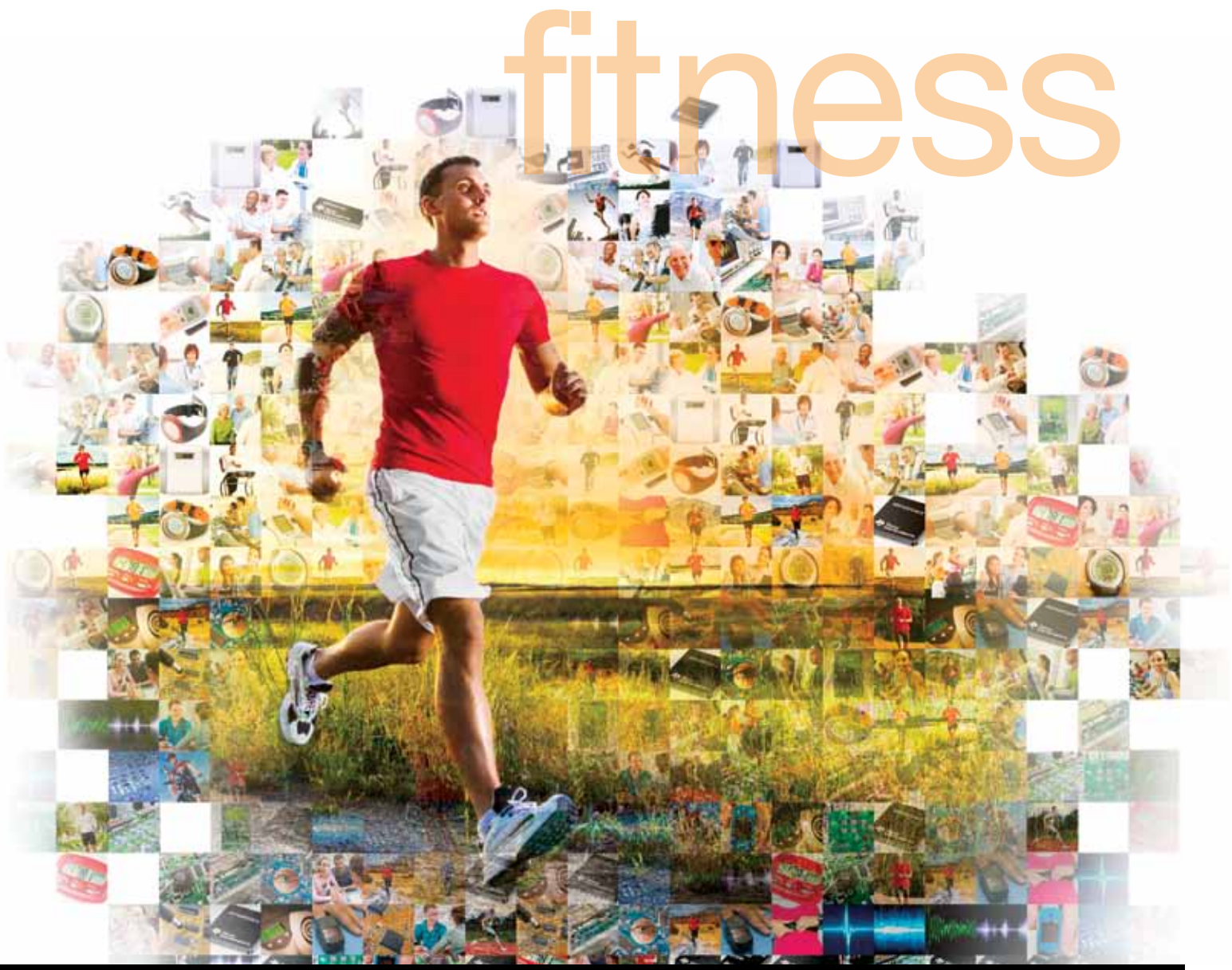

Texas Instruments

TI HealthTech

Engineering components for life.

2013

www.ti.com/healthtech

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Fitness

Resources

TI's HealthTech Applications Guides available for individual download:

- **Health**
- **Imaging**
- **Fitness**

Visit:
www.ti.com/healthtechguides

Overview

Fitness Overview

The consumer market is focused on personal fitness more than ever before. Heart rate monitors, body worn fitness trackers, and body composition weigh scales are just a few of the options out there for athletes and fitness enthusiasts to measure and monitor personal fitness both during exercise and daily activity. By developing innovative ways to increase integration, lower power consumption, and provide smart connectivity, TI components makes fitness more flexible, affordable, and accessible.

Driven by the fitness electronics user's desire to quickly know their health status -- portable and battery operated fitness devices commonly have goals for extended battery life, high precision and fast response times. Additional requirements may drive the need for more memory to allow for historical profiling, cabled or wireless interfaces for data upload or for access to the sensor. Audio feedback for simple good/not good indication or more complex step-by-step utilization instructions may be required as well. Adding these features without increasing power consumption is a significant challenge.

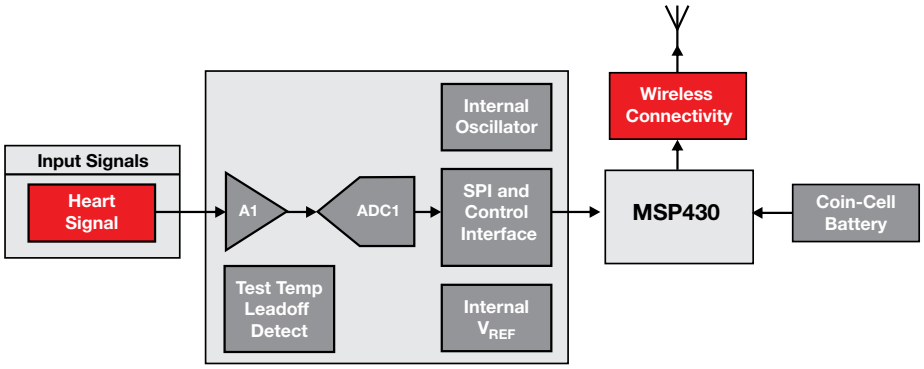
TI features a broad array of comprehensive system block diagrams, selection tables and key design tools to help you accelerate innovation. TI HealthTech's broad portfolio, backed by the resources of the TI global enterprise, is the world's largest producer of analog and embedded processors and the single most experienced source for health-care components in electronic fitness applications.

Heart Rate/Fitness Monitoring Systems

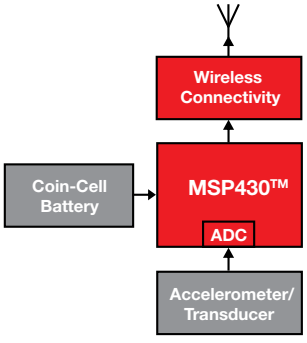
Heart Rate/Fitness Monitors

Fitness monitors measure both a person's amount and rate of exercise (e.g. miles and pace run) as well as effort expended (e.g. through monitoring heart rate). Typically, a wristwatch or wrist-worn display is used for control and providing feedback. Stored data can be downloaded to a computer via USB or a wireless USB dongle. All parts of the system require ultra-low-power embedded controllers and low-power RF for communications. Heart rate monitoring and exercise output monitoring (e.g. running pace sensor or power sensor) require additional signal conditioning.

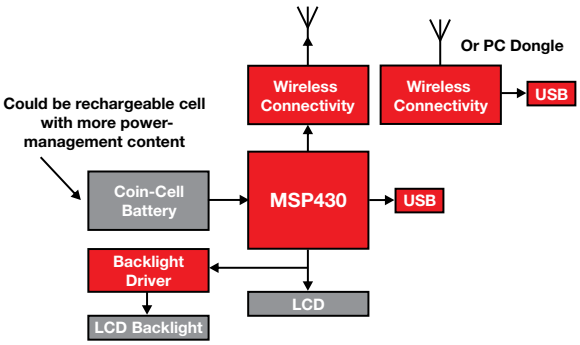
Note: "Heart Rate and EKG Monitor using the MSP430FG439" (slaa280)
www-s.ti.com/sc/techlit/slaa280



Heart rate monitor.



Shoe/footstrike sensor.



Wrist display/watch.

Blood Pressure Monitors

Blood Pressure Monitors

These monitoring systems use Korotkoff, oscillometry or pulse transit time methods to measure blood pressure. A pressure cuff and pump, along with a transducer, are used to measure blood pressure and heart rate in three phases: inflation, measurement and deflation. Also included are LCDs, selection buttons, memory recall, power management and USB interface.

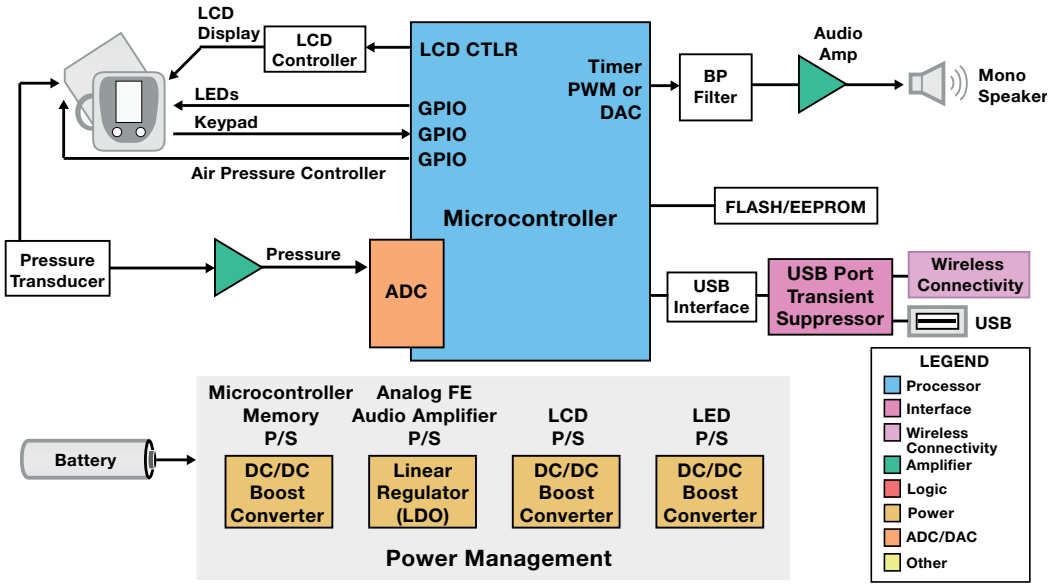
The core subsystems include:

Processor/Memory — Digital pressure measurement and heart rate are performed by the microcontroller. Measurement results are stored in flash memory as a data log that can be uploaded to a computer via USB or wireless connection.

User Interface — Allows the user to control the pressure measurement process and read the results on an LCD display.

Sensor Interface — Allows the processor to control the cuff inflation/deflation and sense blood pressure that is amplified by instrumentation amplifiers and digitized by the ADC.

Power Management — Converts input power from the alkaline or rechargeable batteries to run various functional blocks.



Product Availability and Design Disclaimer – The system block diagram depicted above and the devices recommended are designed in this manner as a reference. Please contact your local TI sales office or distributor for system design specifics and product availability.

Example application block diagram — blood pressure monitor.

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers				
INA321	CMOS Instrumentation Amp	0.02% accuracy, 2ppm/°C drift for gain = 5; 10pA input bias current	High gain accuracy	INA2321 (dual)
INA333	Instrumentation Amp	25µV (max) offset, 50nV/°C drift, 50µA (typ) Iq	Best offset/noise combination, supply down to 1.8V, low power	INA326, INA321
OPA333	Precision Op Amp	1.8V min supply, 0.017mA/ch (max), 10µV offset (max), 0.05µV/°C drift (max)	Zero drift, high precision, low power, EMI input	OPA335, OPA378, OPA330
TPA2006D1	Analog-Input Class-D Amp	1.45W mono, filter-free Class D, 1.8V shutdown		
TPA2010D1	Analog-Input Class-D Amp	2.5W mono, fully differential, filter-free Class D, in WCSP	Loud audio, long battery life, small package size	TPA2031D1
TPA2013D1	Analog-Input Class-D Amp	2.7W constant output power, mono, Class D, integrated boost converter	Louder audio at low battery levels	TPA2014D1
TPA6205A1	Class-AB Audio Amp	1.25W mono, fully differential, Class AB, 1.8V shutdown	Loud audio, low cost	TPA6204A1
TPA6211A1	Class-AB Audio Amp	3.1W mono, fully differential, Class AB	Loud audio	
Data Converters				
ADS1115	Delta-Sigma ADC	16-bit, 860SPS, 4 SE, 2 diff input, PGA, MUX, comparator, V_{REF}	Smallest 16-bit ADC – 2.0 x 1.5 x .04mm leadless QFN pkg – reduces system size/component count	ADS1113/4, ADS1013/14/15
Processors				
MSP430F449	Ultra-Low-Power 16-bit MCU	32 to 60KB Flash, 1KB/2KB RAM, 2x SPI + UART, SVS, 160 segment LCD	8 ch. 12-bit ADC, HW multiplier	
MSP430FG43x	Ultra-Low-Power 16-bit MCU	32 to 60KB Flash, 1KB/2KB RAM, SPI + UART, SVS, 128 segment LCD	12 ch. 12-bit ADC, 2 ch. 12-bit DAC, DMA, 3 op amps	
MSP430FG461x	Ultra-Low-Power 16-bit MCU	92 to 120KB Flash, 4KB/8KB RAM, SPI + I^2C + UART/LIN + IrDA, 160 LCD	12 ch. 12-bit ADC, 2 ch.12-bit DAC, A-comp, 3 op amp, HW multiplier	
MSP430FG47x	Ultra-Low-Power 16-bit MCU	32 to 60KB Flash, 2KB RAM, SPI + I^2C + UART/LIN + IrDA, 128 LCD controller	5 ch. 16-bit SD ADC, 2 ch. 12-bit DAC, comparator_A, 2 op amps	

Electrocardiogram (ECG)/Portable ECG and Electroencephalogram (EEG)

Biophysical Monitoring Overview

The human medical data acquisition system, in particular the patient monitoring system, presents the challenge to designers of measuring very small electrical signals in the presence of much larger common-mode voltages and noise. Front-end amplifiers perform the essential conditioning that complements downstream digital processing, which in turn refines the measurement and communicates with other systems. Biophysical measurements include electrical and mechanical signals for general monitoring, diagnostic and scientific purposes both in clinic and non-clinic environments. Successfully meeting the signal acquisition challenge requires system designers to have knowledge of the signal source, good design practice and ICs with appropriate characteristics, features and performance.

Signal Acquisition Challenges

The action potential created by heart wall contraction spreads electrical currents from the heart throughout the body. The spreading electrical currents create different potentials at different points on the body, which can be sensed by electrodes on the skin surface using biological transducers made of metals and salts. This electrical potential is an AC signal with bandwidth of 0.05Hz to 100Hz, sometimes up to 1kHz. It is generally around 1mV peak-to-peak in the presence of much larger external high frequency noise plus 50/60Hz interference normal-mode (mixed with the electrode signal) and common-mode voltages (common to all electrode signals).

The common-mode is comprised of two parts: 50Hz or 60Hz interference and DC electrode offset potential. Other noise or higher frequencies within the biophysical bandwidth come from movement artifacts that change the skin-electrode interface, muscle contraction or electromyographic spikes, respiration (which may be rhythmic or sporadic), electromagnetic interference (EMI), and noise from other electronic components that couple into the input. Some of the noise can be cancelled with a high-input-impedance instrumentation amplifier (INA), like the INA333 or INA118, which removes the AC line noise common to both inputs and amplifies the remaining unequal signals present on the inputs; higher INA common-mode rejection (CMR) will result in greater rejection. Because they originate at different points on the body, the left-arm and right-arm ECG signals are at different voltage levels and are amplified by the INA. To further reject 50 and 60Hz noise, an operational amplifier deriving common-mode voltage is used to invert the common-mode signal and drive it back into the patient through the right leg using an amplifier. Only a few microamps or less are required to achieve significant CMR improvement and stay within the UL544 limit.

Supply Voltage

As in most other applications, the system supply voltage in biophysical monitoring continues the trend toward low, single-supply levels. While bipolar supplies are still used, 5V systems are now common and trending to single 3.3V supplies. This trend presents a significant challenge for the designer faced with at least a 300mV DC electrode potential and emphasizes the need for a precision signal-conditioning solution.

Frequency Response

Standard –3dB frequency bandwidth for patient monitoring is 0.05Hz to 30Hz, while diagnostic grade monitoring requires 0.05Hz to 100Hz or more. The analog front end must be AC coupled to remove artifacts from the electrode offset potential.

Instrumentation Amplifier Requirements

- Stability in low gain (Gain = 1 to 10)
- High common-mode rejection
- Low input bias current (I_B)
- Good swing to the output rail
- Very low offset and drift

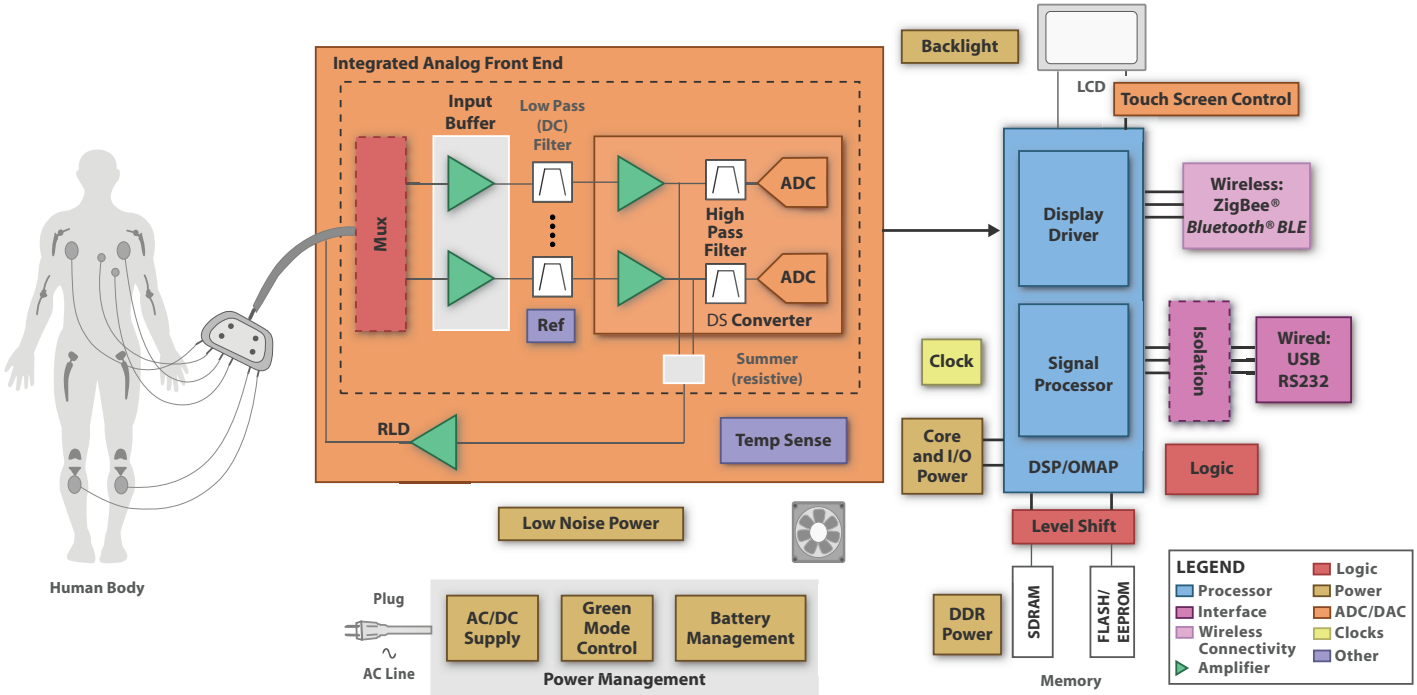
Operational Amplifier Requirements

- Low noise in high gain (Gain = 10 to 1000)
- Rail-to-rail output
- Very low offset and drift

Connectivity for ECG/EEG equipment has become of interest as caregivers require data to move from medical end equipment to data hubs such as the hospital/clinic IT infrastructure, computers or even mobile phones.

For more information, visit www.ti.com/ecg

Electrocardiogram (ECG)/Portable ECG and Electroencephalogram (EEG)



Three ECG electrodes connected to patient using CMOS components w/5V single supply. This circuit will operate on a 3.3V supply.

Product Availability and Design Disclaimer – The system block diagram depicted above and the devices recommended are designed in this manner as a reference. Please contact your local TI sales office or distributor for system design specifics and product availability.

ADS1298ECG Front End Performance Demonstration Kit
ADS1298ECGFE-PDK

Get samples and datasheets at: **www.ti.com/sc/device/ADS1298ecgfe-pdk**

Key Features

- Easy-to-use evaluation software for Microsoft™ Windows XP
- Built-in analysis tools including oscilloscope, FFT, and histogram displays
- Flexible input configurations
- Optional external reference circuits
- Ability to export data in simple test files for post processing

The ADS1298ECG FE is a reference design for the ADS1298, a simultaneous sampling, 24-bit, delta-sigma (ΔΣ) analog-to-digital converter (ADC) with a built-in programmable gain amplifier (PGA), internal reference, and an onboard oscillator. The ADS1298 incorporates all of the features that are commonly required in medical electrocardiogram (ECG) and electroencephalogram (EEG) applications. The ADS1298ECG FE can be used with a variety of patient simulators and allows the user to take advantage of the flexible input multiplexer which can be independently connected to the internally-generated signals for test, temperature, and lead-off detection.

ADS1298ECG front end performance demonstration kit.

Electrocardiogram (ECG)/Portable ECG and Electroencephalogram (EEG)

Low-Power, 8-Channel, 24-Bit Analog Front End for Biopotential Measurements

ADS1298

Get samples and datasheets at: **www.ti.com/sc/device/ads1298**

Key Features

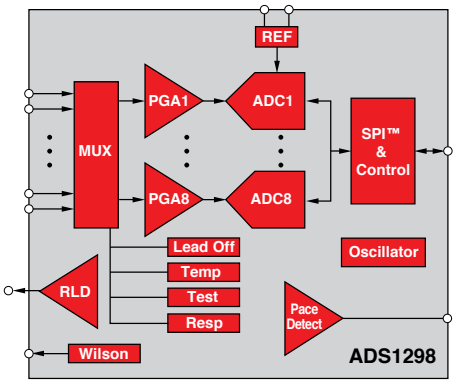
- Eight low-noise PGAs and eight high-resolution ADCs (ADS1298)
- Low power: 0.75mW/channel
- Input-referred noise: 4μVPP (150Hz BW, G = 6)
- Input bias current: 200pA (max)
- Data rate: 250SPS to 32kSPS
- CMRR: –115dB
- Programmable gain: 1, 2, 3, 4, 6, 8 or 12
- Built-in right leg drive amplifier, lead-off detection, WCT, test signals

Applications

- Medical instrumentation (ECG and EEG), including:
  - Patient monitoring; holter, event, stress, and vital signs ECG, AED, telemedicine, fetal ECG
  - Bispectral index (BIS), evoked audio potential (EAP), sleep study monitor
- High-precision, simultaneous, multichannel signal acquisition

The ADS1294/6/8 is a family of multichannel, simultaneous sampling, 24-bit, delta-sigma (ΔΣ) analog-to-digital converters (ADCs) with a built-in programmable gain amplifier (PGA), internal reference and onboard oscillator. The ADS1294/6/8 incorporates all of the features that are commonly required in medical electrocardiogram (ECG) and electroencephalogram (EEG) applications.

