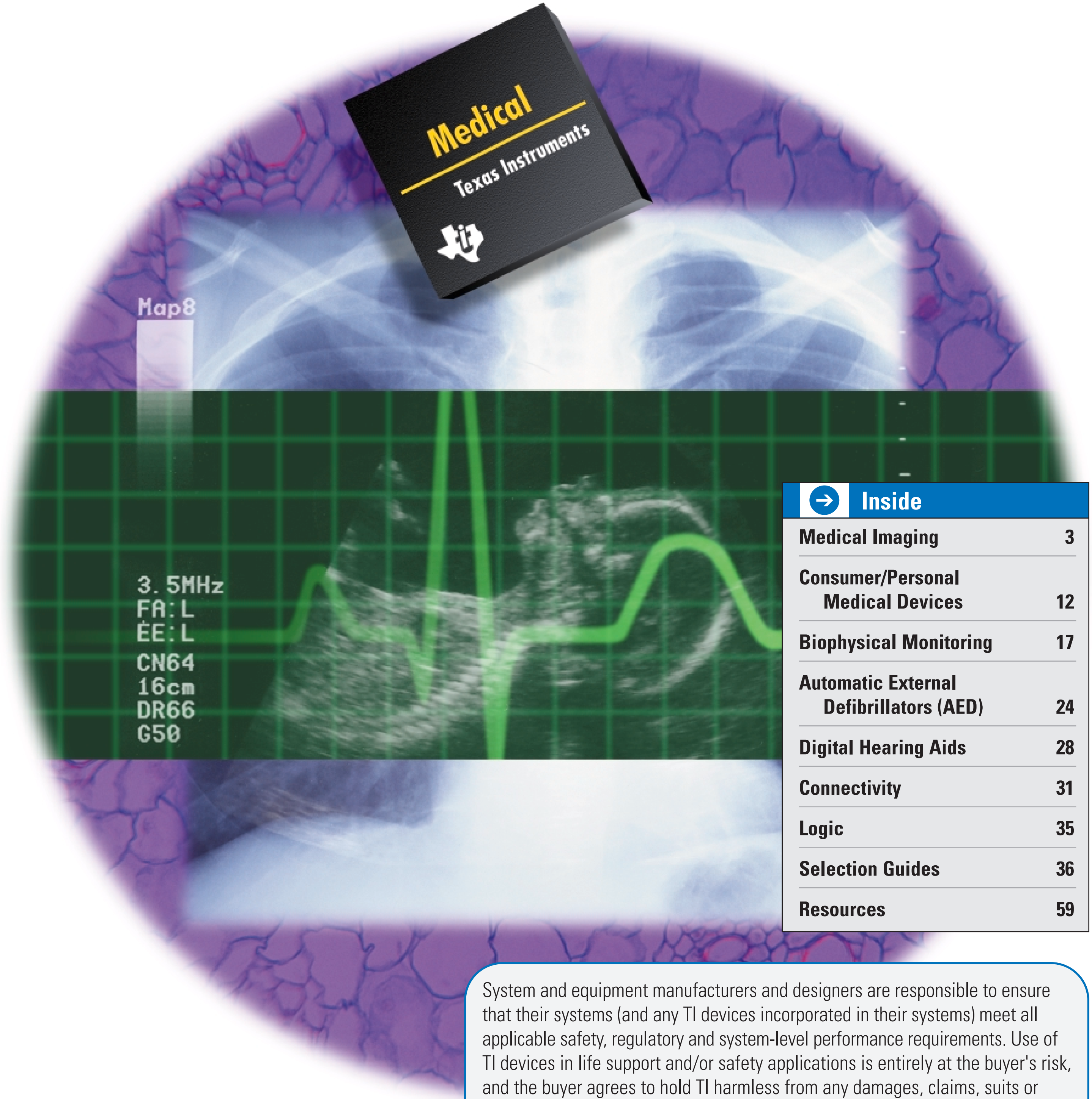
Information for Medical Applications

Amplifiers, Connectivity, Clocks, Data Converters, Digital Signal Processors,
Digital Temperature Sensors, Interface, Logic, Microcontrollers, Power Management

2Q 2004



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Important Notice

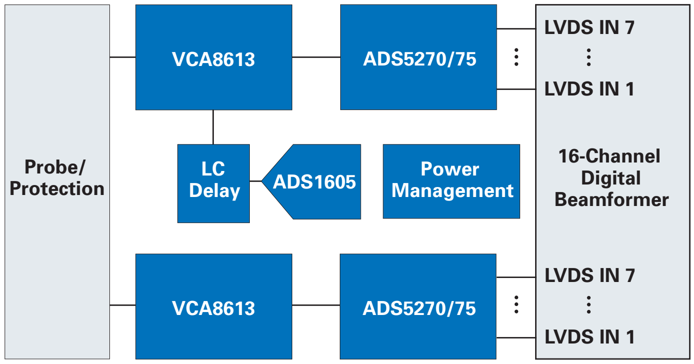
Ultrasound Applications

To Know More

For detailed information about TI products:

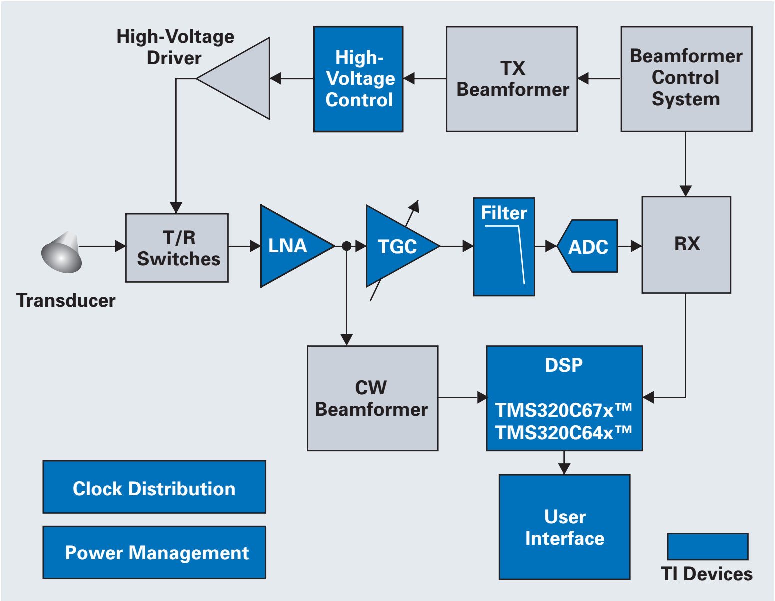
Ultrasound systems, both medical and industrial, use focal imaging techniques to achieve imaging performance far beyond what can be achieved through a single-channel approach. Using an array of receivers, a high-definition image can be built by time shifting, scaling and intelligently summing echo energy. The concept of time shifting and scaling receive signals from a transducer array provides the ability to “focus” on a single point in the scan region. By subsequently focusing at different points, an image is assembled.

When initiating a scan, a pulse is generated and transmitted from each of the eight to 512 transducer elements. These pulses are timed and scaled to “illuminate” a specific region of the body. After transmitting, the transducer element immediately switches into receive mode. The pulse, now in the form of mechanical energy, propagates through the body as high-frequency sound waves, typically in the range of 1 to 15 MHz. As it does, the signal weakens rapidly, falling off as the square of the distance traveled. As the signal travels, portions of the wave front energy are reflected. These reflections are the echoes that the receive electronics must detect. Signals reflected immediately will be very strong, as they are from reflections close to the surface, while reflections that occur long after the transmit pulse will be very weak, reflecting from deep in the body.



16-channel portable solution with Continuous Wave.

Because of limits on the amount of energy that can be put into the body, the industry must develop extremely sensitive receive electronics. At focal points close to the surface, the receive echoes are strong, requiring little if any amplification. This region is referred to as the near field. But at focal points deep in the body, the receive echoes will be extremely weak and must be amplified by a factor of 1000 or more. This region is referred to as the far field. These regions represent the two extremes in which the receive electronics must operate.



Ultrasound system block diagram.

Ultrasound Applications and Featured Products

In the high-gain (far field) mode, the limit of performance is the sum of all noise sources in the receive chain. The two largest contributors of receive noise are the transducer/cable assembly and the receive low noise amplifier (LNA). In low gain (near field), the limit of performance is defined by the magnitude of the input signal. The ratio between these two signals defines the dynamic range of the system. Many receive chains integrate the LNA with a variable gain amplifier.

Some sort of low-pass filtering always follows the LNA+VCA combination. High-end systems implement filters with more than five poles while low-end systems require only two poles. Many mid-range and high-end systems will rebuffer after filtering. In selecting an op amp, the primary considerations include signal swing, minimum and maximum input frequencies, harmonic distortion and gain requirements. Analog-to-digital converters (ADCs) are typically 10- and 12-bit. SNR and power consumption are the most important issues, followed by channel integration.

Another trend in ADCs is the implementation of an LVDS interface between the ADC and the beamformer. By serializing the data coming out of the ADC, the number of interface lines can be reduced from 6044 to 1024 for a 512-channel system. This reduction translates to smaller and lower-cost PC boards, an essential part of portable imaging systems.

The signal assembly is accomplished with a digital beamformer. This is typically a custom-designed ASIC, but this function has been implemented in different forms of programmable logic. Within the beamformer the digitized signal is scaled and time delayed to create the focusing effect in the receive chain. The properly adjusted signals are then summed together across all receive channels and passed to the imaging system. The imaging system can be developed as a separate ASIC, can be a programmable processor such as a DSP, or might be a full desktop computer.

Transmit elements require the control of 100 V to 200 V of signal swing. This is almost always accomplished with the use of high-voltage FETs. Control of the FETs can take one of two forms: on-off (push-pull) or class-AB linear control. The most popular is the push-pull approach, as it requires a much simpler and lower-cost interface to the FETs. The class-AB approach dramatically improves harmonic distortion but requires more complex drivers and consumes more power.

A wide variety of TI products have been chosen by system and equipment manufacturers for their ultrasound imaging applications, including op amps; single, dual and octal ADCs (all with fast-input overload recovery and excellent dynamic performance); and the VCA8613, which integrates a two-pole, low-pass filter. TI is also offering the ADS5270, an advanced 8-channel, 12-bit data converter with serialized LVDS interface, specifically for the ultrasound market.

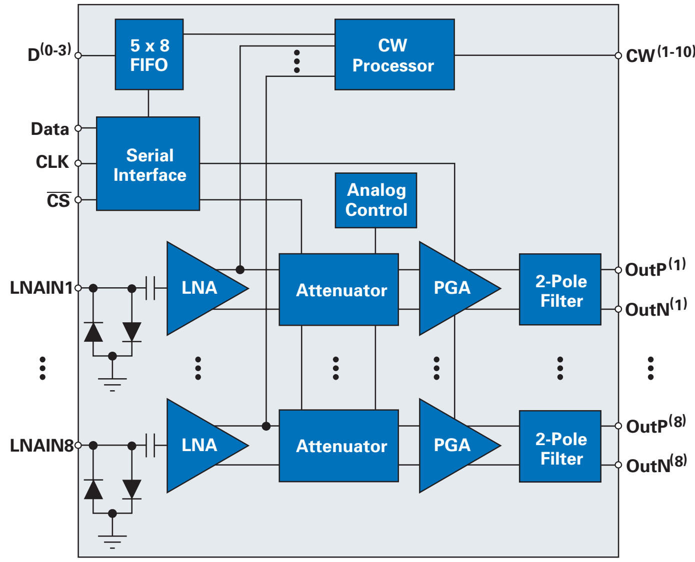
8-Channel Variable-Gain Amplifier
VCA8613

Get samples, datasheets and app reports at:
www.ti.com/sc/device/VCA8613

The VCA8613 is an 8-channel variable-gain amplifier that can meet the needs of system designers in many of their ultrasound applications. Each channel consists of a low-noise pre-amplifier (LNA) and a variable-gain amplifier (VGA). The differential outputs of the LNA can be switched through the 8 x 10 cross-point switch, which is programmable through the serial interface input port.

Key Features
- 3-V operation
- Low input noise: 1.5 nV/$\sqrt{Hz}$ at f_{IN} = 5 MHz
- Extremely low-power operation of 75 mW/channel
- Integrated low-pass, two-pole filter, 15-MHz bandwidth
- Integrated input clamp diodes
- Differential output
- Integrated input LNA
- Readable control registers
- Integrated continuous wave (CW) processor

Applications
- Portable ultrasound
- Portable dedicated scanners
- Industrial scanners
- Portable test equipment



VCA8613 8-channel variable-gain amplifier functional diagram.

Ultrasound Featured Products

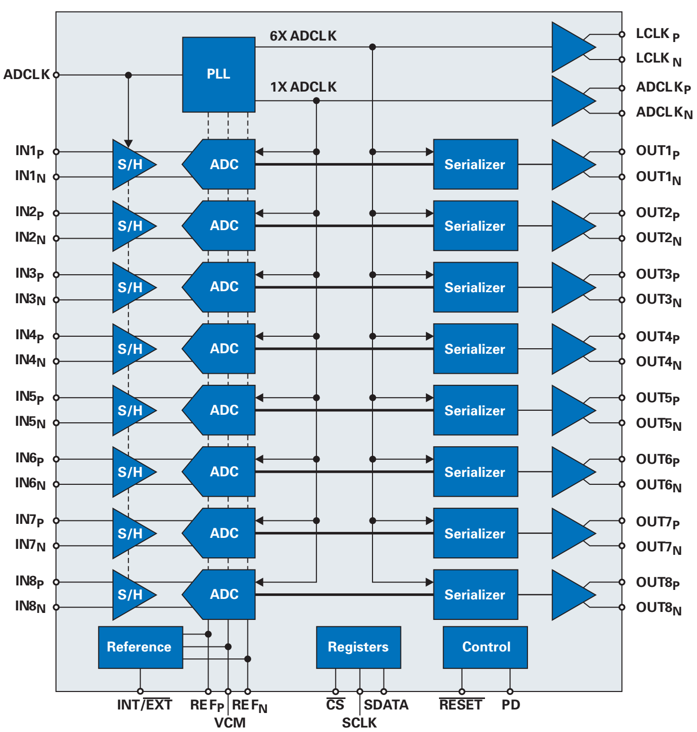
8-Channel, 10- and 12-Bit, 40- to 70-MSPS ADCs With Serialized LVDS Interface
ADS5270, ADS5271, ADS5272, ADS5273, ADS5275, ADS5276, ADS5277

Get samples and app reports at: **www.ti.com/ads527x**

The ADS527x operates from a single +3.3-V analog supply and features internal references to simplify system design, or an external reference can be used. The very low power consumption allows for the highest level of system integration densities. Serialized LVDS outputs reduce the number of interface lines and package size.

Key Features
- 10- and 12-bit resolution
- 40- to 70-MSPS sample rates
- 720-mW to 1-W total power dissipation
- 60-dB SNR (10-bit) and 70-dB SNR (12-bit) with f_{IN} = 10 MHz
- Serialized LVDS outputs meet or exceed requirements of ANSI TIA/EIA-644-A standard
- Internal and external references
- 3.3-V analog/digital supply
- Pin and format compatibility among family
- Packaging: 80-pin TQFP

Applications
- Portable ultrasound
- Portable test equipment



ADS527x functional block diagram.

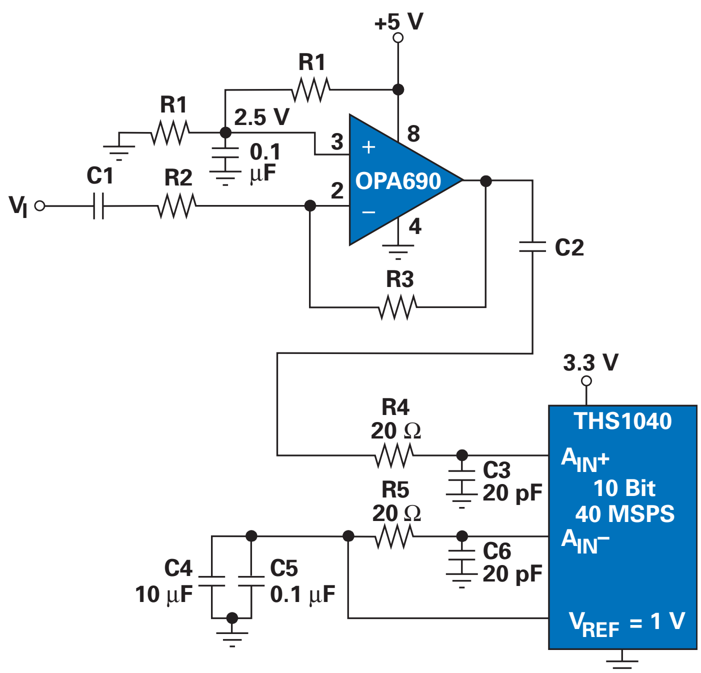
Wideband, Voltage-Feedback Operational Amplifier With Disable
OPA690

Get samples, datasheets, app reports and EVMs at:
www.ti.com/sc/device/OPA690

The new internal architecture of the OPA690 provides slew rate and full-power bandwidth previously found only in wideband current-feedback op amps. Using a single supply, the OPA690 delivers high output currents up to 150 mA with a 150-MHz bandwidth.

Key Features
- Flexible supply range:
  - +5-V to +12-V single supply
  - ±2.5-V to ±5-V dual supply
- Unity-gain stable: 500 MHz (G = 1)
- High output current: 190 mA
- Output voltage swing: ±4.0 V
- High slew rate: 1800 V/µs
- Low supply current: 5.5 mA
- Low disabled current: 100 µA
- Wideband +5-V operation: 220 MHz (G = 2)

Applications
- Video line driver
- High-speed imaging channels
- ADC buffers
- Portable instruments
- Active filters



OPA690 in a single-supply ADC driver application.

Ultrasound Featured Products

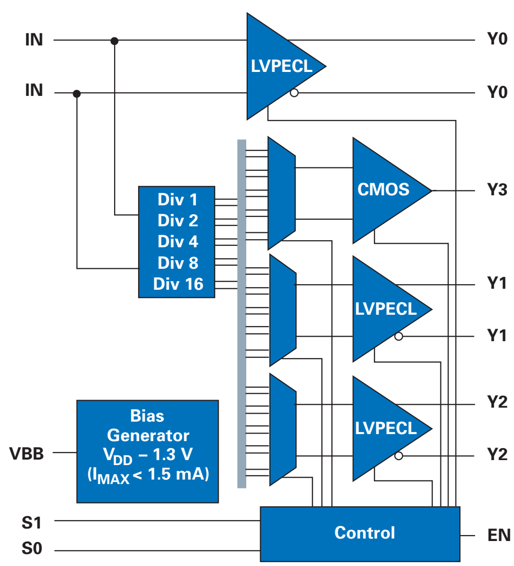
Differential and Single-Ended Output in One Buffer
CDCM1804

Get samples, datasheets and app reports at: **www.ti.com/sc/device/CDCM1804**

The CDCM1804 clock driver distributes one pair of differential clock inputs to three pairs of LVPECL differential clock outputs Y[2:0] and /Y[2:0] with minimum skew for clock distribution. It is specifically designed for driving 50-Ω transmission lines. Additionally, the CDCM1804 offers a single-ended LVCMOS output Y3. This output is delayed by 1 ns over the three PECL output stages to minimize noise impact during signal transitions.

Key Features
- Distributes one differential clock input to three LVPECL differential clock outputs and one LVCMOS single-ended output
- Programmable output divider for two LVPECL outputs and one LVCMOS output
- Low-output 20-ps (typical) skew for clock distribution applications for LVPECL outputs; 1-ns output skew between LVCMOS and LVPECL transitions, minimizing noise
- V_{CC} range 3.0 to 3.6 V
- Signaling rate up to 800 MHz for LVPECL and 200 MHz for LVCMOS
- Differential input stage for very wide common-mode range also provides VBB bias-voltage output for single-ended input signals
- Receiver input threshold ±75 mV
- 24-pin MLF package (4 mm x 4 mm)

Applications
- Medical imaging
- Telecommunications
- Data communications
- Test equipment



CDCM1804 functional diagram.

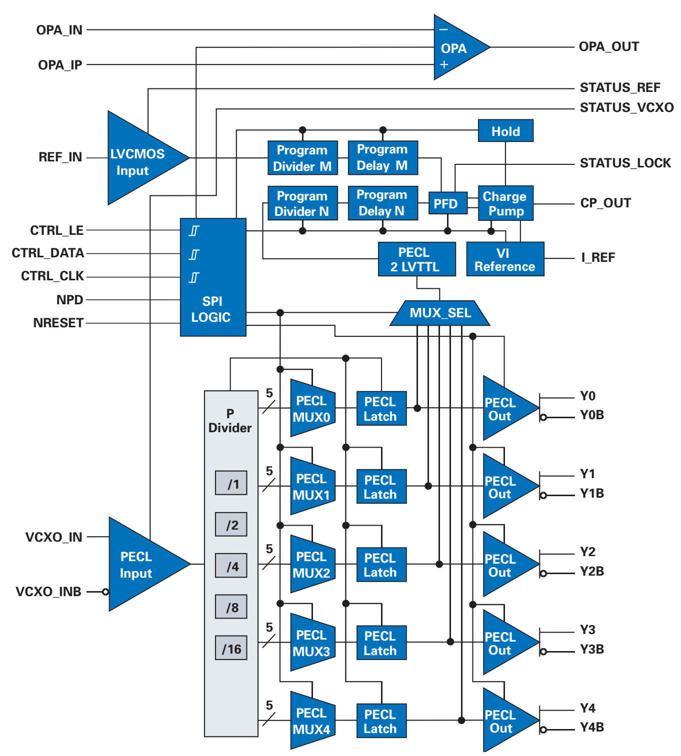
Low-Phase-Noise Clock Synthesizer With Multiplying, Dividing and Jitter Cleaning
CDC7005

Get samples, datasheets and app reports at: **www.ti.com/sc/device/CDC7005**

A synchronizing clock can be used to take a system clock signal (from a backplane, for example) and provide outputs to a subsystem at the same frequency or an even multiple/divisor of that frequency. In addition to synchronizing the system clock, synchronizers can also remove jitter from the clock source.

Key Features
- High-performance 1:5 PLL clock synchronizer and jitter cleaner
- Programmable multiplier and divider
- Two clock inputs: VCXO_IN clock is synchronized to REF_IN clock
- VCXO is external to allow for flexible application frequencies
- Supports five differential LVPECL outputs
- Efficient jitter cleaning from low PLL loop bandwidth
- Low-phase noise characteristic
- Programmable delay for phase adjustments
- Packaged in a 64-pin BGA (0.8-mm pitch - ZVA)
- Industrial temperature range –40°C to 85°C

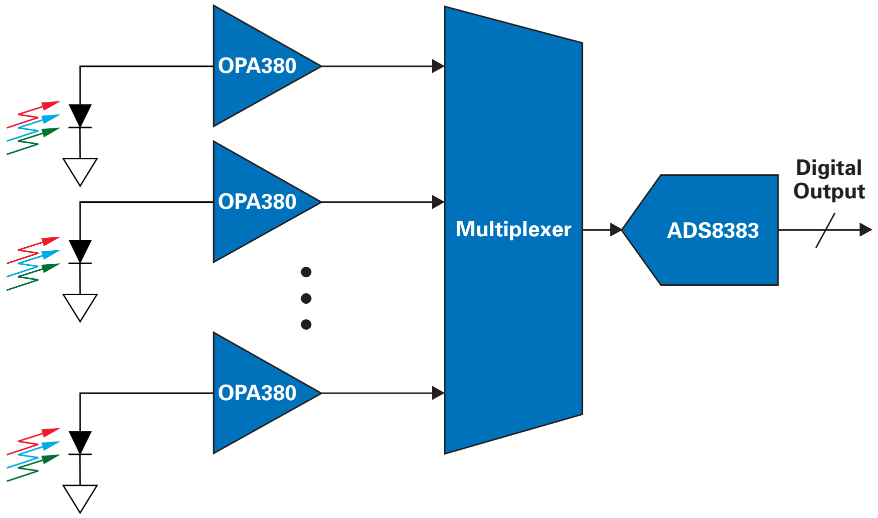
Applications
- Medical imaging
- Telecommunications
- Wireless infrastructure
- Data communications
- Test equipment



CDC7005 functional diagram.

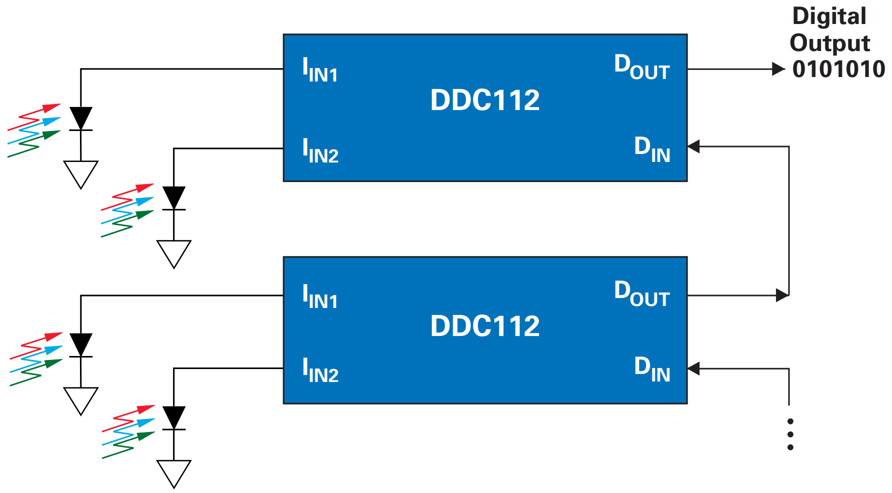
CT Scanner Applications

Texas Instruments offers several products that can meet the needs of designers of medical imaging systems by enabling the measurement of low-level currents produced by the photodiode arrays within a computed tomography (CT) scanner. The OPA380 family of transimpedance amplifiers provides high-speed (90-MHz gain bandwidth [GBW]) operation, with extremely high precision, excellent long-term stability, and very low 1/f noise. It is ideally suited for high-speed CT scanner photodiode applications. The ADS8383 is an 18-bit 500-kSPS ADC. The high-speed operation of the ADS8383 makes it well-suited for use with a multiplexer to measure multiple OPA380 channels.



