

Connected Sensors Building Automation Systems Guide



Connected Sensors Building Automation Systems Guide

Table of Contents and Sensor Solutions

Introduction

Monitoring devices or nodes in building control systems, fire safety systems, lighting control, and other building automation and Internet of Things (IoT) applications are becoming more prevalent in today's world.

The use of connected sensors has a wide range of uses in building automation applications, from monitoring human safety and security, controlling the environment and ambience specified by the comfort preferences of the end user, or either periodic or continuous data logging of environmental and system data to detect irregular system conditions.

Texas Instruments (TI) has a broad portfolio of products that cater to connected sensing in building automation applications. This portfolio ranges from innovative sensor analog front-end products to low-power wireless connectivity solutions.

Table of Contents

Sensor Solutions

- 2 Temperature Sensing
- 2 Humidity and Temperature Sensing
- 2 Ambient Light Sensing
- 3 Inductance Sensing
- 3 Capacitance Sensing
- 3 Hall Effect Sensor

Amplifiers and Comparators

- 4 Low Power Amplifiers
- 4 General Purpose Amplifiers
- 4 Comparators
- 4 Analog-to-Digital Converters

Wireless Connectivity

- 5 Wi-Fi
- 5 Sub-1GHz
- 5 Bluetooth®
- 5 ZigBee®
- 5 NFC

Embedded Processing Solutions

- 7 MSP430 Low Power FRAM MCUs
- 7 MSP430 Low Power MCUs
- 7 ARM Based MCUs and MPUs

Power Management

- 8 DC/DC Switching Regulators
- 8 Linear Regulators
- 8 Voltage Reference
- 9 AC/DC Converters
- 9 Ultra Low Power Harvester Power Management IC
- 9 System Timer
- 9 Load Switches

Haptic Drivers

- 10 Piezo Drivers
- 10 Haptic Drivers

Interface and Protection

- 11 Integrated ESD Protection
- 11 High Performance TVs Diodes
- 11 Peripheral Drivers
- 11 RS-485
- 11 eFuses

Sensor Solutions

TI has a rich, five-decade history of sensing innovation and, combined with best-in-class sensing technologies, tools, and resources, we continue to deliver better solutions today and new possibilities for tomorrow.

Learn more about sensor solutions at: www.ti.com/sensing

Temperature Sensing

Part No.	Type	Local Sensor Accuracy (Max) At Given Temp Range (±°C)	Supply Current (Max) (µA)	Supply Range (V)	Interface	Infrared Sensor Accuracy (Max) (±°C)	Operating Temp. (°C)	Pin / Package	Approx. Price (US\$ 1ku)
LMT70/70A	Analog	±0.2°C from 20 to 90	12	2.0 to 5.5	Analog Out	–	–55 to 150	4DSBGA	0.54 / 0.65
LMT84	Analog	±2.7°C from –50 to 150	8.1	1.5 to 5.5	Analog Out	–	–50 to 150	5SC70	0.18
TMP112	Digital	±0.5°C from 0 to 65	10	1.4 to 3.6	I ² C, SMBus, 2-wire	–	–40 to 125	6SOT	0.90
TMP75	Digital	±2°C from –25 to 85	85	2.7 to 5.5	I ² C, SMBus, 2-wire	–	–40 to 125	8SOIC, 8VSSOP	0.45
TMP007	Contactless	±1°C from –40 to 125	350	2.2 to 5.5	I ² C, SMBus	3	–40 to 125	8DSBGA	1.90

Humidity and Temperature Sensing

Part No.	Relative Humidity Accuracy (Typ) (%RH)	RH Operating Range (Typ) (%RH)	Temperature Accuracy (Typ) (°C)	Supply Range (V)	Average Supply Current (Typ) (µA)	Interface	Operating Temp. (°C)	Pin / Package	Approx. Price (US\$ 1ku)
HDC1000/1050	±3	0 - 100	±0.2	3 to 5	1.2 @ 1 sps	I ² C	–40 to 125	8DSBGA, 6DFN	2.20
HDC1008	±4	0 - 100	±0.2	3 to 5	1.2 @ 1 sps	I ² C	–40 to 125	8DSBGA	1.76

*Quantities of 1,000 begin at this suggested resale price in U.S. dollars.

Preview products are listed in **bold teal**.

Sensor Solutions

Ambient Light Sensing

Part No.	Supply Range (Nom) (V)	Iq (Max) (µA)	Lux Range (Nom)	Dark Response @ 0 Lux (Max)	Gain Selection	Interface	Benefits	Operating Temp. (°C)	Pin / Package	Approx. Price (US\$ 1ku)
OPT3001	1.6 to 3.6	2	0.01 to 83K	1 Code	11 Gains with Auto-ranging	I ² C	Matches photopic response of the human eye Rejects > 99% (Typ) of IR	-40 to 85	USON	0.99

Inductance Sensing

Part No.	Key Applications	Special Features	Input Channels	L (Inductance) Resolution (Bits)	Supply Range	Active State Current (mA)	Interface	Sensor Frequency (Hz)	Operating Temp. (°C)	Pin / Package	Approx. Price (US\$ 1ku)
LDC1312/4	<ul style="list-style-type: none"> Position Sensing Angle/Rotation sensing 	<ul style="list-style-type: none"> Contactless sensing Ultralow cost sensors (coils, PCB coils) Immune to dust, dirt etc. 	2 / 4	12	2.7 to 3.6	2.1	I ² C	1k to 10M	-40 to 125	WSON, WQFN	2.38 / 3.50
LDC1612/4	<ul style="list-style-type: none"> Position Sensing Angle/Rotation sensing 	<ul style="list-style-type: none"> Contactless sensing Ultralow cost sensors (coils, PCB coils) Immune to dust, dirt etc. 	2 / 4	28	2.7 to 3.6	2.1	I ² C	1k to 10M	-40 to 125	WSON, WQFN	3.25 / 4.75

