



THE DATASHEET OF OPA4316IDR



Connected Sensors Building Automation Systems Guide



Connected Sensors Building Automation Systems Guide

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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.

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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.

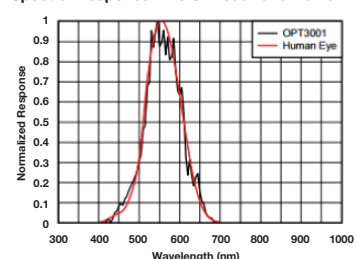
Find the Perfect Sensor Reference Design to Get Started

| | | | |
|---|---|---|--|
|  | 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

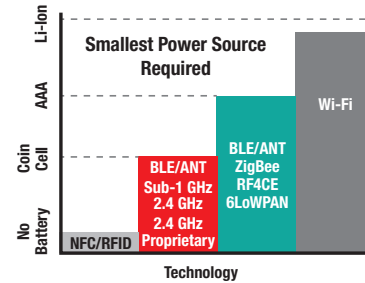
| Part No. | Type | Resolution (bits) | Sample Rate (SPS) | Input Channels | Interface | Supply Range (V) | Features | Operating Temp. (°C) | Approx. Price (US\$ 11ku) |
|-----------------|------|-------------------|-------------------|----------------|-----------|------------------|-------------------------------------|----------------------|---------------------------|
| 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 |

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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 LMS160 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 |

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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

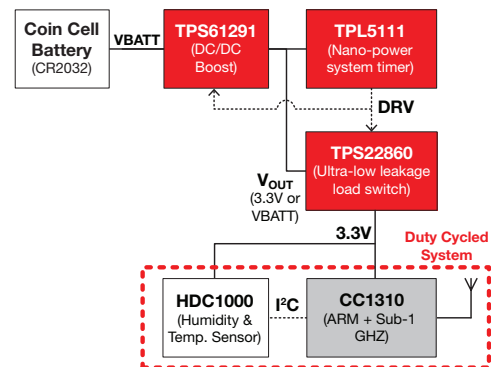
| Part No. | Vin (Max) (V) | I _{max} (A) | R _{on} @ 3.6V (Typ) (mΩ) | Leakage Current (uA) (Typ) | Channels | Special Features | Operating Temp. (°C) | Pin / Package | Approx. Price (US\$ 1ku) |
|-------------------------------|---------------|----------------------|-----------------------------------|----------------------------|----------|--------------------------|----------------------|------------------|----------------------------|
| 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

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Piezo Driver


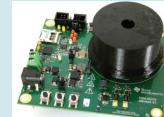
| Part No. | Maximum Differential Output Voltage (Vpp) | Maximum Single-Ended Output Voltage (Vp) | Supply Voltage (V) | Small-signal Bandwidth (kHz) | Gain-Bandwidth (kHz) | Load Capacitance (µF) | Slew Rate (V/µs) | Operating Temp. (°C) | Pin / Package | Approx. Price (US\$ 1ku) |
|----------------|---|--|--------------------|------------------------------|----------------------|-----------------------|------------------|----------------------|---------------|----------------------------|
| 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 |

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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 |

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