CT scanner application using the OPA380 and the ADS8383.

The DDC112 is a complete two-channel solution for measuring photodiodes. Its patented topology includes both the switched integrator front end and a high speed 20-bit ADC. Two photodiodes directly connect to each device. A selection of internal integration capacitors along with optional external capacitors provides a full-scale range from 50 pC to 1000 pC. The continuous conversion rate is 3 kSPS; single integrations can be performed as quickly as 50 µs. The simple serial output can be daisy-chained to minimize wiring when using multiple devices.



Photodiode measurement using the DDC112 ADC.

CT Scanner Featured Products

Precision, High-Speed Transimpedance Amplifier
OPA380

Get datasheets and app reports at: **www.ti.com/sc/device/OPA380**

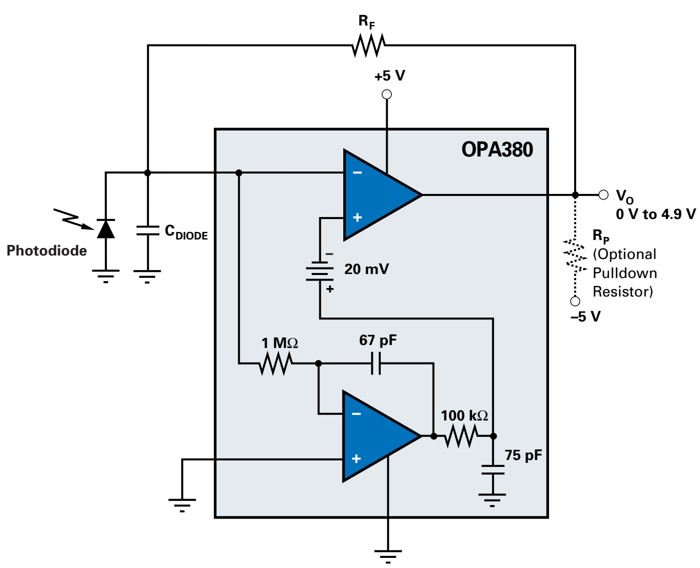
The OPA380 transimpedance amplifier family provides high speed, high precision and long-term stability. It exceeds the offset, drift and noise performance that conventional JFET op amps provide. The OPA380 is well suited for fast control loops that detect and react to fast changes in the optical power level on a fiber.

Key Features

- Over 1-MHz TIA bandwidth
- Dynamic range: 5 decades
- Inherent long-term stability
- Output swing includes ground
- Very low 1/f noise
- Bias current: 50 pA (max)
- Offset voltage: 25 µV (max)
- Drift: 0.1 µV/°C
- Gain bandwidth: 90 MHz
- Quiescent current: 6 mA
- Supply range: 2.7 V to 5.5 V
- Single and dual versions
- Packaging: MSOP-8 and SO-8

Applications

- CAT-scanner frontend
- Precision current-to-voltage measurements
- Optical amplifiers
- Photodiode monitoring



OP380 application diagram.

18-Bit, 500-kSPS, Unipolar Input, Sampling ADC With Parallel Interface
ADS8383

Get samples, datasheets, app reports and EVMs at:
www.ti.com/sc/device/ADS8383

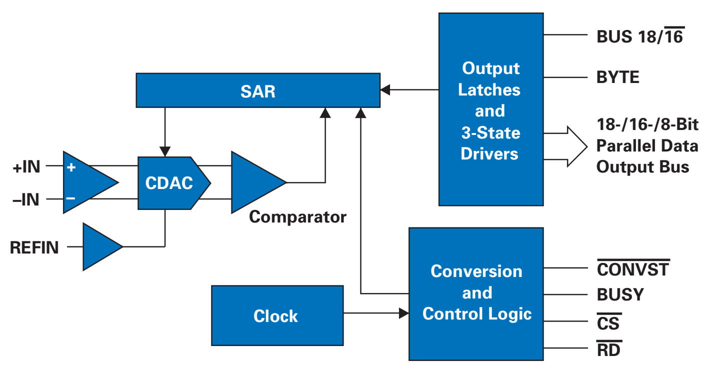
The ADS8383 includes an 18-bit, capacitor-based SAR ADC with inherent sample and hold. It offers a full 18-bit interface: a 16-bit option where data is read using two read cycles or an 8-bit option using three read cycles.

Key Features

- 500-kSPS sample rate
- 18-bit NMC over temperature
- Zero latency
- Low power: 110 mW at 500 kHz
- Onboard reference buffer
- High-speed parallel interface
- Wide digital supply
- 8-/16-/18-bit bus transfer
- Packaging: 48-pin TQFP

Applications

- Medical instruments
- Transducer interface
- High accuracy data acquisition systems



ADS8383 functional diagram.

Dual Current-Input, 20-Bit ADC
DDC112

Get samples, datasheets, app reports and EVMs at:
www.ti.com/sc/device/DDC112

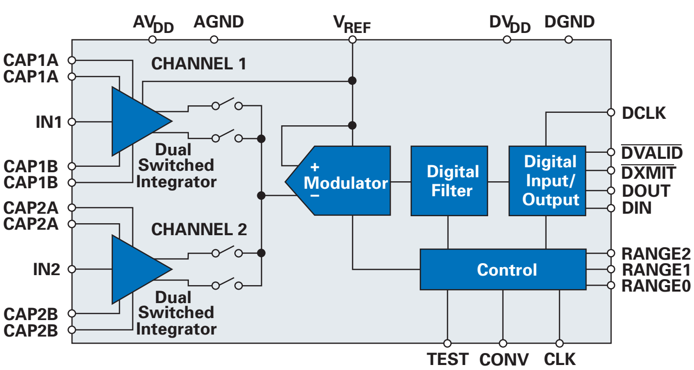
Low-level current-output devices like photosensors can be directly connected to the DDC112 inputs. Charge integration is continuous as each input uses two integrators. While one integrator is being digitized, the other is integrating. For each of its two inputs, the DDC112 combines current-to-voltage conversion, continuous integration, programmable full-scale range, analog-to-digital conversion and digital filtering to achieve a precision, wide-range digital result.

Key Features

- Monolithic charge measurement ADC
- Digital filter noise reduction: 3.2 ppm, rms
- Integral linearity: ±0.005% Reading ±0.5-ppm FSR
- High precision, true integrating function
- Programmable full scale
- Single supply
- Cascadable output
- Packaging: 28-pin SO or 32-pin TQFP

Applications

- Direct photosensor digitization
- CT scanner DAS
- Infrared pyrometer
- Liquid/gas chromatography
- Blood analysis



DDC112 functional diagram.

8-Channel, 10-Bit, 65-MSPS, 1.8-V CMOS ADC
ADS5122

Get samples, datasheets and app reports at:
www.ti.com/sc/device/ADS5122

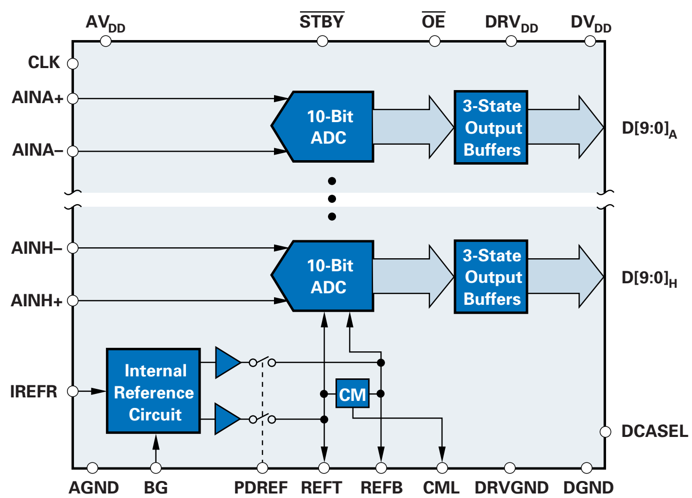
The ADS5122 operates from a single 1.8-V supply which offers flexibility for 1.8-V and 3.3-V digital I/O. A single-ended input clock is used for simultaneous sampling of up to eight analog differential input channels. The flexible duty-cycle-adjust circuit allows the use of a non-50% clock duty cycle.

Key Features

- Eight different analog input channels
- 1-V_{PP} differential input range
- Int/Ext voltage reference
- Analog/digital supply: 1.8 V/3.3 V
- Differential nonlinearity: ±0.4 LSB
- Integral nonlinearity: ±1.0 LSB
- Signal-to-noise: 59 dB at f_{IN} = 20 MHz
- Power dissipation: 733 mW
- Individual channel power down
- Packaging: 257-lead, 0.8 ball pitch, MicroStar BGA™

Applications

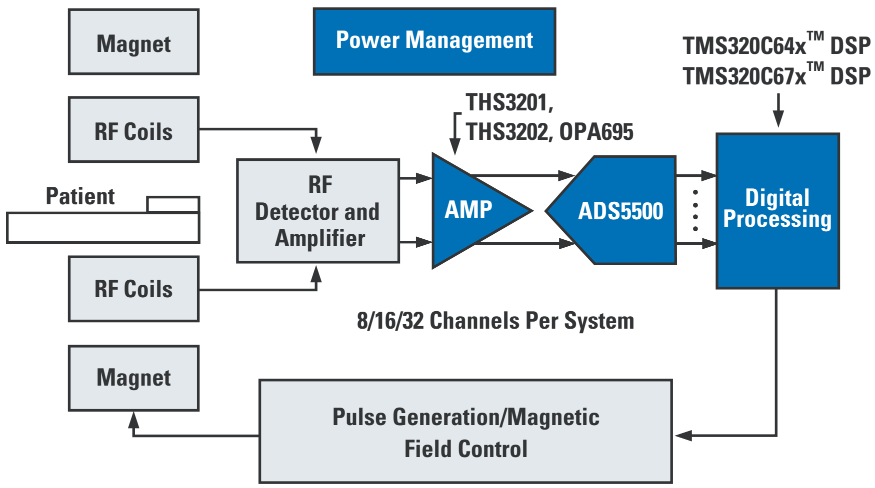
- Portable ultrasound
- Portable instrumentation



ADS5122 functional diagram.

Magnetic Resonance Imaging (MRI) Applications and Featured Product

The ADS5500 can be designed into medical MRI equipment. The 14-bit resolution provides higher SNR, which allows the designer to lower the magnetic field energy necessary for high-image quality. Additionally, 125 MSPS allows for oversampling, which also contributes to higher



MRI application using ADS5500 and OPA695.

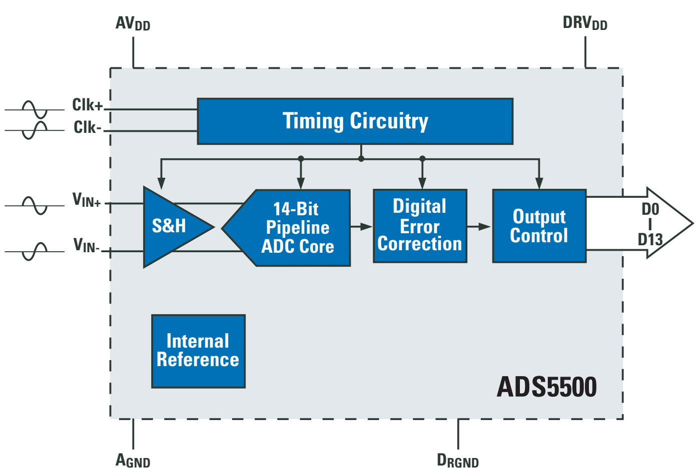
14-Bit, 125-MSPS ADC
ADS5500

Get datasheets, app reports and EVMs at: **www.ti.com/ads5500**

The ADS5500 provides a complete converter solution. It includes a high-bandwidth linear sample-and-hold stage and internal reference. Designed for applications demanding the highest speed and dynamic performance in very little space, the ADS5500 has low 780-mW power consumption with a 3.3-V single supply voltage. An internal reference is provided, and parallel CMOS-compatible output ensures seamless interfacing with common logic. Available in a 64-pin TQFP PowerPAD™ package, the ADS5500 is specified over a –40°C to +85°C temperature range.

Key Features

- 14-bit resolution
- 125-MSPS sample rate
- High SNR: 70.5 dB at 100-MHz f_{IN}
- High SFDR: 82 dB at 100-MHz f_{IN}
- 2.2-V_{PP} differential input voltage
- Internal voltage reference
- 3.3-V single-supply voltage
- Power dissipation: 780 mW
- Packaging: 64-pin TQFP PowerPAD
- Recommended op amps: THS3202, THS3201, THS4503, OPA695, OPA847



ADS5500 functional diagram.

Applications

- MRI equipment
- Test and measurement instrumentation
- Single and multichannel digital receivers
- Video and imaging

DSPs for Imaging Applications

High-Performance Digital Signal Processors
TMS320C67x™ Floating-Point DSPs

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

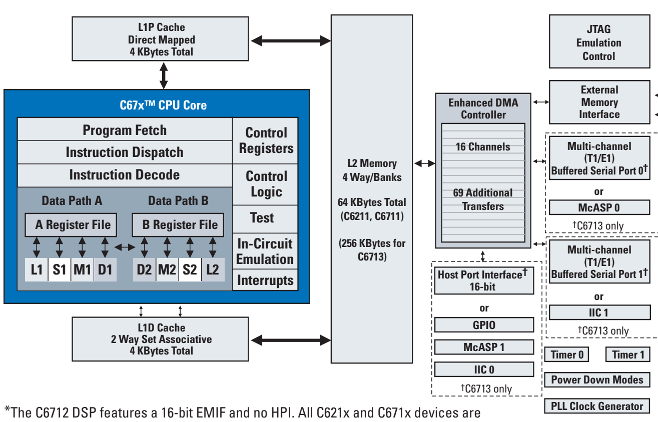
To develop high-precision applications, TMS320C67x™ DSPs offer the speed, precision, power savings and dynamic range to meet a wide variety of design needs. These dynamic DSPs are the ideal solution for demanding applications such as medical imaging. TI's C67x™ DSPs are backed by an extensive selection of optimized algorithms and industry-leading development tools.

Key Features

- Up to 1350 MFLOPS at 225 MHz (less than $0.02/MFLOPS)
- C67x DSPs are 100% code-compatible with 32-bit instructions, single and double precision
- C6000™ DSP platform VelociTI™ advanced VLIW architecture
- Two inter-integrated circuit (I^2C) bus interfaces
- Two multichannel buffered serial ports (McBSPs)
- Up to 256 Kbytes of on-chip memory
- 16-channel DMA controller
- Up to eight 32-bit instructions executed each cycle
- Eight independent, multipurpose functional units and thirty-two 32-bit registers
- Industry's most advanced DSP C compiler and assembly optimizer maximize efficiency and performance
- IEEE floating-point format
- Packaging: 27/35-mm BGA and 28-mm TQFP options

Applications

- Digital imaging
- Medical ultrasound
- Portable ultrasound equipment
- CT scanners
- Magnetic resonance imaging



*The C6712 DSP features a 16-bit EMIF and no HPI. All C621x and C671x devices are pin compatible. The C6713 DSP is a superset of the C6711 DSP and will include I^2S, I^2C and S/PDIF transmit support as well as enhanced memory space.

The C67x™ DSPs' innovative two-level cache memory structure enables a breakthrough in system cost/performance.

High-Performance Digital Signal Processors
TMS320C64x™ Fixed-Point DSPs

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

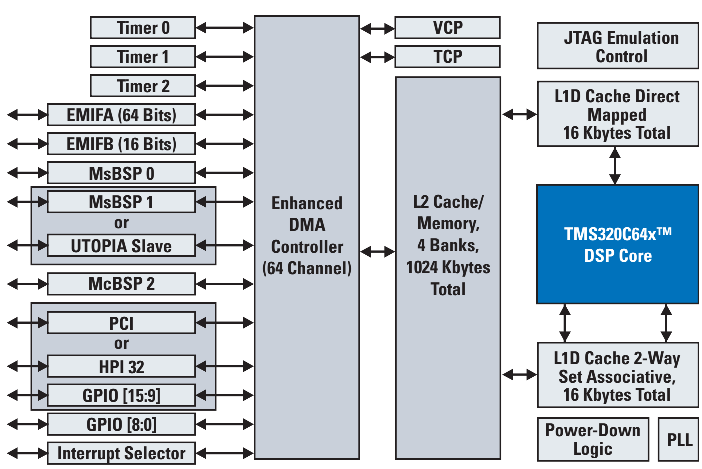
TMS320C64x™ DSPs offer the highest level of performance to meet the demands of the digital age. At clock rates of up to 1 GHz, the C64x™ DSPs can process information at a rate of more than 5760 MIPS. TI's C64x DSPs are backed by an extensive selection of optimized algorithms and industry-leading development tools.

Key Features

- Highest in-class performance with devices running at clock speeds of up to 1 GHz
- TMS320C64x DSPs are 100% code-compatible with C6000™ DSPs
- C64x DSPs offer up to 8000 MIPS with costs as low as $19.95
- 64-channel enhanced direct memory access (EDMA) controller
- Two synchronous external memory interfaces (EMIFs)
- Up to three multichannel buffered serial ports (McBSPs)
- PCI or Utopia Slave option
- Turbo and Viterbi coprocessors
- Ethernet MAC
- Special instructions/capabilities: imaging, audio, accelerated video and data
- Industry's most advanced DSP C compiler and assembly optimizer maximize efficiency and performance
- Packaging: 23/27-mm BGA options

Applications

- CT medical imaging
- PET medical imaging
- MRI medical imaging
- Ultrasound



The C64x™ fixed-point DSPs offer the highest level of performance to address the demands of the digital age.

Design Example

To Know More

For detailed information about TI products:

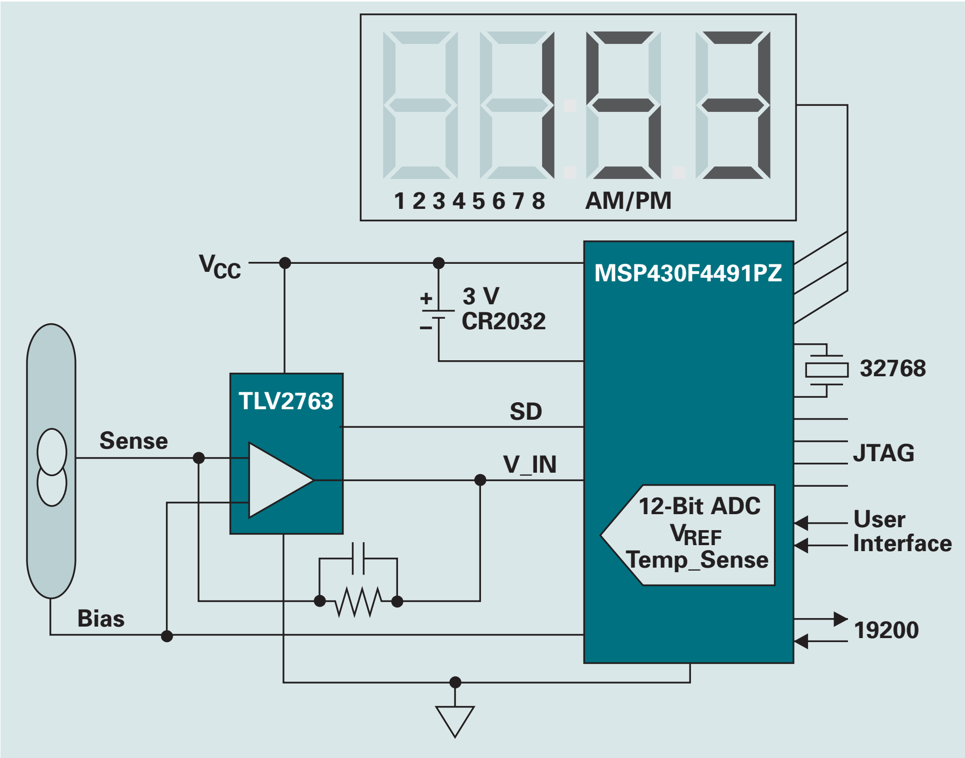
Modern handheld medical devices require a sensor interface, precision conversion circuit, flash MCU, user display, communication features and a power supply. In the past, to meet the conflicting electronics requirements of low power and high precision, handcrafted application-specific integrated circuit (ASIC) solutions were used. Glucose meter designers today are moving toward using off-the-shelf, ultra-low-power, mixed-signal controllers with embedded analog to meet the power, precision, fast time-to-market and cost requirements.

This design implements a blood glucose measurement system with ultra-low power consumption and numerous features. The primary interface is a numeric LCD requiring just 1 µA to 2 µA when active. Additional features include user input buttons, an alert buzzer and a serial communication link. A typical block diagram is shown for a modern glucose meter implementing all features using just two devices—the MSP430F449 ultra-low-power microcontroller and the TLV2763 amplifier with shutdown.

System designers indicate that glucose measurements can be taken in several ways, including optical or electrochemical methods. In electrochemical meters, a disposable biocatalyst test strip is used to measure the glucose content of a small blood sample. When the sample is applied, the test strip generates a signal that is amplified and measured by the operational amplifier. The operational amplifier's output is scaled to a range that can be measured by the MSP430's embedded 12-bit analog-to-digital converter (ADC). In addition to the test strip output current, measurement of temperature is also required. The chemical reaction of the test strip is temperature-sensitive. The temperature can be measured using the integrated temperature sensor in the MSP430F449's embedded 12-bit ADC.

These measurements are often logged and downloaded later to a PC for analysis by the user and the user's doctor. The data logging is a key reason to use flash memory. The MSP430 can be easily programmed in-system and by the system itself. Allocating 8 Kbytes of flash memory for data logging is adequate for 1000 measurements, each with an associated time stamp. The flash memory can be erased and reprogrammed 100,000 times, exceeding the life of the instrument.

All of these features can easily be implemented by glucose meter system designers using the 12-bit ADC, reference voltage, temperature sensor and hardware serial communication interface integrated on the



MSP430F43x/44x family of products. MSP430 also easily interfaces to TI's portfolio of high-performance analog, including a broad range of high-resolution data converters, precision amplifiers and power management products for complete design flexibility.

For more demanding applications that require higher-resolution ADCs, system designers will find that the ADS83xx and ADS11xx families offer an outstanding solution. Both families feature 16-bit resolution and ultra-low power consumption, and they are offered in some of the industry's smallest footprints available today. Additionally, both families support single-channel or multichannel requirements.

As with any portable device, power management is critical. To reduce power, the first task is to shut off analog circuits when not in use. Many designers often look for the lowest-power amplifier. While low power consumption is key, most important is the ability to shut down. The TLV276x will typically draw current in the 10-nA range in shutdown mode. Since the meter is used only three to five times a day, it is important to have the lowest current possible when the meter is in inactive mode.

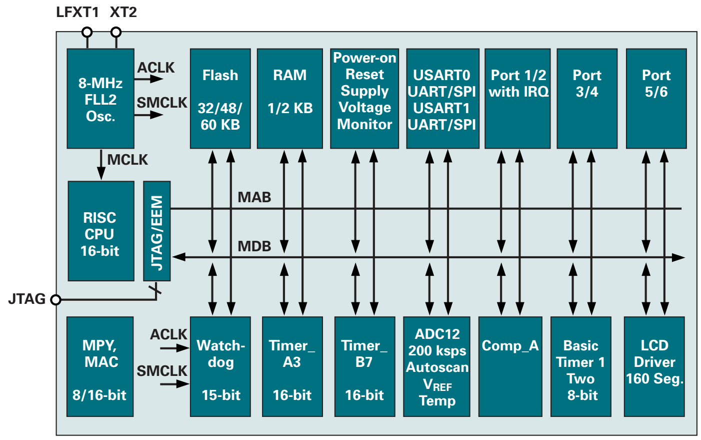
Regarding the microcontroller, low standby-mode power consumption and fast wake-up times are critical. The MSP430F449 features a fast-responding, high-speed clocked system with a digitally controlled oscillator (DCO). This system starts up in less than 6 µs to service requests as fast as possible and then returns to standby. This extends the time in inactive mode, resulting in total reduction in power consumption. The DCO can be used in conjunction with a 32-kHz watch crystal to provide a stable time base for an ultra-low-power embedded real-time clock. With an active CPU current of 280 µA, the real-time clock function adds less than 25 nA to the overall system power budget.

TI's MSP430 microcontroller and high-performance analog portfolio provide exceptional performance/cost solutions featuring ultra-low power consumption and high-precision performance.