Capacitance Sensing

Part No.	Input Channels	Special Features	Shield Drive Channels	Special Features	Supply Range	Supply Current (mA)	Interface	Prog. Sampling Rate (Typ) (SPS)	Operating Temp. (°C)	Pin / Package	Approx. Price (US\$ 1ku)
FDC1004	4	<ul style="list-style-type: none"> Liquid level sensing (with interferers) 	2	Integrated Shield Drivers	3 to 3.6	0.75	I ² C	100 / 200 / 400	-40 to 125	WSON	2.50
FDC2114/12	4 / 2	<ul style="list-style-type: none"> Proximity Sensing Liquid Level Sensing 	–	EMI resistant core	2.7 to 3.6	2.1	I ² C	40 to 4080	-40 to 125	WQFN	2.38 / 3.50
FDC2214/12	4 / 2	<ul style="list-style-type: none"> Proximity Sensing Liquid Level Sensing 	–	EMI resistant core	2.7 to 3.6	2.1	I ² C	40 to 13300	-40 to 125	WQFN	3.25 / 4.75



Hall Effect Sensor

Part No.	Type	Type	Supply Range	Output	Output Bandwidth (Typ) (kHz)	Operating Temp. (°C)	Pin / Package	Approx. Price (US\$ 1ku)
DRV5013/23/33	Digital	Latch / Switch / Omnipolar Switch	2.5 to 38	Open Drain	–	-40 to 125	SOT-23, T0-92	0.29
DRV5053	Analog	Analog Bipolar	2.5 to 38	0.2 to 1.8 V	10	-40 to 125	SOT-23, T0-92	0.31

*Quantities of 1,000 begin at this suggested resale price in U.S. dollars.

New products are listed in bold red.

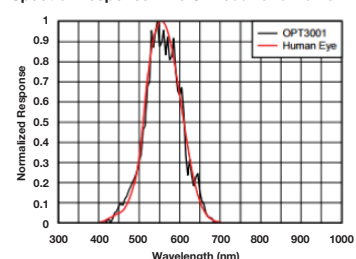
Find the Perfect Sensor Reference Design to Get Started

	16-Button Keypad using the LDC1314 Inductive-to-Digital Converter Reference Design - TIDA-00509	Key Features <ul style="list-style-type: none"> Contactless buttons with superior reliability over electrical/mechanical contact solutions Support simultaneous button presses 	TI Devices LDC1314 LP2985-N MSP430F5528
	Backlight and Smart Lighting Control by Ambient Light and Proximity Sensor Reference Design - TIDA-00373	Key Features <ul style="list-style-type: none"> Good Human Eye Spectral Matching Dynamically Adjusts Backlight Brightness UV Filter for Outdoor Using 	TI Devices OPT3001 FDC1004 HDC1000 MSP430FR5969

Ambient Light Sensor with Human Eye Visibility

The OPT3001 is a single-chip lux meter, measuring the intensity of light as visible by the human eye. The precision spectral response and strong IR rejection of the device enables the OPT3001 to accurately meter the intensity of light as seen by the human eye regardless of light source. The strong IR rejection also aids in maintaining high accuracy when industrial design calls for mounting the sensor under dark glass for aesthetics.

Spectral Response: The OPT3001 and Human Eye



Amplifier and Comparator Solutions

Texas Instruments delivers a broad portfolio of amplifier and linear solutions including precision and high speed op amps, instrumentation and differential amplifiers along with comparators. TI has an amplifier suited for any application.

Learn more about Amplifier solutions at: www.ti.com/amplifier

Low Power Amplifiers

Part No.	Supply Range (V)	Channels	Iq per ch. (Max) (mA)	GBW (Typ) (MHz)	Slew Rate (Typ) (V/μs)	CMRR (Typ) (dB)	Offset Voltage @ 25°C (Max) (mV)	Offset Drift (Typ) (μV/°C)	Rail-Rail	Operating Temp. (°C)	Approx. Price (US\$ 11ku)
LMV611/2/4	1.8 to 5.5	1 / 2 / 4	0.21	1.5	0.42	60	4	5.5	RRIO	-40 to 125	0.22 / 0.25 / 0.30
LPV521	1.6 to 5.5	1	0.0004	0.0062	0.0024	102	1	0.4	RRIO	-40 to 125	0.49
OPA369	1.8 to 5.5	1	0.0012	0.012	0.005	100	0.75	0.4	RRIO	-40 to 85	0.65
OPA349	1.8 to 5.5	1	0.002	0.065	0.02	52	10	15	RRIO	0 to 70	0.50

General Purpose Amplifiers

Part No.	Supply Range (V)	Channels	Iq per ch. (Max) (mA)	GBW (Typ) (MHz)	Slew Rate (Typ) (V/μs)	CMRR (Typ) (dB)	Offset Voltage @ 25°C (Max) (mV)	Offset Drift (Typ) (μV/°C)	Operating Temp. (°C)	Approx. Price (US\$ 11ku)
TLC271/2/4	3 to 16	1 / 2 / 4	1.6	1.7	3.6	65	10	1.8	-40 to 85	0.31 / 0.41 / 0.60
LM2904	3 to 26	2	0.6	0.7	0.3	50	7	7	-40 to 125	0.07
LM358	3 to 32	2	0.6	0.7	0.3	65	7	7	0 to 70	0.07
OPAx313	1.8 to 5.5	1, 2, 4	0.06	1	0.5	70	2.5	2	-40 to 125	0.26 / 0.38 / 0.55
OPAx314	1.8 to 5.5	1, 2, 4	0.21	3	1.5	75	2.5	1	-40 to 125	0.30 / 0.45 / 0.65
OPAx316	1.8 to 5.5	1, 2, 4	0.5	10	6	76	2.5	2	-40 to 125	0.48 / 0.72 / 1.08
OPAx170	2.7 to 36	1, 2, 4	0.145	1.2	0.5	104	1.8	0.3	-40 to 125	0.40 / 0.60 / 0.90
OPAx171	2.7 to 36	1, 2, 4	0.595	3	1.5	104	1.8	0.3	-40 to 125	0.40 / 0.60 / 0.90
OPAx172	2.7 to 36	1, 2, 4	1.8	10	10	90	1	0.3	-40 to 125	0.65 / 0.99 / 1.49