With its high levels of integration and exceptional performance, the ADS1294/6/8 family enables the creation of scalable medical instrumentation systems at significantly reduced size, power and overall cost.



ADS1298 functional block diagram.

Biopotential Sensing (ECG/EEG) Delta-Sigma ADCs

Device	Res. (Bits)	Sample-Rate (kSPS)	Number of Input Channels	Interface	Input-Referred Noise (μVpp)	Common Mode Rejection (dB)	Power (mW)	HiRel Avail.	Package(s)	Price*
ADS1298	24	32	8 Diff	SPI	4	115	6	N	BGA-64, TQFP-64	23.95
ADS1298R	24	32	8 Diff	SPI	3	115	6	N	BGA-64	23.95
ADS1296	24	32	6 Diff	SPI	4	115	5.1	N	BGA-64, TQFP-64	17.95
ADS1293	24	25.6	3 Diff	SPI	10	100	0.9	N	QFN = 28	5.5
ADS1294	24	32	4 Diff	SPI	4	115	3.6	N	BGA-64, TQFP-64	11.95
ADS1198	16	8	8 Diff	SPI	12	100	4.5	N	BGA-64, TQFP-64	8.00
ADS1196	16	8	6 Diff	SPI	12	100	3.9	N	BGA-64, TQFP-64	11.95
ADS1194	16	8	4 Diff	SPI	12	100	3	N	BGA-64, TQFP-64	15.95

**Suggested resale price in U.S. dollars in quantities of 1,000.*

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

Electrocardiogram (ECG)/Portable ECG and Electroencephalogram (EEG)

24-bit, Low Noise AFE for EEG Applications

ADS1299

Get samples and datasheets at: **www.ti.com/sc/device/ads1299**

Key Features

- Fully integrated solution
  - 8 low-noise programmable amps
  - 8 high-resolution ADC's
  - Test signals, bias amp, oscillator & ref
- Outstanding performance
  - Noise: 1uV p-p (@ 70Hz BW)
  - CMRR: 120dB
- Continuous lead-off detect option
- Pin compatible with ADS1298

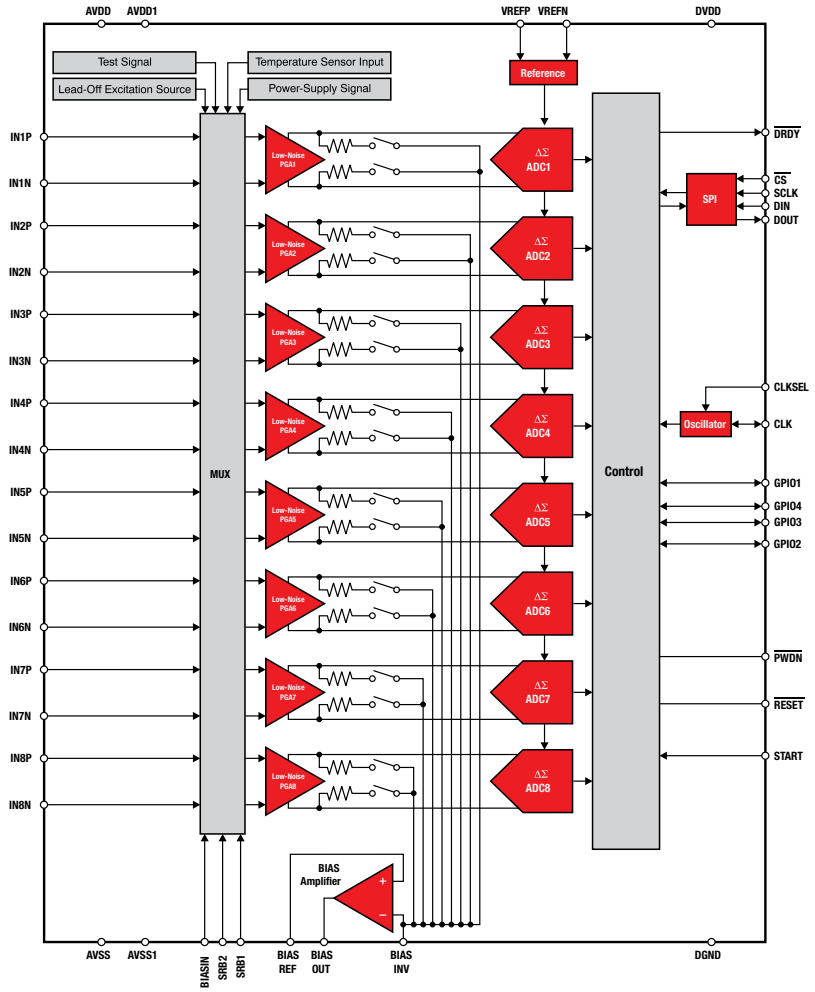
Applications

- Electroencephalography (EEG)
- Bispectral index studies (BIS)
- Evoked audio potential (EAP)
- Sleep study monitoring
- High-precision, simultaneous, multichannel signal acquisition up to 16kSPS

The ADS1299 drastically reduces printed circuit board space while improving performance and system reliability. Due to the extremely low input-referred noise of the ADS1299, it allows for direct interface to EEG bio-potential signals. The ADS1299 enables reliable and precise acquisition of minute extra-cranial biopotential signals even in the presence of large EMI signals.

Before such a low input-referred noise option existed, designers would have to discretely lay out ICs to accommodate an EEG signal, due to the signal amplitude only being 10µV-100µV. In a typical 32-electrode EEG system, about 149 ICs would have to be used to realize the full analog signal chain. With ADS1299, only four of the ADS1299 devices would have to be used, resulting in a 97% reduction in overall ICs used, making it the only one-chip solution for the EEG signal chain.

This fact, combined with the easy-to-use SPI interface that allows for daisy-chaining, enables a fully realized analog signal chain that greatly reduces board complexity for EEG designers.



ADS1299 functional block diagram.

Electrocardiogram (ECG)/Portable ECG and Electroencephalogram (EEG)

2-Ch., 24-Bit Fully Integrated ADC for Medical Instrumentation and Sports and Fitness Applications
ADS1292

Get samples and datasheets at: **www.ti.com/sc/device/ads1292**

Key Features

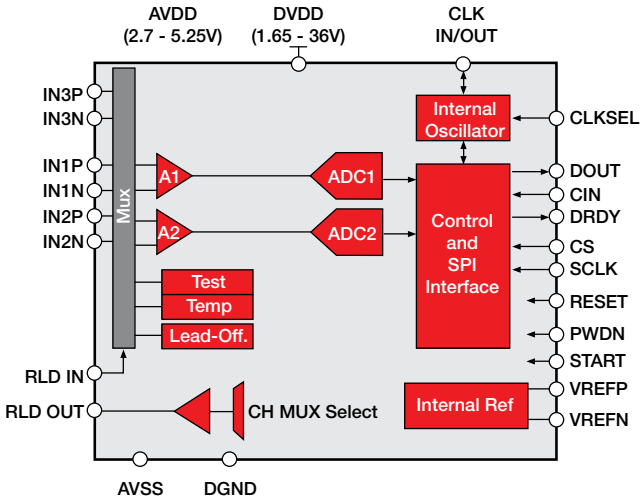
- Fully integrated ECG solution
- Optimized low noise PGA and 24-bit ADC
  - ADS1291: 1 channel
  - ADS1292: 2 channels
- Test signals, RLD amp, oscillator, reference
- Outstanding performance
  - Noise: less than 8µV p-p (150Hz BW, G=6)
  - CMRR: 105dB with G = 6
- Continuous lead off detection
- Low Power
  - Less than 350µW per channel
  - Standby mode: 160µW overall consumption

Applications

- Medical instrumentation:
  - 1- and 3-Lead ECG
  - Heart rate
  - AED
  - Holter
- Sports and fitness applications
  - Chest straps
  - Work-out equipment
  - Wrist watches

An ADS1292 solution takes up 92% less PCB space, consumes 94% less power, and uses 92% fewer components compared to a discrete implementation of a 2-channel Holter. Similarly, an ADS1291 solution takes up 52% less PCB space, 89% lower power consumption, and 75% fewer components over a discrete implementation.

Designers interested in creating a complete line of biopotential measurement products now have a family of devices to meet their needs from low lead count heart rate monitors (ADS1291) to 12-lead ECG systems (ADS1298).



ADS1292 functional block diagram.

Alternative Solutions

Device	Resolution	No. of Input Chs.	Respiration	Input-Referred Noise (μV_{pp})	Price*
ADS1298	24-bit	8	No	3	23.95
ADS1298R	24-bit	8	Yes	3	23.95
ADS1198	16-bit	8	No	12.2	14.35
ADS1296	24-bit	6	No	3	17.95
ADS1296R	24-bit	6	Yes	3	17.95
ADS1196	16-bit	6	No	12.2	11.35
ADS1294	24-bit	4	No	3	11.95
ADS1294R	24-bit	4	Yes	3	11.95
ADS1194	16-bit	4	No	12.2	7.80
ADS1293	24- bit	3	No	10	5.5
ADS1292	24-bit	2	No	8	3.50
ADS1292R	24-bit	2	Yes	8	4.50
ADS1192	16-bit	2	No	24	2.50
ADS1291	24-bit	1	No	8	2.00
ADS1191	16-bit	1	No	24	1.50

**Suggested resale price in U.S. dollars in quantities of 1,000.*

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

Electrocardiogram (ECG)/Portable ECG and Electroencephalogram (EEG)

Low Power, 3-Channel, 24-Bit Analog Front End for Biopotential Measurements

ADS1293

Get samples and datasheets at: **www.ti.com/sc/device/ads1293**

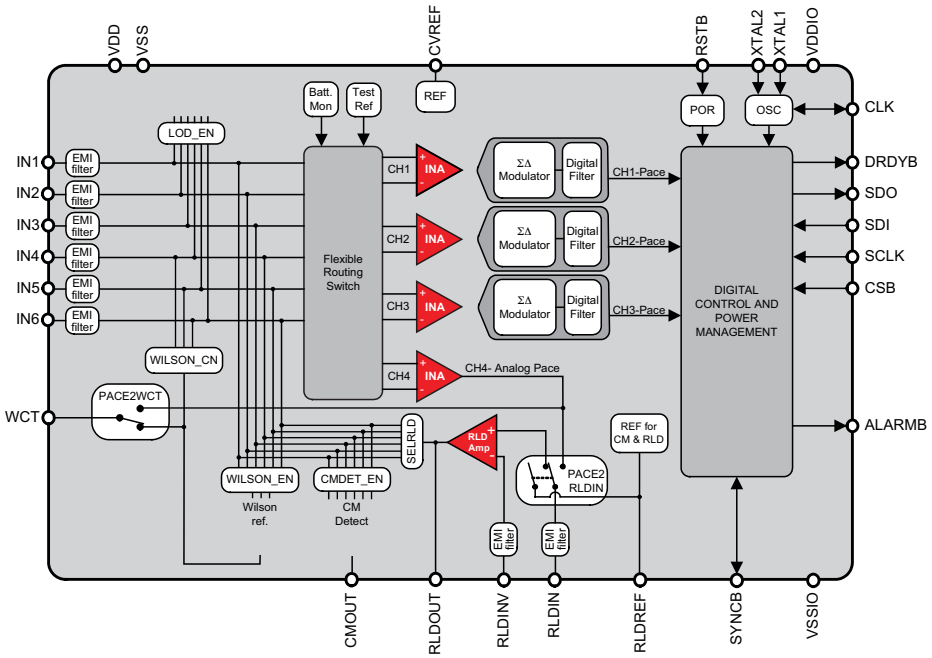
Key Features

- 3 High Resolution Digital ECG Channels with Simultaneous Pace Output
- EMI Hardened Inputs
- Low Power: 0.3mW/channel
- Input-Referred Noise: 10µVpp (40Hz BW)
- Input Bias Current: 100pA
- Data Rate: Up to 25.6kSPS
- Differential Input Voltage Range: ±400mV
- Analog Supply Voltage: 2.7V to 5.5V
- Digital I/O Supply Voltage: 1.65V to 3.6V
- Right Leg Driver Amplifier
- AC and DC Lead-Off Detection
- Wilson and Goldberger Terminals
- ALARM Pin for Interrupt Driven Diagnostics
- Battery Voltage Monitoring
- Flexible Power-Down and Standby

Applications

- Portable 1/2/3/5/6/7/8/12-Lead ECG
- Patient vital sign monitoring: holter, event, stress, and telemedicine
- Automated External Defibrillator
- Sports and fitness (heart rate and ECG)

The ADS1293 is an integrated three-channel analog front end that provides very low power consumption with low noise. The ADS1293 delivers a solution that can extend battery life, simplify product design and improve overall performance. The ADS1293 incorporates all features commonly required in portable, low-power medical electrocardiogram (ECG), sports, and fitness applications. With high levels of integration and exceptional performance, the ADS1293 enables the creation of scalable medical instrumentation systems from one to twelve channels at significantly reduced size, power and overall cost.



ADS1293 block diagram.

Electrocardiogram (ECG)/Portable ECG and Electroencephalogram (EEG)

High-Performance, Low-Power, Fixed-Point Digital Signal Processor

TMS320C5515

Get datasheets, samples and technical documents at: **www.ti.com/sc/device/tms320c5515**

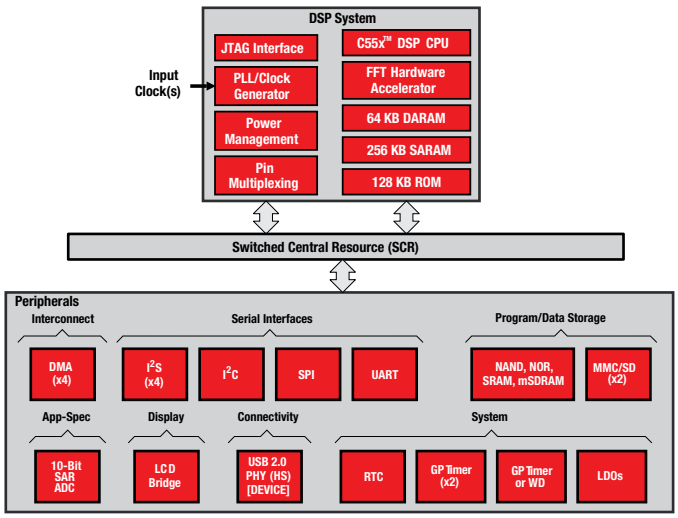
Key Features

- 320K bytes zero-wait state on-chip RAM, composed of:
  - 64K bytes of dual-access RAM (DARAM), 8 blocks of 4K × 16-bit
  - 256K bytes of single-access RAM (SARAM), 32 blocks of 4K × 16-bit
- 128K bytes of zero wait-state on-chip ROM (4 blocks of 16K × 16-bit)
- 4M × 16-bit maximum addressable external memory space (SDRAM/mSDRAM)
- 16-/8-bit external memory interface (EMIF)
- Direct memory access (DMA) controller

Applications

- Industrial controls
- Portable medical devices
- Wireless audio devices

The TMS320C5515 fixed-point DSP is based on the TMS320C55x™ DSP generation CPU processor core. The C55x™ DSP architecture achieves high performance and low power through increased parallelism and total focus on power savings. The CPU supports an internal bus structure that is composed of one program bus, one 32-bit data read bus and two 16-bit data read buses, two 16-bit data write buses, and additional buses dedicated to peripheral and DMA activity. These buses provide the ability to perform up to four 16-bit data reads and two 16-bit data writes in a single cycle.



TMS320C5515 block diagram.

Electrocardiogram (ECG)/Portable ECG and Electroencephalogram (EEG)

Mixed-Signal Microcontroller

MSP430F6638

Get datasheets, samples and technical documents at: **www.ti.com/sc/device/msp430f6638**

Key Features

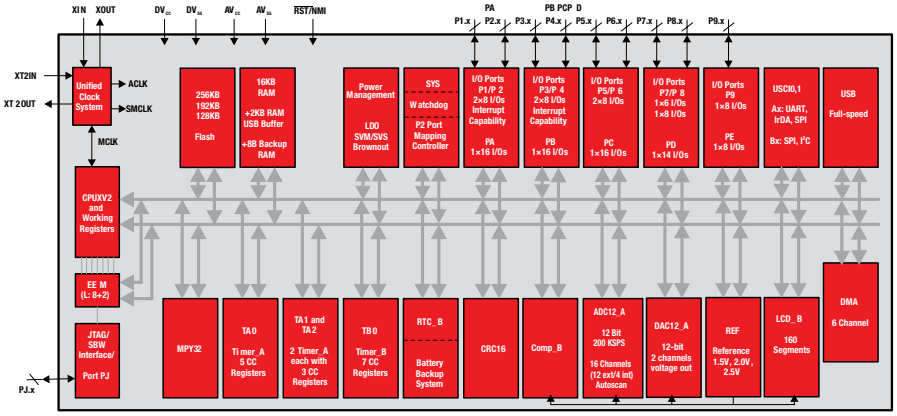
- Low supply voltage range, 1.8V to 3.6V
- Ultra-low power consumption
- Wake-up from standby mode in < 5µs
- 16-bit RISC architecture, extended memory, up to 20-MHz system clock
- Flexible power management system
- Unified clock system
- 16-bit timer TA0, Timer_A with five capture/compare registers
- 16-bit timer TA1, Timer_A with three capture/compare registers

Applications

- Analog and digital sensor systems
- Digital timers
- Hand-held meters
- Thermostats

The Texas Instruments MSP430™ family of ultra-low-power microcontrollers consists of several devices featuring different sets of peripherals targeted for various applications. The architecture, combined with five low power modes is optimized to achieve extended battery life in portable measurement applications. The device features a powerful 16-bit RISC CPU, 16-bit registers, and constant generators that contribute to maximum code efficiency. The digitally controlled oscillator (DCO) allows wake-up from low-power modes to active mode in less than 5µs.

The MSP430F663x series are microcontroller configurations with four 16-bit timers, a high performance 12-bit analog-to-digital (A/D) converter, 12-bit digital to analog (D/A) converter, two universal serial communication interfaces (USCI), hardware multiplier, DMA, real-time clock module with alarm capabilities, comparator and USB 2.



MSP430F6638 functional block diagram.

Electrocardiogram (ECG)/Portable ECG and Electroencephalogram (EEG)

Sitara™ ARM Microprocessor

AM1802

Get datasheets, samples and technical documents at: **www.ti.com/sc/device/am1802**

Key Features

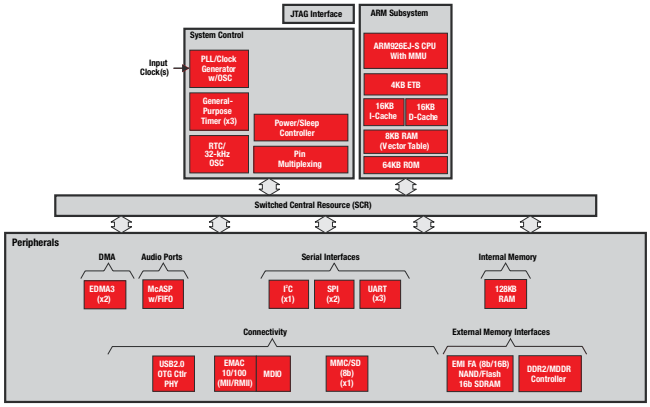
- ARM9 memory architecture
- Enhanced direct-memory-access controller 3 (EDMA3)
- Two external memory interfaces
- Two serial peripheral interfaces (SPI)
- Three configurable 16550 type UART modules
- Multiamedia card (MMC)/secure digal (SD) card interface with secure data I/O (SDIO)
- One master/slave integrated circuit
- One multichannel audio serial port
- 10/100 Mb/s Ethernet MAC (EMAC)

Applications

- Electrocardiogram (ECG)
- Pulse oximetry

The device is a low-power applications processor based on ARM926EJ-S™. The ARM926EJ-S is a 32-bit RISC processor core that performs 32-bit or 16-bit instructions and processes 32-bit, 16-bit, or 8-data. The core uses pipelining so that all parts of the processor and memory system can operate continuously.

The device enables OEMs and ODMs to quickly bring to market devices featuring robust operating systems support, rich user interfaces, and high processing performance life through the maximum flexibility of a fully integrated mixed processor solution.



AM1802 functional block diagram.

Digital Media Processor

DM3730

Get datasheets, samples and technical documents at: **www.ti.com/sc/device/dm3730**

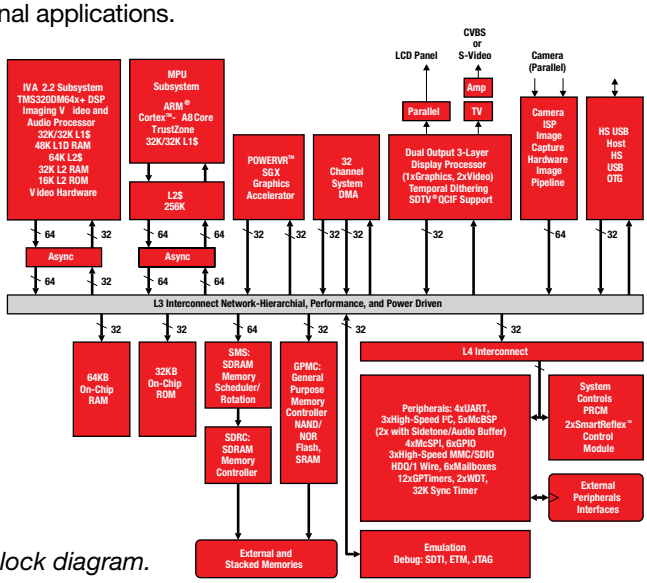
Key Features

- Compatible with OMAP™ 3 architecture
- ARM® microprocessor (MPU) subsystem
- High performance image, video, audio (IVA2.2™) accelerator subsystem
- Power SGX™ graphics accelerator

Applications

- Human interface
- Medical imaging
- Portable data terminals

The DM37x generation of high-performance, applications processors are based on the enhanced device architecture and are integrated on TI's advanced 45-nm process technology. This architecture is designed to provide best in class ARM and Graphics performance while delivering low power consumption. This balance of performance and power allow the device to support medical imaging, human interface and portable data terminal applications.



DM3730 functional block diagram.

Electrocardiogram (ECG)/Portable ECG and Electroencephalogram (EEG)

Zero-Drift, Low-Offset, Single-Supply Op Amps

OPA334, OPA335

Get samples, datasheets, evaluation modules and application reports at: **www.ti.com/sc/device/opa334** or **www.ti.com/sc/device/opa335**

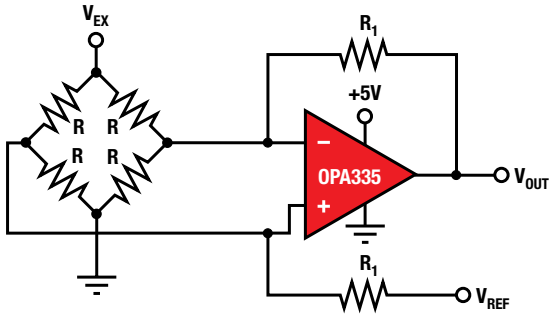
Key Features

- GBW: 2MHz
- Low offset voltage: 5µV (max)
- Zero drift: 0.05µV/°C (max)
- Quiescent current: 285µA
- EMI input filtered
- Shutdown available on OPA344
- Packaging: SOT23-5, SOT23-6, SO-8, MSOP-10 (dual)

Applications

- Transducer applications, such as pressure sensing
- Electronic weight scales
- Temperature measurement

The OPA334 and OPA335 CMOS op amps use auto-zeroing techniques to simultaneously provide very low offset voltage and near-zero drift over time and temperature. These high-precision amps offer high input impedance and rail-to-rail output swing.