16-Bit Ultra-Low-Power Microcontroller
MSP430F43x/44x

Get app reports and EVMs at: **www.ti.com/msp430**

The MSP430F43x/44x 16-bit mixed-signal microcontroller (MCU) family further improves the MSP430's industry-leading ultra-low-power flash memory technology—breaking the 1-µA barrier. The MSP430F43x/44x delivers a standby mode of less than 800 nA typical, with a 32K oscillator, basic timer and LCD driver active. An "instant-on" digitally controlled oscillator (DCO) together with an integrated frequency lock loop (FLL) provides a stable, high-speed system clock in less than 6 µs. This saves battery power by allowing the system to stay in standby longer and utilize modern event-driven programming techniques. In active mode, the MSP430F449 consumes only 280 µA/MIPS at 2.2 V and can operate from 1.8 V to 3.6 V over full industrial temperature range. The MSP430F43x/44x family integrates mixed-signal peripherals that expand design possibilities.



MSP430F43x typical functional diagram.

Key Features

- Ultra-low power consumption:
  - Active mode: 280 µA at 1 MHz, 2.2 V
  - Standby mode: 0.7 µA
  - Off mode (RAM retention): 0.1 µA
- Wake-up from standby mode in 6 µs
- High-performance integrated analog and digital peripherals including 12-bit ADC, supply voltage supervisor, analog comparator, serial communication interface and hardware multiplier
- Two 16-bit PWM timers with multichannel capture/compare
- Integrated LCD driver for 160 segments
- Available in 80- or 100-pin quad flat pack

Applications

- Handheld medical devices

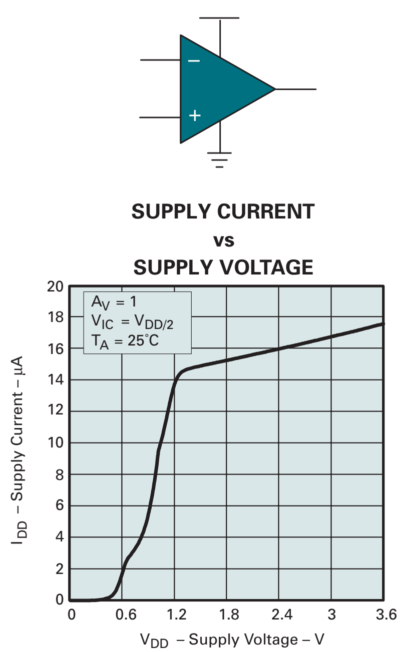
Featured Products

1.8-V, Single-Supply Operational Amplifier
TLV2763

Get samples, datasheets and app reports at:
www.ti.com/sc/device/TLV2763

The TLV276x single-supply operational amplifiers provide 500-kHz bandwidth from only 20 µA while operating down to 1.8 V over the industrial temperature range (±1.8 V supplies down to ±0.9 V). The maximum recommended supply voltage is 3.6 V, which allows the devices to be operated from two AA or AAA cells. The devices have been characterized at 1.8 V (end of life of two AA or AAA cells) and at 2.4 V (nominal voltage of two NiCd/NiMH cells). The TLV276x family has rail-to-rail input and output capability, which is a necessity at 1.8 V.

Key Features
- Low supply voltage: 1.8 to 3.6 V
- Very low supply current: 20 µA (per channel)
- Ultra-low-power shutdown mode: $I_{Q(SHDN)}$ = 10 nA/channel
- CMOS rail-to-rail input/output
- Input common-mode voltage range: –0.2 V to V_{DD} + 0.2 V
- Input offset voltage: 550 µV
- Wide bandwidth: 500 kHz
- Ultra-small packaging:
  - 5- or 6-pin SOT-23 (TLV2760/1)
  - 8- or 10-pin MSOP (TLV2762/3)



TLV2763 single-supply performance.

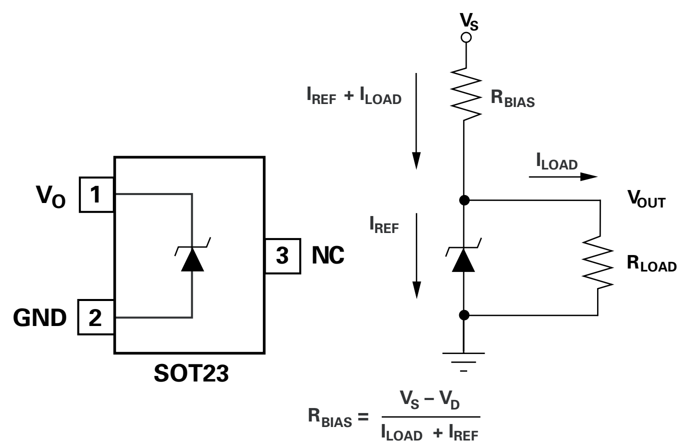
1.25-V, 1-µA, 30-ppm/°C Max Shunt Voltage Reference
REF1112

Get samples, datasheets and app reports at:
www.ti.com/sc/device/REF1112

The REF1112 is a two-terminal shunt reference designed for power- and space-sensitive applications. It features an operating current of just 1 µA and is available in the SOT23-3 package.

Key Features
- Wide output current range: 1 µA to 5 mA
- High initial accuracy: 0.2%
- Excellent specified drift performance:
  30 ppm/°C (max) from 0°C to 70°C
  50 ppm/°C (max) from –40°C to 85°C
- Micro-package: SOT23-3

Applications
- Medical equipment
- Battery-powered instruments
- Calibration circuits
- Micropower current and voltage reference



Typical REF1112 shunt reference application.

Featured Products

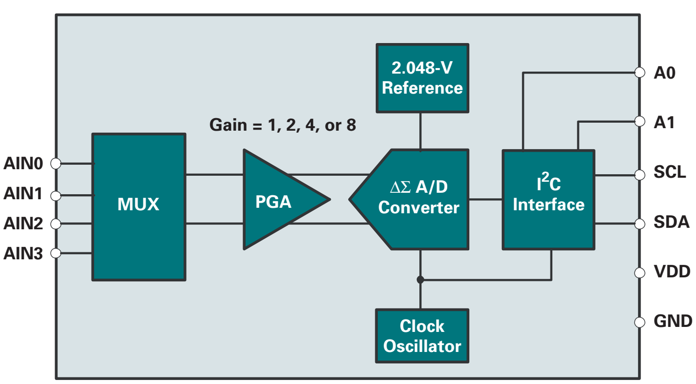
16-Bit ADC With Input Multiplexer and Onboard Reference
ADS1112

Get samples, datasheets and app reports at:
www.ti.com/sc/device/ADS1112

The ADS1112 is a precision, continuously self-calibrating ADC with two differential or three single-ended channels. It uses an I^2C-compatible serial interface and has two address pins that allow the user to select one of the eight I^2C slave addresses.

Key Features
- Complete data acquisition system in the MSOP-10 and leadless QFN-style packages
- Measurement from two differential channels or three single-ended channels
- I^2C interface: eight addresses are pin selectable
- Onboard reference: 2.048 V ±0.05%, drift 5 ppm/°C
- Onboard PGA
- Onboard oscillator
- 16 bits, no missing codes
- INL: 0.01% of FSR max
- Continuous self-calibration
- Single-cycle conversion
- Programmable data rate: 15 SPS to 240 SPS
- Power supply: 2.7 V to 5.5 V
- Low current consumption: 240 µA

Applications
- Medical equipment
- Battery-powered instruments
- Smart transmitters
- Temperature measurement



ADS1112 block diagram.

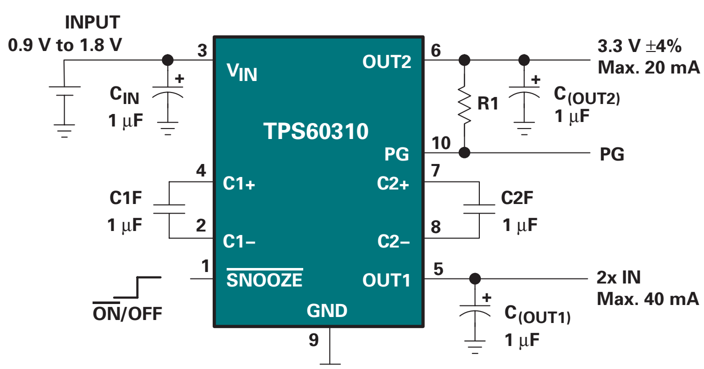
Single-Cell to 3.0/3.3-V, 20-mA, Ultra-Low Quiescent Current Charge Pump
TPS60310

Get samples, datasheets and app reports at:
www.ti.com/sc/device/TPS60310

The TPS60310 is a high-efficiency step-up charge pump capable of delivering either 3.0 V or 3.3 V from a 0.9-V to 1.8-V input voltage (one alkaline, NiCd, or NiMH battery). It has an additional output capable of providing two times the input voltage. Requiring no inductors, the device requires as few as five capacitors. It has the unique ability to provide 2 mA of output current while in its snooze mode (2 µA), thus providing a significant power savings to many ultra-low-power applications.

Key Features
- Regulated output voltage with up to 40-mA current from a 0.9-V to 1.8-V source
- High power-conversion efficiency, greater than 80%
- Snooze mode of 2 µA still capable of supplying 2-mA output current
- Additional output (dual output)
- Integrated supervisor (SVS)
- No inductors required, only five small capacitors

Applications
- MSP430 applications
- Medical instrumentation
- Portable measurement
- Metering applications
- Portable smartcard readers



Typical application.

Featured Products

Single-Chip Multiband RF Transceiver
TRF6903

Product Preview *

Get datasheet at: **www.ti.com/sc/device/TRF6903**

The TRF6903 single-chip solution is a low-cost multiband FSK or OOK transceiver to establish a frequency programmable, half-duplex, bidirectional RF link. Intended for use in the North American and European 315-MHz, 533-MHz, 868-MHz and 915-MHz bands, the transceiver operates down to 2.2 V with low power consumption.

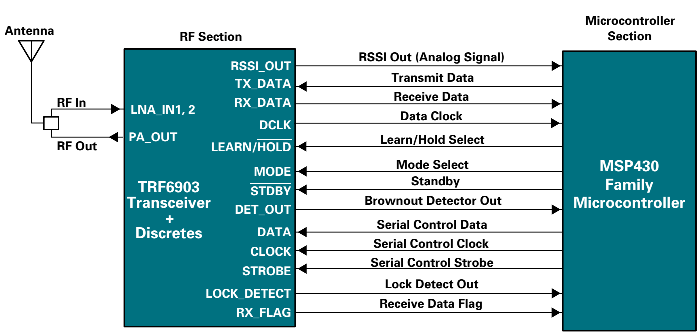
Key Features

- ISM-band frequencies: 315, 433, 868 and 915 MHz
- 2.2-V to 3.6-V operation
- Low power consumption
- FSK/OOK operation
- Integer-N synthesizer with fully integrated voltage-controlled oscillator (VCO)
- On-chip reference oscillator and phase-locked loop (PLL)
- Class-selectable power amplifier with 8-dBm typical output power
- Programmable brownout detector
- Clock recovery with integrated data-bit synchronizer and baud-rate selection
- Packaging: Low-profile 48-pin PQFP

Applications

- Personal and portable measurement products
- Handheld medical diagnostics
- Battery-powered instruments
- Medical equipment

**Planned availability is June 2004.*



System diagram for interfacing to the MSP430 microcontroller.

Power-Efficient Digital Signal Processors
TMS320C55x™ Fixed-Point DSPs

Get samples, datasheets and app reports at: **www.ti.com/c55xdsps**

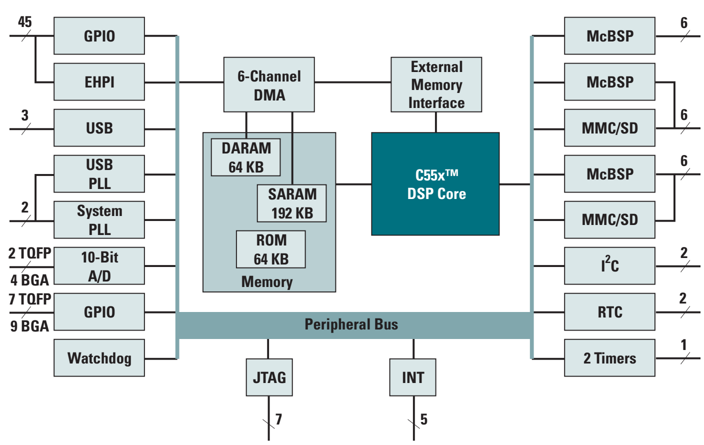
TMS320C55x™ DSPs offer the optimal combination of performance, peripheral options, small packaging and power efficiency in the industry. This combination gives designers an edge while designing applications such as handheld medical imaging devices. TI's C55x™ DSPs offer power consumption as low as 0.33 mA/MHz and performance up to 600 MIPS.

Key Features

- Power consumption as low as 0.33 mA/MHz and performance up to 600 MIPS
- Active power: 65 to 194 mW
- C55x DSPs are 100% code-compatible with C5000™ DSPs
- Video hardware extensions (DCT, motion estimation, pixel interpolation)
- McBSP
- USB 2.0, full-speed
- 16-bit HPI
- 6-channel DMA
- 16/32-bit EMIF
- ADC
- I^2C
- MMC/SD
- UART
- Special instructions: variable-length (8- to 48-bit) instructions
- Packaging: MicroStar BGA™

Applications

- Feature-rich, miniaturized personal and portable products
- Handheld medical diagnostics
- Hearing aids
- Voice/speech recognition



The C55x™ DSP core is driving digital applications ranging from portable Internet appliances to high-speed wireless to power-efficient infrastructure.

To Know More

For detailed information about TI products:

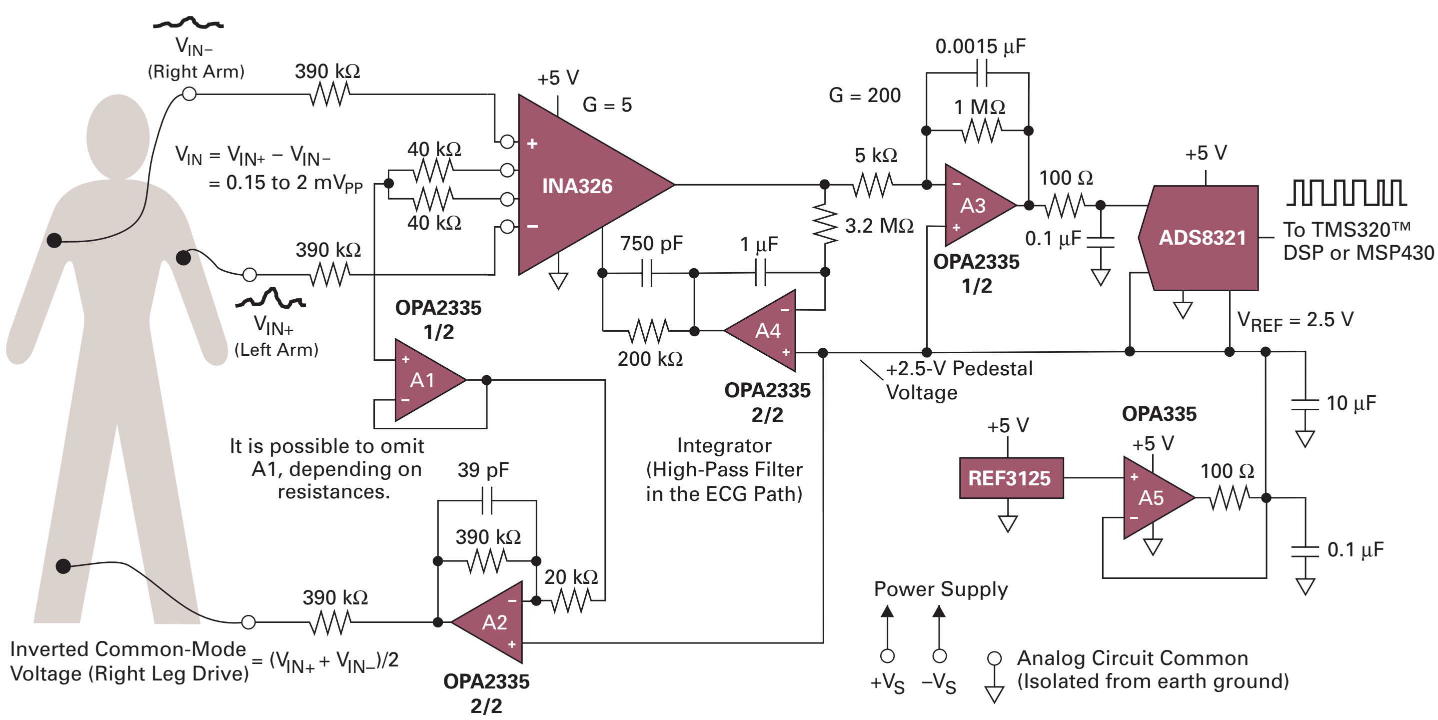
Biophysical Monitoring Overview

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 0.05 Hz to 100 Hz, sometimes up to 1 kHz. It is generally around 1-mV peak-to-peak in the presence of much larger external high frequency noise plus 50-/60-Hz 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: 50- or 60-Hz 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 devices that couple into the input. Some of the noise can be cancelled with a high-input-impedance instrumentation amplifier (INA), like the INA326 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 60-Hz 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 amplifier A2. Only a few microamps or less are required to achieve significant CMR improvement and stay within the UL544 limit.



Three ECG electrodes connected to patient using CMOS devices with 5-V single supply. This circuit will operate on a 3.3-V supply.

Electrocardiogram (ECG) Front End

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, 5-V systems are now common and trending to single 3.3-V supplies. This trend presents a significant challenge for the designer faced with at least a 300-mV DC electrode potential and emphasizes the need for a precision signal-conditioning solution. While the following discussion concentrates on the single supply design, the principles involved apply to bipolar designs as well. A list of recommended single and bipolar supply devices can be found below.

Frequency Response

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

Electrode Potential

Because electrode potential can in practice reach ±500 mV, eliminating the effects of electrode potential by AC coupling is essential. A DC restorator amplifier in a feedback configuration nulls out the DC offset. If the left arm DC offset is +300 mV and the right arm electrode is 0-V DC, the differential input voltage is 300 mV. Because the instrumentation amp has a gain of 5, 1.5 V appears at the output of the instrumentation amp. With a gain of 50 or more, the output amplifier would try to drive the signal up to 75 V but never does because a feedback integrator applies an equal negative voltage to the reference point. Using this linear summing effect, the electrode offset is cancelled. The result of this DC restorator is to turn the original DC-coupled amplifier into an AC-coupled amplifier. With the DC normal-mode voltage removed, the output stage can amplify the AC ECG signal without becoming saturated.

Instrumentation Amplifier Requirements

- Stability in low gain (G = 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

Device Recommendations

Device Type	Recommended Devices	Device Characteristics
5-V Single Supply		
Instrumentation Amplifiers	INA326	110-dB CMRR at G = 100, 100-µV max offset, 0.4-µV/°C max drift, RRIO, MSOP package
	INA321	94-dB CMRR, 500-µV max offset, 7-µV/°C drift, 40-µA supply current, RRO, MSOP package
Operational Amplifiers	OPA335	5-µV max offset, 0.05-µV/°C max drift, 350-µA max supply current, SOT23 package
	OPA336	125-µV max offset, 1.5-µV/°C drift, 32-µA max supply current, SOT23 package
Data Converters	ADS8325	16-bit, 100-kSPS, micropower serial output ADC, operates on 2.7 V to 5.5 V, 3mm x 3mm QFN
	ADS1255, ADS1256	24-bit, 30-kSPS ADC, high effective resolution and fast conversion rate
	ADS1252	24-bit, 41-kSPS ADC, world's fastest 24-bit ADC
Voltage Reference	REF31xx	0.2% max initial accuracy, 15 ppm/°C max drift, SOT23 package (1.25, 2.048, 2.5, 3.0, 3.3, 4.096 V)
	REF02	5-V precision voltage reference, 0.2% initial accuracy max, 10 ppm/°C max drift, excellent line/load regulation, low noise, SO-8 package
	REF102	10-V ultra-precision voltage reference, 0.05% accuracy, 2.5ppm/°C max drift, excellent stability and line/load regulation, operation to 36 V, SO-8 package
Digital Signal Processor	TMS320C5000™ DSP	Power-efficient, high-performance DSPs
Power Management	bq24703	Multichemistry battery charger
Bipolar Supplies		
Instrumentation Amplifiers	INA128	120-dB min CMRR, 5-nA max bias current, 50-µV max offset, 0.5-µV/°C max drift, 700-µA supply current
	INA118	110-dB min CMRR, 5-nA max bias current, 50-µV max offset, 0.5-µV/°C max drift, 350-µA supply current
	INA121	106-dB CMRR, 4-pA max bias current, 2-µV/°C max drift, 200-µV offset, 0.001% max non-linearity
	INA126/dual INA2126	Low power: 175-µA/channel supply current, 3-µV/°C max drift, 250-µV max offset
Operational Amplifiers	OPA130 for Integrator	20-pA max bias current, 90-dB min CMRR, 120-dB min open loop gain, 1-MHz bandwidth
	OPA277 for Right Leg Drive	Very low voltage offset and drift, wide bandwidth, low noise
Data Converters	ADS8342	4-channel, 16-bit NMC, 250-kSPS, ±2.5-V input range, parallel interface in TQFP-48 package
	ADS7809UB	16-bit NMC, 100-kSPS, 100-dB SFDR, ±10-V input range on 5-V single supply, SPI serial interface
	DDC112	Dual current input, wide dynamic range, charge digitizing, 20-bit ADC
Digital Signal Processor	TMS320C5000 DSP	Power-efficient, high-performance DSPs
Power Management	TPS40500	DC/DC controller with 8-V to 40-V input voltage range
	TPS546xx	6-A DC/DC converter with onboard power FETs

Pulse Oximetry

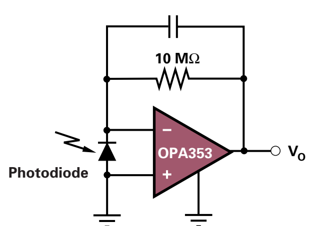
Overview

The pulse oximeter measures blood oxygenation by sensing the infrared and red light absorption properties of deoxygenated and oxygenated hemoglobin.

It is comprised of a sensing probe attached to a patient's earlobe, toe or finger that is connected to a data acquisition system for calculation and display of oxygen saturation level, heart rate and blood flow. Light sources, typically light-emitting diodes, 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 an amount of light at those wavelengths proportional to the oxygen saturation (or desaturation) of the hemoglobin.

Because of the use of light in the absorbance measurement, the designer needs a true "light-to-voltage" conversion using current as the input signal. The classes of photodiode amplifiers suitable for pulse oximetry applications are the classical resistor-feedback transimpedance amplifier and the capacitor-feedback switched integrator. In either amplifier configuration, the resulting output voltage is read by an analog-to-digital converter and serialized for MSP430 microcontroller or TMS320™ DSP for processing.

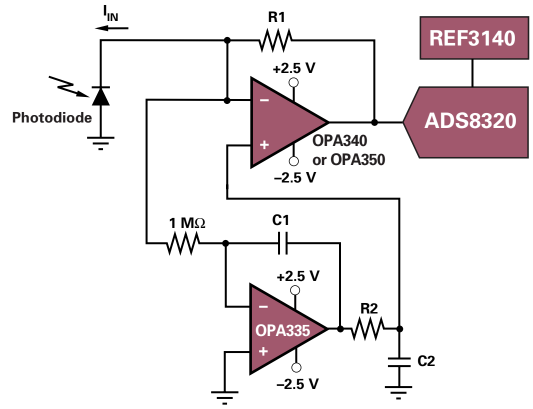
Signal Acquisition Challenges



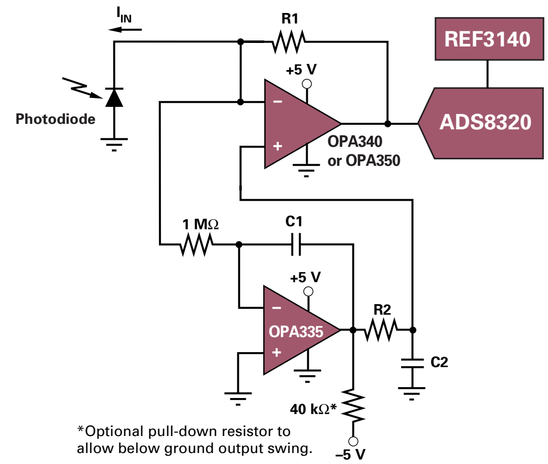
The resistor-feedback amplifier circuit shown at right is the most common bioelectric transimpedance circuit. With the amplifier used in the inverting configuration, the light shining on a photodiode produces a small current that flows to the amplifier summing junction and through the feedback resistor. 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 0.001 µW 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 configurations shown in the next column will allow swing to ground in Figure A and very close to ground in Figure B. A pull-down resistor tied to –5 V will allow swing slightly below ground to minimize errors as the output gets very close to zero volts.