Comparators

Part No.	Type	Supply Range (V)	Channels	tRESP Low-to-High (μs)	Iq per ch. (Max) (mA)	Input Bias Current (±) (Max) (nA)	VICR (V)	Offset Voltage @ 25°C (Max) (mV)	Operating Temp. (°C)	Approx. Price (US\$ 11ku)
TLV3691	Push-Pull	0.9 to 6.5	1	24	0.00015	0.1	-0.1 to 6.6	15	-40 to 85	0.40
TLV3012	Push-Pull	1.8 to 5.5	1	6	0.005	0.01	-0.2 to 5.7	12	-40 to 85	0.75
TLC3702	Push-Pull	3 to 16	2	1.1	0.02	0.03	0 to 15	5	-40 to 85	0.36
TLV1701/2/4	Open Collector	2.2 to 36	1, 2, 4	0.56	0.075	15	2.2 to 36	2.5	-40 to 125	0.38 / 0.61 / 0.97

Analog-to-Digital Converters

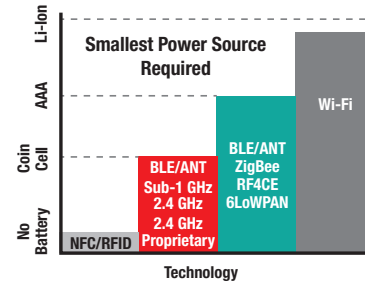
Part No.	Type	Resolution (bits)	Sample Rate (SPS)	Input Channels	Interface	Supply Range (V)	Features	Operating Temp. (°C)	Approx. Price (US\$ 11ku)
ADS7040/1/2/3/4	SAR	8 to 12	1000	1	SPI	0 to 3.6	Nanowatt Power Consumption	-40 to 125	1.00 / 1.60 / 2.10
ADS1018	ΣΔ	12	3300	4	SPI	2 to 5.5	Temp. Sensor (0.5°C accurate)	-40 to 125	1.15
ADS1120/1220	ΣΔ	16, 24	2000	4	SPI	2.3 to 5.5	Single cycle setting, sensor, IDACs	-40 to 125	3.15 / 3.95

*Quantities of 1,000 begin at this suggested resale price in U.S. dollars.

Wireless Connectivity

With the industry's broadest wireless connectivity portfolio TI offers cost-effective, low-power solutions for short-range, long-range, mesh, and IP networks

Learn more about Wireless Connectivity solutions at:
www.ti.com/wireless



Wi-Fi

Part No.	Benefits	TI Designs and Development Tools
CC3200	SimpleLink Wi-Fi Wireless MCU with ARM Cortex®-M4, Integrated Wi-Fi Connectivity, security, low power, ease of use: Certified Wi-Fi modules available	CC3200MODLAUNCHXL, TIDA-00372, TIDC-CC3200SMARTPLUG, TIDC-CC3200CAMBOOST
CC3100	SimpleLink Wi-Fi Wireless Network Processor: provides easy Wi-Fi connectivity for building automation applications. Fully integrated 802.11 b/b/n radio, baseband, and MAC. Connect serially Interface to any 8, 16, or 32-bit micro-controllers. Certified Wi-Fi modules available	CC3100MODBOOST
WL1837MOD	High performance, low power, certified combo modules integrating Wi-Fi + Bluetooth + Bluetooth Low Energy. Connects to any Linux Processor with SDIO interface, available up to 85°C, 2.4GHz and 5GHz	WL1837MODCOM8I

Sub-1GHz

Part No.	Benefits	TI Designs and Development Tools
CC1200	High performance, long distance, low power radio transceiver: optimized for wide band applications	CC1200DK, CC1200EMK-868-930, TIDC-CHN
CC1120	High performance, long distance, low power radio transceiver: optimized for Narrowband	CC1120DK, CC1120EMK-169, CC1120EMK-420-470, CC1120EMK-868-915, TIDC-MULTIBAND-WMBUS
CC1101	Ultra-low power radio transceiver	CC1101DK433, CC1101DK868-915, TIDM-SUB1GHZ-MESH-NETWORK
CC1310	SimpleLink Ultra-low power ARM® Cortex®-M Based Wireless MCU	TIDA-00484

Bluetooth®

Part No.	Benefits	TI Designs and Development Tools
CC2650	SimpleLink Wi-Fi Ultra-Low power ARM® Cortex®-M Based Wireless MCU: multi-standard supported Bluetooth Low-Energy, 6LowPAN and ZigBee. Ideal for end point sensors	CC2650DK, CC2650STK, TIDA-00374
CC2640	SimpleLink Wi-Fi Ultra-Low power ARM® Cortex®-M Based Wireless MCU supporting Bluetooth Low-Energy: ultra-low power, small size and ease of use. Ideal for end point sensors	CC2650DK, CC2650STK, TIDA-00374
CC2540T	Extreme temperature Bluetooth Low Energy (up to 125 degree C) wireless MCU combined with low power and ease of use	CC2541DK-MINI, TIDC-BLUETOOTH-LOW-ENERGY-LONG-RANGE, TIDC-BLUETOOTH-SMART-TO-RS-485-GATEWAY
CC2564MODA	Dual Mode Bluetooth (Bluetooth Low energy + Bluetooth Classic) transceivers module with antenna integrated: low-power, stable and robust SW stack	CC256XQFNEM CC2564MODAEM (RTM September)