OPA335 –5V supply bridge amplifier for high CMRR.

Low-Power Precision Instrumentation Amplifier

INA333

Get samples and datasheets at: **www.ti.com/sc/device/ina333**

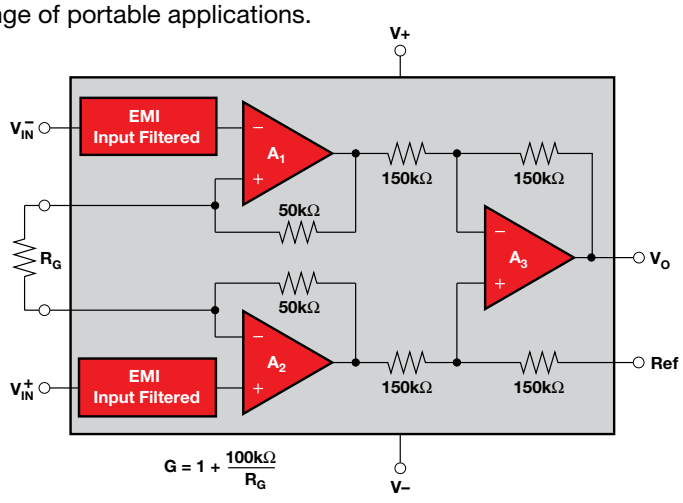
Key Features

- Low offset voltage: 20µV (max)
- Low drift: 50nV/°C
- Low input bias current: 200pA (max)
- Low noise: 50nV/$\sqrt{Hz}$
- Supply voltage: +1.8V to +5.5V
- Quiescent current: 50µA (max)
- EMI input filtered
- Packaging: MSOP-8, DFN-10

Applications

- Bridge amplifier
- Weigh scales
- Thermocouple amplifier
- RTD sensor amplifier
- Medical instruments
- Data acquisition

The INA333 is a low-power precision instrumentation amplifier offering excellent accuracy. A single external resistor sets any gain from 1 to 1000 and provides the industry-standard gain equation G = 1 + (100kΩ/R_G). With three op amps, low quiescent current, and operation with power supplies as low as +0.9V, it is ideal for a wide range of portable applications.



INA333 functional block diagram.

Electrocardiogram (ECG)/Portable ECG and Electroencephalogram (EEG)

3ppm/°C Drift, 0.05% Accurate, Low-Noise, Precision Series Voltage References
REF5020, REF5025, REF5030, REF5040, REF5045, REF5050, REF5010

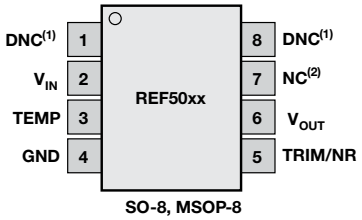
Get samples, datasheets and app reports at: **www.ti.com/sc/device/PARTnumber** (Replace **PARTnumber** with **ref5020**, **ref5025**, **ref5030**, **ref5040**, **ref5045**, **ref5050** or **ref5010**)

Key Features
- High accuracy: 0.05%
- Low temperature drift: 3ppm/°C (max)
- Very low noise: 3μV_{PP}/V
- High output current: ±10mA
- Wide supply range: 2.7V to 18V
- Industrial temperature range: –40°C to +125°C
- Packaging: SO-8, MSOP coming soon

Applications
- Test and measurement
- 16-bit data acquisition systems
- Medical and patient monitoring
- Industrial process control

The REF50xx brings a new level of precision to the TI series voltage reference line. Offering 3ppm/°C (max) drift and 0.05% initial accuracy and very low noise, the REF50xx is designed for industrial, medical and test applications that require performance over temperature.

Model	Voltage Out
REF5020	2.048V
REF5025	2.5V
REF5030	3.0V
REF5040	4.096V
REF5045	4.5V
REF5050	5V
REF5010	10V



REF50xx package diagram.

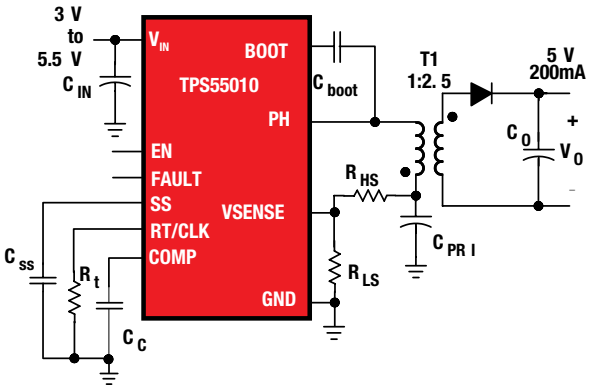
2.95V to 6V Input, 2W, Isolated DC/DC Converter with Integrated FETS
TPS55010

Get samples, datasheets, evaluation modules and application reports at: **www.ti.com/sc/device/tps55010**

Key Features
- Isolated fly-buck topology
- Primary side feedback
- 100kHz to 2000kHz switching frequency
- Synchronizes to external clock
- Adjustable slow start
- Adjustable input voltage UVLO
- Open-drain fault output
- Cycle-by-cycle current limit
- Thermal shutdown protection
- 3mm x 3mm 16-pin QFN package

Applications
- Noise immunity in PLCs, data acquisition and measurement equipment
- Isolated RS-232 and RS-485 communication channels
- Powers line drivers, ISO amplifiers, sensors, CAN transceivers
- Floating supplies for IGBT gate drivers
- Promotes safety in medical equipment

The TPS55010 is a transformer driver designed to provide isolated power for isolated interfaces, such as RS-485 and RS-232, from 3.3V or 5V input supply. The device uses fixed frequency current mode control and half bridge power stage with primary side feedback to regulate the output voltage for power levels up to 2W. The switching frequency is adjustable from 100kHz to 2000kHz so solution size, efficiency and noise can be optimized. The switching frequency is set with a resistor or is synchronized to external clock using the RT/CLK pin. To minimize inrush currents, a small capacitor can be connected to the SS pin. The EN pin can be used as an enable pin or to increase the default input UVLO voltage from 2.6V.



TPS55010 functional block diagram.

Electrocardiogram (ECG)/Portable ECG and Electroencephalogram (EEG)

60mA Charge Pump Voltage Inverter with Fixed 250kHz Operation

TPS60403

Get samples, datasheets, evaluation modules and application reports at: **www.ti.com/sc/device/tps60403**

Key Features

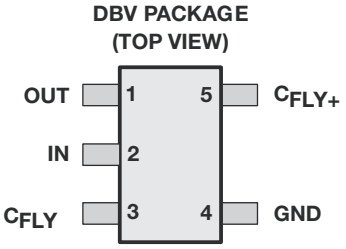
- Inverts input supply voltage
- Up to 60-mA output current
- Only three small 1-µF ceramic capacitors needed
- Input voltage range from 1.6V to 5.5V
- PowerSave-mode for improved efficiency at low output currents (TPS60400)
- Device quiescent current typical 65µA
- Integrated active Schottky-diode for start-up into load
- Small 5-pin SOT23 package

Applications

- Battery-operated equipment
- LCD bias
- Medical instruments
- Sensor supply in portable instruments

The TPS6040x is a family of devices that generate an unregulated negative output voltage from an input voltage ranging from 1.6V to 5.5V. The devices are typically supplied by a preregulated supply rail of 5V or 3.3V. Due to its wide input voltage range, two or three NiCd, NiMH, or alkaline battery cells, as well as one Li-Ion cell can also power them.

Only three external 1-µF capacitors are required to build a complete dc/dc charge pump inverter. Assembled in a 5-pin SOT23 package, the complete converter can be built on a 50mm2 board area. Additional board area and component count reduction is achieved by replacing the Schottky diode that is typically needed for start-up into load by integrated circuitry.



TPS60403 package.

800-mA Low-Dropout Adjustable and Fixed-Voltage Regulators

TLV1117, TLV1117-xx

Get samples, datasheets and application reports at: **www.ti.com/sc/device/tlv1117** or **tlv1117-xx**

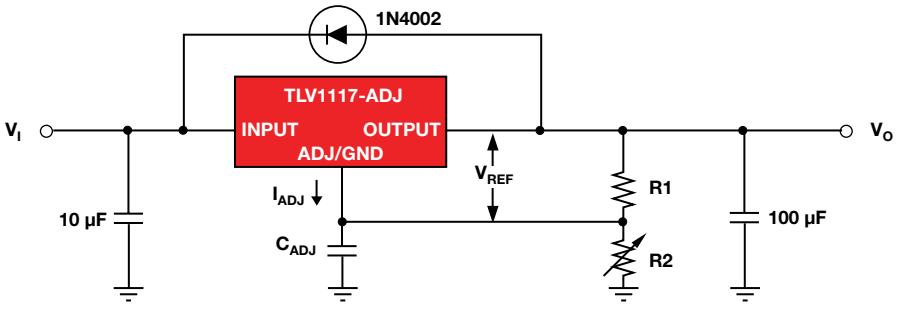
Key Features

- 1.5-V, 1.8-V, 2.5-V, 3.3-V, 5-V and adjustable-output voltage options
- Output current of 800mA
- Specified dropout voltage at multiple current levels
- 0.2% line regulation max
- 0.4% load regulation max

Applications

- Power supplies
- Set-top boxes
- Laptops

The TLV117 is a positive low-dropout voltage regulator designed to provide up to 800mA of output current. The device is available in 1.5-V, 1.8-V, 2.5-V, 3.3-V, 5-V and adjustable-output voltage options. All internal circuitry is designed to operate down to 1-V input-to-output differential. Dropout voltage is specified at a maximum of 1.3 at 800mA, decreasing at lower load currents. The TLV1117 is designed to be stable with tantalum and aluminum electrolytic output capacitors having an ESR between 0.2Ω and 10Ω. Unlike pnp-type regulators, in which up to 10 percent of the output current is wasted as quiescent current, the quiescent current of the TLV117 flows into the load, increasing efficiency.



V_{OUT} is calculated as: $V_{OUT} = V_{REF} (1 + \frac{R2}{R1}) + (I_{ADJ} \times R2)$

Because I_{ADJ} typically is 55 µA, it is negligible in most applications.

Application information.

Electrocardiogram (ECG)/Portable ECG and Electroencephalogram (EEG)

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers				
INA118	Instrumentation Amp	110dB CMRR, 5nA (max) bias current, 50µV (max) offset	Wide BW at high gain, ±1.35V to ±18V supply	INA128, INA121
INA121	Instrumentation Amp	106dB CMRR, 4pA (max) bias current, 200µV (max) offset	Low input bias current	INA126
INA126	Instrumentation Amp	175µA/ch supply, 3µV/°C (max) drift, 250µV (max) offset	Precision low power, ±1.35V to ±18V supply	INA2126
INA128	Instrumentation Amp	120dB CMRR, 5nA (max) bias current, 50µV (max) offset	High CMRR, wide BW at high gain, ±2.25V to ±18V supply	INA129
OPA277	Op Amp	10µV offset, ±0.1µV/°C drift, 134dB open-loop gain	High precision, low drift, low power	OPA2277 (dual) OPA4277 (quad)
INA326	Instrumentation Amp	120dB CMRR (G = 100), 100µV (max) offset, 0.4µV/°C (max) drift	High CMRR, low cost, +2.7V to +5.5V	INA321, INA333
INA333	Instrumentation Amp	25µV (max) offset, 50nV/°C drift, 50µA (typ) Iq	Best offset/noise combination, supply down to 1.8V, low power	INA326, INA321
INA826	Instrumentation Amp	35ppm/°C (max) gain error drift, 250µA (typ) Iq	Cuts gain error and gain error drift in less than half compared to neares competitor while consuming 40% less power	
LM324	Quadruple Operational Amplifier	Wide supply range 3V to 32V Supply current independent of supply voltage 0.8mA Low input bias 20nA	Excellent performance and reliability	
LM358	Dual Operational Amplifiers	Wide supply range 3V to 32 Supply current independent of supply voltage 0.7mA Low input bias 20nA	Excellent performance and reliability	LMV358
OPA130	FET-Input Amplifier	20pA (max) bias current, 90dB (min) CMRR, 1MHz BW	Precision, low input bias, low power	OPA131, OPA137
OPA333	Precision Op Amp	1.8V min supply, 0.017mA/ch (max), 10µV offset (max), 0.05µV/°C drift (max)	Zero drift, high precision, low power, EMI input	OPA335, OPA378, OPA330
OPA334/5	Op Amp	2MHz, 5µV (max) offset, 0.05µV/°C (max) drift, 285µA	Provides very low offset voltage and near-zero drift over time and temperature; SOT23	OPA735, OPA333, OPA334
OPA336	Op Amp	125µV (max) offset, 1.5µV/°C drift, 20µA supply	micoPower, SOT23 package	OPA379
OPA378	Low Noise Precision Op Amp	0.1µV/°C Vos drift, 125µA, 900kHz, 0.4μV_{PP} (0.1Hz to 10Hz) 0.4µ V_{pp} (0.1Hz to 10Hz), 0.9MHz	Lowest noise, power, price, precision zero-drift option	OPA330, OPA333
OPA2378	Precision Op Amp	2.2V to 5.5V supply, 20µV voltage, 0.1µV/°C drift, 125µA quiescent current	Has excellent PSRR which makes it an ideal choice for applications that run direct from batteries without regulation	
THS4521/22/24	Low Power FDA	1.14mA quiescent current (typ), 4.6nV/$\sqrt{Hz}$ voltage noise, 2.5V to 5.5V supply	Low power, low noise enables high accuracy	
Data Converters				
ADS1258	Delta-Sigma ADC	16-channel, 24-bit, 125kSPS, 23.7kSPS/channel	Fastest multi-channel, delta-sigma ADC, measures all 16 inputs in <675µs	ADS1256, ADS1255, ADS8344
ADS1271/74/78	Delta-Sigma ADC	24-bit, 128kSPS, 8-channel, 111dB SNR	Simultaneous measurement, onboard decimation filter	
ADS1292R	ECG/EEG AFE	24-bit, 2 PGA, 2 ADC, plus RLD and RESP	Complete front end, reduction in power and size, increase reliability	ADS1291, ADS1292, ADS1191, ADS1192
ADS1293	ECG/EEG AFE	24-bit, 3 PGA, 3 ADC, plus RLD and very low power	Very low power AFE. Flexible for 1, 2, 3, 5, 6, 7, 8, 12 lead battery powered applications.	ADS1292, ADS1294
ADS1298	ECG/EEG AFE	24-bit, 8 PGA, 8 ADC, plus RLD and RESP	Complete front end, reduction in power and size, increase reliability	ADS1294, ADS1296, ADS1198, ADS1258
ADS8317	SAR ADC	16-bit, 250kSPS, 2.7V to 5.5V supply, ±1.5 LSB (max) INL, differential input	Low power, small package, and wide supply range	ADS8326
ADS8326	Low-Power ADC	16-bit, 250kSPS, 2.7V to 5.5V supply, ±1.5 LSB (max) INL	Small package, wide supply range	
ADS8331/32	SAR ADC	16-bit, 500kSPS, 4/8 channels, with serial interface	Mux out feature can be used to reduce system part count and overall cost	ADS8342
ADS8341/2/3/4/5	Serial Output ADC	16-bit, 4-/8-channel single-ended or 2-channel differential input, 2.7V to 5V single supply ADC	Easy to use	
ADS8519	High Volt. SAR ADC	16-bit, 250kSPS, 1.5LSB (max) INL, 92dB SNR	Single supply, high voltage inputs	ADS8515
DDC112	Charge-Digitizing ADC	Dual current input, 20-bit ADC, ±0.005% INL reading ±0.5ppm FSR	High precision, true integrating function	DDC114, DDC118, DDC232

To view more system block diagram compatible products, visit **www.ti.com/ecg**

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

Electrocardiogram (ECG)/Portable ECG and Electroencephalogram (EEG)

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
References				
LM4040x	Precision Micropower Shunt Voltage Reference	35µV_{RMS} typ, ABCD grade, 45µA (typ) to 15mA 2.048V, 2.5V, 3V, 4.096V, 5V, 8.192V, 10V	Highly precise with low output noise and a wide operating current range	
REF02	Precision V_{REF}	0.2% (max) initial accuracy, 10ppm/°C (max) drift, 1.4mA (max)	Excellent line/load regulation, low noise	REF5050
REF102	10V, Ultra Precision	0.05% (max) initial accuracy, 2.5ppm/°C (max) drift, 1.4mA (max)	Excellent stability and line/load regulation	REF5010
REF30xx	Low-Power, Low-Drift Ref.	50µA, 0.2% initial accuracy, 50ppm/°C max drift, ±25mA output, 1.25V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V		REF31xx, REF33xx, REF29xx
REF32xx	Ultra-Low-Drift Series Reference	100µA, 0.2% initial accuracy, 7ppm/°C max drift, ±10mA output, 1.25V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V	Improves system accuracy	
REF33xx	Very Low-Power Series Reference	5µA, 0.15% initial accuracy, 30ppm/°C max drift, ±5mA output, 1.25V, 1.8V, 2.048V, 2.5V, 3.0V, 3.3V	Preserves battery life, fits into physically constrained systems	REF30xx, REF31xx, REF29xx
REF5010	10V, High-Precision, Very Low-Drift Series Reference	0.05% initial accuracy, 3ppm/°C max drift, ±10mA output, 10V	Improves system accuracy	REF102
REF50xx	High-Precision, Very Low-Drift Series Reference	0.05% initial accuracy, 3ppm/°C max drift, ±10mA output, 2.048V, 2.5V, 3.0V, 4.096V, 4.5V, 5.0V	Improves system accuracy	REF02
TL43x	Adjustable Precision Shunt Regulator	Output voltage V_{REF} to 36V, 0.2-Ω (typ), sink-current capability 1mA to 100mA	Easy to use, low output noise, great replacement for Zener Diodes	
Processors				
AM3354	Applications Processor	ARMR Cortex-A8, graphics accelerators, touch screen controller	ARM Cortex-A8 performance at power levels of an ARM9	AM3352, AM3356, AM3357, AM3358, AM3359
DM3730	Digital Media Processor	Compatible with OMAP™ 3 architecture, ARM® microprocessor (MPU) subsystem, high performance image, video, audio (IVA2.2™) accelerator subsystem, power SGX™ graphics accelerator	Designed to provide best in class ARM and Graphics performance while delivering low power consumption.	
MSP430F20xx	Ultra-Low-Power 16-bit MCU	1KB/2KB Flash, 128B RAM, SPI+I^2C 16-bit MCU	8 ch. 12-bit ADC or 4 ch. 16-bit SD ADC, 4 x 4mm package	
MSP430F22x4	Ultra-Low-Power 16-bit MCU	8 to 32KB Flash, 512B/1KB RAM, SPI + I^2C + UART/LIN + IrDA	12 ch. 10-bit ADC, 2 operational amplifiers	
MSP430F23x0	Ultra-Low-Power 16-bit MCU	8 to 32KB Flash, 1KB/2KB RAM, SPI + I^2C + UART/LIN + IrDA	Analog comparator, HW multiplier	
MSP430F41x	Ultra-Low-Power 16-bit MCU	4 to 32KB Flash, 256B to 1KB RAM, SVS, 96 segment LCD	Analog comparator	
MSP430F42x	Ultra-Low-Power 16-bit MCU	8 to 32KB Flash, 256B to 1KB RAM, SPI + UART, SVS, 128 segment LCD	3 x 16-bit SD ADC	
MSP430F42x0	Ultra-Low-Power 16-bit MCU	16 to 32KB Flash, 256B RAM, 56 segment LCD	5 ch. 16-bit SD ADC, 12-bit DAC	
MSP430F43x	Ultra-Low-Power 16-bit MCU	16 to 32KB Flash, 512B/1KB RAM, SPI + UART, SVS, 160 segment LCD	8 ch. 12-bit ADC, analog comparator	
MSP430F44x	Ultra-Low-Power 16-bit MCU	32 to 60KB Flash, 1KB/2KB RAM, 2x SPI + UART, SVS, 160 segment LCD	8 ch. 12-bit ADC, HW multiplier	
MSP430F47xx	Ultra-Low-Power 16-bit MCU	60KB Flash, 256B RAM, (4) USCI, 160 segment LCD	(4) SD16 ADC, HW multiplier, temp. sensor, analog comparator	
MSP430F241x	Ultra-Low-Power 16-bit MCU	120KB Flash, 8KB RAM, (4) USCI, SVS, temp. sensor	8 ch. 12-bit ADC, analog comparator, HW multiplier	
MSP430F261x	Ultra-Low-Power 16-bit MCU	120KB Flash, 8KB RAM, (4) USCI, SVS, DMA, temp. sensor	Analog comparator, 2 ch. 12-bit DAC, 8 ch. 12-bit ADC, HW multiplier	
MSP430F471xx	Ultra-Low-Power 16-bit MCU	120KB Flash, 8KB RAM, (4) USCI, DMA 160 segment LCD	(7) SD16 ADC, HW multiplier, temp. sensor, analog comparator	
MSP430F54xxA	Ultra-Low-Power 16-bit MCU	128 to 256KB Flash, 16KB RAM, (4) USCI, PMM, DMA, temp. sensor	16 ch. 12-bit ADC, analog comparator, RTC, internal voltage regulator for power optimization	
MSP430F6638	Ultra-Low-Power 16-bit MCU	1.8V to 3.6V low supply voltage range, wake-up from standby mode in > 5µs, unified clock system	This device is optimized to achieve extended battery life in portable measurement applications.	
MSP430FG42x0	Ultra-Low-Power 16-bit MCU	16 to 32KB Flash, 256B RAM, 56 segment LCD	5 ch. 16-bit SD ADC, 12-bit DAC, 2 integrated op amps	

To view more system block diagram compatible products, visit **www.ti.com/ecg**

Electrocardiogram (ECG)/Portable ECG and Electroencephalogram (EEG)

