHz	Up to 1 GHz
Data rates (baud)	12M, 6M, 3M, 1.5M, 500k, 187.5k, 93.75k, 45.45k 19.2k, 9.6k	
Telegram size	Up to 244 bytes	
DPv0 support	Cyclic exchange of data and diagnosis	
DPv1 support	Acyclic/cyclic data exchange and alarm handling	
DPv2 support	Isochronous Mode (IsoM) and Data-Exchange-Broadcast (DXB)	
Response time	11-bit minimum TSDR response time	
Watchdog	10ms time base	

### *PROFIBUS master*

Feature	AM437x Processor	AM335x Processor
ARM frequency	Up to 1 GHz	Up to 1 GHz
Data rates (baud)	12M, 6M, 3M, 1.5M, 500k, 187.5k, 93.75k, 45.45k 19.2k, 9.6k	
Telegram size	Up to 244 bytes	
Modes of operation	Class 1 and Class 2	
Multi-master mode	Supported	
DPv0 support	Cyclic exchange of data and diagnosis	
DPv1 support	Acyclic/cyclic data exchange and alarm handling	
DPv2 support	Isochronous Mode (IsoM) and Data-Exchange-Broadcast (DXB)	

## Easy PROFIBUS integration

TI has made the process of integrating PROFIBUS into the Sitara processors straightforward and simple. All the tools and software code required to integrate PROFIBUS are available as part of the software development kits (SDKs) for each device.

For a typical use case, the PROFIBUS firmware, the stack, the drivers and the high-level operating system (if needed) are all reused from the respective device's software development kit. There is usually only one file to be modified by the user.

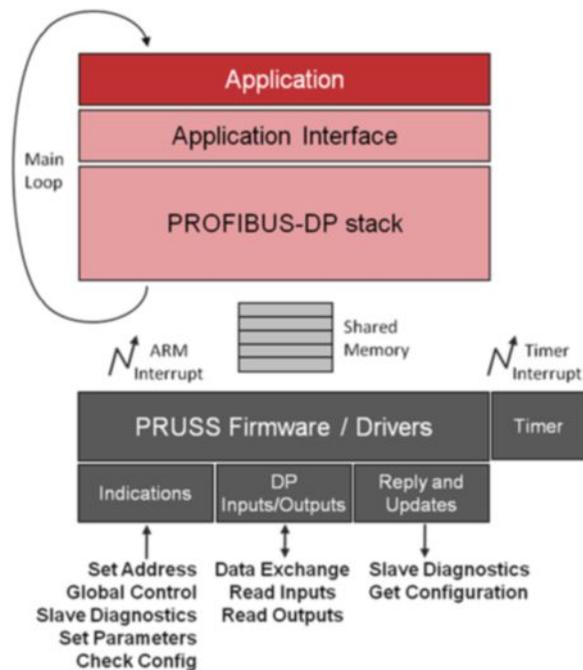


Figure 7. PROFIBUS® software integration

### **Integrating PROFIBUS solution on end products**

TI's totally integrated PROFIBUS solution can be quickly designed into industrial applications in need for PROFIBUS master or slave interface. For slave devices, customers can directly use TI's PROFIBUS implementation and complete their design process using the evaluation copy of the PROFIBUS slave stack that is provided by TI. The slave stack was developed by a third-party vendor and it can be licensed by customers for a one-time licensing fee. If desired, customers can also use a slave stack from a different vendor or develop their own. Once the development is complete, the customer can take their product to the PROFIBUS test labs for certification. For certification for PROFIBUS master, please visit [www.ti.com/e2e\\_sitara](http://www.ti.com/e2e_sitara) for further information.

### **Devices for PROFIBUS implementation**

TI provides the applications processor for PROFIBUS implementation, as well as analog signal chain and power management products for interfacing to the physical layer. A brief description of these products is provided in the table on the following page. These products are available in the industrial grade temperature range and have long-term availability.

### **Development tools for PROFIBUS implementation**

TI provides Evaluation Module (EVM) development platforms for its Sitara processors with comprehensive design data to assist customers with their implementations. All design data for these EVMs such as schematics

and layout is available for accelerating development of customer designs. For more information on the tools available for specific processors, [click here](#).

In addition, TI also collaborates with external vendors for an additional development platform targeted for industrial applications.

### *Summary*

TI offers integrated PROFIBUS master and slave solutions on the Sitara AM335x ARM Cortex-A8 devices, which are targeted for industrial I/O devices, sensors, PLCs and HMIs. In addition, the Sitara AM437x processors have been equipped with all of the resources required for integrating PROFIBUS. The integration of PROFIBUS with the powerful yet low-power ARM cores featured in Sitara processors results in lower cost end products without compromising functional or operational requirements. TI also offers the ISO 1176T PROFIBUS transceiver with built-in isolation. With comprehensive software and hardware development tools and worldwide support, customers can look forward to greatly simplified PROFIBUS integration with an added benefit of significant cost savings.

Important Notice: The products and services of Texas Instruments Incorporated and its subsidiaries described herein are sold subject to TI's standard terms and conditions of sale. Customers are advised to obtain the most current and complete information about TI products and services before placing orders. TI assumes no liability for applications assistance, customer's applications or product designs, software performance, or infringement of patents. The publication of information regarding any other company's products or services does not constitute TI's approval, warranty or endorsement thereof.

Sitara and SYS/BIOS are trademarks of Texas Instruments Incorporated. All other trademarks are the property of their respective owners.

## 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 as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

### 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 Applications 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

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
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>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

### TI E2E Community

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