ZigBee®

Part No.	Benefits	TI Designs and Development Tools
CC2630	SimpleLink Wi-Fi Ultra-Low power ARM® Cortex®-M Based Wireless MCU : ideal for end point sensors	CC2650DK, CC2650STK, TIDA-00374
CC2530	ZigBee Wireless MCU: enables robust network nodes to be built with very low total bill-of-material costs	CC2530DK, CC2530EMK, CC2531EM-IOT-HOME-GATEWAY-RD, CC2530-CC2592EM-RD
CC2538	512kB ARM® Cortex®-M Based Wireless MCU: handle complex network stacks with security, demanding applications, and over-the-air download	CC2538DK, CC2538EMK, TIDC-ZNP-HOST-SW3

NFC






Part No.	Benefits	TI Designs and Development Tools
RF430FRL152H	13.56-MHz transponder chip with a programmable 16-bit MSP430 low-power microcontroller. Optimized for operation in fully passive (battery-less) or single-cell battery-powered (semi-active) mode.	TIDM-RF430-TEMPSENSE, TIDM-RF430FRLSENSE
RF430CL330H	NFC Tag Type 4 device which combines a wireless NFC interface and a wired SPI/I2C interface to connect the device to a host	TIDA-00217

*Quantities of 1,000 begin at this suggested resale price in U.S. dollars.

New products are listed in **bold red**.

Wireless Connectivity

Find the Perfect Connectivity Reference Design to Get Started

	SimpleLink™ Bluetooth Smart®/ Multi-Standard SensorTag Reference Design - CC2650STK-RD	Key Features <ul style="list-style-type: none"> • More Sensors! 10 Sensors including light, humidity, pressure, magnetic, accelerometer, gyroscope, and others • Flexibility for IoT applications; Enable ZigBee or 6LoWPAN through a firmware upgrade 	TI Devices CC2650 TMP007 OPT3001 HDC1000
	Wired (UART or RS-485) to Wi-Fi® Bridge with 24-VAC Power Reference Design - TIDA-00375, TIDA-00485, TIDA-00486	Key Features <ul style="list-style-type: none"> • Add Wi-Fi® Connectivity to an existing wired network • Wide Input Voltage Range of 18- to 30-VAC, 12- to 48-VDC • Galvanically Isolated or Non-Isolated variations 	TI Devices CC3200MOD CC3100MOD LM5160 LMR16006
	Battery-less NFC/RFID Temperature Sensing Patch Reference Design - TIDM-RF430-TEMPSENSE	Key Features <ul style="list-style-type: none"> • No batteries required • “Over the air” configuration of the ADC • Different antenna configurations allow many form factors 	TI Devices RF430FRL152H
	Dynamic Field Powered NFC Reference Design for Data Logging and Security Applications Reference Design - TIDA-00217	Key Features <ul style="list-style-type: none"> • User can receive updated information from a field unit • Battery-less sensor interface; NFC reader provides 	TI Devices TMP103 RF430CL330H MSP430FR5969
	SimpleLink™ Wi-Fi® CC3200 Smart Plug Reference Design - TIDC-CC3200SMARTPLUG	Key Features <ul style="list-style-type: none"> • Single-Phase energy measurement that calculates Current, Voltage, Power, and Energy • SimpleLink™ Wi-Fi® connectivity over 802.11 b/g/n networks from any mobile device • Isolated flyback power supply to provide Constant-Voltage and Constant-Current output regulation without optical coupler” 	TI Devices CC3200 UCC28910 TPS61097A-33

Embedded Processing Solutions

Microcontrollers and processors from Texas Instruments offer a broad range of performance and power consumption options. From MSP430 MCU with ultra-low power consumption to the Sitara™ AM335x family with integrated multi-protocol industrial communications support to connect various kinds of sensors in real-time for better automation; TI is tailored to meet your design challenges.

Learn more about Microcontroller solutions at: www.ti.com/msp430 and www.ti.com/msp432.

Learn more about processor solutions at: www.ti.com/processors.

MSP430 Low Power FRAM MCUs

Part No.	Frequency (MHz)	Non-volatile Memory (KB)	SRAM (KB)	GPIO	I ² C	SPI	UART	DMA	ADC	Comparator (Channels)	Timers 16-Bit	Multipliers	AES	Additional Features	Operating Temp. (°C)	Package	Approx. Price (US\$ 1ku)
MSP430FR4133	16	15.5	2	60	1	2	1	0	ADC10-10ch	0	2	N/A	N/A	LCD, RTC, BOR, Temp Sensor	-40 to 85	LQFP, TSSOP	1.55
MSP430FR5969	16	64	2	40	1	3	2	3	ADC12-16ch	16	5	32x32	AES256	RTC, BOR, IrDA, Temp Sensor	-40 to 85	VQFN	2.35
MSP430FR6972	16	64	2	51	2	4	2	3	ADC12-8ch	8	5	32x32	AES256	LCD, RTD, BOR, IrDA, Temp Sensor	-40 to 85	LQFP	2.55
MSP430FR6989	16	128	2	83	2	4	2	3	ADC12-16ch	16	5	32x32	AES256	LCD, RTC, Scan I/F, BOR, IrDA, Temp Sensor	-40 to 85	LQFP	4.50

*Quantities of 1,000 begin at this suggested resale price in U.S. dollars.

New products are listed in bold red.

Embedded Processing Solutions

MSP430 Low Power MCUs

Part No.	Frequency (MHz)	Non-volatile Memory (KB)	SRAM (KB)	GPIO	I ² C	SPI	UART	ADC	Comparator (Channels)	Timers 16-Bit	Multipliers	Additional Features	Operating Temp. (°C)	Package	Approx. Price (US\$ 1 1ku)
MSP430G2553	16	16	0.5	24	1	1	1	ADC10-8ch	8	2	N/A	Temp Sensor, BOR, IrDA	-40 to 85	TSSOP, VQFN	0.90
MSP430G2955	16	56	4	32	1	2	1	ADC10-12ch	8	3	N/A	Temp Sensor, BOR, IrDA	-40 to 85	TSSOP, VQFN	1.30
MSP430F2274	16	32	1	32	1	1	1	ADC10-12ch	0	2	N/A	Temp Sensor, BOR, OpAmp	-40 to 105 -40 to 85	DSBGA, TSSOP, VQFN	1.80
MSP430I2041	16	32	2	16	1	2	1	SigmaDelta 24-4ch	0	2	16 x16	Temp Sensor, BOR, IrDA	-40 to 105	TSSOP, VQFN	1.75