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Processors (Continued)				
MSP430FG43x	Ultra-Low-Power 16-bit MCU	32 to 60KB Flash, 1KB/2KB RAM, SPI + UART, SVS, 128 segment LCD	12 ch. 12-bit ADC, 2 ch. 12-bit DAC, DMA, 3 op amps	
MSP430FG461x	Ultra-Low-Power 16-bit MCU	92 to 120KB Flash, 4KB/8KB RAM, SPI + I^2C + UART/LIN + IrDA, 160 LCD	12 ch. 12-bit ADC, 2 ch.12-bit DAC, A-comp, 3 op amp, HW multiplier	
MSP430FG47x	Ultra-Low-Power 16-bit MCU	32 to 60KB Flash, 2KB RAM, SPI + I^2C + UART/LIN + IrDA, 128 LCD controller	5 ch. 16-bit SD ADC, 2 ch. 12-bit DAC, comparator_A, 2 op amps	
AM3354	Applications Processor	ARM® Cortex-A8, graphics accelerators, touch screen controller	ARM Cortex-A8 performance at power levels of an ARM9	AM3352, AM3356, AM3357, AM3358, AM3359
AM37x	Applications Processor	ARM® Cortex-A8 processor that nearly doubles graphics performance and overall system performance while providing a 30 percent decrease in power consumption	Laptop-like performance at handheld power levels	AM3715, AM3703
TMS320C5000™	DSP	Power efficient, high performance		
TMS320F2802x/3x Piccolo™	32-Bit Microcontroller	Up to 60MHz C28x™ core with optional control law accelerator. Up to 128KB Flash, high resolution (150ps) PWMs, 4.6MSPS ADC, CAN/LIN, QEP.	With dedicated, high precision peripherals, Piccolo microcontrollers are the ultimate combination of performance, integration, size, and low cost. Ideal for precision sensing and control applications.	TMS320F283x Delfino, TMS320F280x
TMS320F283x Delfino™	32-Bit Floating-point Microcontroller	Up to 300MHz C28x™ core. Up to 512KB Flash, high resolution (150ps) PWMs, 12MSPS ADC, CAN/LIN, QEP, external memory bus, DMA	Delfino brings floating point and unparalleled performance to MCUs. Native floating point brings increased performance and quicker development. Ideal for precision sensing and control applications.	TMS320F2802x/3x Piccolo, TMS320F280x
Hercules RM48x	Safety Microcontroller	Up to 220MHz dual lockstep ARM® Cortex-R4 CPUs with floating point, up to 3MB flash w/ECC, up to 256KB RAM w/ECC, USB host/device, Ethernet, CAN, SPI, UART, 12-bit ADC, NHET co-processor for PWM generation and input capture	Simplified development for safety critical applications, large integrated flash memory, rich peripherial set	
Linear Regulators				
LP2950x	100-mA Low-Dropout Adjustable and Fixed-Voltage Regulators	Wide input voltage range up to 30V. Rated output current of 100mA. Low dropout: 380 mV typ. Low quiescent current 75µA (typ)	Easy-to-use with wide input voltage range and low dropout	LP2951x
LP2981x	100-mA Ultra-Low-Dropout Fixed Regulators with Shutdown	Output tolerance of 0.75% or 1.25%. Ultra-low dropout, 200mV (typ). Low quiescent current. Shutdown current: 0.01µA (typ)	Ultra-low dropout, low quiescent current, shutdown and small packaging	
LP2985x	150 mA Low-Noise Low-Dropout Fixed Regulators with Shutdown	Output tolerance of 1% or 1.5%. Ultra-low dropout 280 mV (Typ). Shutdown current 0.01mA (Typ). Low noise 30μV_{RMS}	Low dropout, low quiescent current, shutdown, low-ESR capacitor-friendly, low noise and small packaging	
TL750x	750-mA and 150-mA Low-Dropout Fixed-Voltage Regulators	Very low dropout voltage, less than 0.6V at 150mA or 750mA. Very low quiescent current. 60-V load-dump protection	Very low drop out voltage with extremely low quiescent current	TL751x
TLV1117	800-mA Low-Dropout Adjustable and Fixed-Voltage Regulators	1.5-V, 1.8-V, 2.5-V, 3.3-V, 5-V and adjustable-output voltage options. Output current of 800mA.	Very efficient and stable	LM317, TL431, TLV431, TLVH431, TLVH432, UA7805
TPS2051C	USB Power Switch	USB compliant power source, short circuit protection	USB switch accurate limit and fast turn off	TPS2065C
TPS2511	USB Switch with BC1.2 Charging Control	USB compliant and able to handshake with BC1.2 compliant clients	USB switch allows charging of peripheral devices with no uC support	TPS2540/40A/41/41A/43
TPS2552/3	Precision Adjustable USB Power Switch	Family of precision adjustable current limit devices	Accurate limits provide greater protection and require less supply margining	TPS2554/5/6/7
TPS3839	Supervisor and Reset IC	Ultra-low 150nA, ultra-small voltage supervisor	monitors voltage rails and provides high accuracy reset	TPS3808
TPS7A3001	Low-Noise Negative Voltage (–36V) LDO	V_{IN} –3V to –36V, –200mA, ultra-low noise, High PSRR, low-dropout linear regulator	Low-noise negative power rails for sensitive analog components	

To view more system block diagram compatible products, visit **www.ti.com/ecg**

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

Electrocardiogram (ECG)/Portable ECG and Electroencephalogram (EEG)

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Linear Regulators (Continued)				
TPS7A4700	Lowest-Noise 1A High Voltage (36V) LDO	Low noise (3µVrms), 1A, high voltage low-dropout linear regulator	Low-noise power rails for sensitive analog components	TPS7a3301
TPS7A4901	Low-Noise High Voltage (36V) LDO	V_{IN} 3V to 36V, 150mA, ultra-low noise, high PSRR, low-dropout linear regulator	Low-noise power rails for sensitive analog components	
TPS717xx	Low-Noise Single-Channel LDO	High bandwidth, very high rejection of power-source noise	Low-noise power rails for sensitive analog components	TPS799xx
TPS75005	PMU	Dual, 500mA low-dropout regulators and triple voltage rail monitor	Core and I/O voltage rails in one LDO	
Comparators				
LM339	Quad Differential Comparator	Wide supply range: 2V to 36V. Low supply current drain independent of supply voltage: 0.4mA typ per comparator. Low input bias and offset parameters	Very accurate and easy-to-use	
LM393	Dual Differential Comparator	Wide supply range: 2V to 36V. Low supply current drain independent of supply voltage: 0.4mA typ per comparator. Low input bias and offset parameters	Very accurate and easy-to-use	LM311, LMV331, LMV393
RF Transceivers				
CC1120	Sub-1GHz RF Transceiver	Industry leading RF blocking and selectivity: 65dB adjacent channel rejection at 12.5kHz offset 90dB blocking. High output power (up to +16dBm) and excellent sensitivity (–123dBm @1.2kbps). WaveMatch; Advanced DSP sync detector with high sensitivity and strong noise immunity.	The most robust RF transceiver on the market. Reliable communication in presence of RF interference. Up to 139dB RF link budget. More reliable links, no false sync detects in noise. Enables RF sniff mode with <3mA current consumption.	
CC2520	2.4GHz ZigBee®/ IEEE 802.15.4 RF Transceiver	Best-in-class coexistence and selectivity properties; excellent link budget (103dBm); extended temperature range; AES-128 security module	Reliable RF link with interference present; 400m line-of-sight range with the development kit; ideal for industrial applications; no external processor needed for secure communication	CC2530
CC2560	*Bluetooth*® v2.1 + EDR (Enhanced Data Rate)	Fully qualified *Bluetooth*® v2.1 + EDR, +10dBm Tx power with transmit power control, –93dBm received sensitivity, support for *Bluetooth*® power saving modes (sniff, hold), hardware and software pre-integration with TI's MSP430 and Tiva® C Series ARM® MCU platforms, FCC, CE and IC certified module options, broad market offering with extensive documentation, sample software, and support forums	Supports replacement of serial cables for personal area networks, High throughput, robust connection with extended range, extended battery life and power efficiency reduced development time and costs, flexibility to use various MCUs	
CC2564	*Bluetooth*® v4.0	Fully qualified *Bluetooth*® v4.0 with dual mode capability, +10dBm Tx power with transmit power control, –93dBm received sensitivity, support for *Bluetooth*® power saving modes (sniff, hold), hardware and software pre-integration with TI's MSP430 and Tiva® C Series ARM® MCU platforms, FCC, CE and IC certified module options, broad market offering with extensive documentation, sample software, and support forums, ability to connect to existing mobile devices without BLE and some newer devices with BLE	Supports replacement of serial cables for personal area networks, High throughput, robust connection with extended range, extended battery life and power efficiency reduced development time and costs, flexibility to use various MCUs and connect to any type of existing device	
RF Systems-on-Chip				
CC2530/31	Second Gen. System-on-Chip Solution for 2.4GHz IEEE 802.15.4/ RF4CE/ZigBee®	Excellent RX sensitivity, low power, easy to use development tools	RF design system-on-chip for quick time to market. Provides a robust and complete ZigBee® USB dongle or firmware-upgradable network node.	CC2590/91, CC2530ZNP
CC254x	2.4 GHz *Bluetooth*® low energy compliant RF System-on-Chip	Best-in-class system-on-chip *Bluetooth*® low energy solution enabling devices to connect to smartphone/ tablets with extremely low power. Able to run on coin cell battery	System-on-chip for quick time to market. Provides a robust and complete *Bluetooth*® low energy stack enabling extremely long battery life and ability to run on a single coin-cell	CC2590/91, CC2530ZNP
RF Network Processor				
CC3000	SimpleLink™ Wi-Fi® CC3000 Module	One step configuration with SmartConfig Technology, easy to use Wi-Fi® solution with compact code size to be used with microcontrollers, best-in-class link budget, precertified FCC/IC/CE module, small form factor module and $9.99 price point for 1k units, proven Wi-Fi® interoperability, broad market offering with extensive documentation, sample software, and support forums	Universal IP connectivity can be enabled on low memory, low-cost, low-power microcontroller systems, has low certification cost and is easy to use for development	DLP® Pico™
Toolkits				
ADS1298ECGFE-PDK	Reference design for the ADS1298	Easy-to-use evaluation software, built-in analysis tools including oscilloscope, FFT, and histogram displays, flexible input configurations, optional external reference circuits	The ADS1298ECG FE can be used with a variety of patient simulators and allows the user to take advantage of the flexible input multiplexer which can be independently connected to the internally-generated signals for test, temperature, and lead-off detection.	

To view more system block diagram compatible products, visit **www.ti.com/ecg**

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

Pulse Oximeter

Overview

The pulse oximeter measures blood oxygenation by sensing the infrared and red-light absorption properties of deoxygenated and oxygenated hemoglobin. The oximeter is comprised of a sensing probe that attaches to a patient's ear lobe, toe or finger and is connected to a data acquisition system for the calculation and display of oxygen saturation level, heart rate and blood flow.

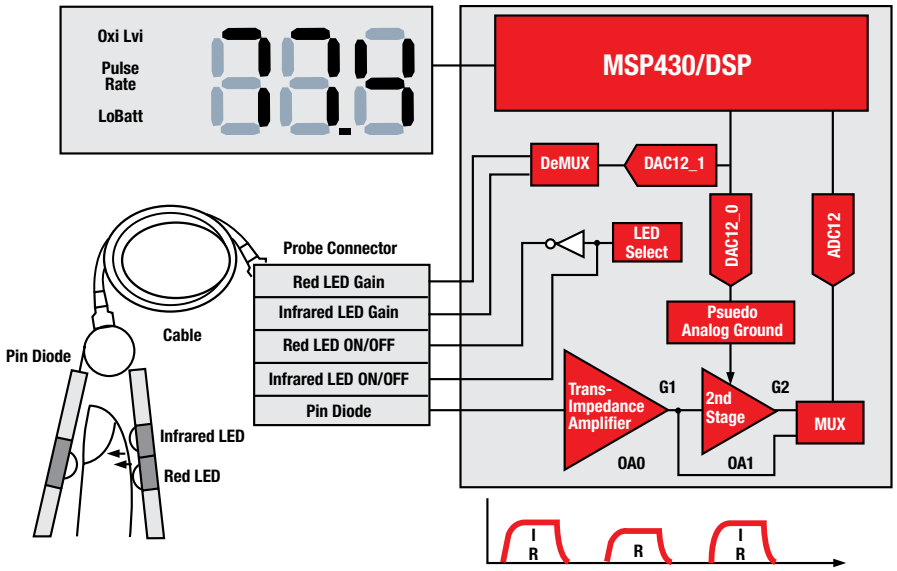
Light sources, typically light-emitting diodes (LEDs), shine visible red and infrared light. Deoxygenated hemoglobin allows more infrared light to pass through and absorbs more red light. Highly oxygenated hemoglobin allows more red light to pass through and absorbs more infrared light.

The oximeter senses and calculates the amount of light at those wavelengths proportional to the oxygen saturation (or desaturation) of the hemoglobin. The use of light in the absorbency measurement requires the designer to have a true "light-to-voltage" conversion using current as the input signal.

Amplifiers and Processors

The classic resistor-feedback transimpedance amplifier and capacitor-feedback switched integrator are suitable for pulse oximetry applications. In either amplifier configuration, the resulting output voltage is read by an analog-to-digital converter and serialized for the MSP430™ microcontroller or TMS320™ DSP for processing.

Processor selection should be based on signal-processing needs. TI has a wide variety of MSP430 products offering up to 25MIPS performance and extensive mixed-signal integration. For mid-range to high-end systems requiring much higher digital signal performance for enhanced signal conditioning and processing, low-power DSP processors such as C55x™ can be used. These processors offer higher than 100MIPS at very low power.



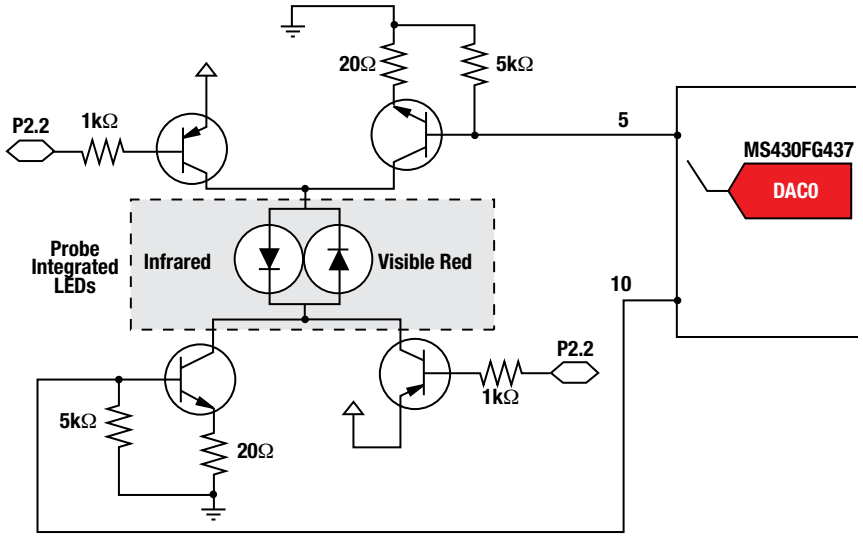
Apart from the MCU and four transistors, only passive components are needed for this design.

Low-End Portable Pulse Oximeter

For low-end designs, TI's highly integrated MSP430FG437 reduces the number of external components. The design of a non-invasive optical pulse oximeter using the MSP430FG437 microcontroller (MCU) consists of a peripheral probe combined with the MCU displaying the oxygen saturation and pulse rate on an LCD glass. In this application, the same sensor is used for heart-rate detection and pulse oximetry.

The probe is placed on a peripheral point of the body, such as a fingertip, an ear lobe or the nose. The probe includes two LEDs — one in the visible red spectrum (660nm) and the other in the infrared spectrum (940nm). The percentage of oxygen in the body is determined by measuring the intensity from each frequency of light after it is transmitted through the body. Then, the ratio between these two intensities is calculated.

The diagram below demonstrates the implementation of a single-chip, portable pulse oximeter using the ultra-low-power capability of the MSP430 MCU.



LED drive circuit.

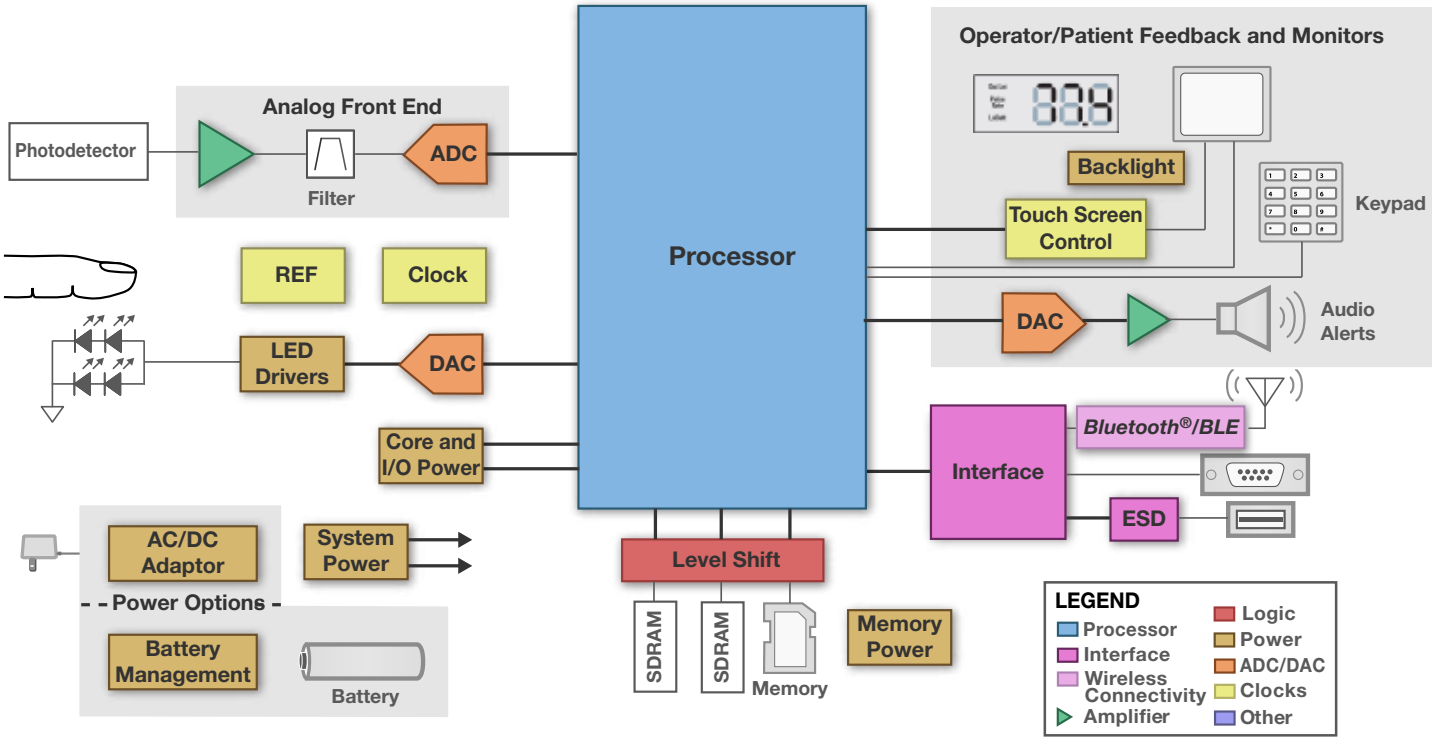
Pulse Oximeter

Because of the high level of analog integration, the number of external components is kept to a minimum. Keeping ON time to a minimum and power cycling the two light sources also reduces power consumption.

Mid-Range and High-End Applications

For mid-range and high-end applications where higher performance and higher measurement accuracy are necessary, there is a need for higher-performance processors and high-precision analog components that provide lower system power.

For example, several sources of interference such as neon lamps, UV lamps and other light emitters may influence the optical path between LEDs and the photoreceiver, affecting measurement accuracy. There could also be signal distortion caused by motion that occurs while the reading is taken. Sophisticated DSP technology can be applied to eliminate or reduce these effects and extract the vital signal of interest. Often, these DSP technologies require high-sample-rate signal-processing operations such as demodulation, digital filtering, decimation, and frequency-domain analysis, which can be efficiently mapped to a C55x™ low-power digital signal processor.



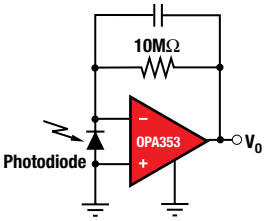
Product Availability and Design Disclaimer – The system block diagram depicted above and the devices recommended are designed in this manner as a reference. Please contact your local TI sales office or distributor for system design specifics and product availability.

Pulse oximeter system block diagram.

Pulse Oximeter

Signal Acquisition Challenges

The resistor-feedback amplifier circuit is the most common bioelectric transimpedance circuit. With the amplifier used in the inverting configuration, the light shining on a photodiode produces a small current that flows to the amplifier summing junctions and through the feedback resistor. Given the very large feedback resistor value, this circuit is extremely sensitive to changes in light intensity. For example, an input light signal of just 0.001µW can produce a full-swing output.



Depending on design requirements, it can be very useful to achieve output swing down to or below ground. The auto-zero transimpedance amplifier configuration shown in Figure A at right allows swing to ground, while the one in Figure B allows swing very close to ground. A pull-down resistor tied to –5V allows swing slightly below ground to minimize errors as the output gets very close to 0V.

TI's OPA380 is a monolithic combination of the high-speed OPA355 and auto-zero OPA335 amplifiers. It offers a 90MHz gain-bandwidth product and performs well as a 1MHz transimpedance amplifier with extremely high precision (25µV maximum offset and 0.1µV/°C maximum drift).

Depending on design requirements, the switch integrator can be a very effective solution. TI's IVC102 does not have the thermal noise of a feedback resistor and does not suffer from stability problems commonly found in transimpedance amps with a large feedback resistor.

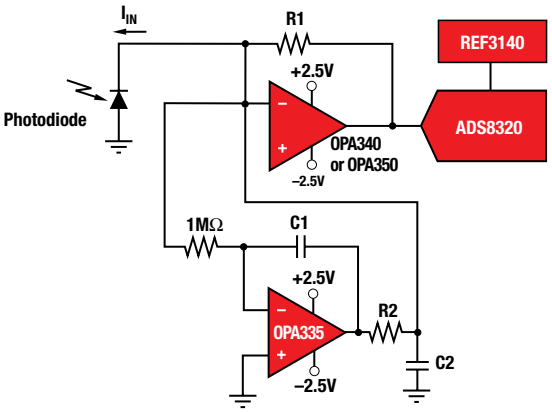
Using one photodiode with two IVC102s eliminates dark current and ambient light errors, since errors common to both can be subtracted.

Additionally, IVC203 allows for synchronized sampling at an integer multiple of the AC line frequency, giving extremely high noise rejection. Transimpedance gain can be easily changed by extending or shortening integration time with switch S2.

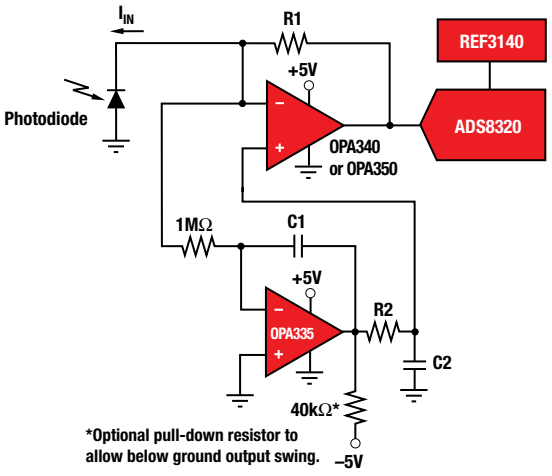
Transimpedance Amplifier Requirements

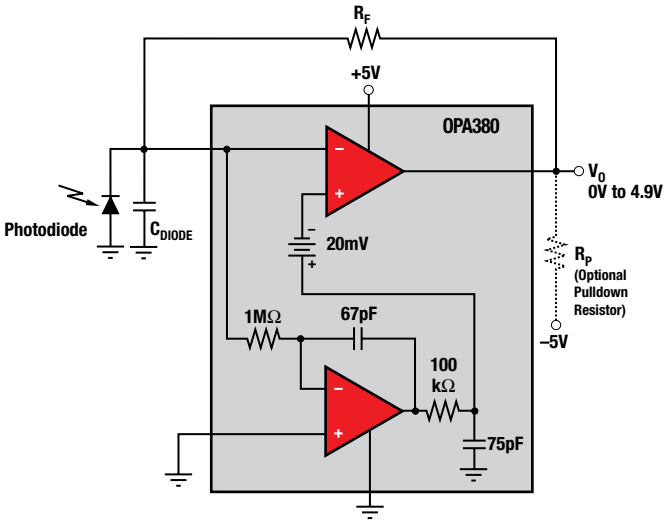
- Low input bias current over temperature range of interest
- Low input capacitance relative to photodiode capacitance
- High gain-bandwidth product
- Low voltage noise
- For maximum precision, low offset drift over temperature
- For single-supply systems:
  - Rail-to-rail input (including OV) and output if operating the photodiode in photovoltaic (zero-bias) mode
  - Rail-to-rail output only if operating the photodiode in photoconductive mode (biased)
  - Shutdown and/or low supply current if battery-powered system

A. Dual Supply



B. Single Supply





Pulse Oximeter

Design Hints

A small (<1pF) capacitor in the feedback loop (C_F) controls gain-peaking caused by diode capacitance. Noise (voltage-output fluctuation) is caused by resistor noise, amplifier and current noise, and environmental noise pickup (e.g., 50Hz or 60Hz line noise). To minimize noise in the circuit, the designer should choose a low-noise amplifier, select the largest practical feedback resistor, RF shield the amplifier inputs, include low-pass filtering and use good PCB layout techniques.