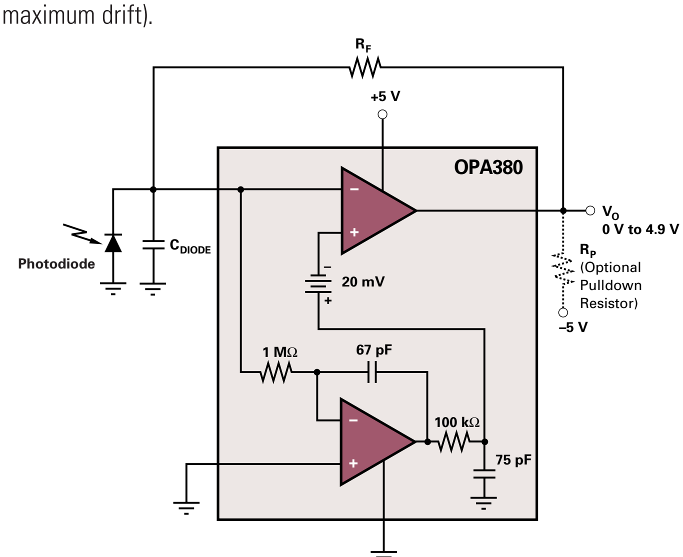
A. Dual Supply



B. Single Supply

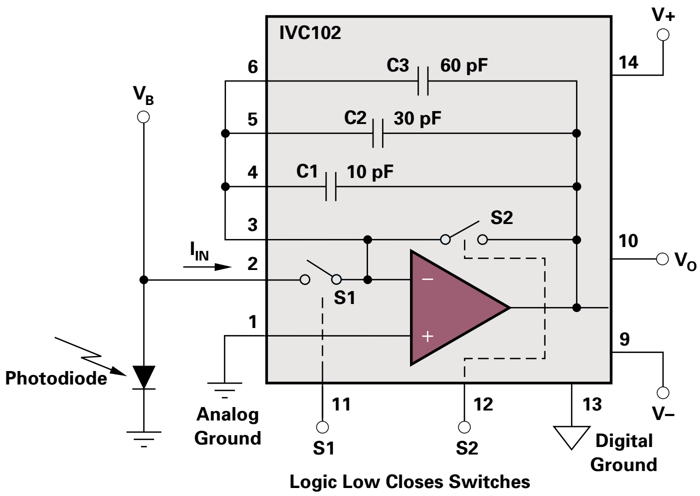


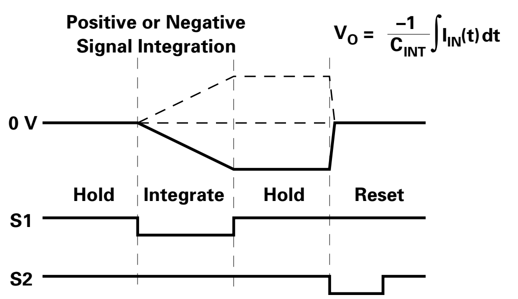
TI's new OPA380 is a monolithic combination of the high-speed OPA355 and auto-zero OPA335 amps. It offers 90-MHz gain bandwidth product and performs well as a 1-MHz transimpedance amplifier with extremely high precision (25-µV maximum offset and 0.1-µV/°C maximum drift).



Pulse Oximetry

Depending on design requirements, the switched 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 will eliminate dark current and ambient light errors, as errors common to both can be subtracted. Additionally, IVC102 allows for synchronized sampling at an integer multiple of AC line frequency, giving extremely high noise rejection. Transimpedance gain can easily be 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 0 V) 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

Design Hints

A small (< 1-pF) capacitor in the feedback loop (C_F) will control gain-peaking caused by the diode capacitance. Noise (voltage-output fluctuation) is caused by resistor noise, amplifier and current noise, and environmental noise pickup (e.g., 50- or 60-Hz 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 technique.

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

Device Recommendations

Device Type	Recommended Devices	Device Characteristics
Transimpedance Amplifier	OPA380	90 GBW, over 1-MHz transimpedance BW, 25-µV max offset, 0.1-µV/°C max drift, MSOP package
	IVC102	Precision switch integrator transimpedance amp
Operational Amplifiers	OPA335 (5 V)	5-µV max offset, 0.05-µV/°C max drift, 350-µA max supply current, SOT23 package
	OPA735 (12 V)	5-µV max offset, 0.05-µV/°C max drift, 750-µA max supply current, SOT23 package, 2.7-V to 12-V operation
	OPA336	125-µV max offset, 1.5-µV/°C drift, 32-µA max supply current, SOT23 package
	OPA350	500-µV V_{OS}, 38-MHz, 2.5-V to 5-V supply
	OPA353	High-speed single-supply rail-to-rail MicroAmplifier™ series
	OPA363/364	1.8-V high CMR, RRIO op amp with shutdown
	OPA703	12-V, CMOS, rail-to-rail I/O op amp
	OPA725	Very low noise, high-speed 12-V CMOS op amp
Data Converter	DDC112	Dual current input, wide dynamic range, charge digitizing, 20-bit ADC

Featured Products

Auto-Zero, Rail-to-Rail I/O Instrumentation Amplifier INA326

Get samples, datasheets, app reports and EVMs at:
www.ti.com/sc/device/INA326

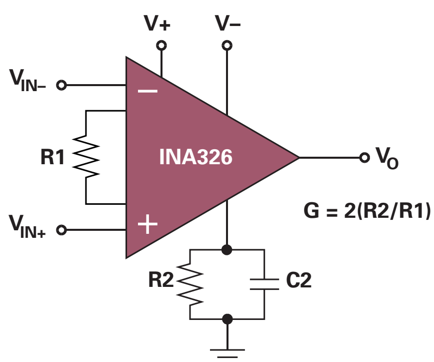
The INA326 is a true single-supply instrumentation amplifier with very low DC errors and input common-mode range that extends beyond the positive and negative rails.

Key Features

- Precision
  - Low offset: 100 µV (max)
  - Low offset drift: 0.4 µV/°C (max)
- True rail-to-rail I/O
  - Input common-mode range: 20 mV beyond rails
  - Wide output swing: Within 10 mV of rails
  - Supply range: Single +2.7 V to +5.5 V
  - High CMRR: 110 dB at Gain = 100
- Simple gain setting
- 125°C version: INA337
- Packaging: MSOP-8

Applications

- Patient monitor analog front end
- Wide dynamic-range sensor measurement
- High-resolution data acquisition system



INA326 block diagram.

Auto-Zero, Single-Supply CMOS Op Amp OPA335

Get samples, datasheets and app reports at: **www.ti.com/sc/device/OPA335**

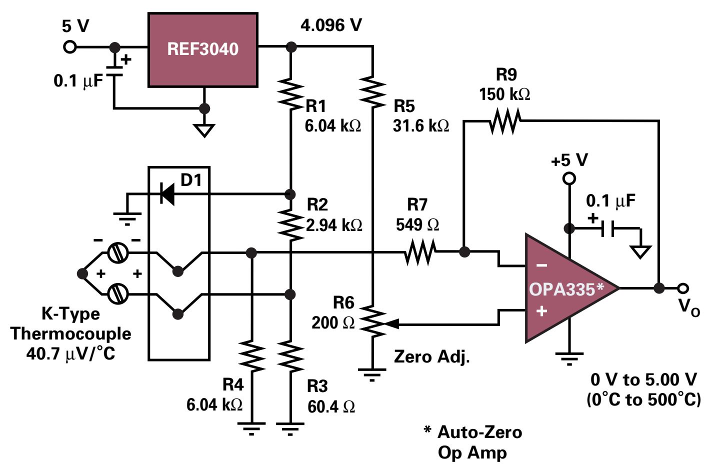
The OPA335 offers the ultimate combination of DC precision and low power consumption. It is offered in the small SOT23 package and consumes a maximum quiescent current of just 350 µA. In addition to having ultra-low voltage offset and drift, the OPA335 has significantly better bandwidth and lower 1/f noise than previous auto-zero designs.

Key Features

- 5-µV max voltage offset
- 0.05-µV/°C max drift
- 2-MHz gain bandwidth
- Low 1/f noise
- 350-µA max quiescent current
- 12-V version: OPA735 (suitable for ±5-V supplies)
- Packaging: SOT23

Applications

- Patient monitor signal amplification
- Right leg device
- Precision general-purpose signal conditioning



Typical OPA335 temperature-measurement application.

Featured Products

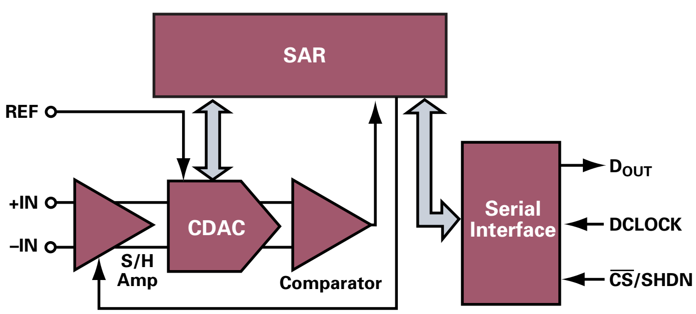
High-Speed, 16-Bit, Micropower Sampling ADCs
ADS8320, ADS8321, ADS8325

Get samples, datasheets, app reports and EVMs at:
www.ti.com/sc/device/PARTnumber
(Replace **PARTnumber** with **ADS8320**, **ADS8321** or **ADS8325**)

The ADS8320/21/25 are 16-bit sampling ADCs with guaranteed specifications over a 2.7-V to 5.5-V supply range (4.75-V to 5.25-V supply range for ADS8321). The devices require very little power even when operating at the full 100-kSPS data rate. At lower data rates, the devices' high speed enables them to spend most of their time in the power-down mode.

Key Features
- 100-kSPS sampling rate (ADS8320, ADS8321)
- Micropower:
  - 1.8 mW at 100 kSPS and 2.7 V (ADS8320)
  - 0.3 mW at 10 kSPS and 2.7 V (ADS8320)
  - 4.5 mW at 100 kSPS (ADS8321, ADS8325)
  - 1 mW at 10 kSPS (ADS8321, ADS8325)
- Power down: 3 µA max (ADS8320, ADS8321)
- Pin-compatible to ADS7816 and ADS7822 (ADS8325 also with ADS8320)
- Serial (SPI/SSI) interface
- Packaging: MSOP-8

Applications
- Battery-operated systems
- Remote and isolated data acquisition
- Simultaneous sampling, multichannel systems
- Industrial controls
- Robotics
- Vibration analysis



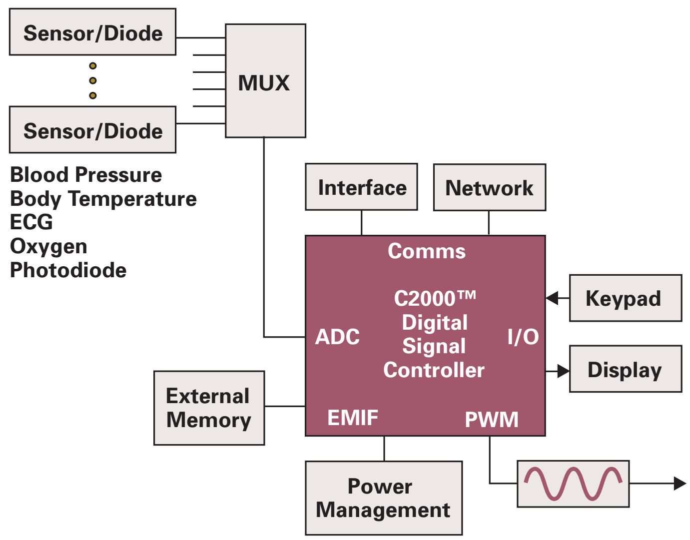
ADS8325 block diagram.

C2000™ Embedded Digital Signal Controller
TMS320C2000™

Get app reports and EVMs at: **www.ti.com/dmc**

With a combination of integrated peripherals, extensive base code, application software and a variety of package types, the C2000™ embedded digital signal controller is the best choice for many medical instrumentation systems.

TMS320C28x™ Benefits
- Truly efficient C/C++ engine
- Real-time general-purpose processing and debugging
- Software-programmable DSP architecture for math-intensive algorithms
- Microcontroller-like interrupt-based events
- Microcontroller-like peripheral integration
- Field reprogrammable systems



Block diagram of typical medical instrumentation applications.

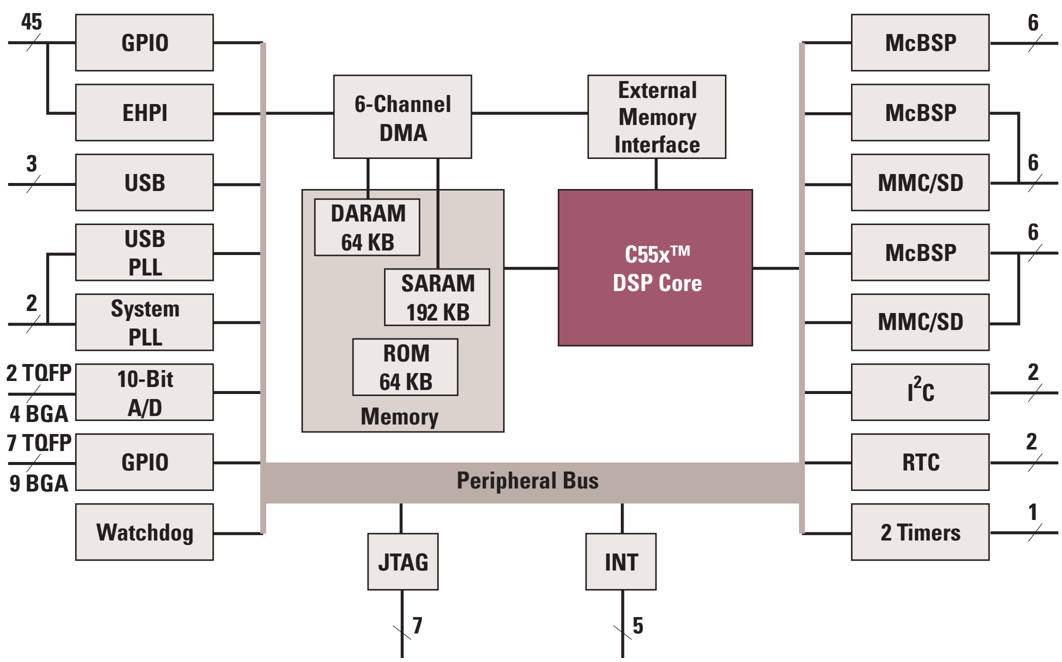
Power-Efficient Digital Signal Processors
TMS320C55x™ Fixed-Point DSPs

Get samples, datasheets and app reports at: **www.ti.com/c55xdsps**

TMS320C55x™ DSPs offer the optimal combination of performance, peripheral options, small packaging and power efficiency in the industry. This combination gives designers an edge while designing applications such as handheld medical imaging devices. TI's C55x™ DSPs offer power consumption as low as 0.33 mA/MHz and performance up to 600 MIPS.

Applications
- Feature-rich, miniaturized personal and portable products
- Handheld medical diagnostics
- Hearing aids
- Voice/speech recognition

Key Features
- Power consumption as low as 0.33 mA/MHz and performance up to 600 MIPS
- Active power: 65 to 194 mW
- C55x DSPs are 100% code-compatible with C5000™ DSPs
- Video hardware extensions (DCT, motion estimation, pixel interpolation)
- McBSP
- USB 2.0, full-speed
- 16-bit HPI
- 6-channel DMA
- 16/32-bit EMIF
- ADC
- I^2C
- MMC/SD
- UART
- Special instructions: variable-length (8- to 48-bit) instructions
- Packaging: MicroStar BGA™



The C55x™ DSP core is driving digital applications ranging from portable Internet appliances to high-speed wireless to power-efficient infrastructure.

Design Example

To Know More

For detailed information about TI products:

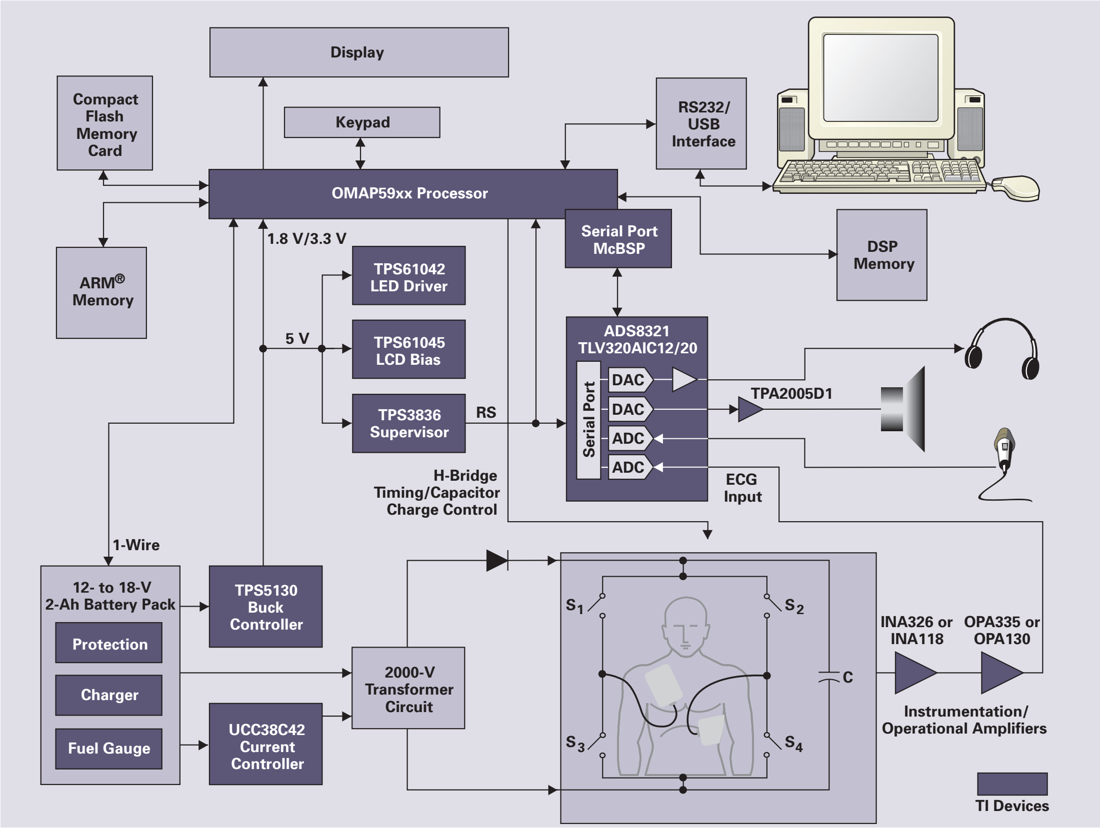
The automated external defibrillator (AED) is a highly sophisticated microprocessor-based device that monitors, assesses and automatically treats patients with life-threatening heart rhythms. It captures ECG signals from the therapy electrodes, runs an ECG-analysis algorithm to identify shockable rhythms, and then advises the operator about whether defibrillation is necessary. A basic defibrillator contains a high-voltage power supply, storage capacitor, optional inductor and patient electrodes (see block diagram). It develops an electrical charge in the capacitor to a certain voltage, creating the potential for current flow. The higher the voltage, the more current can potentially flow. The AED outputs audio instructions and visual prompts to guide the operator through the defibrillation procedure. In a typical defibrillation sequence, the AED provides voice prompts to instruct the user to attach the patient electrodes and starts acquiring ECG data. If the AED analyzes the patient's ECG and detects a shockable rhythm, the capacitor is charged according to energy stored in the capacitor, $W_c = \frac{1}{2}CV_c^2$; and capacitor voltage, $V_{c(t)} = V_{c(0)}e^{-t/RC}$, where R = R(lead) + R(chest).

Then, following the instructions, the operator presses the shock button to deliver the high-voltage pulse; and current begins flowing through the body to depolarize most of the heart cells, which often re-establishes coordinated contractions and normal rhythm. The amount of flowing current is determined by the capacitor and body impedance. The accompanying graph shows the level of current and the length of time the current flows through the body.

Many jurisdictions and medical directors also require that the AED record the audio from the scene of a cardiac arrest for post-event analysis. All AEDs include a means to store and retrieve patient ECG patterns.

The front-end signals of the AED come from the ECG electrodes placed on the patient, which requires an instrumentation amplifier to amplify its very small amplitude (<10 mV). The instrumentation amplifiers INA118/128/326 are designed to have:

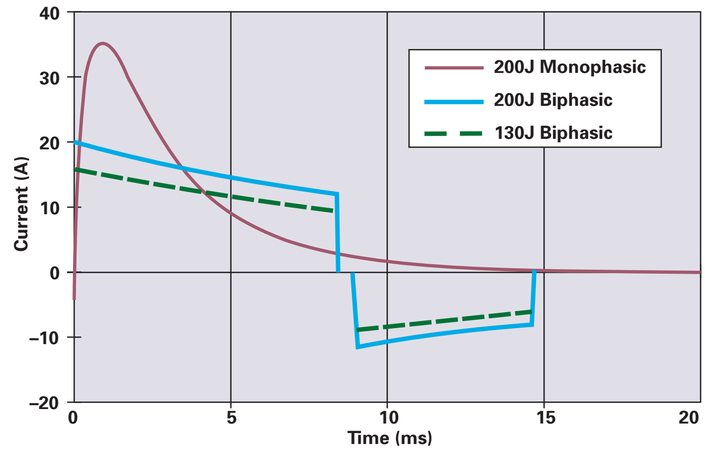
- capability to sense low-amplitude signals from 0.1 mV to 10 mV,
- very high input impedance (>5 MΩ),
- very low input leakage current (<1 µA),
- flat frequency response of 0.1 Hz to 100 Hz and
- high common-mode rejection ratio (CMRR) (>100 dB).



AED block diagram.

Design Example and Featured Products

The other front-end signal of the AED is the microphone input for recording the audio from the scene of a cardiac arrest. Both ECG and microphone input are digitized and processed by a DSP. Most AED designs use a 16-bit processor and therefore work well with 16-bit ADCs to digitize ECG and voice input. The amplified ECG signal has a bandwidth of 0.1 Hz to 100 Hz and requires a minimum SNR of 50 dB. The audio recording/playback signal typically has a bandwidth of 8 kHz and requires a minimum SNR of 65 dB. The microphone input also needs to be amplified with a maximum programmable gain of 40 dB. The AED can have synthesized audio instruction with volume control output to either the headphone speaker or the 8-Ω speaker. System designers will find that the TLV320AIC20 makes the AED front-end digitization very easy and simple because it integrates two ADCs, two DACs, a microphone amplifier, a headphone driver and an 8-Ω driver with volume control; and it can be gluelessly interfaced to a DSP.



Typical AED drive current.

Low-Power, Programmable 16-Bit, 26-kSPS Dual-Channel Codec
TLV320AIC20

Get datasheets, app reports and EVMs at:
www.ti.com/sc/device/TLV320AIC20

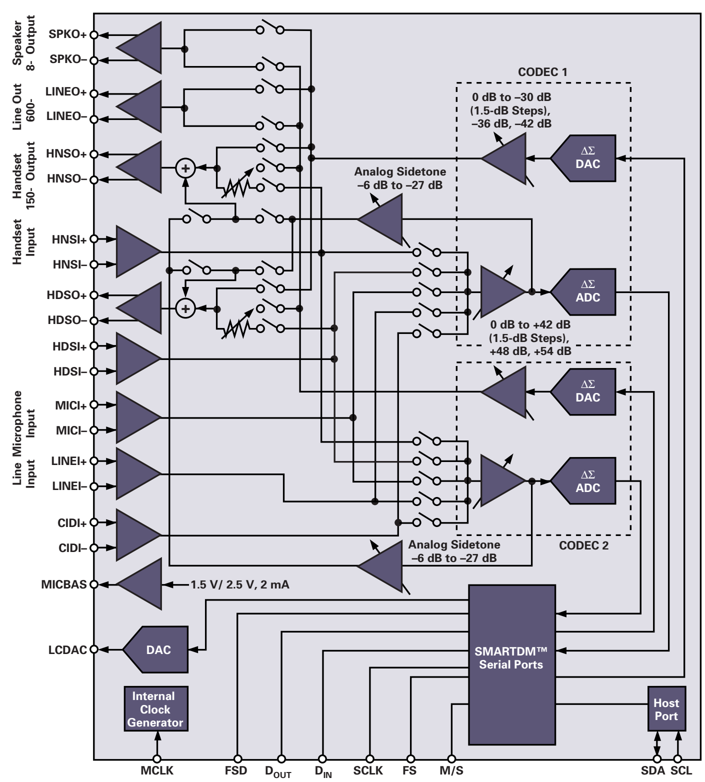
The TLV320AIC20 is a low-cost, low-power, highly integrated, high-performance, dual voice codec designed with new technological advances. It features two 16-bit ADC channels and two 16-bit DAC channels, which can be connected to a handset, headset, speaker, microphone or a subscriber line via a programmable analog crosspoint. The TLV320AIC20's SMARTDM™ serial port optimizes the multichannel buffered serial port (McBSP) operation of the DSP.

Key Features

- Two 16-bit oversampling ΔΣ ADCs
- Two 16-bit oversampling ΔΣ DACs
- Programmable sampling rate up to 26 kSPS with IIR/FIR on chip
- Support maximum master clock of 100 MHz
- Built-in functions:
  - Analog and digital sidetone
  - Anti-aliasing filter (AAF)
  - Programmable I/O gain control (PGA)
  - Microphone, handset, headset amplifiers
  - 8-Ω speaker driver
  - Power management with hardware and software power-down modes to 30 µW
- 81-dB SNR for ADC and 78-dB SNR for DAC over 13-kHz BW
- Fully compatible with TI TMS320C54x™ DSP power supplies:
  - 1.65-V to 1.95-V digital core power
  - 2.7-V to 3.6-V analog
- Power dissipation:
  - 20 mW at 3 V in standard operation
  - 30 mW at 3 V with headset/handset drivers
- Packaging: 48-pin TQFP

Applications

- ECG/EKG digitizing
- Data over IP
- Voice recording/playback



TLV320AIC20 functional block diagram.