ARM Based MCUs and MPUs

Part No.	ARM CPU	Benefits	TI Designs and Dev. Tools
MSP432P401R	ARM Cortex-M4F	MSP432P4x microcontrollers are the ideal combination of TI's MSP430 low-power DNA, advanced mixed-signal features, and the high-performance processing capabilities of ARM®'s 32-bit Cortex®-M4F RISC engine.	MSP-EXP432P401R
AM3352	ARM Cortex-A8	Sitara™ AM335x ARM Cortex-A8 Processors deliver the right balance of performance (300 MHz to 1 GHz of processing power), Interfaces (DDR3, LCD, Touch Screen Controller), and Connectivity (UART and Industrial Protocols)	Beaglebk, TMDXEVM3358

*Quantities of 1,000 begin at this suggested resale price in U.S. dollars.

New products are listed in **bold red**.

Find the Perfect MCU Reference Design to Get Started

	Thermostat Implementation with FRAM Microcontroller Reference Design - TIDM-FRAM-THERMOSTAT	Key Features <ul style="list-style-type: none"> • 0°C to 35°C Temperature Measurement with 0.1°C Resolution • 3.4 inch LCD Display • Ultra-Low Power: 1.8 µA Standby Current 	TI Devices MSP430FR4133 SN65HVD75 TPS782
	Smoke Detector with Ultra Low Power MCU Reference Design - TIDM-G2xxSMOKEDETECTOR	Key Features <ul style="list-style-type: none"> • Passive infrared (PIR) smoke chamber with discrete Amplification circuitry to ADC input • Low power (2.07 µA) and small code size (<1 KB Flash) • One timer and multiple GPIOs for proprietary comms 	TI Devices OPT3001 FDC1004 HDC1000 MSP430FR5969

FRAM Technology

Ferroelectric Random Access Memory (FRAM) is a memory technology that combines the best of Flash and SRAM. It is non-volatile like Flash, but offers fast and low power writes, write endurance of 10¹⁵ cycles, code and data security that is less vulnerable to attackers than Flash/EEPROM, resistance to radiation and electromagnetic fields, and unmatched flexibility. This memory technology has been around for decades, but is now being integrated in MSP430 ultra-low-power microcontrollers (MCUs) to bring its unique advantages to real-world applications such as energy harvesting, data security, remote sensing or data logging, and many others.

All-in-one: FRAM MCU delivers max benefits				
Specifications	FRAM	SRAM	EEPROM	Flash
Non-volatile Retains data w/o power	Yes	No	Yes	Yes
Write speed (13 KB)	10ms	<10ms	2 secs	1 sec
Average active Power [µA/MHz] 16 bit word access by the CPU	100	<60	50,000+	230
Write endurance	10 ¹⁵	Unlimited	100,000	10,000
Soft Errors	Below Measurable Limits	Yes	Yes	Yes
Bit-wise programmable	Yes	Yes	No	No
Unified Memory Flexible code and data partitioning	Yes	No	No	No

Power Management

Texas Instruments offers complete power solutions with a full line of high-performance products. These products, which range from standard linear regulators to highly efficient DC/DC converters and battery management, are tailored to meet your design challenges.

Learn more about Power Management solutions at: www.ti.com/power and www.ti.com/powerlab

DC/DC Switching Regulators

Part No.	Topology	Supply Range (V)	Output Voltage (V)	Output Current (Max) (A)	Switching Frequency (Max) (kHz)	Duty Cycle (Max) (%)	Iq (Typ) (mA)	Operating Temp. (°C)	Pin / Package	Approx. Price (US\$ 11ku)
Vin < 24V										
TPS82740A	Buck Module	2.2 to 5.5	1.8 to 2.5	0.2	2000	100	0.00036	-40 to 85	9uSIP	1.50
TPS62730	Buck	1.9 to 3.9	1.9, 2.1, 2.3	0.1	3000	100	0.025	-40 to 85	6SON	0.55
TPS62080	Buck	2.3 to 6	0.5 to 6	1.2	2000	100	0.0045	-40 to 85	8WSON	0.75
TPS62160	Buck	3 to 17	0.9 to 6	1	2500	100	0.017	-40 to 85	8VSSOP, 8WSON	0.80
TPS61291	Boost	0.9 to 5.0	2.5, 3.0, 3.3	0.2	-	-	0.005	-40 to 85	6SON	0.68
TPS61098	Boost	0.7 to 4.5	2.2 to 4.3	0.1	-	-	0.0003	-40 to 85	6WSON	0.72
TPS61220	Boost	0.7 to 5.5	1.8 to 5.5	0.1	2000	90	0.005	-40 to 85	6SC70	0.43
Wide Vin (Vin ≥ 24V)										
TPS62175	Buck	4.7 to 28	1 to 6	0.5	1000	100	0.0048	-40 to 85	10WSON	0.70
LM25017/8/9	Buck	7.5 to 48	1.25 to 40	0.65 / 0.3 / 0.1	1000	90	1.75	-40 to 125	8WSON, 8SO PowerPAD	1.25 / 1.12 / 0.81
TPS54160A	Buck	3.5 to 60	0.8 to 58	1.5	2500	98	0.138	-40 to 125	10MSOP/10SON	1.58
TPS54060A	Buck	3.5 to 60	0.8 to 58	0.5	2500	98	0.116	-40 to 150	10MSOP/10SON	1.27
TPS54061	Buck	4.7 to 60	0.8 to 58	0.2	1100	98	0.09	-40 to 150	8SON	1.04