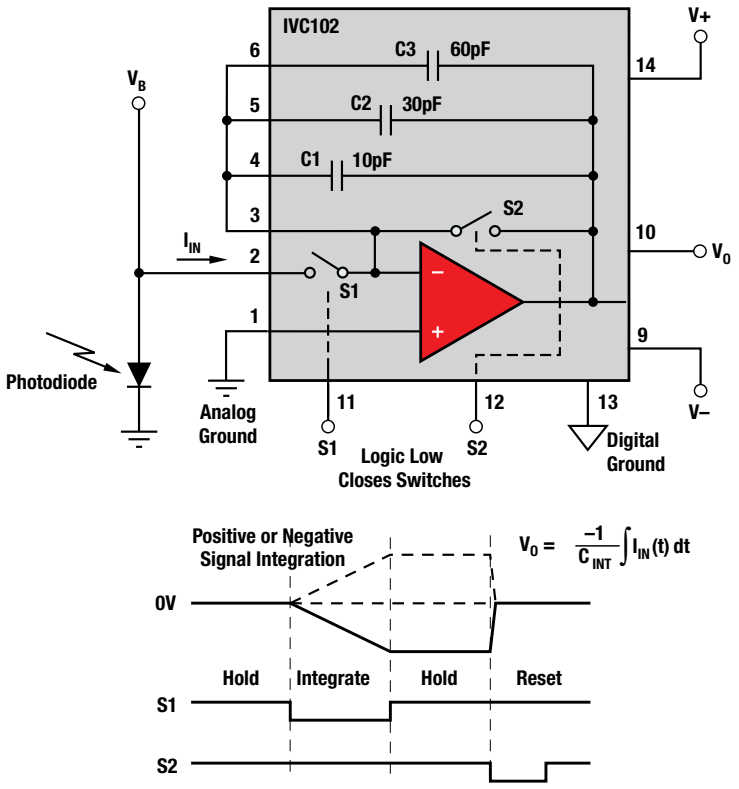
If the photodiode shunt resistance is much larger than that of the feedback resistor, offset voltage is not significant. If offset voltage stability is paramount, an auto-zero solution including the OPA335 is best.

To achieve the highest precision levels, system designers should choose the OPA380. Designed to meet exacting transimpedance application requirements, the OPA380 provides an unbeatable combination of speed (85MHz GBW over 1MHz transimpedance bandwidth) and precision (25µV maximum offset, 0.1µV/°C drift and low 1/f noise). A discrete alternative is to use the OPA365, OPA350, or OPA355, adding the OPA335 in the integrators-stabilized transimpedance configuration for circuits requiring low offset and drift. Adding the OPA335 integrator to a basic transimpedance amplifier will also reduce its very low frequency noise.

Mid-Range Solution Advantages

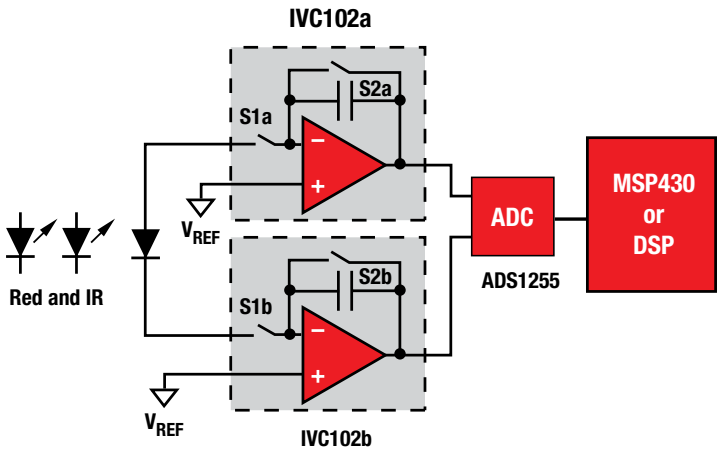
- Single-chip solution
- High resolution
- Low noise
- Wide input range by adjustable integration time
- No need for DC corrections of the diode current

Note: “Pulse Oximeter Design using MSP430FG43x” (slaa274)
www-s.ti.com/sc/techlit/slaa274



High-End Solution Advantages

- Very high resolution
- High noise immunity due to differential input
- High noise immunity due to synchronization on AC supply possible
- High noise immunity due to free access on integration and reset switches by software
- No need for DC correction of the diode currents
- Huge input range can be covered (>24-bit) due to free programmable integration times



High-end solution block diagram.

Pulse Oximeter

Integrated Solution for Photometry (Clinical SpO2)

AFE4490

Get samples and datasheets at: **www.ti.com/product/AFE4490**

Key Features

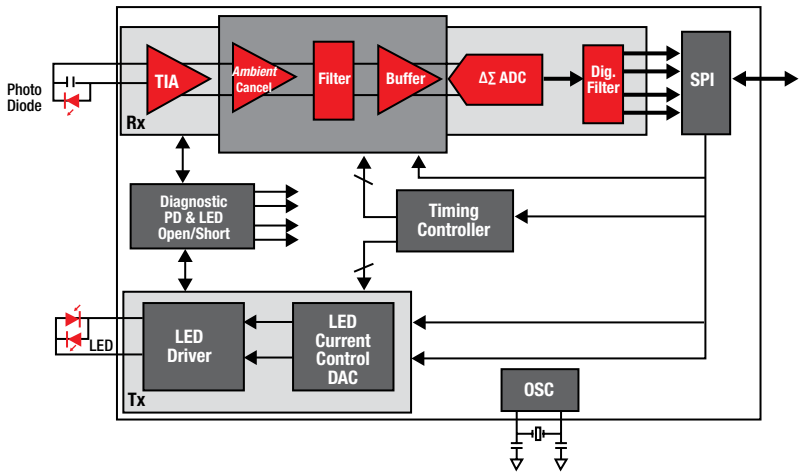
- Transmitter
  - H-bridge LED driver
  - Dynamic range >105dB
  - LED current 150mA (with 8-bit current setting)
  - LED ON (programmable 50uS to 250uS
  - LED current reference (Independent RED and IR)
  - LED open/short detect
- Receiver
  - Pulse frequency 625Hz to 100Hz
  - 1uA photodiode current (>13 noise free bits)
  - 5uA photodiode current (>13.5 noise free bits)
  - Low power receiver (<4mW at 2.2V)
  - Receiver sample time 50uS to 250uS
  - Programmable trans-impedance Amp with 7 resistor settings
  - Independent settings for RED and IR paths
  - Digital ambient estimation and subtraction (separate RED/IR ambient values)
  - Photodiode open/short detect

Other Features

- Flexible pulse sequencing and timing
- Cable on/off detect
- Supplies (Rx: 2.2V to 3.6V, Tx: 5V)

The AFE4490 is a fully-integrated analog front-end (AFE) that is ideally suited for pulse-oximeter applications. The device consists of a low-noise receiver channel with a 22-bit analog-to-digital converter (ADC), an LED transmit section, and diagnostics for sensor and LED fault detection. The AFE4490 is a very configurable timing controller. This flexibility enables the user to have complete control of the device timing characteristics. To ease clocking requirements and provide a low-jitter clock to the AFE4490, an oscillator is also integrated that functions from an external crystal. The device communicates to an external microcontroller or host processor using an SPI™ interface.

This AFE4490 is a complete AFE solution packaged in a single, compact QFN-40 package (6mm × 6mm) and is specified over the operating temperature range of –40°C to +85°C.



AFE4490 block diagram.

Pulse Oximeter

1.1nV/√Hz Noise, Low-Power, Precision Op Amp

OPA211, OPA2211

Get samples, datasheets, evaluation modules and application reports at: **www.ti.com/sc/device/opa211**

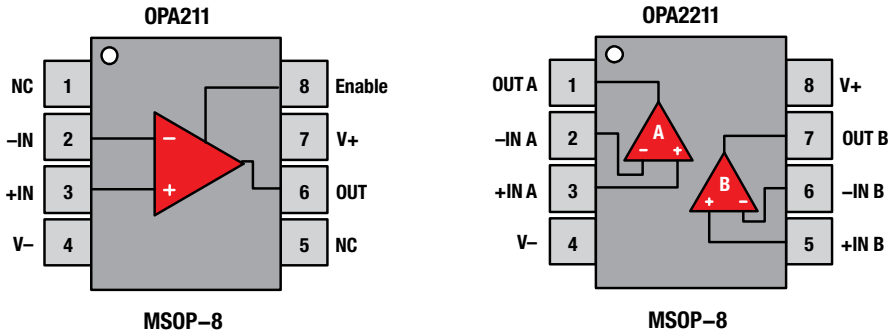
Key Features

- Input voltage noise: 80nV$_{PP}$, 0.1Hz to 10Hz
- Low offset voltage: 50µV (max)
- Low offset voltage drift: 0.15µV/°C (typ)
- Supply current: 3.6mA/ch
- Gain bandwidth product: 80MHz (G = 100)
- Slew rate: 27V/µs
- Supply range: ±2.25V to ±18V, +4.5V to +36V
- Output current: 30mA
- Unity gain stable
- Packaging: Tiny DFN-8, MSOP/SO-8

Applications

- Medical instruments
- Portable medical devices
- Ultrasound amplifiers
- Low-noise, low-power signal processing

The OPA211 series achieves very low 1.1nV/√Hz noise density with a supply current of only 3.6mA. It offers rail-to-rail output swing to maximize dynamic range. In precision data acquisition systems, the OPA211 provides <1µs settling time to 16-bit accuracy even for 10V output swings. By combining AC performance with only 50µV of offset and low drift over temperature, the OPA211 is able to drive fast, high-precision ADCs or buffer the outputs of high-resolution DACs.



Pin configurations.

Low Power Drivers

ULN2003LV, ULN2003V12

Get samples, datasheets, evaluation modules and application reports at: **www.ti.com/sc/device/uln2003lv**

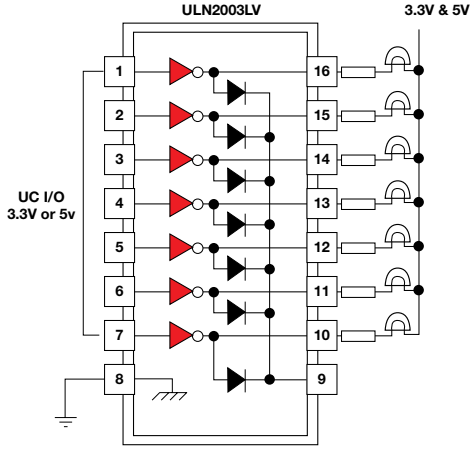
Key Features

- Compatible to 3.3V/5V micro-controllers and relays
- Very low input leakage and stand-by currents
- Low output VOL of 0.6V with internal free-wheeling diodes for inductive kickback protection
- Input pull-down resistor allows tri-state input drivers

Applications

- Relays and similar Inductive Drivers in Telecom, Consumer and Industrial applications
- Uni-polar Stepper Motor Driver
- Lamp and LED Displays
- Logic Level Shifter
- Logic Driver
- Constant current generator

The ULN2003 family of 7-channel Darlington transistor array features 7 low output impedance drivers that minimize on-chip power dissipation and support low voltage relay and inductive coil applications. The ULN2003 series supports 3.3V to 5V CMOS logic input interface thus making it compatible to a wide range of micro-controllers and other logic interfaces. The ULN2003 series features an improved input interface that minimizes the input DC current drawn from the external drivers.



ULN2003LV, ULN2003V12 functional block diagram.

Pulse Oximeter

Pulse Oximeter (PO or SpO2) Analog Front End Module for the C5515 PO or SpO2 Medical Development Kit

TMDXMDKPO8328

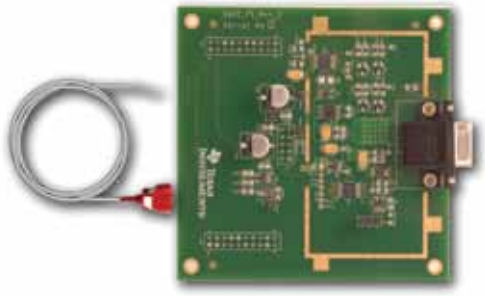
Get samples, datasheets and evaluation modules at: **www.ti.com/tmdxmdkpo8328**

Key Features

- PO AFE module key components
  - ADS8328: low power, 16-bit, 500ksps, analog-to-digital converter (ADC)
  - DAC7573: quad, 12-bit, low power, voltage output digital-to-analog converter DAC
  - OPA381: precision, low power, transimpedance amplifier (current to voltage converter)
  - REF5025: low noise, very low drift, precision voltage reference
- DS MDK system features
  - Based on industry's lowest power DSP processor – TMS320C5515
  - Display of oxygen level percentage ranging from zero to 100 percent
  - Display of pulse rate, ranging from 20 to 300
  - Real-time display of plethysmogram on PC
  - Sensor off detection
  - Common signal conditioning path for red and infrared signal

To reduce the time to market for medical device companies, TI has launched a set of medical application development tools with complete signal chain designs and software for electrocardiograms, digital stethoscopes, and pulse oximeter products. Each of the three medical development kits (MDKs) is comprised by purchasing an analog front-end (AFE) module with specific circuitry design optimized for each end product plus a TMS320C5515 DSP Evaluation Module (EVM) based on the industry's lowest power DSP – TMS320C5515. MDKs provide a great evaluation platform to help medical device manufacturers focus on product differentiation, like algorithm development and feature enhancement.

The TMDXMDKPO8328 Pulse Oximeter (PO or SpO2) Analog Front End (AFE) module consists of the PO AFE module, a processor board (C5505 DSP evaluation module), a set of collateral and C5505 based application sample code to implement the PO application. The PO MDK delivers a complete signal chain solution to enable PO developers to build a complete PO system quickly for evaluation and get to production faster.



Applications

- Pulse oximeters
- Patient monitoring

Pulse Oximeter

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers				
IVC102	Transimpedance Amp	Precision switched integrator	Reduces noise by averaging the input noise of the sensor, amplifier, and external sources	
LM324	Quadruple Operational Amplifier	Wide supply range 3V to 32V Supply current independent of supply voltage 0.8mA Low input bias 20nA	Excellent performance and reliability	
LM358	Dual Operational Amplifiers	Wide supply range 3V to 32 Supply current independent of supply voltage 0.7mA Low input bias 20nA	Excellent performance and reliability	LMV358
LM6211	Low noise precision Op Amp	5V to 24V supply voltage range, 5.5nV/input referred voltage noise, 20MHz unity gain bandwidth, 400Hz 1/f corner frequency, 5.6V/µs slew rate, 1.05mA supply current, 5.5pF low input capacitance, 0.01% @ 1kHz, 600 total harmonic distortion, 25mA output short circuit current	Low noise op amp with very low input bias currents and a large output voltage swing	
LMV772	RRO Op Amp	Voltage noise f = 100Hz 12.5nV/√Hz, f = 10kHz 7.5nV/√Hz; rail-to-rail output swing RL = 600Ω 100mV from rail; 100dB open loop gain with RL = 2kΩI; VCM 0 to V±0.9V; supply current 550µA	Designed for precision, low noise, low voltage, and miniature systems	
LMV832	EMI hardened Op Amp	100dB open loop gain with RL = 2kΩ, 0 to V±0.9V VCM, 550µA supply current, 3.5MHz gain bandwidth	EMI hardened to minimize any interference, ideal for EMI sensitive applications	
LMV852	EMI hardened Op Amp	2.7V to 5.5V supply voltage, 0.4 mA supply current (per channel), 1 mV max Input offset voltage, 0.1pA input bias current, 8MHz GBW, 87dB EMIRR at 1.8GHz, 11nV/√Hz Input noise voltage at 1kHz, 4.5V/µs slew rate, rail-to-rail output voltage swing, 30mA output current drive	EMI hardened to minimize any interference, ideal for EMI sensitive applications	
OPA141	Precision Op Amp	10MHz, 6.5nV/√Hz, ±4.5V to ±18V, 1.8mA typical, FET input: I_B = 20pA max	Common mode voltage range includes GND	OPA827
OPA211/2211	Precision Op Amp	1.1nV/√Hz noise at 1kHz, ±2.25V to ±18V supply, 80MHz BW	Unity gain stable, RRO, wide supply range	OPA227, OPA827
OPA313	Micro-Power Op Amplifier	50µA/ch low IQ, 1.8 V to 5.5 V wide supply range, 25nV/√Hz at 1kHz, 1MHz gain bandwidth, 0.2pA input bias current, 0.5mV offset voltage, unity-gain stable, internal RF/EMI filter	Low-cost, general purpose, micro-power op amp with a robust design for ease-of-use	
OPA314	CMOS Amp	150µA/ch low IQ, 1.8V to 5.5V wide supply range, 14nV/√Hz at 1kHz low noise, 3MHz gain bandwidth, 0.2pA input bias current, 0.5mV offset voltage, unity-gain stable, internal RF/EMI filter	Low-power, general-purpose CMOS amplifiers with a robust design for ease-of-use	
LMV601	Low Cost CMOS Input Op Amp	200µA/ch low IQ, 1MHz gain bandwidth, 0.02pA input bias current, unit gain stable	Lowest-cost, micro-power general purpose CMOS amplifiers	
OPA333	Op Amp	10µV (max) low offset voltage, 0.05µV/°C (max) zero drift, 1.1µVPP 0.01Hz to 10Hz noise, 17µA quiescent current, single-supply operation, 1.8V to 5.5V supply voltage, rail-to-rail I/O, SC70 and SOT23 MicroSIZE packages	Simultaneously provide very low offset voltage (10µV max) and near-zero drift over time and temperature	
OPA334/5	Op Amp	2MHz, 5µV (max) offset, 0.05µV/°C (max) drift, 285µA	Provides very low offset voltage and near-zero drift over time and temperature; SOT23	OPA735, OPA333, OPA334
OPA335	Op Amp	5µV (max) low offset voltage, 0.05 µV/°C (max) zero drift, 285 µA quiescent current, single-supply operation, single and dual versions, shutdown, MicroSIZE packages	Simultaneously provide very low offset voltage (5µV max) and near-zero drift over time and temperature	
OPA336	Op Amp	125µV (max) offset, 1.5µV/°C drift, 20µA supply	micoPower, SOT23 package	OPA379
OPA350	Op Amp	500µV V_{OS}, 38MHz, 2.5V to 5V supply		
OPA353	MicroAmplifier™ Series	High speed, single supply, rail-to-rail		
OPA354	CMOS Single Op Amp	250MHz unity-gain bandwidth, 100MHz GBW wide bandwidth, 150V/µs high slew rate, 6.5nV/√Hz low noise, rail-to-rail I/O, > 100mA high output current, excellent video performance, 3pA low input bias current, 4.9mA quiescent current, thermal shutdown, 2.5V to 5.5V supply range, MicroSIZE and PowerPAD packages	Unity-gain stable, can drive large output currents	
OPA363	Op Amp	1.8V, high CMR, RRIO, shutdown		OPA364
OPA365	Zero-Crossover Op Amp	1.8V to 5.5V, 50MHz BW, 25V/µs slew rate, 0.0004% (typ) THD+N, 4.5nV/√Hz at 100kHz, RRIO	Zero-crossover, high speed, low input bias, low noise, RRIO	
OPA380	Transimpedance Amp	1MHz transimpedance bandwidth, 50pA (max) bias current, 25µV (max) offset voltage, 4 to 5 decades dynamic range, 0.1µV/°C (max) drift, 90MHz gain bandwidth, 7.5mA quiescent current, 2.7V to 5.5V supply range, single and dual versions, MSOP-8 MicroSIZE package	Excellent long-term VOS stability	