Featured Products

OMAP™ Processors for Portable Medical Devices
OMAP5910, OMAP5912

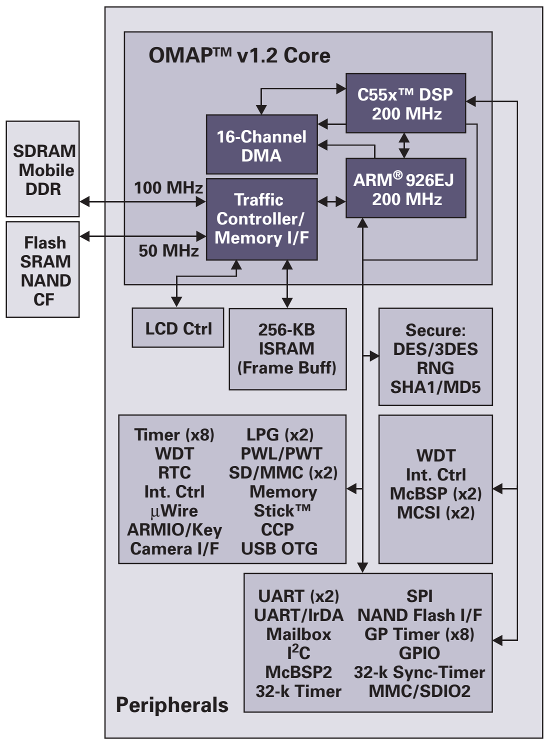
Get datasheets, app reports and EVMs at: **www.ti.com/sc/device/OMAP5910** or **www.ti.com/sc/device/OMAP5912**

The dual-core OMAP59xx processor integrates a TMS320C55x™ DSP core with a TI-enhanced ARM925 on a single chip for the optimal combination of application performance and low power consumption. This unique architecture offers an attractive solution to both DSP and ARM® developers by providing the low-power, real-time signal-processing capabilities of a DSP coupled with the command and control functionality of an ARM.

The OMAP59xx processors are ideal for designers working with devices that require embedded applications processing in a connected environment. The OMAP5912 is sampling today.

OMAP5912 Key Features
- OMAP™ V1.2
- 200-MHz ARM 926EJ
- 200-MHz C55x™ v2.x DSP
- 100-MHz MobileDDR bus (up to 1 GB)
- 50-MHz asynchronous bus (4 × 64 MB)
- 16-channel system DMA
- 256-KB on-chip SRAM
- USB-On-The-Go (OTG)
- (2) SD/MMC 4-bit
- Compact camera interface
- Self-powered RTC
- Lead-free packaging

Applications
- Portable medical devices
- Asset and inventory management



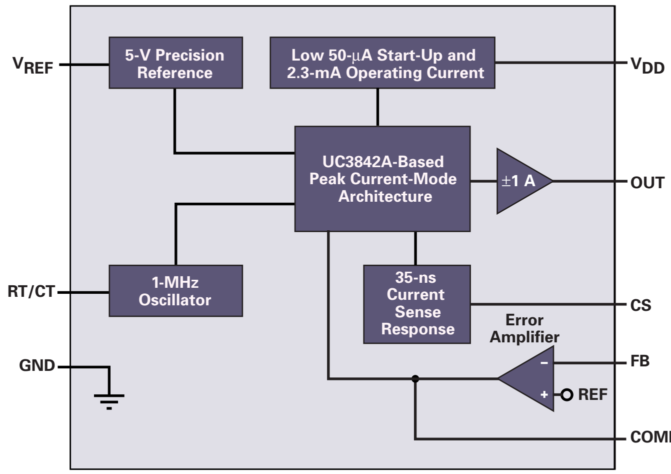
OMAP5912 functional block diagram.

Next-Generation, Current-Mode PWM Controllers Offer Lowest Power and Improved Efficiency
UCC38C4x

Get samples, datasheets and app reports at:
www.ti.com/sc/device/PARTnumber
(Replace **PARTnumber** with **UCC38C40**, **UCC38C41**, **UCC38C42**, **UCC38C43**, **UCC38C44** or **UCC38C45**)

Key Features
- Fastest overcurrent protection: 35-ns delay
- Low, 50-µA start-up current
- Low operating current: 2.3 mA at 50 kHz
- ±1-A peak output current
- Rail-to-rail output swings with 25-ns rise and 20-ns fall times
- ±1% initial trimmed 2.5-V error amplifier reference
- Trimmed oscillator discharge current
- Packaging: 8-pin DIP, 8-pin SOIC and 8-lead MSOP, which minimizes space

Applications
- Switch-mode power supplies
- DC-to-DC converters
- Board-mount power supplies
- Telecom, industrial, medical



UCC38C42 block diagram.

Featured Products

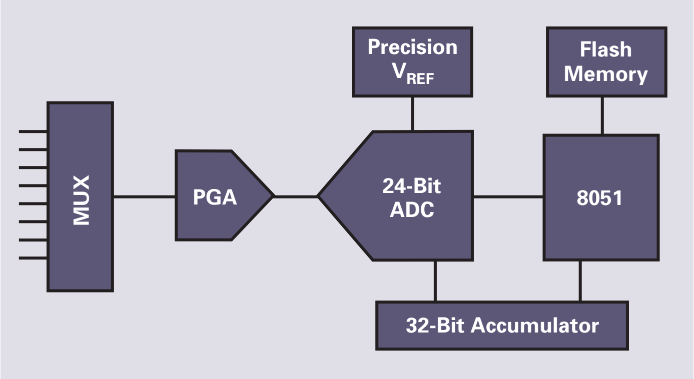
Lowest-Noise Precision Data-Acquisition System-On-a-Chip
MSC1210

Get samples, datasheets, app reports and EVMs at:
www.ti.com/sc/device/MSC1210Y2

The MSC1210 utilizes an enhanced 8051 core with on-chip Flash memory in combination with high-performance analog and peripherals to achieve unparalleled system performance. The integration of the analog and digital cores gives the ability to customize the device to meet specific requirements. It would be extremely costly and difficult to achieve this same level of flexibility and performance using multiple devices. The noise performance of the ADC is better than most stand-alone ADCs on the market and is significantly better than any comparable mixed-signal device available. The accuracy and drift of the V_{REF} is orders of magnitude better than other integrated peripherals, pushing the performance envelope of digital processing to among the best in the industry.

Key Features
- 24-bit ADC with no missing codes
- 22-bits effective resolution
- Eight differential/single-ended analog inputs
- 8051-compatible with up to 8-MIPS operation
- Up to 32-KB on-chip Flash program memory
- PGA 1 to 128
- Precision V_{REF}
- Packaging: 64-lead TQFP

Applications
- Portable instrumentation
- Intelligent sensors
- Liquid/gas chromatography
- Weight scales



MSC1210 block diagram.

15-ppm/°C Max, 100-µA, SOT23-3 Series Voltage Reference
REF31xx

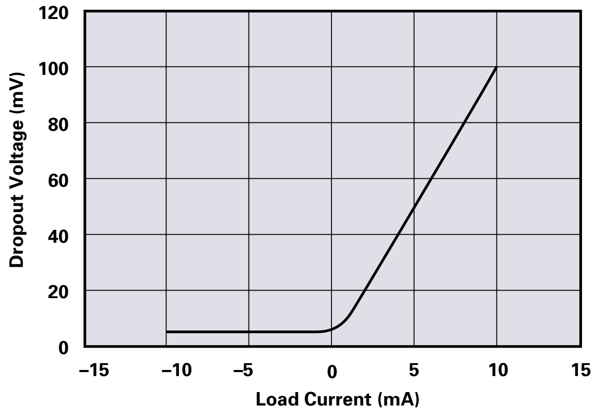
Get samples, datasheets and app reports at:
www.ti.com/sc/device/PARTnumber
(Replace **PARTnumber** with **REF3112**, **REF3120**, **REF3125**, **REF3130**, **REF3133** or **REF3140**)

The new REF31xx is a cost-effective precision voltage reference family. It is well-suited to a wide range of medical applications, particularly those requiring a combination of low power consumption and high precision. With six different output voltage options available, the REF31xx complements a wide range of data converters and converter input-signal levels.

Key Features
- 0.2% max accuracy
- 15-ppm/°C max drift (12 typ)
- ±10-mA output current
- 100-µA max supply current
- Packaging: SOT23-3

Applications
- Medical equipment
- Portable, battery-powered equipment
- Data acquisition systems
- Handheld test equipment
- Low power spot LDO

Product	Voltage (V)
REF3112	1.25
REF3120	2.048
REF3125	2.5
REF3130	3.0
REF3133	3.3
REF3140	4.096



REF3112 typical dropout voltage vs. load current.

Design Example

To Know More

For detailed information about TI products:

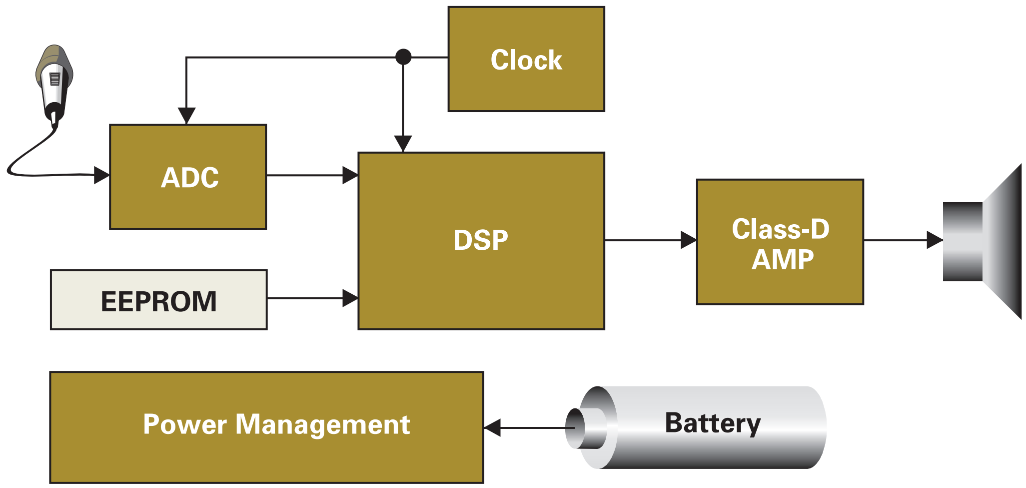
Designers of hearing aids have stringent technological requirements. Hearing aids must be small enough to fit inside or behind one's ear, run with extremely low power, and introduce no noise or distortion. To achieve these requirements, current hearing aid devices consume less than 1 mA, operate at 1 V, and utilize less than 10 mm^2 of silicon area, which usually means two or three devices stacked on top of each other. The typical analog hearing aid consists of an amplifier with a non-linear input/output function and a frequency dependent gain. However, this analog processing suffers from a dependency on custom circuits, lack of programmability and a higher cost when compared to digital processing. Recent digital devices have reduced device costs and lowered power consumption compared to their analog counterparts. The greatest advantage offered by digital devices is their improved processing power and programmability, allowing hearing aids to be customized to a specific hearing impairment and environment. Instead of a simple sound amplification and adjustable frequency compensation, more complex processing strategies can be achieved to improve the sound quality presented to the impaired ear. Such strategies, however, require the sophisticated processing that a DSP can provide.

Typically, hearing loss is divided into two categories: conductive hearing loss and sensorineural hearing loss (SNHL). A conductive hearing loss occurs when the transduction of sound through the patient's outer or middle ear is abnormal, and SNHL occurs when either the sensory cells in the cochlea or the neural mechanisms higher in the auditory system fail.

With a conductive hearing loss, sound is not properly transmitted through the middle or outer ear. Because sound is primarily attenuated with a conductive loss, amplification of sound is essentially all that is required to restore near-normal hearing. No special signal processing is necessary, and traditional analog hearing aids work well. However, only 5% of those inflicted with some hearing loss are attributed to conductive losses alone.

SNHL includes hearing loss that is associated with aging, as well as noise-induced hearing loss and loss caused by drugs that are harmful to the auditory system. Most types of SNHL appear to be caused by a cochlear malfunction. SNHL is thought to be caused by damage to inner hair cells, outer hair cells or both. However, the underlying physiology is complicated. Different people will have different pathologies, which means that patients with identical audiograms will not necessarily have the same kind of hearing loss. Further, patients may even have differing kinds of impairment over different frequency ranges.

The effects of SNHL usually result in lack of input in some frequency channels, lack of sensitivity, and widened auditory filters. These effects, in turn, significantly impact the listener's perception of sound. Compared to listeners with normal hearing, listeners with SNHL will most likely experience loudness recruitment (the range of comfortable listening levels is compressed when compared with normal) and loss of frequency resolution, among other difficulties. These changes in sound perception have significant effects on a listener's ability to understand speech.



DSP-based hearing aid block diagram.

Design Example

Because SNHL is not simply a problem with the transmission of sound, but actually a problem with the processing of sound, this loss is not likely remedied through simple amplification—making garbled sounds louder does not make them clearer. Therefore, one potentially effective way to help an SNHL patient is through pre-processing the signal to enhance complex tonal patterns to compensate for the hearing loss.

It is unlikely that the various manifestations of SNHL will be remedied by the same optimal treatment. Processing of the sound can make speech more intelligible. However, the best processing algorithms will differ among individuals and may even change for one individual in different listening conditions such as a quiet room versus a noisy stadium. The key to accommodating these differences is hearing aid flexibility.

Traditionally, hearing aids have been amplifiers encased in custom ear-molds fitted to the end user. The hearing aid system contains a microphone, an amplifier, a Zinc-Air battery and a receiver/speaker. Most of these amplifiers incorporate some kind of compression function, essentially a non-linear input/output relationship, that is used to compensate for loudness recruitment. Also, the gain in different frequency bands can be adjusted, and the number of frequency bands varies, but is usually two or three bands. Many of the newest aids are digitally programmable, which means that although they have analog signal processing, the processing is controlled by digital parameters that can be adjusted by an audiologist. In addition, some analog aids have several "programs," or sets of parameters, for different listening environments.

Some of the digital hearing aids in the market are ASICs with programmable coefficients. These ASICs provide a few sets of algorithms and several frequency bands that were not possible in typical analog devices. For example, the digital hearing aids have a combination of the following features: 2 to 14 frequency bands with adjustable crossover frequencies, one microphone, dual microphones for directional listening, background noise reduction, automatic gain control (AGC), speech enhancement, feedback reduction and loud sound protection. Overall, the amount of processing that can be done is impressive, especially when compared with the traditional processing in an analog aid.

A DSP-based hearing aid could expand software-controlled features to include: frequency shaping, feedback reduction, noise reduction, binaural processing, pinna and ear canal filtering, reverberation reduction and a provision for direct digital input from a digital telephone, TV or other audio devices. A programmable DSP also means that the hearing aid algorithms and features could be customized or changed without changing the hardware. Hearing-aid practitioners could economically experiment with available algorithms on a near real-time basis. It would even be possible to have user-selectable programs for switching to highly processed sound in difficult listening situations or back to traditional, less distorted sound in quiet environments.

The block diagram on the previous page shows the primary elements for a DSP-based digital hearing aid. A typical digital hearing aid consists of three semiconductor die stacked on top of each other: EEPROM or non-volatile memory, a digital device and an analog device. Recent advances have allowed the integration of these modules into two or even one semiconductor die. Due to the battery's range of voltage from 1.35 V to 0.9 V, these devices are designed to operate at 0.9 V. Some implementations use power management to monitor battery voltage and alert the user when the battery is low and gracefully shut down the system when the voltage drops too low. The analog device normally includes the sigma-delta analog-to-digital converter, microphone preamplifier with compression input limiting function, remote control data decoder, clock oscillator and voltage regulator. The sigma-delta ADC typically has a frequency range of 20 kHz with 16 bits of resolution (14-bit linear). The digital device includes the DSP, logic support functions, programming interface and the output stage. The output stage is normally all digital and uses a pulse-width-modulated (PWM) output with Class D amplifiers that utilizes the speaker impedance to perform the analog-to-digital conversion.

Overall, the power consumption in current analog and digital hearing aids is approximately equal. Total current consumption is about 0.7 mA to 1.0 mA in the analog devices, whereas digital devices consume 0.5 mA to 0.7 mA. A 1.35-V zinc-air battery that provides around 30 to 65 mAh with a 50-µA self-discharge current powers this system. The end-of-life voltage is about 0.9 V. Due to the increased amount of processing in the digital aids, however, a straight comparison of consumption between digital and analog aids is not entirely fair. Digital aids with processing abilities equivalent to those of analog aids would consume even less power.

Featured Products

Micropower Audio Codec
AIC111

Get samples, datasheets, app reports and EVMs at:
www.ti.com/sc/device/AIC111

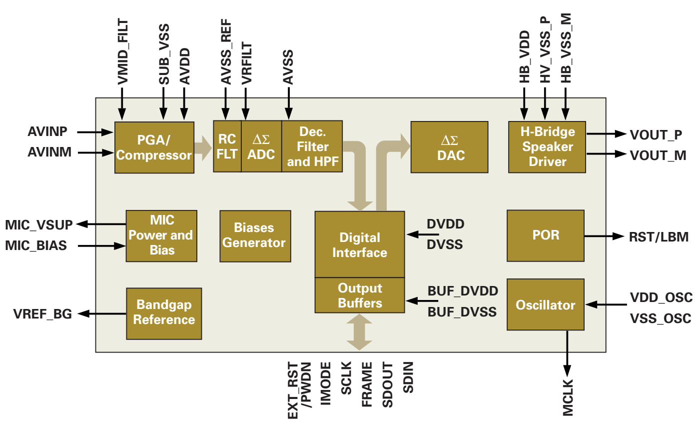
The AIC111 is a micropower DSP- or microcontroller-compatible audio codec that provides a high-performance analog interface solution for applications such as personal medical devices—hearing aids, aural preprocessing—and low-power headsets. The AIC111 supports a 1.3-V CMOS digital SPI interface and includes an external microphone supply and bias, and low battery monitor and indicator.

Key Features

- 400-µW full power operation at 1.3-V supply
- ADC specifications:
  - Dynamic range: 87 dB
  - THD: 73dB at 100 Hz to 10 kHz
  - Sample rate: 40 kSPS
- Low noise PGA/gain compressor front end
- On-chip low-jitter oscillator generates all internal clocks and generates 5-MHz output DSP/microcontroller clock
- SPI interface supports TMS320VC540x, TMS320VC550x DSP protocol and MSP4330F12x microcontroller protocol
- H-bridge output stage for efficient output speaker drive
- 1.3-V nominal power supply
- Packaging: 32-lead QFN or FlipChip bare die

Applications

- Personal medical devices
- Low-power headset applications



AIC111 functional diagram.

Power-Efficient Digital Signal Processor
TMS320C5402 Fixed-Point DSP

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

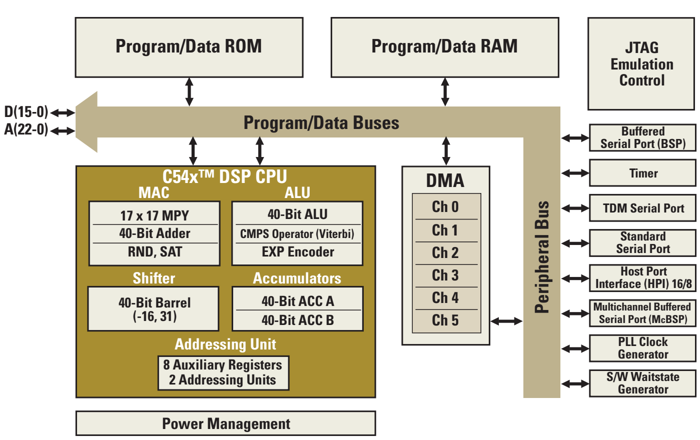
TMS320C5402 DSP offers the power efficiency needed to sustain battery life for digital hearing aids. At 160 MHz, this processor provides an arithmetic logic unit (ALU) with a high degree of parallelism, application-specific hardware logic, on-chip memory and additional on-chip peripherals. The basis of the operational flexibility and speed of this DSP is a highly specialized instruction set.

Key Features

- Advanced multibus architecture with three separate 16-bit data memory buses and one program memory bus
- 40-bit ALU
- Compare, select and store unit (CSSU) for the add/compare selection of the Viterbi operator
- Extended addressing mode for 8M × 16-bit maximum addressable external program space
- 16K × 16-bit on-chip RAM composed of two blocks of 8K × 16-bit on-chip dual-access program/data RAM
- Single-instruction-repeat and block-repeat for program code
- Conditional store instructions
- On-chip peripherals:
  - Software-programmable wait-state generator and bank-switching
  - On-chip programmable phase-locked loop (PLL) clock generator with internal oscillator or external clock source
  - One 16-bit timer
  - 6-channel direct memory access (DMA) controller
  - Three multichannel buffered serial ports (McBSPs)
  - 8/16-bit enhanced parallel host/port interface (HPI8/16)
- Power consumption control with IDLE1, IDLE2 and IDLE3 instructions
- CLKOUT off control to disable CLKOUT
- Packaging: 144-pin BGA and 144-pin low-profile quad flatpack (LQFP)

Applications

- Digital hearing aids



TMS320C54x™ block diagram.

UART and IR Encoder/Decoder Featured Products

To Know More

For detailed information about TI products:

Texas Instruments provides complete interface solutions that empower you to differentiate your products and accelerate time to market. TI's expertise in high-speed, mixed-signal circuits, system-on-a-chip integration and advanced product development processes ensures you will receive the silicon, support tools, software and technical documentation to create and deliver the best products on time and at competitive prices.

Please read on to learn about TI's interface solutions for medical applications, including UARTs, IR encoder/decoder, 1394, USB and PCI bridges. More information on TI's line of interface solutions can be found at **interface.ti.com**

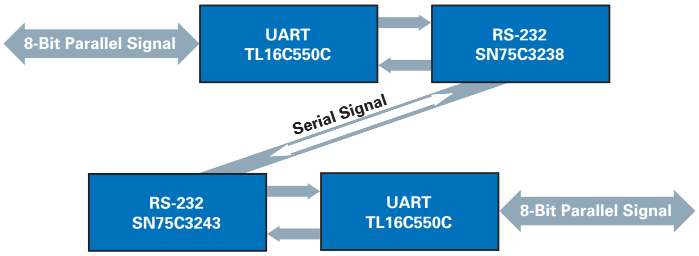
Single and Dual UARTs
TL16C550C, TL16C552A, TL16C750, TL16C752B

Get samples, datasheets and EVMs at:
www.ti.com/sc/device/PARTnumber
(Replace **PARTnumber** with **TL16C550C**, **TL16C552A**, **TL16C750** or **TL16C752B**)

A wide portfolio of space-saving, performance-enhancing UARTS are pin-for-pin compatible with many leading UART manufacturers' devices. The TL16C550C is a 3.3-V/5-V single-channel, industry-standard UART that performs serial-to-parallel and parallel-to-serial data conversion. The TL16C552A enhanced, dual-channel device serves two serial input/output interfaces simultaneously and adds a bi-directional line printer port. The TL16C750 offers a 64-byte FIFO with 16- or 64-byte FIFO programmability. The TL16C752B is a high-performance, dual UART with a 64-byte FIFO capable of 2.9-Mbps data transfer.

Key Features
- Single-, dual- and quad-channel devices available
- Hardware and software auto-flow control
- Programmable sleep mode and low-power mode
- Industrial temperature range available
- Choice of 5-V and 3.3-V supply

Applications
- Medical monitors and scanners



Typical UART system.

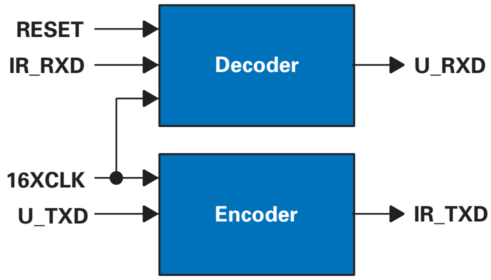
Stand-Alone IrDA Encoder and Decoder
TIR1000

Get samples, datasheets, app reports and EVMs at:
www.ti.com/sc/device/TIR1000

The TIR1000 serial infrared (SIR) encoder/decoder is a CMOS device which encodes and decodes bit data in conformance with the IrDA specification. A transceiver device is needed to interface to the photo-sensitive diode (PIN) and the light-emitting diode (LED). A UART is needed to interface to the serial data lines.

Key Features
- Adds infrared (IR) port to UARTs
- Compatible with IrDA and Hewlett Packard serial infrared (HPSIR)
- Provides 1200 bps to 115 kbps data rate
- Operates from 2.7 V to 5.5 V
- Provides simple interface with UART
- Decodes negative or positive pulses
- Available in two 8-terminal PSOP packages

Applications
- Medical instrumentation



TIR1000 functional block diagram.