Linear Regulators

Part No.	Supply Range (V)	Output Voltage (V)	Output Current (Max) (A)	Iq (Typ) (mA)	Output Options	Accuracy (Max) (%)	PSRR @ 100kHz (dB)	Operating Temp. (°C)	Pin / Package	Approx. Price (US\$ 11ku)
Vin < 24V										
TPS799	2.7 to 6.5	1.2 to 4.5	0.2	0.04	Adj. or Fixed	2	38	-40 to 125	5DSBGA, 5SOT, 6SON	0.28
TLV1117	2.7 to 15	1.25 to 13.7	0.8	0.08	Adjustable	1	28	-40 to 125	3TO, 4SOT, 8SON	0.18
TPS7A37	2.2 to 5.5	1.2 to 5.4	1	0.4	Adj. or Fixed	1	32	-40 to 125	6SON	0.66
LP5907	2.2 to 5.5	1.2 to 4.5	0.25	0.012	Fixed	2	60	-40 to 125	4DSBGA, 4X2SON, 5SOT-23	0.14
Wide Vin (Vin ≥ 24V)										
TPS709	2.7 to 30	1.2 to 6	0.15	0.001	Fixed	2	26	-40 to 125	5SOT-23, 6SON	0.39
LP2951/LP2951-N	2 to 30	1.2 to 29	0.1	0.075	Adjustable	2	53	-40 to 125	8SOIC	0.18
TPS7A16	3 to 60	1.2 to 18.5	0.1	0.005	Adj. or Fixed	2	26	-40 to 125	8SON, 8MSOP-PowerPAD	1.39
LM317	3 to 40	1.25 to 37	1.5	0.05	Adjustable	4	-	0 to 125	4SOT, 3TO, 2PFM	0.18
LM2936	5.5 to 60	3 to 5	0.05	0.015	Fixed	3	35	-40 to 125	3TO-92, 4SOT-223, 8SOIC, 8VSSOP, 3TO-252	0.62

Voltage Reference

Part No.	Supply Range (V)	Output Voltage (V)	Iout/Iz (Max) (mA)	Iq (Typ) (µA)	Initial Accuracy (%)	0.1-10Hz Noise (Max) (µVpp)	Temp. Coeff (Typ) (ppm/°C)	Operating Temp. (°C)	Pin / Package	Approx. Price (US\$ 11ku)
REF3312	2.7 to 5.5	2.5	5	3.9	0.15	70	9	-40 to 125	3SC70, 5SOT-23, 8UQFN	0.85
REF5030	3.2 to 18	3	10	800	0.05	9	3	-40 to 125	8SOIC, 8VSSOP	1.35
ATL431	2.5 to 36	2.5 to 36	100	20	0.5 / 1	-	-	-40 to 125 / -40 to 85	3SOT-23	0.19

*Quantities of 1,000 begin at this suggested resale price in U.S. dollars.

New products are listed in bold red.

Power Management

AC/DC Converters

Part No.	Power Level (Typ) (W)	Current Mode	Topologies	Maximum Practical Frequency	Soft Start	700-V Start-Up Circuit	110-V Start-Up Circuit	Operating Temp. (°C)	Pin / Package	Approx. Price (US\$ 1ku)
Green Mode PWM Controllers										
UCC28722	Up to 25	✓	Flyback w/PSR for Bipolar Power Device	80 kHz	✓		✓	-40 to 125	6SOT-23	0.25
UCC28700/1/2/3	Up to 30	✓	Flyback w/PSR	130 kHz	✓			-20 to 125	6SOT-26	0.35
Switchers with Integrated FETs										
UCC28880	<5		High Voltage Switcher for Non-Isolated AC/DC Conversion	66 kHz	✓	✓		-40 to 125	7SOIC	0.55
UCC28910	<10	✓	High Voltage Flyback Switcher w/PSR	115 kHz	✓	✓		-40 to 125	7SOIC	0.75

Ultra Low Power Harvester Power Management IC

Part No.	Description	Benefits	TI Designs
BQ25570	Power Management IC which efficiently extracts microwatts (uW) to milliwatts (mW) of power generated from high output impedance DC Sources like photo voltaic (solar) or thermal electric generators (TEG).	Integrates nanopower buck converter and high efficient boost charger	TIDA-00242
BQ25505		A high efficiency nano-boost charger that charges a rechargeable energy reservoir, and also provides battery back-up through a nonrechargeable battery to extend run-time.	TIDA-00100

System Timer

Part No.	Supply Current (Typ) (uA)	Supply Range	Prog. Delay Range	Manual Reset	Additional Notes	Programmable Timer Interval (s)	Timekeeping Accuracy (Typ) (%)	Operating Temp. (°C)	Pin / Package	Approx. Price (US\$ 1ku)
TPL5100	0.030	1.8 to 5	Yes	No	MOS-Driver	0.1 to 7200	1	-40 to 105	6SOT	0.40
TPL5110	0.035	1.8 to 5	Yes	Yes	MOS-Driver	0.1 to 7200	1	-40 to 105	6SOT	0.40
TPL5111	0.035	1.8 to 5	Yes	Yes	Active Low MOS-Driver, Active High LDO Enable	0.1 to 7200	1	-40 to 105	6SOT	-

Load Switches

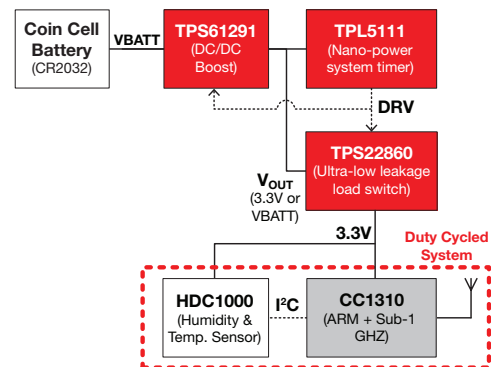
Part No.	Vin (Max) (V)	I _{max} (A)	R _{on} @ 3.6V (Typ) (mΩ)	Leakage Current (uA) (Typ)	Channels	Special Features	Operating Temp. (°C)	Pin / Package	Approx. Price (US\$ 1ku)
Single Channel Devices									
TPS22860	1.65 to 5.5	0.1	1300	0.02	1	-	-40 to 85	6SC70, 6SOT-23	0.25
TPS22907	1.1 to 3.6	1	44	0.5	1	-	-40 to 85	4CSP (0.5 pitch)	0.22
TPS22918	1.05 to 5.5	2	46	2	1	-	-40 to 85	6SOT-23	-
TPS22954	0.7 to 5.5	5	14	5	1	Voltage Monitor (PG Pin)	-40 to 105	10SON	0.36
Multi-channel Devices									
TPS22960	1.62 to 5.5	0.5/ch	435	0.47	2	-	-40 to 85	8SOT-23, 8uQFN	0.36

*Quantities of 1,000 begin at this suggested resale price in U.S. dollars.