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

Pulse Oximeter

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers (Continued)				
OPA381	Transimpedance Amp	Over 250kHz transimpedance bandwidth, 5 decades dynamic range, 10nV/√Hz low voltage noise, 3pA bias current, 25µV (max) offset voltage, 0.1µV/°C (max) offset drift, 18MHz gain bandwidth, 800µA quiescent current, fast overload recovery, 2.7V to 5.5V supply range, single and dual versions, DFN-8, MSOP-8 MicroPACKAGE	Extremely high precision, excellent long-term stability, and very low 1/f noise	
OPA725	12V Op Amp	Very low noise, high speed, 12V CMOS		OPA727
OPA726	CMOS Op Amp	4V to 12V, 20MHz GBW, 30V/µs slew rate, 0.0003% (typ) at 1kHz THD+N	Outstanding ac performance, excellent CMRR, PSRR	
OPA735	Zero-Crossover Op Amp	2.7V to 12V, 0.75µA (max) I_Q/ch, 1.6MHz GBW, 115dB (min) CMRR, RRO	Zero-crossover input offers excellent CMRR over entire input range	
TLC081-083	Op Amp	IOH of 57mA at V_{DD} – 1.5V, IOL of 55 mA at 0.5 V, 16 to 19V/µs slew rate, 4.5V to 16V, 1.9mA/channel supply current, 125µA/Channel, 8.5nV√Hz input noise, 60µV input offset, ultra-small package	Very high input impedance, low-noise CMOS front end with a high-drive bipolar output stage	
TLV2375	RRIO Op Amp	Rail-to-rail input/output, 3MHz, 2.4V/µs slew rate, 2.7V to 16V supply voltage, 550µA/Channel	CMOS inputs enable use in high-impedance sensor interfaces, lower voltage operation ideal in battery-powered applications	
Data Converters				
ADS8318	High-Speed SAR	16-bit, 500kSPS, 18mW at 500kSPS power, ±1 LSB INL	Precision, excellent AC/DC performance	ADS8319
ADS8317	SAR ADC	16-bit, 250kSPS, 2.7V to 5.5V supply, ±1.5 LSB (max) INL, differential input	Low power, small package, and wide supply range	ADS8326
ADS8326	Low-Power ADC	16-bit, 250kSPS, 2.7V to 5.5V supply, ±1.5 LSB (max) INL	Small package, wide supply range	
References				
LM4040x	Precision Micropower Shunt Voltage Reference	35µV_{RMS} typ, ABCD grade, 45µA (typ) to 15mA 2.048V, 2.5V, 3V, 4.096V, 5V, 8.192V, 10V	Highly precise with low output noise and a wide operating current range	
REF31xx	Low-Drift Series Reference	0.2% initial accuracy, 15ppm/°C max drift, ±10mA output, 1.25V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V		REF30xx, REF33xx, REF29xx
REF32xx	Ultra-Low-Drift Series Reference	100µA, 0.2% initial accuracy, 7ppm/°C max drift, ±10mA output, 1.25V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V	Improves system accuracy	
REF33xx	Very-Low-Power Series Reference	5µA, 0.15% initial accuracy, 30ppm/°C max drift, ±5mA output, 1.25V, 1.8V, 2.048V, 2.5V, 3.0V, 3.3V	Preserves battery life, fits into physically constrained systems	REF30xx, REF31xx, REF29xx
REF50xx	High-Precision, Very-Low-Drift Series Reference	0.05% initial accuracy, 3ppm/°C max drift, ±10mA output, 2.048V, 2.5V, 3.0V, 4.096V, 4.5V, 5.0V, 10V	Improves system accuracy	REF02
TL43x	Adjustable Precision Shunt Regulator	Output voltage V_{REF} to 36V, 0.2-Ω (typ), sink-current capability 1mA to 100mA	Easy to use, low output noise, great replacement for Zener Diodes	
Processors				
MSP430F20xx	Ultra-Low-Power 16-Bit MCU	1KB/2KB Flash, 128B RAM, SPI+I^2C	8 ch. 12-bit ADC or 4 ch. 16-bit SD ADC, 4 x 4mm package	
MSP430F22x4	Ultra-Low-Power 16-Bit MCU	8 to 32KB Flash, 512B/1KB RAM, SPI + I^2C + UART/LIN + IrDA	12 ch. 10-bit ADC, 2 op amps	
MSP430F23x0	Ultra-Low-Power 16-bit MCU	8 to 32KB Flash, 1KB/2KB RAM, SPI + I^2C + UART/LIN + IrDA	Analog comparator, HW multiplier	
MSP430F41x	Ultra-Low-Power 16-Bit MCU	4 to 32KB Flash, 256B to 1KB RAM, SVS, 96 segment LCD	Analog comparator	
MSP430F42x	Ultra-Low-Power 16-Bit MCU	8 to 32KB Flash, 256B to 1KB RAM, SPI + UART, SVS, 128 segment LCD	3 x 16-bit SD ADC	
MSP430F42x0	Ultra-Low-Power 16-Bit MCU	16 to 32KB Flash, 256B RAM, 56 segment LCD	5 ch. 16-bit SD ADC, 12-bit DAC	
MSP430F43x	Ultra-Low-Power 16-Bit MCU	16 to 32KB Flash, 512B/1KB RAM, SPI + UART, SVS, 160 segment LCD	8 ch. 12-bit ADC, analog comparator	
MSP430F44x	Ultra-Low-Power 16-Bit MCU	32 to 60KB Flash, 1KB/2KB RAM, 2x SPI + UART, SVS, 160 segment LCD	8 ch. 12-bit ADC, HW multiplier	
MSP430F47xx	Ultra-Low-Power 16-Bit MCU	60KB Flash, 256B RAM, (4) USCI, 160 segment LCD	(4) SD16 ADC, HW multiplier, temp. sensor, analog comparator	
MSP430F241x	Ultra-Low-Power 16-Bit MCU	120KB Flash, 8KB RAM, (4) USCI, SVS, temp. sensor	8 ch. 12-bit ADC, analog comparator, HW multiplier	

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Pulse Oximeter

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Processors (Continued)				
MSP430F261x	Ultra-Low-Power 16-Bit MCU	120KB Flash, 8KB RAM, (4) USCI, SVS, DMA, temp. sensor	Analog comparator, 2 ch. 12-bit DAC, 8 ch. 12-bit ADC, HW multiplier	
MSP430F471xx	Ultra-Low-Power 16-Bit MCU	120KB Flash, 8KB RAM, (4) USCI, DMA, 160 segment LCD	(7) SD16 ADC, HW multiplier, temp. sensor, analog comparator	
MSP430F54xxA	Ultra-Low-Power 16-Bit MCU	128 to 256KB Flash, 16KB RAM, (4) USCI, PMM, DMA, temp. sensor	16 ch. 12-bit ADC, analog comparator, RTC, internal voltage regulator for power optimization	
MSP430FG42x0	Ultra-Low-Power 16-Bit MCU	16 to 32KB Flash, 256B RAM, 56 segment LCD	5 ch. 16-bit SD ADC, 12-bit DAC, 2 integrated op amps	
MSP430FG43x	Ultra-Low-Power 16-Bit MCU	32 to 60KB Flash, 1KB/2KB RAM, SPI + UART, SVS, 128 segment LCD	12 ch. 12-bit ADC, 2 ch. 12-bit DAC, DMA, 3 op amps	
MSP430FG461x	Ultra-Low-Power 16-Bit MCU	92 to 120KB Flash, 4KB/8KB RAM, SPI + I^2C + UART/LIN + IrDA, 160 LCD	12 ch. 12-bit ADC, 2 ch. 12-bit DAC, A-comp, 3 op amp, HW multiplier	
MSP430FG47x	Ultra-Low-Power 16-Bit MCU	32 to 60KB Flash, 2KB RAM, SPI + I^2C + UART/LIN + IrDA, 128 LCD controller	5 ch. 16-bit SD ADC, 2 ch. 12-bit DAC, comparator_A, 2 op amps	
AM3354	Applications Processor	ARM® Cortex-A8, graphics accelerators, touch screen controller	ARM Cortex-A8 performance at power levels of an ARM9	AM3352, AM3356, AM3357, AM3358, AM3359
AM37x	Applications Processor	ARM® Cortex-A8 processor that nearly doubles graphics performance and overall system performance while providing a 30 percent decrease in power consumption	Laptop-like performance at handheld power levels	AM3715, AM3703
TMS320F28x™	32-Bit MCU	32-bit architecture, fixed- or floating-point code, up to 225MIPS operation	Microcontroller integration, real-time control performance	TMS320F2823x, TMS320F2833x
TMS320F2802x/3x Piccolo™	32-Bit Microcontroller	Up to 60MHz C28x™ core with optional control law accelerator. Up to 128KB Flash, high resolution (150ps) PWMs, 4.6MSPS ADC, CAN/LIN, QEP.	With dedicated, high precision peripherals, Piccolo microcontrollers are the ultimate combination of performance, integration, size, and low cost. Ideal for precision sensing and control applications.	TMS320F283x Delfino, TMS320F280x
TMS320F283x Delfino™	32-Bit Floating-point Microcontroller	Up to 300MHz C28x™ core. Up to 512KB Flash, high resolution (150ps) PWMs, 12MSPS ADC, CAN/LIN, QEP, external memory bus, DMA.	Delfino brings floating point and unparalleled performance to MCUs. Native floating point brings increased performance and quicker development. Ideal for precision sensing and control applications.	TMS320F2802x/3x Piccolo, TMS320F280x
Hercules RM48x	Safety Microcontroller	Up to 220MHz dual lockstep ARM® Cortex-R4 CPUs with floating point, up to 3MB flash w/ECC, up to 256KB RAM w/ECC, USB host/device, Ethernet, CAN, SPI, UART, 12-bit ADC, NHET co-processor for PWM generation and input capture	Simplified development for safety critical applications, large integrated flash memory, rich peripherial set	
TMS320VC5506	DSP	200MHz, dual MAC, very low stand-by power of 0.12mW	Supported by eXpressDSP™ and many other software packages and tools	TMS320V5509A, TMS320V5502
TMS320VC5509A	Low-Power DSP	Up to 200MHz, dual MAC, 256KB RAM/64KB ROM, USB 2.0 full speed, MMC/SD, 10-bit ADC	Power efficient, large on-chip memory, rich peripheral set allows for various portable connectivity; C55x code compatibility	C550x DSP
LED Drivers				
DRV777	Integrated Motor and Load Driver	7-Channel, 1.8V, 3.3V, 5V CMOS, low output VOL 0.4V Very low input leakage (<20uA)	Easy to use and low noise with Inductive kickback protection	
ULN2003LV	Low Power 3.3V and 5V Relay Driver	7-Channel, 1.8V, 3.3V, 5V CMOS, switching at 8V, low output VOL of 0.4V, delay time 80ns (typ)	Easy to use and low power dissipation	ULN2003A, ULN2003V12, ULN2004A, ULN2803A
ULN2003V12	Low Power Relay Driver	7-Channel, 1.8V, 3.3V, 5V CMOS, Switching at 16V low output VOL of 0.4V, delay time 80ns (typ)	Easy to use and low power dissipation	

To view more system block diagram compatible products, visit ***www.ti.com/healthtech***

Pulse Oximeter

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
RF Transceivers				
CC2560	*Bluetooth*® v2.1 + EDR (Enhanced Data Rate)	Fully qualified *Bluetooth*® v2.1 + EDR, +10dBm Tx power with transmit power control, –93dBm received sensitivity, support for *Bluetooth*® power saving modes (sniff, hold), hardware and software pre-integration with TI's MSP430 and Tiva® C Series ARM® MCU platforms, FCC, CE and IC certified module options, broad market offering with extensive documentation, sample software, and support forums	Supports replacement of serial cables for personal area networks, high throughput, robust connection with extended range, extended battery life and power efficiency reduced development time and costs, flexibility to use various MCUs	
CC2564	*Bluetooth*® v4.0	Fully qualified *Bluetooth*® v4.0 with dual mode capability, +10dBm Tx power with transmit power control, –93dBm received sensitivity, support for *Bluetooth*® power saving modes (sniff, hold), hardware and software pre-integration with TI's MSP430 and Tiva® C Series ARM® MCU platforms, FCC, CE and IC certified module options, broad market offering with extensive documentation, sample software, and support forums, ability to connect to existing mobile devices without BLE and some newer devices with BLE	Supports replacement of serial cables for personal area networks, high throughput, robust connection with extended range, extended battery life and power efficiency reduced development time and costs, flexibility to use various MCUs and connect to any type of existing device	
RF Systems-on-Chip				
CC254x	2.4 GHz *Bluetooth*® low energy compliant RF System-on-Chip	Best-in-class System-on-chip *Bluetooth*® low energy solution enabling devices to connect to smartphone/ tablets with extremely low power. Able to run on coin cell battery	System-on-chip for quick time to market. Provides a robust and complete *Bluetooth*® low energy stack enabling extremely long battery life and ability to run on a single coin-cell	CC2590/91, CC2530ZNP
Toolkits				
TMDXMDKPO8328	Pulse Oximeter (PO or SpO2) Analog Front End Module for the C5515 PO or SpO2 Medical Development Kit	Display of oxygen level percentage ranging from zero to 100 percent; display of pulse rate, ranging from 20 to 300; real-time display of plethysmogram on PC; sensor off detection; common signal conditioning path for red and infrared signal	Based on industry's lowest power DSP processor – TMS320C5515	

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Weight Scale/Body Composition

Integrated Analog Front-End for Weigh-Scale/ Body Comp Measurement

AFE4300

Get samples and datasheets at: **www.ti.com/device/afe4300**

Key Features

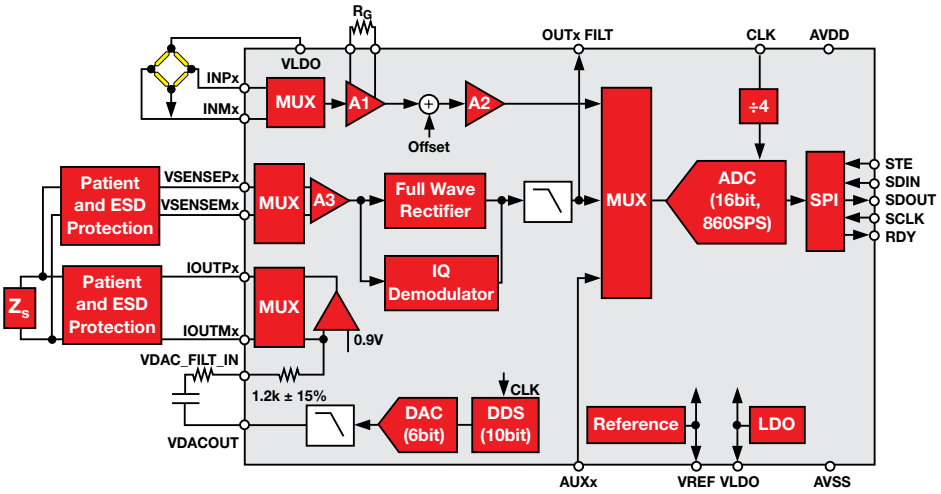
- Fully integrated solution with two signal chains for
  - Weigh scale
  - Body composition
- Provides multiple BCM channels
- Body composition front end options for
  - Tetra-polar measurements
  - Complex impedance measurement
- 2V to 3.6V supply and <1mA supply current

Applications

- Weigh scale – body composition meter
- Body impedance analyzers
- Impedance measurement

The AFE4300 is a low-cost analog front-end incorporating two separate signal chains: one chain for weight measurement and the other for body composition measurement (BCM) analysis. A 16-bit, 860-SPS analog-to-digital converter (ADC) is multiplexed between both chains.

The weight measurement chain includes an instrumentation amplifier (INA) with the gain set by an external resistor, followed by a 6-bit digital-to-analog converter (DAC) for offset correction, and a circuit to drive the external bridge/load cell with a fixed 1.7V for ratiometric measurements.



AFE4300 functional block diagram.

System Support Products

Voltage Level Translation

Applications

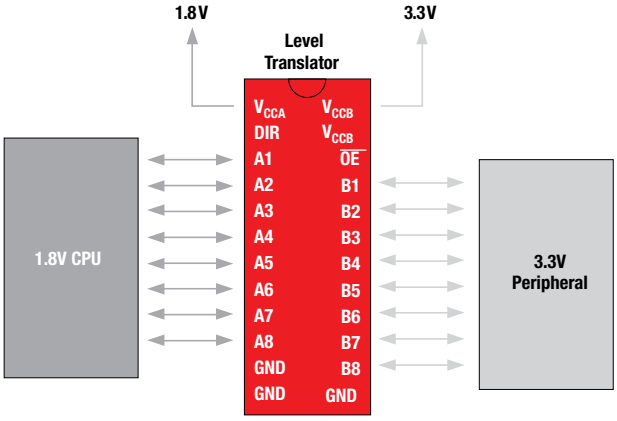
- LCD interface
- Interface devices with different supply voltages

As operating voltage levels in microcontrollers continue to drop, a void that disrupts device interfacing may be created between peripheral devices and processors. TI's translators enable communication between incompatible I/Os with level translation between the 1.2V, 1.5V, 1.8V, 2.5V and 3V nodes. The MSP430™ microcontroller has a 3.6V (max) I/O tolerance, allowing translators to be used to protect the inputs and interface to higher voltage peripherals.

Suggested Components

Component	Description	V_{CC} Range (V)	Power Max I_{CC} (µA)	Smallest Footprint Pins/Packages
SN74AVC1T45*	Single-bit Dual-Supply Bus Transceiver	1.2 to 3.6	10	6/WCSP (NanoStar™)
SN74LVC1T45	Single-bit Dual-Supply Bus Transceiver	1.65 to 5.5	4	6/WCSP (NanoStar)
SN74AVC2T45*	Dual-bit Dual-Supply Transceiver	1.2 to 3.6	10	8/WCSP (NanoStar)
SN74LVC2T45	Dual-bit Dual-Supply Transceiver	1.65 to 5.5	10	8/WCSP (NanoStar)
SN74AUP1T57	Single-Supply Voltage Translator	2.3 to 3.6	0.9	6/WCSP (NanoStar)
SN74AUP1T58	Single-Supply Voltage Translator	2.3 to 3.6	0.9	6/WCSP (NanoStar)
SN74AUP1T97	Single-Supply Voltage Translator	2.3 to 3.6	0.9	6/WCSP (NanoStar)
SN74AUP1T98	Single-Supply Voltage Translator	2.3 to 3.6	0.9	6/WCSP (NanoStar)
PCA9306	Dual Bidirectional I^2C-bus and SMBus Voltage-Level Translator	—	—	8/US

**Bus-hold option available.*



Example application block diagram.

System Support Products

System-Level ESD/EMI Protection

Benefits

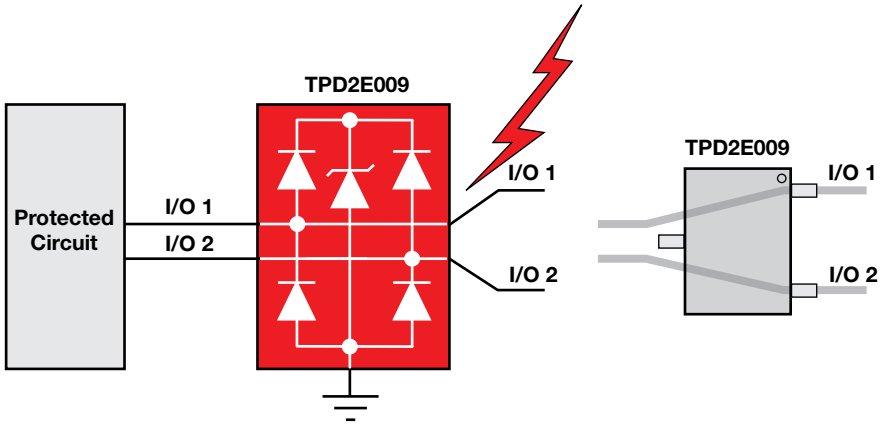
- System-level ESD protection for high-speed interconnects
- Space-saving package and flow-through layout enable glitch-free layout for the high-speed portable applications
- Ultra-low 1nA leakage current enables precision analog measurements like those of glucose meters
- The optional V_{CC} pin allows the device to work as a transient suppressor

Applications

- USB, HDMI, DisplayPort, eSATA, GigEthernet, 1394, Interface
- Analog precision interface

For any external interface connector port, an ESD strike is a constant threat to system reliability. Many low-voltage core chip or system ASICs offer only device-level human-body model (HBM) ESD protection, which does not address system-level ESD. A stand-alone ESD solution is a space- and cost-effective solution to protect the system interconnects from external ESD strikes.

TI's TPDxE series ESD devices provide an IEC-61000-4-2 (Level 4) system-level ESD solution while maintaining signal integrity at the high-speed interfaces. The TPDxF series EMI filter provides immunity against conducted EMI noise while providing system-level ESD protection.



TPD2E009 ESD circuit and board layout.

ESD/EMI Solutions

Device	Number of Channels	V_{DD} (V)	I/O Level (V)	Cap, Resistor	V_{BR} (min) (V)	Package(s)
ESD Solutions						
TPD2E009	2-Channel ESD	0.9 to 5.5/No V_{DD} pin	0 to V_{DD}	0.7pF	6	DRY, DRT, DBZ
TPD4S009	4-Channel ESD	0.9 to 5.5	0 to 5.5	0.8pF	9	DRY, DCK, DBV
TPD4S010	4-Channel ESD	No V_{DD} pin	0 to 5.5	0.8pF	9	QFN
TPD8S009	8-Channel ESD	0.9 to 5.5	0 to 5.5	0.8pF	9	DSM
TPD12S520	12-Channel, HDMI Receiver	0.9 to 5.5	0 to 5.5	0.9pF	9	DBT
TPD12S521	12-Channel, HDMI Driver	0.9 to 5.5	0 to 5.5	0.9pF	9	DBT
TPD4S012	4-Channel ESD with V_{BUS} Clamp	No V_{DD} pin	0 to 5.5	1.0pF, 9pF	7, 20	DRY
TPD2E001	2-Channel ESD	0.9 to 5.5	0 to V_{DD}	1.5pF	11	DRL, DRY, DRS
TPD3E001	3-Channel ESD	0.9 to 5.5	0 to V_{DD}	1.5pF	11	DRL, DRY, DRS
TPD4E001	4-Channel ESD	0.9 to 5.5	0 to V_{DD}	1.5pF	11	DRL, DRS
TPD6E001	6-Channel ESD	0.9 to 5.5	0 to V_{DD}	1.5pF	11	RSE, RSF
TPD6E004	6-Channel ESD	0.9 to 5.5	0 to V_{DD}	1.6pF	6	RSE
TPD4E004	4-Channel ESD	0.9 to 5.5	0 to V_{DD}	1.6pF	6	DRY
TPD4E002	4-Channel ESD	No V_{DD} pin	0 to 6	11pF	6	DRL
EMI Filters						
TPD6F002	6-Channel EMI	0.9 to 5.5	0 to 5.5	17pF, 100Ω, 17pF	6	DSV
TPD6F003	6-Channel EMI	0.9 to 5.5	0 to 5.5	8.5pF, 100Ω, 8.5pF	6	DSV

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Connectivity Solutions

Connectivity plays an important role in clinical, patient monitoring, and consumer medical devices. While wired (USB) connections continue to be used, emphasis is being placed on wireless capabilities that enable connected or networked devices. Portability requirements call for these devices to be small in size, consume minimal power and include the ability to efficiently and accurately feed data to remote sources.

TI has long-time experience providing a wide range of innovative wireless technologies such as ZigBee®, radio frequency identification (RFID), low-power wireless (ISM), *Bluetooth*® technology and WLAN.

USB for Medical Applications

Connectivity for portable medical applications has become critical as data is required to move from medical devices to data hubs such as computers and mobile phones. TI is a promoting member of the Continua Health Alliance aims at solving interoperability issues between connected medical devices. TI offers the first Continua-certified USB platform for Agent Devices.

For more information on the Continua Health Alliance, visit **http://www.continuaalliance.org**

Telehealth

With aging populations, the rise of chronic diseases and increasing health care costs, connected health technologies can help to control the cost of healthcare and enable each of us to maintain a good quality of life.

A telehealth system is designed to transmit vital signs from a personal health device like a heart rate monitor or a blood glucose meter to another location by use of wired or wireless telecommunications technologies to be monitored and analyzed there, e.g. by a health professional.

Industrial, Scientific and Medical (ISM) Band Wireless Offering

TI offers a wide selection of cost-effective ISM bands solutions for both proprietary and standards-based wireless applications that are suitable for medical applications as well. The portfolio includes RF transceivers, RF transmitters and systems-on-chip for applications in the sub-1GHz and 2.4GHz frequency bands.

To choose the right radio for specific applications, designers need to determine at what frequency band to operate. TI's radios operate in either the global 2.4GHz or the sub-1GHz Industrial Scientific Medical (ISM) bands. The 2.4GHz is available for license-free operation in most countries around the world and enables the same solution to be sold in several markets without software/hardware alterations.

The ISM bands devices operating below 1GHz have limitations that vary from region to region, but their strength is their longer range compared to 2.4GHz operating devices when presenting same output power and current consumption. In addition, there is less interference present in the band. Since different sub-1GHz bands are used in different markets, custom solutions become a necessity.

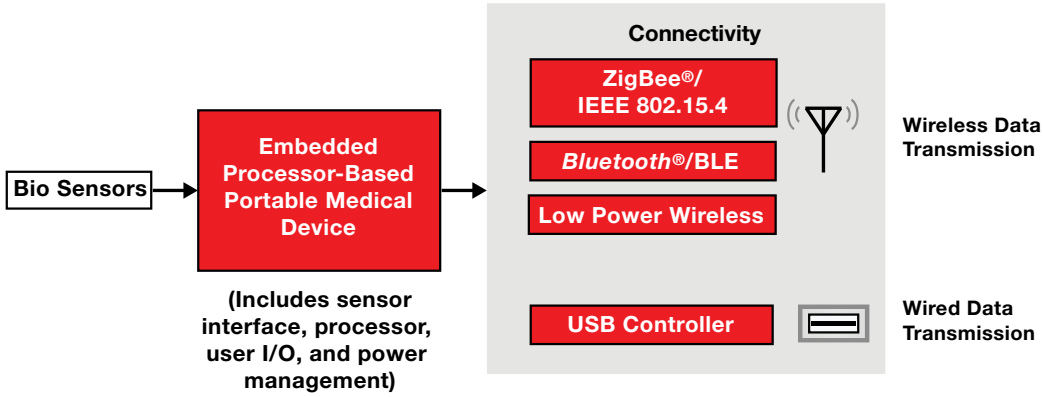
The trade-off between the need for interoperability and the cost of software design and development will, to a large extent, determine the choice of software platform. TI offers a wide range of software to support its different wireless offering. TI's software portfolio ranges from proprietary solutions with a high degree of design freedom and low complexity to fully interoperable ZigBee® solutions.