1394 Featured Products

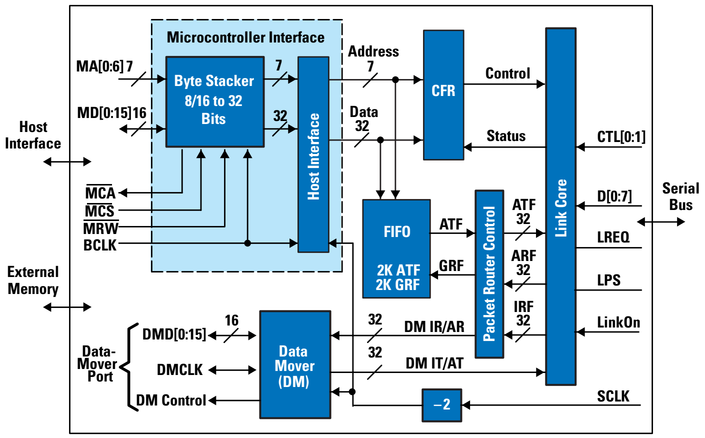
General-Purpose Link-Layer Controller
TSB12LV32

Get samples, datasheets and app reports at:
www.ti.com/sc/device/TSB12LV32

The TSB12LV32 (GP2Lynx) is a high-performance, general-purpose 1394a link-layer controller (LLC) that can transfer data between a host controller, the 1394 PHY-link interface and external devices connected to the local bus interface. The LLC provides the control for transmitting and receiving 1394 packet data between the microcontroller interface and the PHY-link interface via internal 2-KB FIFOs at rates up to 400 Mbps.

Key Features
- Compliant with IEEE 1394-1995 standards and P1394a supplement for high-performance serial bus
- Link core:
  - Transmits and receives correctly formatted 1394 packets
  - Supports asynchronous and isochronous data transfers
  - Contains 2-KB asynchronous-transmit and 2-KB general-receive FIFOs
- PHY interface supports transfer speeds of 400, 200 or 100 Mbps
- Glueless interface to 68000 and ColdFire® microcontrollers/ microprocessors
- Programmable microcontroller interface with 8-bit or 16-bit data bus, multiple modes of operation including burst mode and clock frequency to 60 MHz
- 8-bit or 16-bit data-mover port (DM Port) supports isochronous, asynchronous and streaming transmit/receive from an unbuffered port at a clock frequency of 25 MHz
- Single 3.3-V supply operation with 5-V tolerance using 5-V bias terminals
- Packaging: High-performance 100-pin PZ

Applications
- Vision systems
- Instrumentation
- Command and control
- IDB-1394



TSB12LV32 block diagram.

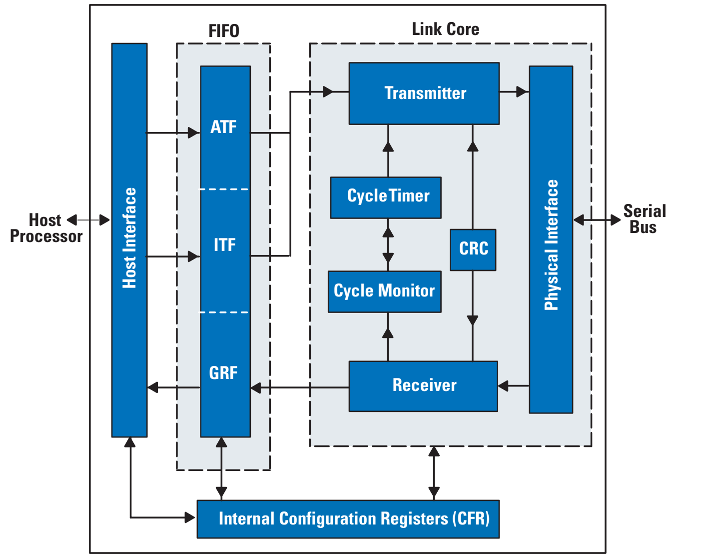
High-Speed Serial-Bus Link-Layer Controller
TSB12LV01B

Get samples, datasheets and app reports at:
www.ti.com/sc/device/TSB12LV01B

The TSB12LV01B is an IEEE 1394-1995 high-speed serial-bus link-layer controller that allows for easy integration into an I/O subsystem. The TSB12LV01B provides a high-performance 1394 interface with the capability of transferring data between the 32-bit host bus, the 1394 PHY-link interface, and external devices connected to the local bus interface. The link-layer controller provides the control for transmitting and receiving 1394 packet data between the FIFO and PHY-link interface at rates of 100, 200 and 400 Mbps.

Key Features
- Compliant with IEEE 1394-1995 standards for high-performance serial bus
- Link core:
  - Transmits and receives correctly formatted 1394 packets
  - Supports asynchronous and isochronous data transfers
  - Contains asynchronous, isochronous, and general-receive FIFOs totaling 2 KB
- PHY interface supports transfer speeds of 100, 200 and 400 Mbps
- Host bus interface provides chip control with directly addressable registers and is interrupt-driven to minimize host polling
- Single 3.3-V supply operation with 5-V tolerance using 5-V bias terminals
- Packaging: 100-pin PZT for –40°C to 85°C operation

Applications
- Vision systems
- Instrumentation
- Command and control
- IDB-1394



TSB12LV01B block diagram.

1394 and USB Featured Products

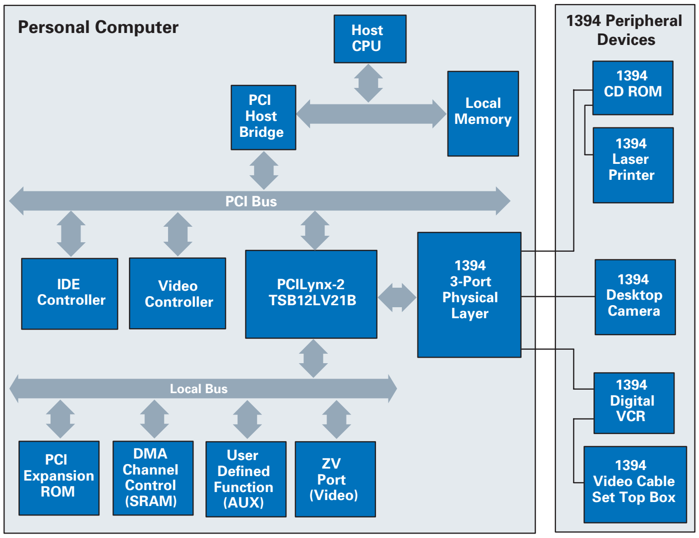
(PCILynx-2) IEEE 1394 Link-Layer Controller
TSB12LV21B

Get samples, datasheets and app reports at:
www.ti.com/sc/device/TSB12LV21B

The TSB12LV21B (PCILynx-2) provides a high-performance IEEE 1394-1995 interface that can transfer data between the 1394 PHY-link interface, the PCI bus interface and external devices connected to the local bus interface. The 1394 PHY-link interface provides the connection to the 1394 physical layer device; it is supported by the onboard link-layer controller (LLC). The LLC provides the control for transmitting and receiving 1394 packet data between the FIFO and PHY-link interface at rates of 100, 200, and 400 Mbps.

Key Features
- IEEE standard for 1394-1995 and 1212-1991 compliant
- Supports IEEE 1394-1995 link-layer control
- PCI local bus specification Rev. 2.1 compliant
- 3.3-V core logic while maintaining 5-V-tolerant inputs
- Performs the function of 1394 cycle master
- Provides 4 Kbytes of configurable FIFO RAM

Applications
- 1394 embedded host controller
- 1394 PC host controller
- Instrumentation
- Command and control



Typical application featuring the TSB12LV21B.

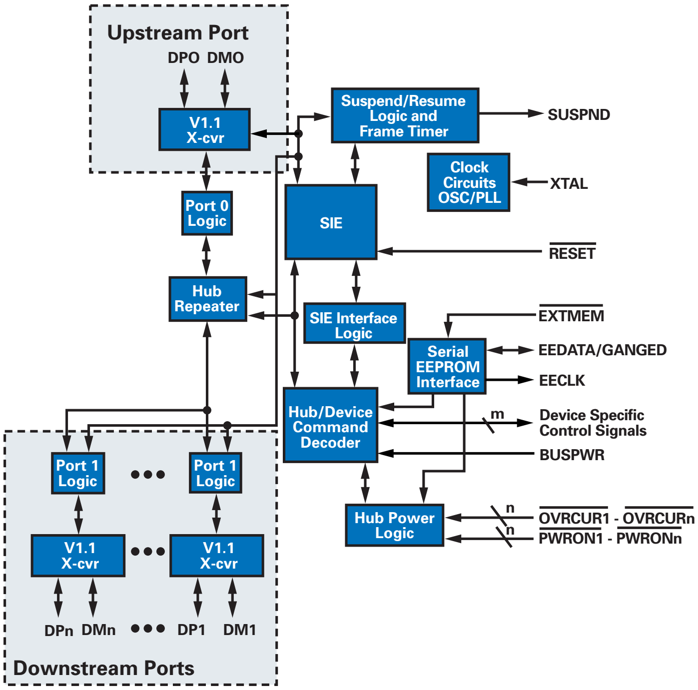
Industry-Leading USB 1.1 Hub Controller
TUSB2036, TUSB2046B, TUSB2077A

Get samples, datasheets, app reports and EVMs at:
www.ti.com/sc/device/PARTnumber
(Replace **PARTnumber** with **TUSB2036**, **TUSB2046B** or **TUSB2077A**)

TI offers a variety of USB hub ICs for various applications that are fully compliant to the USB 1.1 specification and are on the USB-IF integrator's list.

Key Features
- Self- and bus-powered support
- USB suspend/resume operation support
- Custom VID and PID with external serial EEPROM
- ESD filtering for babble, overcurrent, reset, bus-powered inputs
- TUSB2036: Pin-selectable configuration for 2 or 3 ports
- TUSB2046B: 4-port hub
- TUSB2077A: 7-port hub, self-powered for 7 ports and bus-powered for 4 ports

Applications
- Stand-alone hub boxes
- Motherboard
- Monitor with embedded control functions
- Embedded in peripheral (printer, scanners)
- All-in-one control unit



TUSB20xx block diagram.

USB and PCI Bridge Featured Products

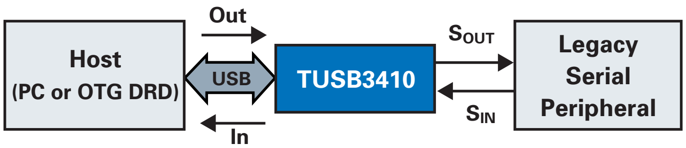
USB-to-Serial Bridge
TUSB3410

Get samples, datasheets, app reports and EVMs at:
www.ti.com/sc/device/TUSB3410

The TUSB3410 provides an easy way to move your serial-based legacy device to a fast, flexible USB interface by bridging between a USB port and an enhanced UART serial port. The TUSB3410 contains all the necessary logic to communicate with the host computer using the USB bus.

Key Features
- USB full-speed compliant: data rate of 12 Mbps
- 8052 microcontroller with 16 Kbytes of RAM that can be loaded from the host or from external onboard memory via an I^2C bus
- Integrated, enhanced UART features including:
  - Programmable software/hardware flow control
  - Automatic RS-485 bus transceiver control, with and without echo
  - Software-selectable baud rate from 50 to 921.6 kbaud
  - Built-in, two-channel DMA controller for USB/UART bulk I/O
- An evaluation module can jump-start your USB development, or you can use it as a complete USB-to-RS-232 converter

Applications
- Handheld meters
- Health metrics/monitors
- Any legacy serial device that needs to be upgraded to USB



TUSB3410 data flow.

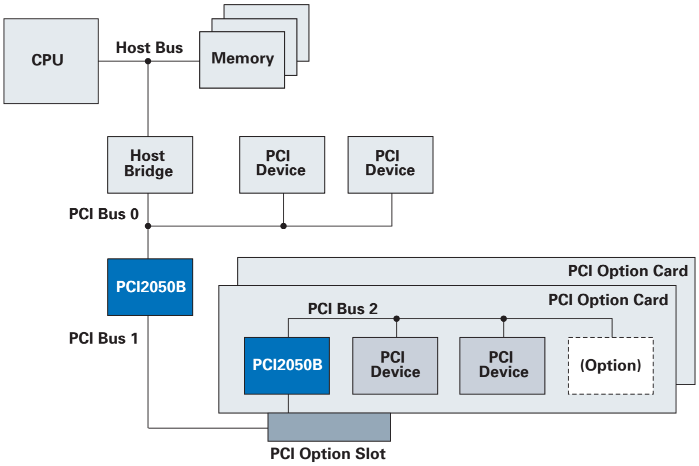
32-Bit, 66-MHz PCI-to-PCI Bridge
PCI2050B

Get samples and datasheets at: **www.ti.com/sc/device/PCI2050B**

The PCI2050B PCI-to-PCI bridge provides a high-performance connection path between two peripheral component interconnect (PCI) buses operating at a maximum bus frequency of 66 MHz. Transactions occur between masters on one and targets on another PCI bus, and the PCI2050B allows bridged transactions to occur concurrently on both buses.

Key Features
- Two 32-bit, 66-MHz PCI buses
- Compliant with PCI-to-PCI Bridge Spec, Rev 1.1
- 3.3-V core logic with universal PCI interfaces compatible with 3.3-V and 5-V PCI signaling environments
- Internal two-tier arbitration for up to nine secondary bus masters and supports an external secondary bus arbiter
- Ten secondary PCI clock outputs
- Burst data transfers with pipeline architecture to maximize data throughput in both directions
- CompactPCI hot-swap functionality
- 208-terminal PDV, 208-terminal PPM or 257-terminal MicroStar BGA™ package

Applications
- Server add-ons
- Data storage
- System control backplanes



Typical PCI2050B application.

Little Logic: Single-, Dual- and Triple-Gate Logic Devices

Get samples, datasheets and app. reports at: **www.ti.com/littlelogic**

Little Logic offers voltage-range operating levels from 5.5-V all the way down to sub-1-V V_{CC} and can be utilized with AHC/T (5-V), LVC (3.3-V), and AUC (1.8-V) product families. Designs that require signal switching can take advantage of TI's CBT Little Logic families. The CBT devices provide bus switch solutions in a variety of options including CBTD for 5-V to 3.3-V translation and CBTLV for low-voltage operation. Little Logic provides packaging options in 5-, 6- and 8-pin packages, including NanoStar™ and NanoFree™, that are 70% smaller than the 5-pin SC-70 and 13% smaller than any other logic package available today.

Key Features

- 1.8-V to 5.5-V optimized performance
- Sub 1 V operation with AUC Little Logic
- World's smallest package NanoStar™
- Low-voltage bus switching (CBTLV)
- Pb-Free offering
- Packaging: See below

Applications

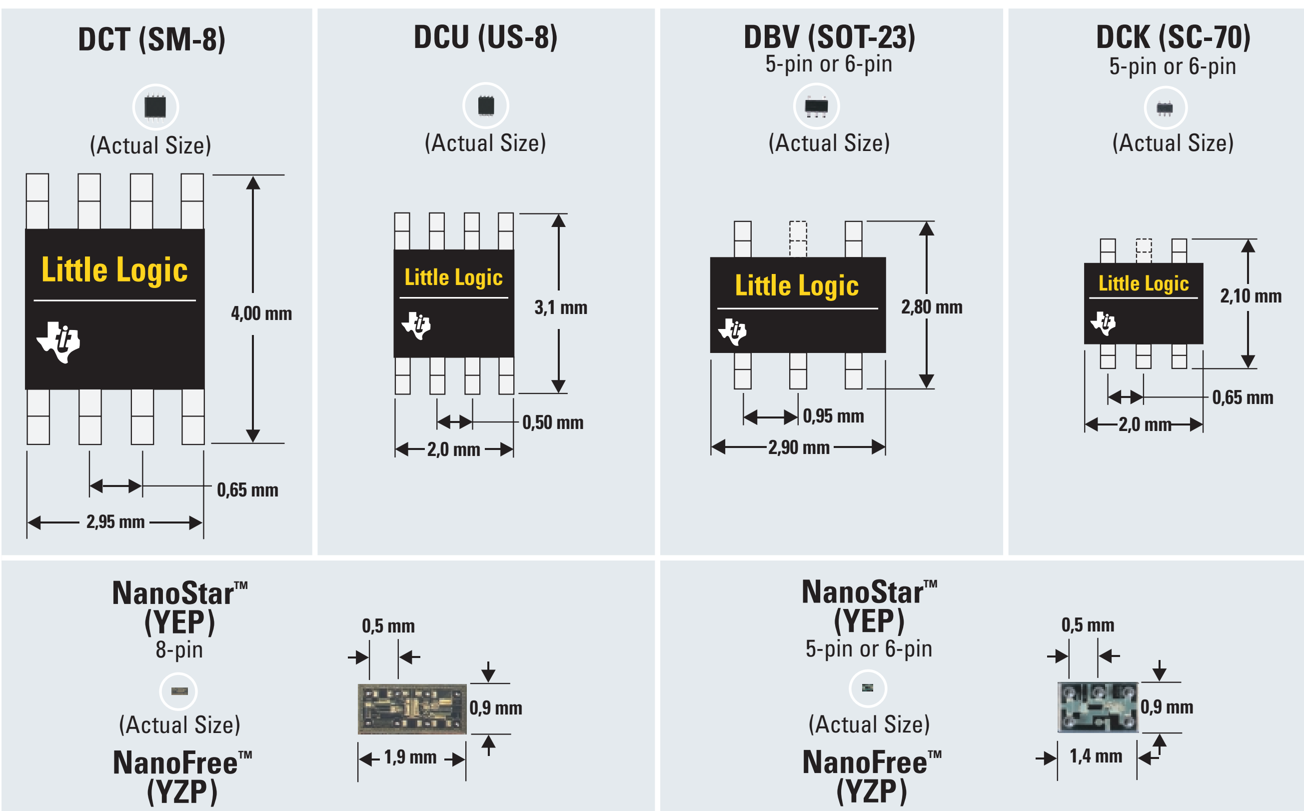
- Portable media device
- PDA/pocket PC
- Cellular phone
- Computing

Little Logic Performance Comparisons

Family	Operating Voltage Range (V)	Optimized Voltage (V)	Propagation Delay, t_{pd} (ns) (typ)	Output Drive (mA)	Input Tolerance (V)	I_{OFF} Protection
AUC	0.8 to 2.7	1.8	2.0	8	3.6	Yes
LVC	1.65 to 5.5	3.3	3.5	24	5.5	Yes
AHC	2.0 to 5.5	5.0	5.0	8	5.5	No
AHCT	4.5 to 5.5	5.0	5.0	8	5.5	No
CBT	4.5 to 5.5	5.0	0.25[1]	—[2]	5.5	Yes
CBTD	4.5 to 5.5	5.0	0.25[1]	—[2]	5.5	Yes
CBTLV	2.3 to 3.6	3.3	0.25[1]	—[2]	3.6	Yes

[1]The propagation delay is the calculated RC time constant of the typical on-state resistance of the switch and the specified load capacitance, when driven by an ideal voltage source (zero output impedance). The value listed is a maximum.

[2]The FET switch has no output drive. The drive current at the output terminal is determined by the drive current of the device connected at the input terminal of the FET switch.



Space-saving Little Logic packages.

Amplifiers

Voltage-Controlled Amplifiers

Device	Channels	Voltage Noise (nV/√Hz)	Low-Noise Pre-Amplifier	Power Per Channel (mW)	Gain Range (dB)	Analog Supply (V)	Package	Price[1]
VCA2611	2	1	Yes	205	40	5.0	TQFP-48	9.97
VCA2616	2	1	Yes	205	40	5.0	TQFP-48	9.75
VCA2619	2	5.9	No	120	50	5.0	TQFP-32	7.97
VCA8613	8	1.5	Yes	88	40	3.0	TQFP-64	25.40

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

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

Difference Amplifiers

Device	Description	Spec[1] Temp Range	Ch.	Gain	Offset (μV) (max)	Offset Drift (μV/°C) (max)	CMRR (dB) (min)	BW (MHz) (typ)	Output Voltage Swing (V) (min)	Power Supply (V)	I_Q (mA) (max)	Package(s)	Price[3]
General Purpose													
INA132	Micropower, High-Precision	I	1, 2	1	250	5	76	0.3	(V+) – 1 to (V–) + 0.5	+2.7 to +36	0.185	DIP, SO	0.99
INA133	High-Precision, Fast	I	1, 2	1	450	5	80	1.5	(V+) – 1.5 to (V–) + 1	±2.25 to ±18	1.2	SOIC-8/-14	0.99
INA143	High-Precision, G = 10 or 1/10	I	1, 2	10, 1/10	250	3	86	0.15	(V+) – 1 to (V–) + 0.5	±2.25 to ±18	1.2	SOIC-8/-14	0.99
INA145	Resistor Programmable Gain	I	1, 2	1-1000	1000	10[2]	76	0.5	(V+) – 1 to (V–) + 0.5	±1.35 to ±18	0.7	SOIC-8	1.40
INA152	Excellent Swing to Rail	I	1	1	750	5	86	0.7	(V+) – 0.2 to (V–) + 0.2	+2.7 to +20	0.65	MSOP-8	1.10
INA154	High-Speed, Precision, G = 1	I	1	1	750	20	80	3.1	(V+) – 2 to (V–) + 2	±4 to ±18	2.9	SOIC-8	0.99
INA157	High-Speed, G = 2 or 1/2	I	1	2, 1/2	500	20	86	4	(V+) – 2 to (V–) + 2	±4 to ±18	2.9	SOIC-8	0.99
Audio													
INA134	Low Distortion: 0.0005%	I	1, 2	1	1000	2[2]	74	3.1	(V+) – 2 to (V–) + 2	±4 to ±18	—	SOIC-8/-14	0.99
INA137	Low Distortion, G = 1/2 or 2	I	1, 2	2, 1/2	1000	2[2]	74	4	(V+) – 2 to (V–) + 2	±4 to ±18	2.9	SOIC-8/-14	0.99
High Common-Mode Voltage													
INA117	±200-V CM Range	I	1	1	1000	20	86	0.2	(V+) – 5 to (V–) + 5	±5 to ±18	—	SOIC-8	2.70
INA146	±100-V CM Range, Prog. Gain	I	1	0.1-100	5000	100[2]	70	0.55	(V+) – 1 to (V–) + 0.15	±1.35 to ±18	0.7	SOIC-8	1.60
INA148	±200-V CM Range, 1-MΩ Input	I	1	1	5000	100[2]	70	0.1	(V+) – 1 to (V–) + 0.25	±1.35 to ±18	0.3	SOIC-8	1.95

[1]I = –40°C to +85°C.
[2]Denotes single supply.
[3]Suggested resale price in U.S. dollars in quantities of 1,000.