New products are listed in bold red. Preview products are listed in bold teal.





Duty-Cycled Power Design Theory for Star Networks

One method to achieve extremely long battery life is through the use of a nano-power system timer. This type of device is intended to replace the internal timer of any standard microcontroller with a discrete analog system timer that consumes much less power than the MCUs internal timer. The nano-power timer can also bring an MCU out of sleep mode by means of a pin interrupt, or to completely shut off power to the system, in whole, or in part. This reduces the system off-state current draw to the tens or hundreds of nanoamps.



TIDA-00484 Block Diagram which Demonstrates a Duty-Cycled Sensor Node

Power Management

Find the Perfect Low Power Reference Design to Get Started			
	Humidity & Temp Sensor Node for 2.4-GHz Star Networks Enabling 10+ Year Coin Cell Battery Life Reference Design - TIDA-00374	Key Features <ul style="list-style-type: none"> • Use of nano-power system timer results in 10+ years of battery life on a coin cell battery • ±3% relative humidity accuracy, ±0.2°C temperature accuracy 	TI Devices TPL5110 TS5A3160 CC2650 HDC1000
	Humidity & Temp Sensor Node for Sub 1-GHz Star Networks Enabling 10+ Year Coin Cell Battery Life Reference Design - TIDA-00484	Key Features <ul style="list-style-type: none"> • Use of nano-power system timer results in 10+ years of battery life on a coin cell battery • ±3% relative humidity accuracy, ±0.2°C temperature accuracy 	TI Devices TPL5111 TPS22860 TPS61291 CC1310
	Energy Buffering for Long-Life Battery Applications Reference Design - PMP9753	Key Features <ul style="list-style-type: none"> • Efficient Super Capacitor Charging • Peak Power Assistance • Longer Battery Runtime 	TI Devices TPL5110 TS5A3160 CC2650 HDC1000
	110-VAC to 5-VDC @ 30-mA Non-Isolated Power Supply Reference Design Reference Design - TIDA-00379	Key Features <ul style="list-style-type: none"> • Solution does not require a custom transformer • Optimized, low-cost BOM • Output ripple of less than 10-mV 	TI Devices UCC28880 LP2985-50

Haptic

Texas Instruments offers a complete line of haptic devices which have the ability to drive eccentric rotating mass (ERM), linear resonant actuator (LRA), and piezoelectric actuators. With TI's haptic drivers you can add that extra sensory element that is missing in modern day touch interfaces.

Learn more about Haptic Feedback solutions at: www.ti.com/haptics

Piezo Driver


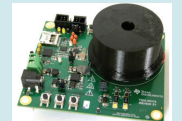
Part No.	Maximum Differential Output Voltage (Vpp)	Maximum Single-Ended Output Voltage (Vp)	Supply Voltage (V)	Small-signal Bandwidth (kHz)	Gain-Bandwidth (kHz)	Load Capacitance (µF)	Slew Rate (V/µs)	Operating Temp. (°C)	Pin / Package	Approx. Price (US\$ 1ku)
DRV2700	±100	1000	3 to 5.5	20	550	4.7	0.6	-40 to 85	QFN	4.95

Haptic Driver

Part No.	Haptic Acuator Type	Input Signal	Supply Voltage (V)	Startup Time (ms)	Vout (Max) (V)	Iq (Typ) (mA)	Shutdown Current (Typ) (µA)	Operating Temp. (°C)	Pin / Package	Approx. Price (US\$ 1ku)
DRV2605L	ERM, LRA	PWM, Analog, I ² C	2 to 5.2	0.7	5.5	0.5	4	-40 to 85	10VSSOP, 9DSBGA	1.65
DRV2667	Piezo	PWM, Analog, I ² C	3 to 5.5	2	200	0.13	-	-40 to 85	20QFN	2.95

*Quantities of 1,000 begin at this suggested resale price in U.S. dollars.

New products are listed in bold red.

Find the Perfect Haptic Reference Design to Get Started			
	Touch on Metal Buttons with Integrated Haptic Feedback Reference Design - TIDA-00314	Key Features <ul style="list-style-type: none"> • Replaces Mechanical Buttons with Inductive-Sensing Based Touch on Metal Detection • Customizable Haptic Feedback and Waveforms Provide High Quality User Experience • Programmable Button Sensitivity (from Light Touch to Hard Press) 	TI Devices DRV2605L DRV2667 LDC1614 MSP430F5528
	Piezo Speaker Strobe Notification Reference Design Reference Design - TIDA-00376	Key Features <ul style="list-style-type: none"> • 86.5 dBA @ 3m (520 Hz Square Wave) • 80.5 dBA @ 3m (2.84 kHz Sine Wave) • 77.5 dBA @ 3m (Pre-Recorded Speech) • 300 candela @ 3m (Flash Mode) 	TI Devices DRV2700 LMV344 LM3550 MSP430FR5969

Interface and Protection

Texas Instruments offers a comprehensive interface portfolio enabling system connectivity. With a variety of communication standards such as CAN, UART, USB, RS-232, RS-485 and 10-/100-Mbit Ethernet, TI delivers a variety of options for your interface needs.