Connectivity Solutions

Radio Frequency Identification (RFID)
TI's high-frequency RFID product family consists of 13.56MHz high-frequency (HF) transponders and low-power RFID readers that are compliant with ISO/IEC 15693 and ISO/IEC 18000-3 global open standards.

Typical RFID medical applications include blood bag and medical supply tracking, patient/staff authentication, pharmaceutical authentication, medical imaging, product authentication and remote digital healthcare management applications.

TI's Tag-it™ HF-1 family of transponder inlays consists of 13.56MHz HF transponders that are compliant with ISO/IEC 15693 and ISO/IEC 18000-3 global open standards. These products are available in six different antenna shapes with frequency offset for integration into paper, PVC or other substrates manufactured with TI's patented laser-tuning process to provide consistent read performance.



TI has considerable experience designing connectivity solutions for interoperability and coexistence.

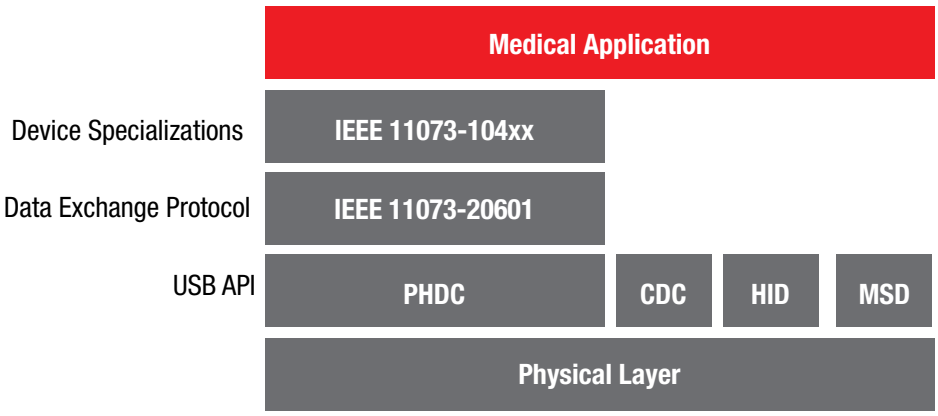
Medical USB Platform

TI offers a Continua-certified USB hardware-software platform that implements the Personal Healthcare Device Class (PHDC) along with IEEE 11073. As personal healthcare devices become more ubiquitous, companies are developing products with connectivity that allow data to be exchanged easily. PHDC (Personal Healthcare Device Class), which is part of the USB standard, is designed for portable medical and wellness devices to be able to send measurements to USB hosts such as personal computers, cell phones, etc. The Continua Health Alliance has released guidelines for interoperability between various types of devices implementing the USB standard. Texas Instruments offers a hardware-software platform that has been certified by the Continua Health Alliance after having passed a rigorous testing procedure. Customers can use the software stacks of this platform to reduce development time for devices that will comply with the medical industry standards such as the Continua Health Alliance. These stacks are available for use on TI's industry-leading, ultra-low-power MSP430™ MCUs.

For more information on the medical USB platform, visit **http://www.ti.com/usbplatform.**

For more information on the Continua Health Alliance, visit **http://www.continuaalliance.org.**

Continua®
HEALTH ALLIANCE

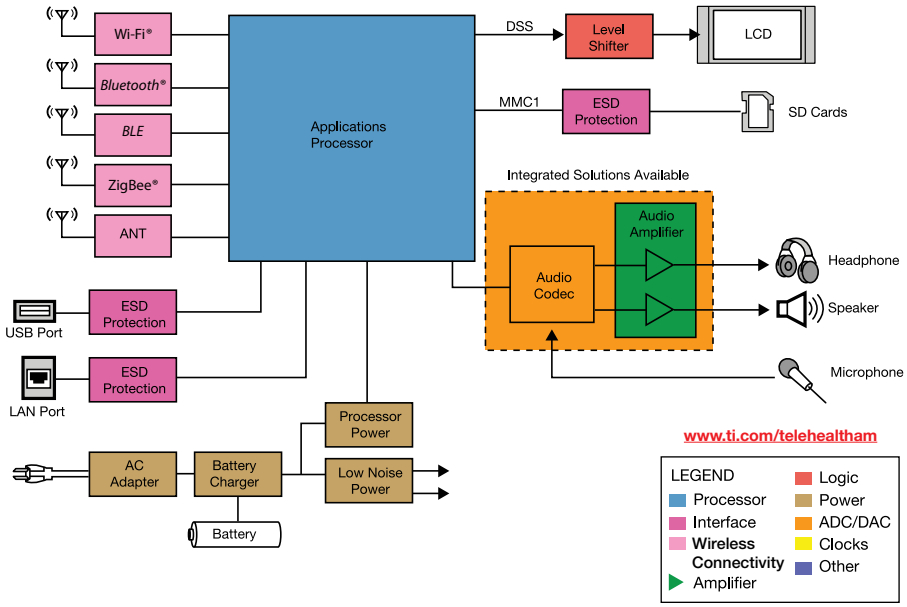


Telehealth Aggregator Manager

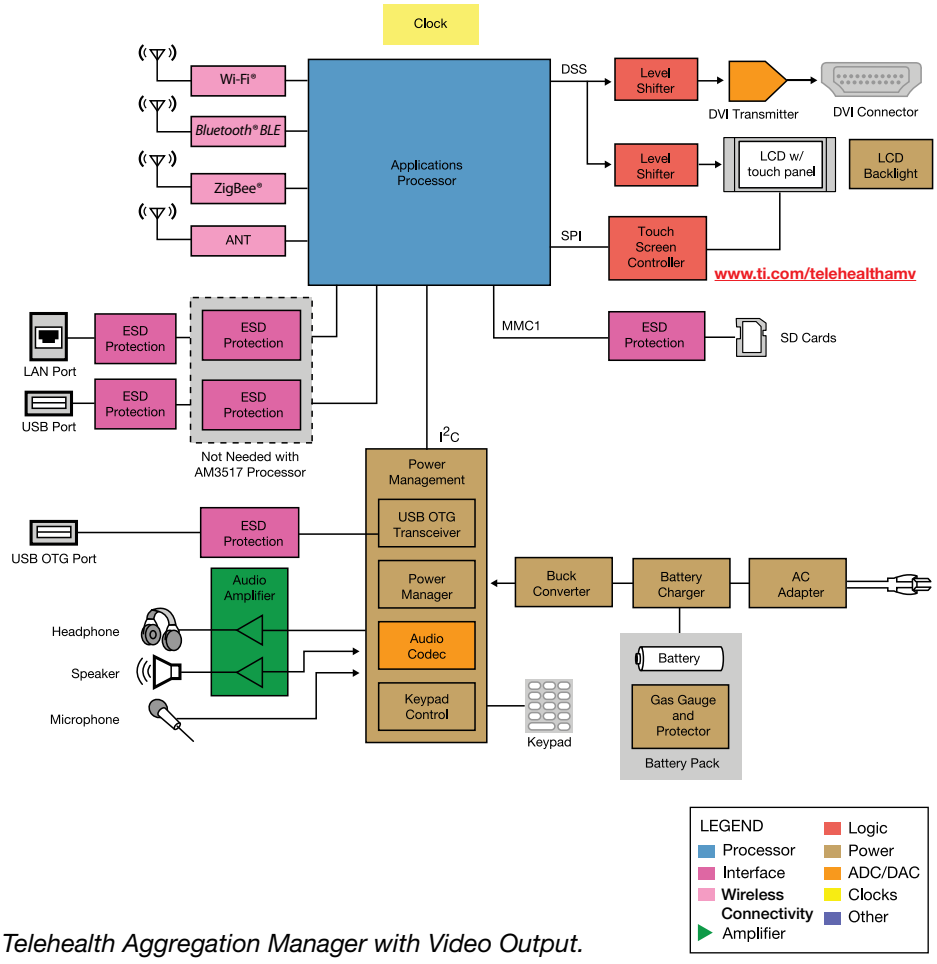
TI products that fit your Telehealth Aggregation Manager design

With aging populations, increasing incidence of chronic diseases, and the need to control health care costs, connected health technologies are becoming increasingly important. The Telehealth/Telemedicine Aggregation Manager is an essential device in the connected health system enabling personal health devices to log data in a remote EHR (Electronic Health Record) for family and clinical review. Higher end Aggregation Managers can also support multimedia functions. Get your design started now with complete solutions from TI for a dedicated low power Aggregation Manager with or without video output.

- Visit **www.ti.com/telehealth** for more information
- View our Continua white paper: **http://www.ti.com/litv/pdf/swpy026**
- View interactive system block diagrams:
  - Telehealth aggregation manger at **www.ti.com/telehealtham**
  - Telehealth aggregation manager with video output at **www.ti.com/telehealthamv**



Telehealth Aggregation Manager



Telehealth Aggregation Manager with Video Output.

Wireless Connectivity Solutions

Wi-Fi® Module

SimpleLink™ Wi-Fi® CC3000 Module

Get samples and datasheets at: **www.ti.com/sc/device/cc3000**

Key Features

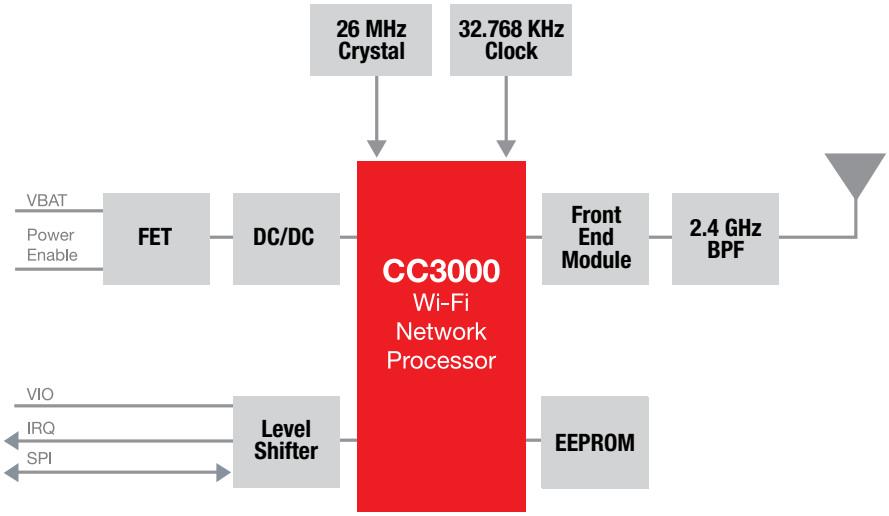
- Wireless Network Processor
  - IEEE 802.11 b/g
  - Embedded IPv4 TCP/IP Stack
- Best-in-class Radio Performance
  - Tx Power: +18dBm, 11Mbps
  - Rx Sensitivity: –88dBm, 11Mbps
- Single Power Supply 2.7V to 4.8V
- Pair with low MIPS, low cost MCU's with compact memory footprint
- FCC/IC/CE certified reference design with dipole or chip antenna
- Small form factor module
  - 16.3mm x 13.5mm x 2mm
- Temperature range –20C to +70C
- SmartConfig™ technology enables simple Wi-Fi® configuration using a smartphone, tablet or PC
- Proven Wi-Fi® interoperability based on TI's 7th generation Wi-Fi® solution
- Complete platform solution including user and posting guides, API guide, sample applications and support community

Development Tools and Software

- Evaluation Module (EM) to connect to a variarty of development boards including MSP430™, Tiva™ C Series, C2000™, and C55x
- Boosterpack for TI MCU LaunchPads available
- Integrated Development Kit: CC3000FRAMEMK-L and CC3000FRAMEMK-M available today with MSP-EXP430FR5739 included
- Stand-alone EM board available through distributors such as Arrow, Avnet, Digi-Key and Mouser
- Sample applications available: **www.ti.com/tool/cc3000-platform**

TI continues to advance Wi-Fi® technology solutions for the Internet of Things with the enhancement of the self-contained SimpleLink™ Wi-Fi® CC3000 module. CC3000 features enhanced software designed to dramatically simplify design and development while advancing the user experience. The new SimpleLink CC3000 is an ideal solution for developers of health and fitness, home automation, smart metering, security, and safety applications.

The CC3000 is provided as a certified module by TI to reduce development time, lower manufacturing costs, save board space and minimize RF expertise required. Additionally, it is provided as a complete platform solution including software drivers, sample applications, API guide, user documentation and a world-class support community.



CC3000 module diagram.

Wireless Connectivity Solutions

Bluetooth® Solutions

CC2560 (*Bluetooth*®) and CC2564 (*Bluetooth*® + *Bluetooth*® low energy or ANT™) Module

Get more information at: **www.ti.com/cc256xwiki**

Key Features

- Communicates with *Bluetooth* low energy or ANT single mode devices
- Best-in-class *Bluetooth*® RF performance (Tx Power, Rx sensitivity)
- Operating temperature range: –40°C to +85°C
- Supply voltage range: 0.5V to 4.8V
- Pre-integrated *Bluetooth*® stack for with TI's ultra-low-power MSP430 and Tiva™ C Series ARM® MCUs
- Supports extended range Tx power with 10dBm typical output
- Low power scan method and inquiry scans at 1/3rd normal power
- UART rates up to 4Mbps
- Receive sensitivity: –95dBm

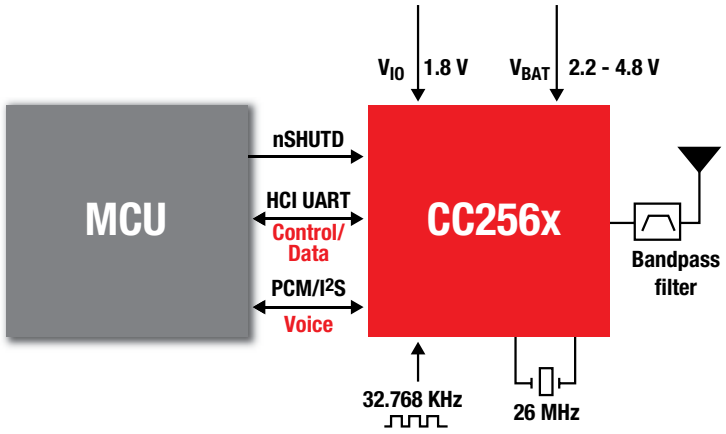
Benefits

- Best-in-class link budget extends application range
- Simplified hardware and software development
- Reduced development time and costs
- Enables simultaneous operations of *Bluetooth*® with *Bluetooth*® low energy or ANT
- 2x Range for *Bluetooth*® low energy applications

Development Tools

- CC256x *Bluetooth*® Development Platform with PAN1323EMK (works with MSP430 boards sold separately – MSP430F5438/5529)
- EZ430-RF256x *Bluetooth*® Evaluation Tool
- Tiva™ C Series + CC2560 *Bluetooth*® Development Platform- DK-EMZ-2560B
- ANT + *Bluetooth*® Health and Fitness Aggregator – CC2567PAN1327ANTBT

TI now provides *Bluetooth*® v4.0 technology through easy-to-integrate CC2560 (*Bluetooth*®) and CC2564 (*Bluetooth*® + *Bluetooth*® low energy or ANT™) devices in QFN packages through its distribution partners. With the QFN device, TI also provides and supports a reference design that can be copied and pasted into end applications. The same technology is also provided in pre-certified modules from partners such as Panasonic, LSR, Murata and Stonestreet One/BlueRadios, Inc. TI also provides a royalty-free *Bluetooth*® and *Bluetooth*® low energy stack and profiles for TI's MSP430™ and Tiva™ C Series ARM® microcontrollers. Customers have flexibility with partner, Stonestreet One, to customize the stack for different configurations and platforms.



TI's CC2560 (Bluetooth®) and Dual-Mode CC2564 (Bluetooth® + Bluetooth® low energy or ANT) system diagram.

Wireless Connectivity Solutions

Single-Mode Bluetooth® Low Energy System-on-Chip
CC2540

Get samples, evaluation modules and app reports at: **www.ti.com/sc/device/CC2540**

See also: **www.ti.com/product/tps62730**

Key Features

- True one-chip single mode *Bluetooth*® low energy solution
- Optimized RF performance including Tx/Rx power and selectivity
- Extensive peripheral set including USB, DMA, GPIO, USARTs, ADC, timers
- Flexible low power modes to maximize system lifetime when battery powered

Benefits

- Versatile feature-rich device allows lowest cost system when integrating application and stack on single chip
- RF performance maximizes communication range while simultaneously minimizing the effect of interference sources
- Supports range of applications and reduces BOM cost through all-in-one SoC solution
- Ultra low average-power consumption in low-duty cycle systems

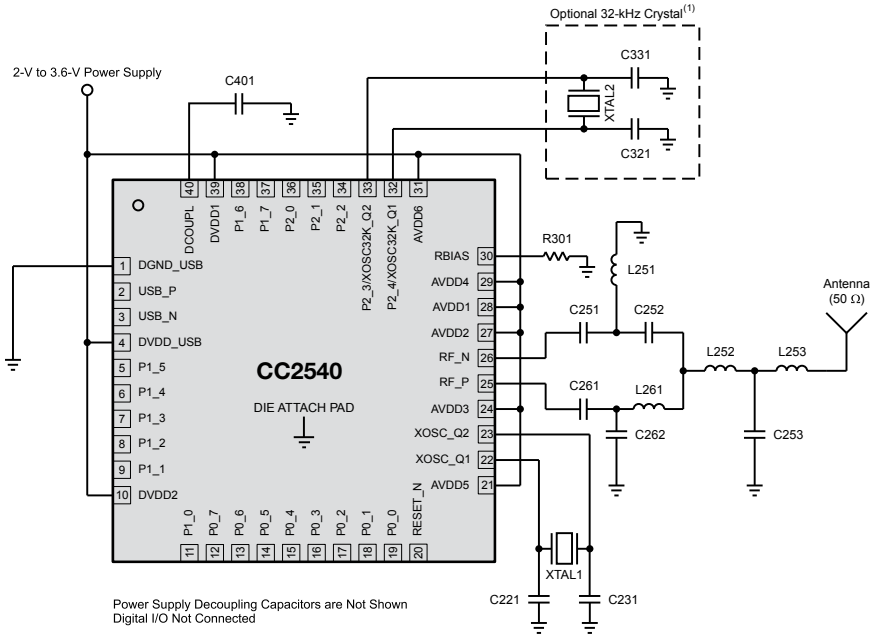
Applications

- Mobile/laptop accessories
- Sports and fitness
- Consumer health and medical
- Proximity

Development Tools and Software

- Single mode *Bluetooth*® low energy compliant software stack
- CC2540DK-MINI Development Kit for quick product development
- *Bluetooth*® low energy packet sniffer
- Application profiles, sample applications, documentation and more

The CC2540 is a cost-effective, low- power, true System-on-Chip (SoC) solution for single-mode *Bluetooth*® low energy applications, including mobile accessories, sports and fitness, consumer health, sensors and actuators, remote controls, HID, proximity, and more. The CC2540 combines a 1Mbps GFSK RF transceiver, offering superior range over the competition with a peripheral rich 8051 MCU core. This highly integrated and low cost SoC, coupled with TI's *Bluetooth*® low energy stack, offers a true one-chip integrated solution.



CC2540 application circuit.

General Characteristics

Parameter	Min	Typ	Max	Unit
Frequency range	2402		2480	MHz
Data rate	—	1000	—	kBaud
Operating voltage	2	—	3.6	V
Operating temperature	–40	—	85	°C
Output power	–20	—	4	dBm
RX mode				
Receiver sensitivity	—	–93	—	dBm
Adjacent channel rejection, +1MHz	—	5	—	dB
Adjacent channel rejection, –1MHz	—	5	—	dB
Alternate channel rejection, +2MHz	—	30	—	dB
Alternate channel rejection, –2MHz	—	30	—	dB
Current consumption				
Current consumption, RX	—	19.6	—	mA
Current consumption, TX, +4dBm	—	31.6	—	mA
Current consumption, TX, 0 dBm	—	27	—	mA
Current consumption, power down	—	0.4	—	µA

Wireless Connectivity Solutions

Single-Mode Bluetooth® Low Energy System-on-Chip
CC2541

Get samples, evaluation modules and app reports at: **www.ti.com/cc2541**

Key Features

- True one-chip single mode *Bluetooth*® low energy solution
- Optimized RF performance including Tx/Rx power and selectivity
- Extensive peripheral set including I²C, DMA, GPIO, USARTs, ADC, timers
- Flexible low power modes to maximize system lifetime when battery powered

Benefits

- Versatile feature-rich device allows lowest cost system when integrating application and stack on single chip
- RF performance maximizes communication range while simultaneously minimizing the effect of interference sources
- Supports range of applications and reduces BOM cost through all-in-one SoC solution
- Ultra low average-power consumption in low-duty cycle systems

Applications

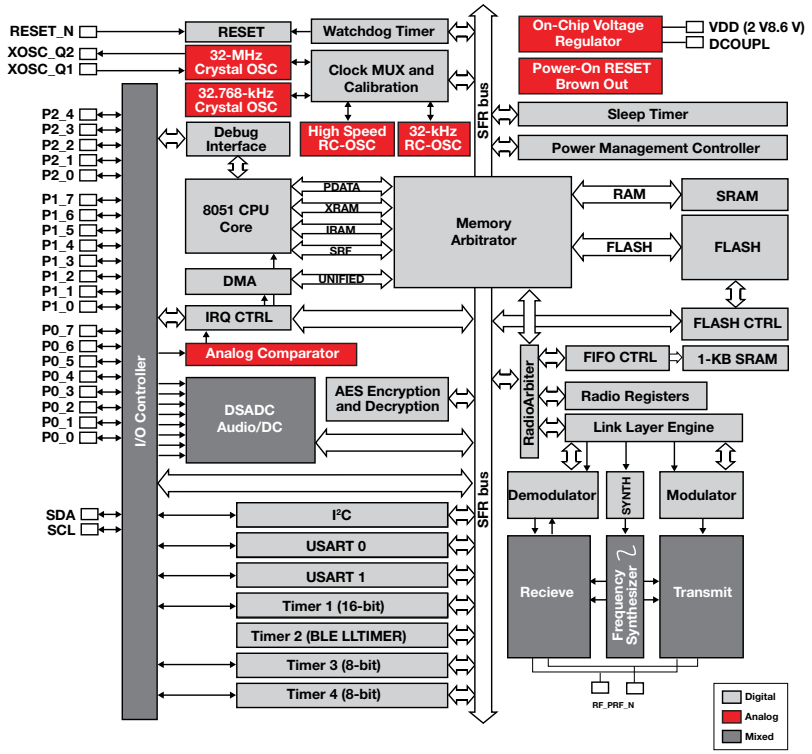
- Mobile/laptop accessories
- Sports and fitness
- Consumer health and medical
- Proximity

Development Tools and Software

- Single mode *Bluetooth*® low energy compliant software stack
- CC2541EMK Evaluation Module Kit for quick product development
- CC2541DK-MINI Development Kit for quick product development
- CC2540DK Development Kit for advance prototyping
- *Bluetooth*® low energy packet sniffer
- Application profiles, sample applications, documentation and more

The CC2541 is a power-optimized true system-on-chip (SoC) solution for both low energy and proprietary 2.4-GHz applications. It enables robust network nodes to be built with low total bill-of-material costs. The CC2541 combines the excellent performance of a leading RF transceiver with an industry-standard enhanced 8051 MCU, in-system programmable flash memory, 8-KB RAM, and many other powerful supporting features and peripherals. The CC2541 is highly suited for systems where ultralow power consumption is required. This is specified by various operating modes. Short transition times between operating modes further enable low power consumption.