Current Shunt Monitors

Device	Description	Ch.	Gain (μV)	Offset (μV) (max)	Offset Drift (μV/°C) (max)	CMRR (dB) (min)	BW (MHz) (typ)	Output Voltage Swing (V) (min)	Power Supply (V)	I_Q Per Ch. (mA) (max)	Package(s)	Price[1]
High-Side Current Shunt Monitors												
INA138	36V max	1	200	1000	1	100	0.8	0 to (V+) –0.8	+2.7 to 36	0.045	SOT23-5	0.95
INA139	High-Speed, 40V max	1	1000	1000	1	100	4.4	0 to (V+) –0.9	+2.7 to 40	0.125	SOT23-5	0.95
INA168	60V max	1	200	1000	1	100	0.8	0 to (V+) –0.8	+2.7 to 60	0.045	SOT23-5	1.15
INA169	High-Speed, 60V max	1	1000	1000	1	100	4.4	0 to (V+) –0.9	+2.7 to 60	0.125	SOT23-5	1.15
INA170	Bi-directional	1	1000	1000	1	100	0.4	0 to (V+) –0.9	+2.7 to 60	0.125	MSOP-8	1.21

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

Single-Supply Instrumentation Amplifiers

Device	Description	Spec[2] Temp Range	Gain	Non Linearity (%) (max)	Input Bias Current (nA) (max)	Offset at G = 100 (µV) (max)	Offset Drift (µV/°C) (max)	CMRR at G = 100 (dB) (min)	BW at G = 100 (kHz) (min)	Noise at 1kHz ($nV/\sqrt{Hz}$) (typ)	Power Supply (V)	I_Q Per Amp (mA) (max)	Package(s)	Price[5]
Single-Supply, Low Power I_Q < 525 µA Per Instrumentation Amp														
INA321	RRO, SHDN, Low Offset and Gain Error	WI	5 to10000	0.01	0.01	1000	7[3]	90	50	100	2.7 to 5.5	0.06	MSOP-8	1.10
INA2321	Dual INA321	WI	5 to10000	0.01	0.01	1000	7[3]	90	50	100	2.7 to 5.5	0.06	TSSOP-14	2.02
INA322	RRO, SHDN, Low Cost	WI	5 to 10000	0.01	0.01	10000	7	60	50	100	2.7 to 5.5	0.06	MSOP-8	0.91
INA2322	Dual INA322	WI	5 to 10000	0.01	0.01	10000	7	60	50	100	2.7 to 5.5	0.06	TSSOP-14	1.72
INA122	µPower, RRO, CM to Gnd	I	5 to 10000	0.012	25	250	3	90	5	60	2.2 to 36	0.085	SOIC-8	1.95
INA332	RRO, Wide BW, SHDN	WI	5 to 1000	0.01	0.01	10000	7[3]	60	500	100	2.7 to 5.5	0.1	MSOP-8	0.80
INA2332	Dual INA332	WI	5 to 1000	0.01	0.01	10000	7[3]	60	500	100	2.7 to 5.5	0.1	MSOP-8	1.45
INA126	µPower, < 1 V VSAT, Low Cost	I	5 to 10000	0.012	25	250	3	83	9	35	2.7 to 36	0.2	SO/MSOP-8	0.99
INA2126	Dual INA126	I	5 to 10000	0.012	25	250	3	83	9	35	2.7 to 36	0.2	SO/MSOP-16	1.80
INA118	Precision, Low Drift, Low Power[1]	I	1 to 10000	0.002	5	55	0.7	107	70	10	2.7 to 36	0.385	SOIC-8	3.73
INA331	RRO, Wide BW, SHDN	WI	5 to 1000	0.01	0.01	500	5[3]	90	2000	46	2.7 to 5.5	0.5	MSOP-8	1.05
INA2331	Dual INA331	WI	5 to 1000	0.01	0.01	1000	5[3]	80	2000	46	2.7 to 5.5	0.5	TSSOP-14	2.35
INA125	Internal Ref, Sleep Mode[1]	I	4 to 10000	0.01	25	250	2	100	4.5	38	2.7 to 36	0.525	SOIC-16	2.10
Single-Supply, Low Input Bias Current I_B < 100 pA														
INA155	Low Offset, RRO, SR = 6.5 V/µs	WI	10, 50	0.015	0.01	1000	5[3]	86	110	40	2.7 to 5.5	2.1	MSOP-8	1.00
INA156	Low Offset, RRO, Low Cost, SR = 6.5 V/µs	WI	10, 50	0.015	0.01	8000	5[3]	86	110	40	2.7 to 5.5	2.1	SOIC-8, MSOP-8	0.90
INA321	RRO, SHDN, Low Offset and Gain Error	WI	5 to 10000	0.01	0.01	1000	7[3]	90	50	100	2.7 to 5.5	0.06	MSOP-8	1.10
INA2321	Dual INA321	WI	5 to 10000	0.01	0.01	1000	7[3]	90	50	100	2.7 to 5.5	0.06	TSSOP-14	2.02
INA322	RRO, SHDN, Low Cost	WI	5 to 10000	0.01	0.01	10000	7	60	50	100	2.7 to 5.5	0.06	MSOP-8	0.91
INA2322	Dual INA322	WI	5 to 10000	0.01	0.01	10000	7	60	50	100	2.7 to 5.5	0.06	TSSOP-14	1.72
INA331	RRO, Wide BW, SHDN	WI	5 to 1000	0.01	0.01	500	5[3]	90	2000	46	2.7 to 5.5	0.5	MSOP-8	1.05
INA2331	Dual INA331	WI	5 to 1000	0.01	0.01	1000	5[3]	80	2000	46	2.7 to 5.5	0.5	TSSOP-14	2.35
INA332	RRO, Wide BW, SHDN	WI	5 to 1000	0.01	0.01	10000	7[3]	60	500	100	2.7 to 5.5	0.1	MSOP-8	0.80
INA2332	Dual INA332	WI	5 to 1000	0.01	0.01	10000	7[3]	60	500	100	2.7 to 5.5	0.1	TSSOP-14	1.45
Single-Supply, Precision V_{OS} < 300 µV, Low V_{OS} Drift														
INA118	Precision, Low Drift, Low Power[1]	I	1 to 10000	0.002	5	55	0.7	107	70	10	2.7 to 36	0.385	SOIC-8	3.73
INA326	RRIO, Auto Zero, CM > Supply, Low Drift	I	0.1 to 10000	0.01	2	100	0.4	100	1	33	2.7 to 5.5	3.4	MSOP-8	1.70
INA327	RRIO, Auto Zero, SHDN, CM > Supply, Low Drift	I	0.1 to 10000	0.01	2	100	0.4	100	1	33	2.7 to 5.5	3.4	MSOP-10	1.85
INA337	RRIO, Auto Zero, Low Drift, CM > Supply, 125°C	EI	0.1 to 10000	0.01	2	100	0.4	106	1	33	2.7 to 5.5	3.4	MSOP-8	1.71
INA338	RRIO, Auto Zero, Low Drift, CM > Supply, SHDN, 125°C	EI	0.1 to 10000	0.01	2	100	0.4	106	1	33	2.7 to 5.5	3.4	MSOP-10	1.85
INA122	µPower, RRO, CM to Gnd	I	5 to 10000	0.012	25	250	3	90	5	60	2.2 to 36	0.085	SOIC-8	1.95
INA125	Internal Ref, Sleep Mode[1]	I	4 to 10000	0.01	25	250	2	100	4.5	38	2.7 to 36	0.525	SOIC-16	2.10
INA126	µPower, < 1 V V_{SAT}, Low Cost	I	5 to 10000	0.012	25	250	3	83	9	35	2.7 to 36	0.2	SO/MSOP-8	0.99
INA2126	Dual INA126	I	5 to 10000	0.012	25	250	3	83	9	35	2.7 to 36	0.2	SO/MSOP-16	1.80
Signal Amplifiers for Temperature Control					I_B (nA)		Temp Error[4]			1/F Noise				
INA330	Optimized for Precision 10-kΩ Thermistor Applications	I	—	—	0.2[3]	—	0.009°C[3]	—	1	0.0001 °C pp[2]	2.7 to 5.5	3.6	MSOP-10	1.45

[1]Internal +40-V input protection.
[2]WI = –55°C to +125°C; I = –40°C to +85°C; EI = –40°C to +125°C.
[3]Typical.
[4]–40°C to +85°C.
[5]Suggested resale price in U.S. dollars in quantities of 1,000.

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

Amplifiers

Dual-Supply Instrumentation Amplifiers

Device	Description	Spec[4] Temp Range	Gain	Non Linearity (%) (max)	Input Bias Current (nA) (max)	Offset at G = 100 (µV) (max)	Offset Drift (µV/°C) (max)	CMRR at G = 100 (dB) (min)	BW at G = 100 (kHz) (min)	Noise at 1kHz (nV/√Hz) (typ)	Power Supply (V)	I_Q Per Amp (mA) (max)	Package(s)	Price[5]
Dual-Supply, Low Power I_Q < 850 µA Per Instrumentation Amp														
INA122	µPower, RRO, CM to Gnd	I	5 to 10000	0.012	25	250	3	90	5	60	±1.3 to ±18	0.085	DIP-8, SOIC-8	1.95
INA126[1]	µPower, < 1 V V_{SAT}, Low Cost	I	5 to 10000	0.012	25	250	3	83	9	35	±1.35 to ±18	0.2	DIP/SO/MSOP-8	0.99
INA118	Precision, Low Drift	I	1 to 10000	0.002	5	55	0.7	107	70	10	±1.35 to ±18[2]	0.385	SOIC-8	3.73
INA121	Low Bias, Precision	I	1 to 10000	0.005	0.05	500	5	100	50	20	±2.25 to ±18[2]	0.525	SO-8	2.35
INA125	Internal Ref, Sleep Mode[2]	I	4 to 10000	0.01	25	250	2	100	4.5	38	±1.35 to ±18	0.525	SOIC-16	2.10
INA128[1]	Precision, Low Noise, Low Drift[2]	I	1 to 10000	0.002	5	60	0.7	120	200	8	±2.25 to ±18	0.8	SOIC-8	3.31
INA129	Precision, Low Noise, Low Drift, AD620 Second Source[2]	I	1 to 10000	0.002	5	60	0.7	120	200	8	±2.25 to +18	0.8	SOIC-8	3.31
INA141[1]	Precision, Low Noise, Low Power, Pin Com. w/AD6212[2]	I	10, 100	0.002	5	50	0.7	110	200	8	±2.25 to +18	0.8	SOIC-8	3.31
Dual-Supply, Low Input Bias Current I_B < 100 pA														
INA110	Fast Settle, Low Noise, Wide BW	C	1,10,100, 200, 500	0.01	0.05	280	2.5	106	470	10	±6 to ±18	4.5	CDIP-16	6.70
INA121	Precision, Low Power[2]	I	1 to 10000	0.005	0.05	500	5	100	50	20	±2.25 to ±18[2]	0.525	SO-8	2.35
INA111	Fast Settle, Low Noise, Wide BW	I	1 to 10000	0.005	0.02	520	6	106	450	10	±6 to ±18	4.5	SO-16	3.91
INA116	Ultra Low I_B 3 fA (typ), with Buffered Guard Drive Pins[2]	I	1 to 10000	0.01	0.0001	5000	40	80	70	28	±4.5 to ±18	1.4	SO-16	3.95
Dual-Supply, Precision V_{OS} < 300 µV, Low V_{OS} Drift														
INA114	Precision, Low Drift[2]	I	1 to 10000	0.002	2	50	0.25	110	10	11	±2.25 to ±18	3	SO-16	3.55
INA115	Precision, Low Drift, with Gain Sense Pins[2]	I	1 to 10000	0.002	2	50	0.25	120	10	11	±2.25 to ±18	3	SO-16	4.00
INA131	Low Noise, Low Drift[2]	I	100	0.002	2	50	0.25	110	70	12	±2.25 to ±18	3	PDIP-8	3.59
INA141[1]	Precision, Low Noise, Pin Com. w/AD6212	I	10, 100	0.002	5	50	0.7	110	200	8	±2.25 to ±18[2]	0.8	SOIC-8	3.31
INA118	Precision, Low Drift	I	1 to 10000	0.002	5	55	0.7	107	70	10	±1.35 to ±18[2]	0.385	SOIC-8	3.73
INA128[1]	Precision, Low Noise, Low Drift[2]	I	1 to 10000	0.002	5	60	0.7	120	200	8	±2.25 to ±18	0.8	SOIC-8	3.31
INA129	Precision, Low Noise, Low Drift, AD620 Second Source[2]	I	1 to 10000	0.002	5	60	0.7	120	200	8	±2.25 to ±18	0.8	SOIC-8	3.31
INA122	µPower, RRO, CM to Gnd	I	5 to 10000	0.012	25	250	3	90	5	60	±1.3 to ±18	0.085	SOIC-8	1.95
INA125	Internal Ref, Sleep Mode[2]	I	4 to 10000	0.01	25	250	2	100	4.5	38	±1.35 to ±18	0.525	SOIC-16	2.10
INA126[1]	µPower, < 1 V V_{SAT}, Low Cost	I	5 to 10000	0.012	25	250	3	83	9	35	±1.35 to ±18	0.2	SO/MSOP-8	0.99
INA101	Low Noise, Wide BW, Gain Sense Pins	C	1 to 10000	0.007	30	259	23	100	25000	13	±5 to ±18	8.5	T0-100, CDIP-14, PDIP-14, SO-16	7.52
INA110	Fast Settle, Low Noise, Low Bias, Wide BW	C	1,10,100, 200, 500	0.01	0.05	280	2.5	106	470	10	±6 to ±18	4.5	CDIP-16	6.70
Dual-Supply, Lowest Noise														
INA103	Precision, Fast Settle, Low Drift, Audio, Mic Pre Amp, THD+N = 0.0009%	C	1, 100	0.0006[3]	12000	255	1.2[3]	100	800	1	±9 to ±25	13	SO-16	4.65
INA163	Precision, Fast Settle, Low Drift, Audio, Mic Pre Amp, THD+N = 0.002%	I	1 to 10000	0.0006[3]	12000	300	1.2[3]	100	800	1	±4.5 to ±18	12	SOIC-14	1.95
INA166	Precision, Fast Settle, Low Drift, Audio, Mic Pre Amp, THD+N = 0.09%	I	2000	0.005	12000	300	2.5[3]	100	450	1.3	±4.5 to ±18	12	SO-14 Narrow	5.66
INA217	Precision, Low Drift, Audio, Mic PreAmp, THD+N = 0.09% SSM2017 Replacement	I	1 to 10000	0.0006[3]	12000	300	1.2[3]	–100	800	1.3	±4.5 to ±18	12	SO-16	2.35

[1]*Parts also available in a dual version.* [2]*Internal +40-V input protection.* [3]*Typical.* [4]*I = –40°C to +85°C; C = 0°C to 70°C.*
[5]*Suggested resale price in U.S. dollars in quantities of 1,000.*

High-Speed Amplifiers

Device	Ch.	SHDN	Supply Voltage (V)	A_{CL} (min)	BW at A_{CL} (MHz) (typ)	BW G = +2 (MHz) (typ)	GBW Product (MHz) (typ)	Slew Rate (V/µs)	Settling Time 0.1% (ns) (typ)	THD 2 Vpp G = 1 1 MHz (dB) (typ)	Differential Gain (%)	Differential Phase (°)	V_N (nV/√Hz) (typ)	V_{OS} (mV) (max)	Package(s)	Price[1]
Fully Differential																
THS4120/21	1	Y	3.0 to 3.6	1	100	—	—	55	60	–75	—	—	5.4	8	MSOP PowerPAD™	1.78
THS4130/31	1	Y	5, ±5, ±15	1	150	90	90	52	78	–97	—	—	1.3	2	MSOP PowerPAD	3.30
THS4140/41	1	Y	5, ±5, ±15	1	160	—	—	450	96	–79	—	—	6.5	7	MSOP PowerPAD	3.22
THS4150/51	1	Y	5, ±5, ±15	1	150	81	100	650	53	–84	—	—	7.6	7	MSOP PowerPAD	4.45
THS4500/01	1	Y	5, ±5	1	370	175	300	2800	6.3	–100	—	—	7	7	MSOP PowerPAD	3.45
THS4502/03	1	Y	5, ±5	1	370	175	300	2800	6.3	–100	—	—	6	7	MSOP PowerPAD	3.77
THS4504/05	1	Y	5, ±5	1	260	110	210	1800	20	–100	—	—	8	7	MSOP PowerPAD	1.65
Fixed and Variable Gain																
BUF634	1	N	5, ±5, ±15	1	180	—	—	2000	200	—	0.4	0.1	4	100	SOIC	3.82
OPA692	1	Y	5, ±5	2	280	225	—	2000	8	–70	0.07	0.02	1.7	2.5	SOT23, SOIC	1.25
OPA3692	3	Y	5, ±5	2	280	225	—	2000	8	–79	0.07	0.02	1.7	3	SSOP, SOIC	2.88
THS4302	1	Y	3, 5	5	2400	—	12000	5500	—	–82	—	—	2.8	4.25	Leadless MSOP PowerPAD	1.97
THS7001	1	Y	±5, ±15	1	—	100	—	85	85	–60	0.02	0.01	1.7	5	TSSOP PowerPAD	3.52
THS7002	2	Y	±5, ±15	1	—	100	—	85	85	–88	0.02	0.01	1.7	5	TSSOP PowerPAD	5.61
THS7530	1	Y	5	4	300	—	—	1750	—	–51	—	—	1.27	—	TSSOP PowerPAD	3.65
CMOS Amplifiers																
OPA354	1	N	2.5 to 5.5	1	250	90	100	150	30	—	0.02	0.09	6.5	8	SOT23, SOIC PowerPAD	0.69
OPA2354	2	N	2.5 to 5.5	1	250	90	100	150	30	—	0.02	0.09	6.5	8	SOIC PowerPAD, MSOP	1.14
OPA4354	4	N	2.5 to 5.5	1	250	90	100	150	30	—	0.02	0.09	6.5	8	SOIC, TSSOP	1.71
OPA355	1	Y	2.5 to 5.5	1	450	100	200	300	30	—	0.02	0.05	5.8	9	SOT23, SOIC	0.85
OPA2355	2	Y	2.5 to 5.5	1	450	100	200	300	30	—	0.02	0.05	5.8	9	MSOP	1.40
OPA3355	3	Y	2.5 to 5.5	1	450	100	200	300	30	—	0.02	0.05	5.8	9	SOIC	1.79
OPA356	1	N	2.5 to 5.5	1	450	100	200	300	30	—	0.02	0.05	5.8	9	SOT23, SOIC	0.85
OPA358	1	N	2.7 to 3.3	1	80	35	70	70	—	—	0.02	0.05	5.8	9	SC-70, SOT23	0.45
OPA360	1	N	2.7 to 3.3	1	80	35	70	70	—	—	0.02	0.05	5.8	9	SC-70, SOT23	0.49
OPA2356	2	N	2.5 to 5.5	1	450	100	200	300	30	—	0.02	0.05	5.8	9	SOIC, MSOP	1.40
OPA357	1	Y	2.5 to 5.5	1	250	90	100	150	30	—	0.02	0.09	6.5	8	SOT23, SOIC PowerPAD	0.69
OPA2357	2	Y	2.5 to 5.5	1	250	90	100	150	30	—	0.02	0.09	6.5	8	MSOP	1.14
FET-Input																
OPA655	1	N	±5	1	400	185	240	290	8	–100	0.01	0.01	6	2	SOIC	9.24
OPA656	1	N	±5	1	500	200	230	290	—	–80	0.02	0.05	7	1.8	SOT23, SOIC	3.35
OPA657	1	N	±5	7	350	300	1600	700	10	–80	—	—	4.8	1.8	SOT23, SOIC	3.74
THS4601	1	N	±5, ±15	1	440	95	180	100	135	–76	0.02	0.08	5.4	4	SOIC	9.95
Voltage Feedback																
OPA2652	2	N	±5	1	700	200	200	335	—	–75	0.05	0.03	8	7	SOT23, SOIC	1.24
OPA2822	2	N	5, ±5	1	400	200	240	170	32	–86	0.02	0.03	2	1.2	SOIC, MSOP	2.16
OPAy690	1, 2, 3	Y	5, ±5	1	500	220	300	1800	8	–80	0.06	0.03	5.5	4	SOT23, SOIC	1.39
OPA842	1	N	±5, 5	1	350	—	—	400	15	—	0.003	0.006	2.6	0.3	SOIC, SOT23	1.35
OPA846	1	N	±5	7	500	—	1750	625	10	—	0.02	0.02	1.2	0.15	SOIC, SOT23	1.59
OPA2846	2	N	±5	7	500	—	1750	625	10	—	0.02	0.02	1.2	0.15	SOIC	—
OPA843	1	N	±5, 5	3	500	—	800	1000	7.5	—	0.001	0.012	2	0.3	SOIC, SOT23	1.39
OPA847	1	N	±5, 5	12	600	—	3800	950	10	—	—	—	0.85	0.1	SOIC, SOT23	1.49
SN10501y	1, 2, 3	N	±5, 5	1	230	—	120	990	25	–88	0.007	0.007	13	12	SOIC, SOT23	0.70
THS4001	1	N	5, ±5, ±15	1	270	—	100	400	40	–72	0.04	0.15	12.5	8	SOIC	1.99
THS4011/12	1, 2	N	±5, ±15	1	290	50	100	310	37	–80	0.006	0.01	7.5	6	SOIC, MSOP PowerPAD	2.26
THS4021/22	1, 2	N	±5, ±15	10	350	—	1600	470	40	–68	0.02	0.08	1.5	2	SOIC, MSOP PowerPAD	2.16

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

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

Amplifiers

High-Speed Amplifiers (Continued)

Device	Ch.	SHDN	Supply Voltage (V)	A_{CL} (min)	BW at A_{CL} (MHz) (typ)	BW G = +2 (MHz) (typ)	GBW Product (MHz) (typ)	Slew Rate (V/µs)	Settling Time 0.1% (ns) (typ)	THD 2 Vpp G = 1 1 MHz (dB) (typ)	Differential Gain (%)	Differential Phase (°)	V_N (nV/√Hz) (typ)	V_{OS} (mV) (max)	Package(s)	Price[1]
Voltage Feedback (Continued)																
THS4031/32	1, 2	N	±5, ±15	2	100	100	200	100	60	–72	0.015	0.025	1.6	2	SOIC, MSOP PowerPAD	1.96
THS4041/42	1, 2	N	±5, ±15	1	165	60	100	400	120	–75	0.01	0.01	14	10	SOIC, MSOP PowerPAD	1.62
THS4051/52	1, 2	N	±5, ±15	1	70	38	—	240	60	–82	0.01	0.01	14	10	SOIC, MSOP PowerPAD	1.08
THS4061/62	1, 2	N	±5, ±15	1	180	—	100	400	40	–72	0.02	0.02	14.5	8	SOIC, MSOP PowerPAD	1.37
THS4081/82	1, 2	N	±5, ±15	1	175	—	100	230	43	–64	0.01	0.05	10	7	SOIC, MSOP PowerPAD	1.76
THS4211/15	1	Y	5, ±5, 15	1	1000	325	350	970	22	–95	0.007	0.003	7	12	SOIC, MSOP PowerPAD	1.11
THS4222/26	2	Y	3, 5, ±5, 15	1	230	100	120	975	25	–100	0.007	0.007	13	10	SOIC, MSOP PowerPAD, TSSOP PowerPAD	1.79
THS4271/75	1	Y	5, ±5, 15	1	1400	390	400	1000	25	–110	0.007	0.004	3	10	SOIC, MSOP PowerPAD, Leadless MSOP PowerPAD	2.69
THS4304	1	N	5	1	2500	—	1000	1000	5	–92	—	—	2.4	0.5	SOIC, MSOP	—
Current Feedback																
OPAy658	1, 2	N	±5	1	900	680	—	1700	11.5	–70	0.025	0.02	2.7	5.5	SOT23, SOIC	1.43
OPAy683	1, 2	Y	3, 5, ±5	1	200	150	—	540	—	–75	0.06	0.03	4.4	4.1	SOT23, SOIC	1.05
OPA693	1, 3	N	5, ±5	2	800	—	—	2400	3	–85	0.02	0.01	1.6	0.7	SOT23, SOIC	1.30
OPA695	1	N	5, ±5	1	1200	—	—	2400	3	–85	0.02	0.01	1.6	0.7	SOT23, SOIC	1.35
OPA2674	2	N	5, ±6	1	260	—	—	2000	—	—	0.03	0.01	1	2	SOIC, SOT23	1.71
OPAy684	1, 2, 3, 4	Y	5, ±5	1	210	170	—	820	11	–75	0.04	0.02	3.7	3.5	SOT23, SOIC	1.19
OPAy691	1, 2, 3	Y	5, ±5	1	280	225	—	2100	8	–80	0.07	0.02	1.7	2.5	SOT23, SOIC	1.35
THS3001	1	N	±5, ±15	1	420	385	—	6500	40	–93	0.01	0.02	1.6	3	SOIC, MSOP PowerPAD	3.05
THS306y	1, 2	N	±5, ±15	1	300	275	—	7000	30	–85	0.02	0.01	2.6	3.5	SOIC, SOIC PowerPAD MSOP PowerPAD	2.95
THS3091/5	1	Y	±5, ±15	1	235	210	—	5000	42	–72	0.013	0.02	2	3	SOIC, SOIC PowerPAD	3.59
THS3092/6	2	Y	±5, ±15	1	235	210	—	5000	42	–72	0.013	0.02	2	4	SOIC, SOIC PowerPAD	5.96
THS3112/15	2	Y	±5, ±15	1	110	110	—	1550	63	–78	0.01	0.011	2.2	8	SOIC, SOIC PowerPAD, TSSOP PowerPAD	3.03
THS3110/11	1	Y	±5, ±15	1	100	90	—	1300	27	–78	0.01	0.03	3	6	SOIC, MSOP PowerPAD	1.81
THS3120/1	1	N	±5, ±15	1	130	—	—	1500	11	–53	0.007	0.018	2.5	2	SOIC, MSOP PowerPAD	2.25
THS3122/25	2	Y	±5, ±15	1	160	128	—	1550	64	–78	0.01	0.011	2.2	6	SOIC, SOIC PowerPAD, TSSOP PowerPAD	3.74
THS3201	1	N	±5, ±15	1	1800	850	—	6200	20	–85	0.006	0.03	1.65	0.7	MSOP, SOT23, SOIC	1.59
THS3202	2	N	±5, 15	1	1200	1000	—	9000	10	–65	0.02	0.01	6.8	4	SOIC, MSOP PowerPAD	2.89