Learn more about Wired Connectivity solutions at: www.ti.com/interface and www.ti.com/esd

Integrated ESD Protection

Part No.	Interface	Channels	IO Capacitance (Typ) (pF)	Breakdown Voltage (Min) (V)	IEC 61000-4-2 Contact (+/- kV)	IEC 61000-4-2 Air-Gap (+/- kV)	Special Features	Current Limit Rating (Min) (mA)	Operating Temperature Range(C)	Pin / Package	Approx. Price (US\$ 1ku)
TPD4F003	LCD Display, Memory / SIM Card	4	17	6	12	20	EMI Filter	–	–40 to 85	WSON	0.18

High Performance TVS Diodes

Part No.	Interface	Channels	IO Capacitance (Typ) (pF)	Breakdown Voltage (Min) (V)	IEC 61000-4-2 Contact (+/- kV)	IEC 61000-4-2 Air-Gap (+/- kV)	Bi-/Uni-Directional	Operating Temp. (°C)	Pin / Package	Approx. Price (US\$ 1ku)
TPD1E10B06	Audio, General Purpose	1	12	6	30	30	Bi-Directional	–40 to 125	X1SON	0.05
TPD2E007	RS-232/485, CAN, Audio	2	15	14	8	15	Bi-Directional	–40 to 85	DSLGA, SC70	0.20

Peripheral Drivers

Part No.	Type	Peak Output Current (mA)	Output Voltage (Max) (V)	Delay Time (Typ) (ns)	Input Compatibility	Drives per Package	Gate	Output Clamp Diodes	Operating Temp. (°C)	Pin / Package	Approx. Price (US\$ 1ku)
TPL7407L	NMOS Array	600	40	250	CMOS, TTL	7	INVERT	Yes	–40 to 125	16SOIC, 16TSSOP	0.20
ULN2003A	Darlington Transistor Array	500	50	250	CMOS, TTL	7	INVERT	Yes	–20 to 70	16SO, 16SOIC, 16TSSOP	0.14

RS-485

Part No.	TX/RX	Duplex	Supply Voltage (V)	Features	Signaling Rate (Mbps)	HBM ESD (kV)	Receiver Fail-Safe	Nodes	Pin / Package	Approx. Price (US\$ 1ku)
SN65HVD72	1/1	Half	3.3	High Hysteresis, ±12kV IEC 61000-4-2 ESD, ±4kV EFT	0.25	15	Short, Open, Idle	256	8SOIC, 8SON, *VSSOP	0.70
SN65HVD82	1/1	Half	5	Low Power, ±12kV IEC 61000-4-2 ESD, ±4kV EFT	0.25	16	Short, Open, Idle	256	8SOIC	1.00
SN65HVD3082E/5E/8E	1/1	Half	5	Ultra-Low Power, Optimized for Low, Medium, & High Speeds	0.2, 1, 20	15	Short, Open, Idle	256	8SOIC, 8MSOP, 8PDIP	0.90, 1.00, 1.10

eFuses

Part No.	Supply Range (V)	Vabsmax cont (V)	Current Limit Threshold (A)	Current Limit Accuracy	Internal FET RON (mOhm)	Fault Response	On_Off Control Input(s)	Special Features	Pin / Package	Approx. Price (US\$ 1ku)
TPS25921A	4.5 to 18	20	0.4 to 1.6	±2% @ 1A	90	Auto Retry	ENUV, OV	No Rsense Required	8SOIC	0.50
TPS25926	4.5 to 13.8	20	2 to 5	±8% @ 3.7A	30	Auto Retry	ENUV	BLK FET Driver, Output Clamp, No Rsense Required	10VSON	0.55
TPS25927	4.5 to 18	20	1 to 5	±15% @ 2.1A	30	Auto Retry	ENUV	BLK FET Driver, No Rsense Required	10VSON	0.55

*Quantities of 1,000 begin at this suggested resale price in U.S. dollars.



Now more powerful

- Industry's largest reference design library
- Over 1,000 power management reference designs
- Enhanced search tool: Parameters, topologies, keyword, application, or product
- Direct access to fully tested analog, embedded processor, and connectivity reference designs

This robust tool offers complete solutions across the board.



TI Worldwide Technical Support

Internet

TI Semiconductor Product Information Center Home Page
support.ti.com

TI E2E™ Community Home Page
e2e.ti.com

Product Information Centers

Americas	Phone	+1(512) 434-1560
Brazil	Phone	0800-891-2616
Mexico	Phone	0800-670-7544
	Fax	+1(972) 927-6377
	Internet/Email	support.ti.com/sc/pic/americas.htm

Europe, Middle East, and Africa

Phone		
European Free Call	00800-ASK-TEXAS (00800 275 83927)	
International	+49 (0) 8161 80 2121	
Russian Support	+7 (4) 95 98 10 701	
Note: The European Free Call (Toll Free) number is not active in all countries. If you have technical difficulty calling the free call number, please use the international number above.		

Fax	+ (49) (0) 8161 80 2045
Internet	www.ti.com/asktexas
Direct Email	asktexas@ti.com

Japan

Phone	Domestic (toll-free number)	0120-92-3326
Fax	International	+81-3-3344-5317
	Domestic	0120-81-0036
Internet/Email	International	support.ti.com/sc/pic/japan.htm
	Domestic	www.tij.co.jp/pic

Asia

Phone	Toll-Free Number
Note: Toll-free numbers may not support mobile and IP phones.	
Australia	1-800-999-084
China	800-820-8682
Hong Kong	800-96-5941
India	000-800-100-8888
Indonesia	001-803-8861-1006
Korea	080-551-2804
Malaysia	1-800-80-3973
New Zealand	0800-446-934
Philippines	1-800-765-7404
Singapore	800-886-1028
Taiwan	0800-006800
Thailand	001-800-886-0010
International	+86-21-23073444
Fax	+86-21-23073686
Email	tiasia@ti.com or ti-china@ti.com
Internet	support.ti.com/sc/pic/asia.htm

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.

B012014

The platform bar and E2E are trademarks of Texas Instruments. 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	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

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

TI E2E Community

e2e.ti.com