The CC2541 is pin-compatible with the CC2540 in the 6-mm × 6-mm QFN40 package, if the USB is not used on the CC2540 and the I²C/extra I/O is not used on the CC2541.



General Characteristics

Parameter	Min	Typ	Max	Unit
Frequency range	2402		2480	MHz
Data rate	—	1000	—	kBaud
Operating voltage	2	—	3.6	V
Operating temperature	–40	—	85	°C
Output power	–20	—	0	dBm
RX mode				
Receiver sensitivity	—	–93	—	dBm
Current consumption				
Current consumption, RX	—	17.9	—	mA
Current consumption, TX, 0dBm	—	18.2	—	mA
Current consumption, power down	—	0.4	—	µA

Wireless Connectivity Solutions

Ultra-High Performance RF Narrowband Transceiver

CC1125

Get samples, datasheets, evaluation modules and application reports at: **www.ti.com/sc/device/cc1125**

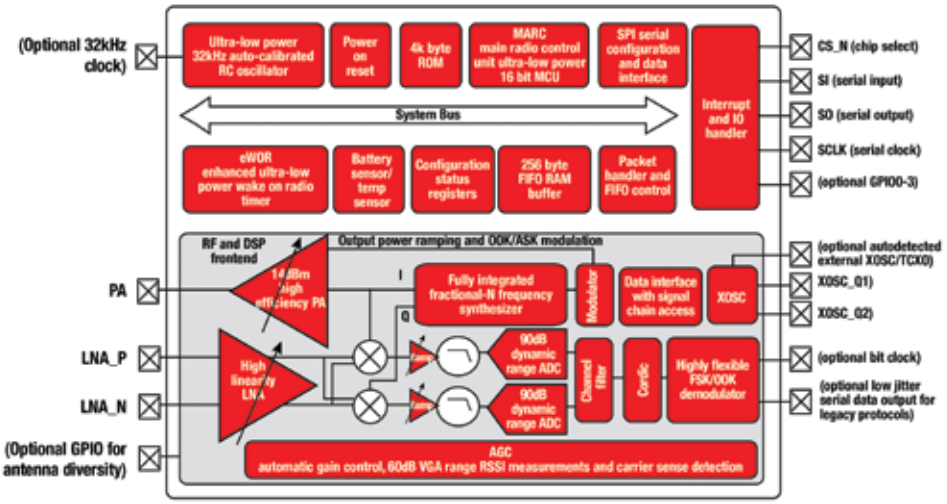
Key Features

- High performance single chip transceiver
- Suitable for systems targeting ETSI cat. 1 compliance
- High spectral efficiency (9.6kbps in 12.5kHz channel in compliance with FCC narrowbanding mandate)
- Wide supply voltage range and low current consumption
- Programmable output power up to +16dBm with 0.4dB step size
- Automatic output power ramping

Applications

- Wireless healthcare applications
- Social alarms
- Wireless alarm and security systems
- Industrial monitoring and control
- Wireless sensor networks and active RFID

The CC1125 sub-1 GHz RF transceiver is the industry's first single-chip solution suitable for wireless social alarms and ultra narrowband applications, targeting ETSI EN 300 220 category 1 (ETSI Cat.1) compliance for the European 869MHz band. To guarantee a highly reliable wireless connection, the ETSI Cat.1 requires conformity to one of Europe's strictest radio frequency regulations. Up till now this performance has only been available through the use of costly and space demanding discrete designs. The high RF performance and narrow channel spacing also benefit applications that require exceptional RF range and robustness.



CC1125 functional block diagram.

RFID and Tag-it™

Radio Frequency Identification (RFID)

TI's high-frequency RFID product family consists of 13.56MHz high-frequency (HF) transponders and low-power RFID readers that are compliant with ISO/IEC 15693 and ISO/IEC 18000-3 global open standards. Typical RFID implementations include asset tracking, access control, blood bag tracking, medical supply tracking, patient/staff authentication, pharmaceutical authentication, medical imaging, product authentication, remote digital healthcare management applications and many non-medical related applications.

Tag-it HF-I Transponder Inlays

TI's Tag-it HF-I family of transponder inlays consists of 13.56MHz HF transponders that are compliant with ISO/IEC 15693 and ISO/IEC 18000-3 global open standards. These products are available in six different antenna shapes with frequency offset for integration into paper, PVC or other substrates manufactured with TI's patented laser-tuning process to provide consistent read performance. Prior to delivery, the transponders undergo complete functional and parametric testing to provide the high quality customers have come to expect.

Tag-it HF-I Family

Product Specifications

- Supported standards: ISO/IEC 15693-2, -3; ISO/IEC 18000-3
- Recommended operating frequency: 13.56MHz
- Factory programmed read-only numbers: 64-bit
- Typical programming cycles (at +25°C): 100,000
- Data retention time (at +55°C): >10 years

Key Features

- User and factory lock per block
- Application Family Identifier (AFI)

Standard

- 256-bit user memory, 8 x 32-bit
- FastSID

Pro

- 256-bit user memory, 8 x 32-bit
- Password-protected write command
- Command to disable IC functionality
- FastSID

Plus

- 2Kbit user memory, 64 x 32 6-bit
- Data Storage Format Identifier (DSFID)
- Combined inventory read block

Tag-it™ HF-I Plus Inlay Shapes

Part Number	RI-I11-112A-03	RI-I11-112B-03	RI-I02-112A-03	RI-I02-112B-03	RI-I03-112A-03	RI-I15-112B-03	RI-I16-112A-03	RI-I17-112A-03
Available Memory	2K bits organized in 64 x 32-bit blocks							
Antenna Size (mm)	45 x 45	45 x 45	45 x 76	45 x 76	22.5 x 38	34 x 65	θ 24.2	θ 32.5
Foil Pitch (mm)	50.8 + 0.1/ –0.4 (2 in)	50.8 + 0.1/ –0.4 (2 in)	96 + 0.1/ –0.4 (~3.78 in)	96 + 0.1/ –0.4 (~3.78 in)	58 +0.1/ –0.4 (~1.89 in)	101.6 +0.1/ –0.4 (4 in)	50.8 +0.1/ –0.4 (2 in)	50.8 +0.1/ –0.4 (2 in)
Frequency Offset for Lamination Material	Paper	PVC	Paper	PVC	Paper/PVC	PVC	Paper/PVC	Paper/PVC
Delivery	Single tape row with 48mm foil width wound on cardboard reel							

Tag-it™ HF-I Pro Transponder Inlays

Part Number	RI-I11-114A-S1	RI-I11-114B-S1	RI-I02-114A-S1	RI-I02-114B-S1	RI-I03-114-S1	RI-I16-114-S1	RI-I17-114-S1
Available Memory	256 bits organized in 8 x 32-bit blocks						
Foil Width (mm)	48mm ±0.5mm						
Antenna Size (mm)	45 x 45	45 x 45	45 x 76	45 x 76	22.5 x 38	θ 24.2	θ 32.5
Foil Pitch (mm)	50.8 +0.1/ –0.4 (2 in)	50.8 +0.1/ –0.4 (2 in)	96 +0.1/ –0.4 (~3.78 in)	96 +0.1/ –0.4 (~3.78 in)	48 +0.1/ –0.4 (~1.89 in)	50.8 +0.1/ –0.4 (2 in)	50.8 +0.1/ –0.4 (2 in)
Frequency Offset for Lamination Material	Paper	PVC	Paper	PVC	Paper/PVC	Paper/PVC	Paper/PVC
Delivery	Single row tape wound on cardboard reel						

Tag-it™ HF-I Standard Transponder Inlays

Part Number	RI-I11-114A-01	RI-I11-114B-01	RI-I02-114A-01	RI-I02-114B-01	RI-I03-114-01	RI-I16-114-01	RI-I17-114-01
Available Memory	256 bits organized in 8 x 32-bit blocks						
Foil Width (mm)	48mm ±0.5mm						
Antenna Size (mm)	45 x 45	45 x 45	45 x 76	45 x 76	22.5 x 38	θ 24.2	θ 32.5
Foil Pitch (mm)	50.8 +0.1/ –0.4 (2 in)	50.8 +0.1/ –0.4 (2 in)	96 +0.1/ –0.4 (~3.78 in)	96 +0.1/ –0.4 (~3.78 in)	48 +0.1/ –0.4 (~1.89 in)	50.8 +0.1/ –0.4 (2 in)	50.8 +0.1/ –0.4 (2 in)
Frequency Offset for Lamination Material	Paper	PVC	Paper	PVC	Paper/PVC	Paper/PVC	Paper/PVC
Delivery	Single row tape wound on cardboard reel						

RFID and Tag-it™

Multi-Protocol Fully Integrated 13.56MHz RFID/NFC Transceiver IC

TRF7970A

Get samples and datasheets at: **www.ti.com/sc/device/trf7970A**

Key Features

- NFCIP-1, NFCIP-2
- Peer-to-peer, card emulation, Reader/writer functionality
- ISO14443A, ISO14443B, FeliCa, ISO15693
- Supply voltage range: 2.7V to 5.5V
- Parallel or SPI interface
- Integrated data framing, CRC and/or parity checking
- Integrated voltage regulators for MCU supply (20mA)
- Clock output for MCU
- Selectable receive gain with AGC
- Antenna driver using OOK or ASK modulation
- Programmable output power, 100mW and 200mW
- RF field detector with programmable wake-up levels
- Eight user selectable power modes
- Power down 1µA
- NFC software library available

The TRF7970A is an integrated analog front end and data-framing device for a 13.56-MHz RFID/near field communication system. Built-in programming options make it suitable for a wide range of applications for proximity and vicinity identification systems.

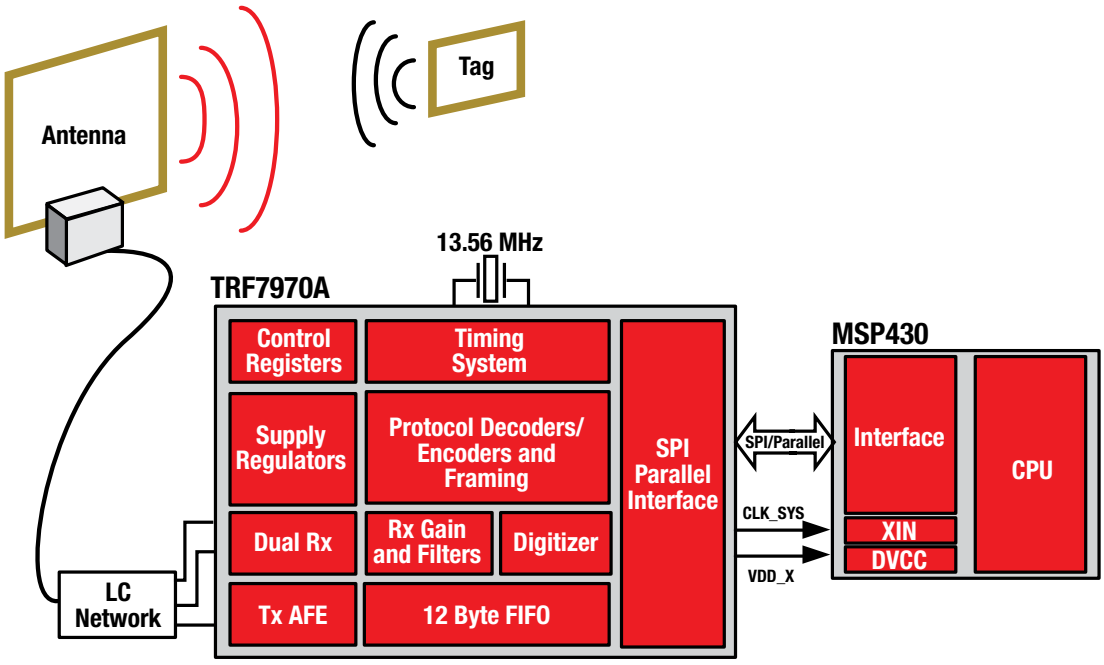
It can perform in one of three modes: RFID/NFC reader, NFC peer, or in card emulation mode. Built-in user-configurable programming options make it suitable for a wide range of applications.

Benefits

- High level of integration enables reduction in system size and cost
- Ultra-low-power capability extends battery life
- High level of flexibility and configurability
- TRF7970A supports NFC tag type 1, 2, 3, and 4 operations, so this architecture enables the customer to build a complete cost-effective yet high-performance multi-protocol 13.56-MHz RFID/NFC system together with a low-cost microcontroller, MSP430™

Applications

- Medical
- Patient and staff authentication
- Pharmaceutical authentication
- Product authentication and calibration
- Remote digital healthcare management
- RFID reader/tag
- Access control/digital door-lock
- POS contactless payment
- Secure pairing of *Bluetooth*®/WiFi



Functional block diagram.

Wired Solutions

USB-to-Serial Bridge

TUSB3410

Get samples, datasheets, application reports and evaluation modules at: **www.ti.com/sc/device/tusb3410**

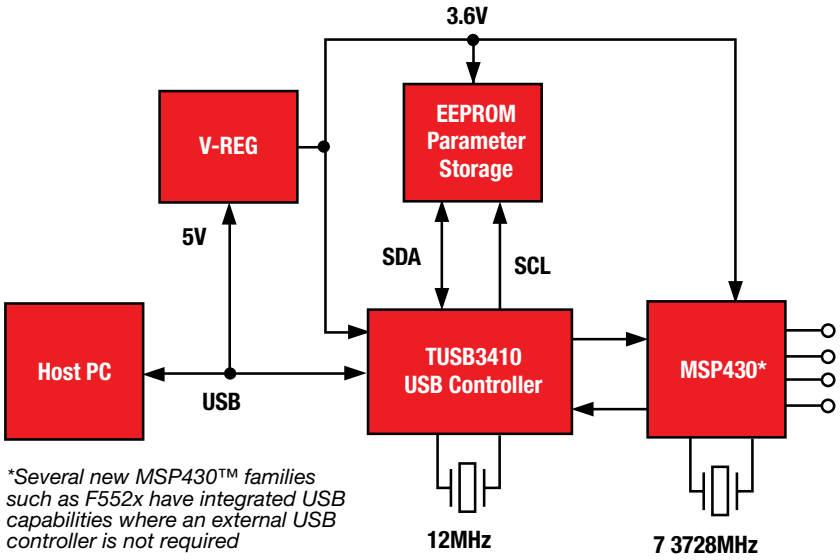
Key Features

- USB full-speed (12Mbps) compliant
- Integrated 8052 microcontroller with 16K bytes of RAM that can be loaded from the host or external memory via an I²C bus
- Integrated, enhanced UART features include:
  - Programmable software/hardware flow control
  - Automatic RS-485 bus transceiver control, with and without echo
  - Software-selectable baud rate from 50 to 921.6K baud
  - Built-in, 2-channel DMA controller for USB/UART bulk I/O
- TUSB3410UARTPDK product development kit can jump-start USB-to-serial development

Applications

- Handheld meters
- Health metrics/monitors
- Legacy-free PC COM port replacement

TUSB3410 and TUSBWINVCP software provides an easy way to move serial-based legacy devices to a fast, flexible USB interface by bridging a USB port and an enhanced UART serial port. The TUSB3410 contains all of the logic needed to communicate with the host computer using the USB bus. The TUSBWINVCP software package enables the TUSB3410 to act as a virtual COM port and appear as legacy COM ports on the back of older model computers. This enables the use of existing devices and application software without making any changes.



TUSB3410/MSP430™ implementation block diagram.

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
RF Transceivers				
CC1120	Sub-1GHz RF Transceiver	Industry leading RF blocking and selectivity: 65dB adjacent channel rejection at 12.5kHz offset 90dB blocking. High output power (up to +16dBm) and excellent sensitivity (–123dBm @1.2kbps). WaveMatch; Advanced DSP sync detector with high sensitivity and strong noise immunity.	The most robust RF transceiver on the market. Reliable communication in presence of RF interference. Up to 139dB RF link budget. More reliable links, no false sync detects in noise. Enables RF sniff mode with <3mA current consumption.	
CC2520	2.4GHz ZigBee®/ IEEE 802.15.4 RF Transceiver	Best-in-class coexistence and selectivity properties; excellent link budget (103dBm); extended temperature range; AES-128 security module	Reliable RF link with interference present; 400m line-of-sight range with the development kit; ideal for industrial applications; no external processor needed for secure communication	CC2530
CC2560	*Bluetooth*® v2.1 + EDR (Enhanced Data Rate)	Fully qualified *Bluetooth*® v2.1 + EDR, +10dBm Tx power with transmit power control, –93dBm received sensitivity, support for *Bluetooth*® power saving modes (sniff, hold), hardware and software pre-integration with TI's MSP430 and Tiva™ C Series ARM® MCU platforms, FCC, CE and IC certified module options, broad market offering with extensive documentation, sample software, and support forums	Supports replacement of serial cables for personal area networks, high throughput, robust connection with extended range, extended battery life and power efficiency reduced development time and costs, flexibility to use various MCUs	
CC2564	*Bluetooth*® v4.0	Fully qualified *Bluetooth*® v4.0 with dual mode capability, +10dBm Tx power with transmit power control, –93dBm received sensitivity, support for *Bluetooth*® power saving modes (sniff, hold), hardware and software pre-integration with TI's MSP430 and Tiva™ C Series ARM® platforms, FCC, CE and IC certified module options, broad market offering with extensive documentation, sample software, and support forums, ability to connect to existing mobile devices without BLE and some newer devices with BLE	Supports replacement of serial cables for personal area networks, high throughput, robust connection with extended range, extended battery life and power efficiency reduced development time and costs, flexibility to use various MCUs and connect to any type of existing device	CC2530
RF Systems-on-Chip				
CC2530/31	Second Gen. System-on-Chip Solution for 2.4GHz IEEE 802.15.4/RF4CE/ ZigBee®	Excellent RX sensitivity, low power, easy to use development tools	RF design system-on-chip for quick time to market. Provides a robust and complete ZigBee® USB dongle or firmware-upgradable network node.	CC2590/91
CC254x	2.4 GHz *Bluetooth*® low energy compliant RF System-on-Chip	Best-in-class System-on-chip *Bluetooth*® low energy solution enabling devices to connect to smartphone/ tablets with extremely low power. Able to run on coin cell battery	System-on-chip for quick time to market. Provides a robust and complete *Bluetooth*® low energy stack enabling extremely long battery life and ability to run on a single coin-cell	CC2590/91
RF Network Processor				
CC3000	SimpleLink™ Wi-Fi® CC3000 Module	One step configuration with SmartConfig Technology, easy to use Wi-Fi® solution with compact code size to be used with microcontrollers, best-in-class link budget, precertified FCC/IC/CE module, small form factor module and $9.99 price point for 1k units, proven Wi-Fi® interoperability, broad market offering with extensive documentation, sample software, and support forums	Universal IP connectivity can be enabled on low memory, low-cost, low-power microcontroller systems, has low certification cost and is easy to use for development	
RF NFCs				
TRF7970A	Multi-Protocol Fully Integrated 13.56MHz RFID/NFC Transceiver IC	NFCIP-1, NFCIP-2. Peer-to-peer, card emulation, reader/writer functionality ISO14443A, ISO14443B, FeliCa, ISO15693 NFC software library available.	High level of integration enables reduction in system size and cost ultra low power capability extends battery life high level of flexibility and configurability	TRF7960

To view more system block diagram compatible products, visit ***www.ti.com/healthtech***

Enhanced Products/Die and Wafer Sales Solutions

Enhanced Products

TI's Enhanced Product (EP) line offers design flexibility while still meeting HiRel and Medical standards for operating environments where high reliability and long service life are a requirement. The EP line offering can benefit avionic, defense, aerospace, medical, and industrial designers as well as designers in other rugged operating environments and long service life application fields. TI's Enhanced Product line is a commercial of-the-shelf (COTS) solution with the following key benefits:

- Fabrication/assembly controlled baseline
- Extended product change notification (PCN)
- Extended temperature performance (typically -55°C to +125°C)
- Standalone data sheet
- Qualification pedigree
- Product traceability
- Long life cycles

TI's EP products are guaranteed to perform to data sheet specifications in environments that require extended temperatures (typically -55°C to +125°C). To ensure that a device exhibits the highest quality and reliability possible for targeted applications, TI performs the following qualification procedures before the device is released:

- All EP devices undergo extensive requalification
- Qualification data is reviewed and audited for accuracy and compliance
- Reliability and electromigration monitoring is performed at maximum recommended operating conditions in the targeted package.
- Certified test programs & test hardware
- Electrical characterization is performed across specified temperature range
- Package performance is confirmed over extended temperatures (some mold compounds are not suitable for extended temperatures).
- Nickel/palladium/gold/lead finish eliminates "tin whisker" reliability issues
- Knowledgeable expertise in medical related ISO requirements (ISO13485 and ISO14971)
- Certificate of compliance to datasheet electrical specifications
- Available in military (–55°C/125°C), industrial (–40°C/85°C), commercial (0°C/70°C) and custom temperature ranges

Expected from TI's EP line:

- Qualification summary report
- Access to leading-edge commercial technology
- Commitment to the Industrial, Medical, Avionic and Defense markets
- Customer-driven portfolio
- Enhanced obsolescence management

In addition TI will evaluate the release of other TI's catalog devices in an EP versions based on customer requirements.

Get more information about TI's enhanced products at: **www.ti.com/ep**

TI Die/Wafer Solutions

Texas Instruments offers bare die/wafer solutions for applications that require higher levels of integration to reduce board space. TI provides a wide range of products in bare die and wafer form. A variety of testing and qualification options are available based on product maturity and complexity, as well as customer requirements. Typical screening options include DC probe or AC/DC probe at temperature.

TI offers three categories of die screening:

- Commercial wafers and die
  - Standard TI wafer fabrication
- Known Good Die (KGD)
  - Stand alone datasheet and warranted over temperature
- Customer defined qualification
  - QML Class Q (MIL-STD)
  - QML Class V (Space)
  - Additional options available

Typical processing and capabilities include:

- Mount and bond diagrams
- Probed die – 55°C to +210C° or special temp
- Shipping: Tape and reel, waffle packs, custom trays, Gel-Pak®
- Sidewall and visual inspections

For more information regarding TI's Die and Wafer offerings, visit **www.ti.com/hirel** or email: **diesales@list.ti.com**

TI Worldwide Technical Support

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

TI E2E™ Community Home Page
e2e.ti.com

Product Information Centers

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Internet/Email	International	support.ti.com/sc/pic/japan.htm
	Domestic	www.tij.co.jp/pic

Asia

Phone

International	+91-80-41381665
Domestic	Toll-Free Number

Note: Toll-free numbers do not support mobile and IP phones.

Australia	1-800-999-084
China	800-820-8682
Hong Kong	800-96-5941
India	1-800-425-7888
Indonesia	001-803-8861-1006
Korea	080-551-2804
Malaysia	1-800-80-3973
New Zealand	0800-446-934
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B011012

Printed in U.S.A. by (Printer, City, State)

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