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

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

Operational Amplifiers

Device	Description	Spec[1] Temp Range	S, D, T, Q[2]	Offset (mV) (max)	Drift (µV/°C) (typ)	I_B (pA) (max)	Noise 1 kHz ($nV/\sqrt{Hz}$)	GBW (MHz) (typ)	SR (V/µs) (typ)	V_{SUP} (V)	I_Q/Amp (mA) (max)	Price[3]
Bipolar Input—Low Offset, Low Drift												
OPA277	Lowest offset / drift	I	S, D, Q	0.02	0.1	1 nA	8	1	0.8	±2 to ±18	0.825	0.9
OPA228	Precision, low noise, G>5	I	S, D, Q	0.075	0.1	10 nA	3	33	10	5 to 36	3.8	1.01
OPA227	Very low noise	I	S, D, Q	0.075	0.1	10 nA	3	1	1	±2.5 to ±18	3.8	1
TLE2027	Precision, low noise	I	S	0.1	0.4	90 nA	2.5	13	2.8	8 to 38	5.3	0.83
OPA234	SS, general purpose	I	S, D, Q	0.1	0.5	25 nA	25	0.35	0.2	2.7 to 36	0.3	0.98
TLC220x	SS, low noise	I	S, D	0.2	0.5	10	8	1.8	2.5	4.6 to 16	1.5	1.55
OPA241	Very low power, high precision	I	S, D, Q	0.25	0.4	20 nA	45	0.035	0.01	2.7 to 36	0.03	1.06
OPA251	microPower, high CMRR	I	S, D, Q	0.25	0.4	2 nA	45	0.35	0.1	2.7 to 36	0.025	1.07
OPA244	microPower, SS, low cost	I	S, D, Q	1.5	4	25 nA	22	0.24	0.1	2.6 to 36	0.05	0.5
FET-Input—Low Input Bias Current, Low Noise												
OPA129	Lowest bias current	I	S	2	3	100 fA	15	1	2.5	10 to 36	1.8	$3.20
OPA124	Low noise DiFET	I	S	0.5	2	1	8	1.5	1.6	10 to 36	3.5	$3.95
OPA121	Low cost precision DiFET	I	S	2	3	5	6	2	2	10 to 36	4.5	$5.10
OPA637	Low THD+N, low offset, G>5	I2	S	0.1	0.4	10	5.6	80	135	±4.5 to ±18	7.5	$12.25
OPA627	Very low THD+N, low offset	I2	S	0.1	0.4	10	5.6	16	55	±4.5 to ±18	7.5	$12.25
OPA130	Low power	I	S, D, Q	1	2	20	16	1	2	4.5 to 36	0.65	$1.40
OPA132	THD = 0.00008%	I	S, D, Q	0.5	2	50	8	8	20	±2.5 to ±18	4.8	$1.45
OPA131	General purpose FET-input	I	S, D, Q	0.75	2	50	15	4	10	±4.5 to ±18	1.75	$0.75
OPA134	Low distortion	I	S, D, Q	2	2	100	8	8	20	4.5 to 36	5	$0.95
OPA137	Low-cost FET-input, SOT23	I	S, D, Q	3	15	100	45	1	3.5	4.5 to 36	0.22	$0.60
TLE208x	High-speed, JFET input	I	S, D, Q	6	3.2	175	14	10	45	4.5 to 38	2.2	$0.55
CMOS— Low Power, Low Input Bias Current, Rail-to-Rail In and Out, Low Cost												
TLV240x	SS, RRIO, SOT23	EI	S, D, Q	1.2	3	300	500	0.005	0.002	2.5 to 16	0.95 µA	$0.75
OPA349	70-kHz GBW on 1 µA, SC70	I	S, D	10	10	15	300	0.07	0.02	1.8 to 5.5	0.002	$0.70
TLV276x	SS, SOT23, SHDN	EI	S, D, Q	3.5	9	15	95	0.5	0.2	1.8 to 3.6	0.028	$0.55
OPA336	Lowest power precision amp, SOT23	I	S, D, Q	0.125	1.5	10	40	0.1	0.03	2.3 to 5.5	0.032	$0.60
OPA347	microPower, low cost, SC70	EI	S, D, Q	6	2	10	60	0.35	0.17	2.3 to 5.5	0.034	$0.46
TLV245x	microPower, SS	EI	S, D, Q	1.5	0.3	5000	51	0.22	0.12	2.7 to 6	0.035	$0.59
OPA348	High open-loop gain, SC70	EI	S, D, Q	5	2	10	35	1	0.5	2.1 to 5.5	0.065	$0.45
OPA703/4	RRIO, SOT23 / G>5	I	S, D, Q	0.75	4	10	45	1/3	0.6	4 to 12	0.2	$1.21
OPA364	1.8 V, high CMRR, SS	EI	S, D, Q	0.5	2	10	17	7	5	1.8 to 5.5	0.75	$0.55
OPA373	General purpose, RRIO, SOT23	EI	S	5	3	10	15	6.5	5	2.3 to 5.5	0.75	$0.36
TLV278x	1.8 V, low power, SS, 8 MHz	EI	S, D, Q	3	8	15	18	8	4.3	1.8 to 3.6	0.82	$0.65
OPA340	RRIO, SOT23	I	S, D, Q	0.5	2.5	10	25	5.5	6	2.5 to 5.5	0.95	$0.66
OPA338	RRO, SOT23, G>5	EI	S, D	3	2	10	26	12.5	4.6	2.7 to 5.5	1	$0.43
OPA337	RRO, SOT23	EI	S, D, Q	3	2	10	26	3	1.2	2.7 to 5.5	1	$0.43
OPA743	RRIO, SOT23, 12 V	I	S, D, Q	1.5	8	10	30	7	10	3.5 to 12	1.5	$0.88
TLC07x	Low noise, SHDN, high drive	I	S, D, Q	1	1.2	50	7	10	16	4.6 to 16	2.5	$0.46
TLC08x	Low noise, SHDN, high drive	I	S, D, Q	1	1.2	50	8.5	10	16	4.5 to 16	2.5	$0.46
OPA725	RRIO, SOT23, 0.003% THD+N	EI	S	3	4	200	6	20	30	5.5 to 12	5.5	$0.90
OPA357	High-speed, SS, SHDN	EI	S, D, T	8	4	50	6.5	100	150	2.5 to 5.5	6	$0.69
OPA380	Fastest precision transimpedance	EI	S, D	0.025	0.1	50	5 at 1 MHz	90	80	2.7 to 5.5	7	$1.95
OPA350	16-bit ADC driver RRIO, MSOP	I	S, D, Q	0.5	4	10	8	38	22	2.5 to 5.5	7.5	$1.22
OPA353	High-speed, low voltage	EI	S, D, Q	8	5	10	5	44	22	2.7 to 5.5	8	$1.05
OPA355	High-speed, RRO	EI	S, D, T	9	7	50	5.8	200	300	2.5 to 5.5	11	$1.20
OPA300	Low noise, settling to 16-bits	EI	S, D	5	2.5	5	3	180	80	2.7 to 5.5	12	$1.25
Auto Zero Autocalibration—Highest Precision, Lowest Drift												
OPA335	Auto zero, SOT23 package	EI	S, D	0.005	0.02	200	—	2	1.6	2.7 to 5.5	0.3	0.95
OPA735	12-V auto zero, SOT23	EI	S, D	0.01	0.1	100	60	1.5	1.5	2.7 to 12	0.75	1.35

[1] I = –40°C to +85°C; I2 = –25°C to +85°C; EI = –40°C to +125°C.
[2] S = single, D = dual, T = triple, Q = quad.
[3] Suggested resale price in U.S. dollars in quantities of 1,000.

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

This very brief listing provides only a sampling of the industry's most complete op amp product line. See **amplifier.ti.com** for complete product trees, parametric sorts and application information.

Comparators

Comparators

Device	Description	S, D, Q[1]	I_Q Per Ch. (mA) (max)	Output Current (mA) (min)	t_{RESP} Low-to-Hi (µs)	V_S (V) (min)	V_S (V) (max)	V_{OS} (25°C) (mV) (max)	Output Type	Price[2]
TLV230x	Sub-micropower amp and comp	D	0.0017	—	55	2.5	16	5	Open Drain/Collector	0.84
TLV270x	Sub-micropower amp and comp	S, D	0.0019	—	36	2.5	16	5	Push-Pull	0.84
TLV340x	Nanopower, open drain, RRIO	S, D, Q	0.00055	—	80	2.6	16	3.6	Open Drain/Collector	0.56
TLV349x	Low voltage, excellent speed/power	S, D	0.0012	—	<0.1	1.8	5.5	15	Push-Pull	0.55
TLV3011	Micropower, 1.242-V reference	S	0.003	5	<7	1.8	5.5	15	Open Drain	0.75
TLV3012	Nanopower, 1.242-V reference	S	0.005	0.5	6	1.8	5.5	12	Push-Pull	0.75

[1]S = single, D = dual, Q = quad.
[2]Suggested resale price in U.S. dollars in quantities of 1,000.

Clock Distribution/Synthesizers

Clock Distribution Circuits

Device	Description	Input Level	Output Level	Frequency	V_{CC} (V)	Propagation Delay	Output Skew	Char. Temp. (°C)	# Pins/Pkg	Price[1]
Differential Clocking										
CDCM1804	1:3 LVPECL + 1 LVTTL w/dividers	LVPECL	LVPECL+ LVTTL	800 MHz	3.3	TBA	TBA	TBA	24/MLF	See Web
CDCP1803	1:3 buffer with dividers	LVPECL	LVPECL	0 to 800 MHz	3.3	TBA	TBA	–40 to 85	24/MLF	See Web
CDCLVP110	1:10 LVPECL/HSTL with selectable input clock	LVPECL/ HSTL	LVPECL	0 to 3.5 GHz	2.5/3.3	230 to 370 ps	30 ps	–40 to 85	32/LQFP	5.25 5.60
CDCLVD110	1:10 programmable LVDS clock	LVDS	LVDS	0 to 900 MHz	2.5	3 ns (max)	30 ps (typ)	–40 to 85	32/TQFP	7.00
CDCVF111	1:9 diff LVPECL clock	LVPECL	LVPECL	0 to 650 MHz	3.3	450 to 600 ps	50 ps	0 to 70	28/PLCC	7.70
Single-Ended										
CDC351	1:10 with fast t_{pd} fanout, 3-state outputs	LVTTL	LVTTL/ LVCMOS	0 to 100 MHz	3.3	3 to 4 ns	500 ps	0 to 70	24/SOIC/SSOP	5.36
CDC391	1:6 clock with selectable polarity and 3-state outputs	TTL	TTL	0 to 100 MHz	5	1.5 to 5.0 ns	500 ps	–40 to 85	16/SOIC	3.24
CDCV304	1:4 fanout for PCI-X and general apps	LVTTL	LVCMOS	0 to 140 MHz	3.3	1.8 to 3.0 ns	100 ps	–40 to 85	8/TSSOP	1.05
CDCVF2310[2]	1:10 clock with 2 banks for general-purpose apps	LVTTL/ LVCMOS	LVTTL/ LVCMOS	0 to 170 MHz (V_{DD} = 2.5 V) 0 to 200 MHz (V_{DD} = 3.3 V)	2.5/3.3	1.3 to 2.8 ns (V_{DD} = 2.5 V) 1.5 to 3.5 ns (V_{DD} = 3.3 V)	100 ps @ 3.3 V 170 ps @ 2.5 V	–40 to 85	24/TSSOP	1.94

For more information regarding test conditions used to obtain measurements, see datasheets at: **www.ti.com/clocks**
[1]Suggested resale price in U.S. dollars in quantities of 1,000.
[2]With series output resistors.

Advanced PLL-Based Synthesizers

Device	Description	Input Level	Output Level	Frequency (MHz)	V_{CC} (V)	Jitter (Peak-to-Peak [P-P] or Cycle-to-Cycle [C-C])	Phase Error[1]	Output Skew (max) (ps)	Char. Temp. (°C)	# Pins/ Pkg	Price[2]
Jitter Cleaners											
CDC7005	Jitter cleaner, 5 LVPECL	LVCMOS	LVPECL	10 to 800	3.3	—	—	200	–40 to 85	64/BGA	10.00
Phase Aligners											
CDC5801	Multiplier/divider with programmable delay and phase alignment	LVCMOS	LVPECL/ LVDS/ LVTTL	150 to 500/ 12.5 to 62.5	3.3	P-P: PA bypassed = 40 ps, PA active = 70 ps, Division mode = 75 ps	—	—	–40 to 85	24/SSOP	2.80
CDCF5801	Multiplier/divider with programmable delay and phase alignment	LVCMOS	LVPECL/ LVDS/ LVTTL	25 to 280	3.3	P-P: PA bypassed = 40 ps, PA active = 70 ps, Division mode = 75 ps	—	—	–40 to 85	24/SSOP	2.80

[1]For more information regarding test conditions used to obtain measurements, see datasheets at: **www.ti.com/clocks**
New devices are listed in **bold red**.
[2]Suggested resale price in U.S. dollars in quantities of 1,000.

High-Speed ADCs

Device	Resolution (Bits)	Sample Rate	Channels	SNR @ f_{IN} = 10 MHz (dB)	Power Dissipation (mW)	Input Voltage Range (V)	Analog Supply (V)	Interface	Package(s)	Price[1]
ADS5500	14	125 MSPS	1	70	750	2.2 V_{pp}	3.3	Parallel	TQFP-48	95.00
ADS5273	12	70 MSPS	8	70.5	1104	1.5 to 2 V_{pp}	3.3	LVDS	TQFP-80	121.00
ADS5221	12	65 MSPS	1	70	285	1 to 2 V_{pp}	3.3	Parallel	TQFP-48	13.95
ADS5272	12	65 MSPS	8	70.5	984	1.5 to 2 V_{pp}	3.3	LVDS	TQFP-80	65.00
ADS2807	12	50 MSPS	2	68	720	2 to 3 V_{pp}	5	Parallel	TQFP-64	18.05
ADS5271	12	50 MSPS	8	70.5	936	1.5 to 2 V_{pp}	3.3	LVDS	TQFP-80	50.00
ADS5220	12	40 MSPS	1	70	140	1 to 2 V_{pp}	3.3	Parallel	TQFP-48	9.85
ADS5270	12	40 MSPS	8	63	900	1.5 to 2 V_{pp}	3.3	LVDS	TQFP-80	45.00
ADS5277	10	65 MSPS	8	60.5	872	1.5 to 2 V_{pp}	3.3	LVDS	TQFP-80	40.00
ADS5276	10	50 MSPS	8	60.5	816	1.5 to 2 V_{pp}	3.3	LVDS	TQFP-80	36.00
ADS5121	10	40 MSPS	8	60	500	1 V_{pp}	1.8	Parallel	BGA-257	38.85
ADS5122	10	40 MSPS	8	59	733	1 V_{pp}	1.8	Parallel	BGA-257	42.85
ADS5275	10	40 MSPS	8	59	700	1.5 to 2 V_{pp}	3.3	LVDS	TQFP-80	32.00
THS1040	10	40 MSPS	1	57	100	2 V_{pp}	3.3	Parallel	TQFP-48	5.10
CW Doppler ADCs										
ADS1625	18	1.25 MSPS	1	93	520	±3.75	4.75 to 5.25	P18	TQFP-64	37.65
ADS8381	18	580 kSPS	1	90	88	(V_{REF}), +4.1	4.75 to 5.25	P8/P16	TQFP-48	15.75
ADS8383	18	500 kSPS	1	87	85	(V_{REF}), +4.1	4.75 to 5.25	P8/P16	TQFP-48	14.98
ADS1605	16	5 MSPS	1	88	570	±3.75	4.75 to 5.25	P16	TQFP-64	32.05
ADS8412	16	2 MSPS	1	88	155	(V_{REF}), +4.1	4.75 to 5.25	P8/P16	TQFP-48	21.00

1Suggested resale price in U.S. dollars in quantities of 1,000.
For current pricing, visit **dataconverter.ti.com**

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

ADCs

Device	Res. (Bits)	Sample Rate (kSPS)	Number of Input Channels[1]	Interface	Input Voltage (V)	V_{REF}	Linearity (%)	NMC[2] (Bits)	SINAD (dB)	Power (mW)	Package(s)	Price[3]
ADS1201	24	1 MHz Ck	1 SE/1 Diff	Modulator	±10	Int/Ext	0.0015	24	—	25	SOIC-16	5.83
ADS1252	24	41	1 SE/1 Diff	Serial	±5	Ext	0.0015	24	—	40	SOIC-8	5.31
ADS1256	24	30	8 SE/4 Diff	Serial, SPI	PGA (1-64), ±5V	Ext	0.0015	24	—	35	SSOP-28	8.95
ADS1251	24	20	1 SE/1 Diff	Serial	±5	Ext	0.0015	24	—	7.5	SOIC-8	5.31
ADS1253	24	20	4 SE/4 Diff	Serial	±5	Ext	0.0015	24	—	7.5	SSOP-16	6.38
ADS1254	24	20	4 SE/4 Diff	Serial	±5	Ext	0.0015	24	—	4.36	SSOP-20	6.38
ADS1210	24	16	1 SE/1 Diff	Serial, SPI	PGA (1-16), ±5	Int/Ext	0.0015	24	—	27.5	PDIP-18, SOP-18	9.72
ADS1211	24	16	4 SE/4 Diff	Serial, SPI	PGA (1-16), ±5	Int/Ext	0.0015	24	—	27.5	PDIP-24, SOIC-24, SSOP-28	10.38
ADS1216	24	0.78	8 SE/8 Diff	Serial, SPI	PGA (1-128), ±2.5	Int/Ext	0.0015	24	—	0.6	TQFP-48	6.51
ADS1217	24	0.78	8 SE/8 Diff	Serial, SPI	PGA (1-128), ±5	Int/Ext	0.0012	24	—	0.8	TQFP-48	6.54
ADS1218	24	0.78	8 SE/8 Diff	Serial, SPI	PGA (1-128), ±2.5	Int/Ext	0.0015	24	—	0.8	TQFP-48	7.56
ADS1224	24	0.1	4 SE/4 Diff	Serial	±5	Ext	0.0015	24	—	0.48	TSSOP-20	3.25
ADS1244	24	0.03	4 SE/2 Diff	Serial	±5	Ext	0.0006	24	—	0.27	MSOP-10	2.95
ADS1245	24	0.03	1 SE/1 Diff	Serial	±2.5	Ext	0.0015	24	—	0.51	MSOP-10	3.07
ADS1240	24	0.015	4 SE/2 Diff	Serial, SPI	PGA (1-128), ±2.5	Ext	0.0015	24	—	0.6	SSOP-24	3.64
ADS1241	24	0.015	8 SE/4 Diff	Serial, SPI	PGA (1-128), ±2.5	Ext	0.0015	24	—	0.51	SSOP-28	4.00
ADS1242	24	0.015	4 SE/2 Diff	Serial, SPI	PGA (1-128), ±2.5	Ext	0.0015	24	—	0.6	TSSOP-16	3.44
ADS1243	24	0.015	8 SE/4 Diff	Serial, SPI	PGA (1-128), ±2.5	Ext	0.0015	24	—	0.6	TSSOP-20	3.80
ADS1212	22	6.25	1 SE/1 Diff	Serial, SPI	PGA (1-16), ±5	Int/Ext	0.0015	22	—	1.4	PDIP-18, SOP-18	7.34
ADS1213	22	6.25	4 SE/4 Diff	Serial, SPI	PGA (1-16), ±5	Int/Ext	0.0015	22	—	1.4	PDIP-24, SOIC-24, SSOP-28	8.25
ADS1250	20	25	1 SE/1 Diff	Serial, SPI	PGA (1-8), ±4	Ext	0.003	20	—	75	SOIC-16	6.63
DDC112	20	3	2 SE, 2 L_{IN}	Serial	50-1000 pC	Ext	0.025	20	—	80	SOIC-28, TQFP-32	11.52
ADS1625	18	1250	1 Diff	P18	±3.75	Int/Ext	0.0015	18	—	520	TQFP-64	37.65
ADS8381	18	580	1 SE	P8/P16/P18	V_{REF}	Ext	0.0028	18	88	100	TQFP-48	15.75

[1]SE = Single Ended, Diff = Differential. *[2]NMC = no missing code resolution.*
[3]Suggested resale price in U.S. dollars in quantities of 1,000. For current pricing, visit **www.ti.com** *or* **dataconverter.ti.com**

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

Data Converters

ADCs (Continued)

Device	Res. (Bits)	Sample Rate (kSPS)	Number of Input Channels[1]	Interface	Input Voltage (V)	V_{REF}	Linearity (%)	NMC[2] (Bits)	SINAD (dB)	Power (mW)	Package(s)	Price[3]
ADS8383	18	500	1 SE	P8/P16/P18	(V_{REF}) +4.1 V	Ext	0.006	18	85	110	TQFP-48	14.98
ADS1202	16	10 MHz Ck	1 SE/1 Diff	Modulator	±0.3	Int/Ext	0.018	16	—	30	TSSOP-8	2.95
ADS1605	16	5000	1Diff	P16	±3.75	Int/Ext	0.0015	16	—	570	TQFP-64	32.05
ADS8411	16	2000	1 SE	P8/P16	(V_{REF}) +4.1 V	Int	0.00375	16	87	155	TQFP-48	20.00
ADS8412	16	2000	1 Diff	P8/P16	$\pm V_{REF}$ (4.1 V) at ½ V_{REF}	Int	0.00375	16	90	155	TQFP-48	21.00
ADS8401	16	1250	1 SE	P8/P16	+4, V_{REF}	Int	0.00375	16	85	155	TQFP-48	11.95
ADS8402	16	1250	1 Diff	P8/P16	$\pm V_{REF}$ (4.1 V) at ½ V_{REF}	Int	0.00375	16	88	155	TQFP-48	12.52
ADS8371	16	850	1 SE	P8/P16	+4.2 V (V_{REF})	Ext	0.003	16	87	110	TQFP-48	9.99
ADS8322	16	500	1 Diff	P8/P16	5	Int/Ext	0.009	15	83	85	TQFP-32	7.15
ADS8323	16	500	1 Diff	P8/P16	±2.5 V at 2.5	Int/Ext	0.009	15	83	85	TQFP-32	7.15
ADS8361	16	500	2x2 Diff	Serial, SPI	±2.5 V at +2.5	Int/Ext	0.00375	14	83	150	SSOP-24	9.85
ADS8342	16	250	4 Diff	P8/P16	±2.5 at 0	Ext	0.006	16	85	200	TQFP-48	10.75
ADS7811	16	250	1 SE	P16	±2.5	Int/Ext	0.006	15	87	200	SOIC-28	34.41
ADS7815	16	250	1 SE	P16	±2.5	Int/Ext	0.006	15	84	200	SOIC-28	20.24
ADS8364	16	250	1x6 Diff	P16	±2.5 V at +2.5	Int/Ext	0.0045	14	82.5	413	TQFP-64	17.23
TLC4541	16	200	1 SE	Serial, SPI	V_{REF}	Ext	0.0045	16	84.5	17.5	SOIC-8, VSSOP-8	6.50
TLC4545	16	200	1 Diff	Serial, SPI	V_{REF}	Ext	0.0045	16	84.5	17.5	SOIC-8, VSSOP-8	6.50
ADS7805	16	100	1 SE	P8/P16	±10	Int/Ext	0.0045	16	86	81.5	PDIP-28, SOIC-28	20.75
ADS7809	16	100	1 SE	Serial, SPI	+4, 10, ±3.3, 5, 10	Int/Ext	0.0045	16	88	81.5	SOIC-20	20.75
ADS8320	16	100	1 Diff	Serial, SPI	V_{REF}	Ext	0.012	15	84	1.95	VSSOP-8	4.91
ADS8321	16	100	1 Diff	Serial, SPI	$\pm V_{REF}$ at $+V_{REF}$	Ext	0.012	15	84	5.5	VSSOP-8	4.91
ADS8325	16	100	1 Diff	Serial, SPI	V_{REF}	Ext	0.006	16	91	2.25	VSSOP-8, QFN-8	5.90
ADS8341	16	100	4 SE/2 Diff	Serial, SPI	V_{REF}	Ext	0.006	15	86	3.6	SSOP-16	7.08
ADS8343	16	100	4 SE/2 Diff	Serial, SPI	$\pm V_{REF}$ at $+V_{REF}$	Ext	0.006	15	86	3.6	SSOP-16	7.08
ADS8344	16	100	8 SE/4 Diff	Serial, SPI	V_{REF}	Ext	0.006	15	86	3.6	SSOP-20	7.59
ADS8345	16	100	8 SE/4 Diff	Serial, SPI	$\pm V_{REF}$ at $+V_{REF}$	Ext	0.006	15	85	3.6	SSOP-20	7.59
ADS7807	16	40	1 SE	Serial, SPI/P8	4, 5, ±10	Int/Ext	0.0022	16	88	28	PDIP-28, SOIC-28	26.06
ADS7813	16	40	1 SE	Serial, SPI	+4, 10, ±3.3, 5, 10	Int/Ext	0.003	16	89	35	PDIP-16, SOIC-16	20.24
ADS7825	16	40	4 SE	Serial, SPI/P8	±10	Int/Ext	0.003	16	83	50	PDIP-28, SOIC-28	28.15
ADS1110	16	0.240	1 SE/1 Diff	Serial, I²C	PGA (1-8), ±2.048	Int	0.01	16	—	0.72	SOT23-6	1.95
ADS1112	16	0.240	3 SE/2 Diff	Serial, I²C	PGA (1-8), ±2.048	Int	0.01	16	—	0.675	MSOP-10	2.49
ADS1100	16	0.128	1 SE/1 Diff	Serial, I²C	PGA (1-8), V_{DD}	Ext	0.0125	16	—	0.27	SOT23-6	1.75
TLC3541	14	200	1 SE	Serial, SPI	V_{REF}	Ext	0.006	14	81.5	17.5	SOIC-8, VSSOP-8	4.73
TLC3544	14	200	4 SE/2 Diff	Serial, SPI	4	Int/Ext	0.006	14	81	20	SOIC-20, TSSOP-20	5.72
TLC3545	14	200	1 Diff	Serial, SPI	V_{REF}	Ext	0.006	14	81.5	17.5	SOIC-8, VSSOP-8	4.73
TLC3548	14	200	8 SE/4 Diff	Serial, SPI	4	Int/Ext	0.006	14	81	20	SOIC-24, TSSOP-24	6.05
TLC3574	14	200	4 SE/2 Diff	Serial, SPI	±10	Ext	0.006	14	79	29	SOIC-24, TSSOP-24	6.50
TLC3578	14	200	8 SE/4 Diff	Serial, SPI	±10	Ext	0.006	14	79	29	SOIC-24, TSSOP-24	7.67
ADS8324	14	50	1 Diff	Serial, SPI	$\pm V_{REF}$ at $+V_{REF}$	Ext	0.012	14	78	2.5	VSSOP-8	3.95
ADS7871	14	40	8 SE/4 Diff	Serial, SPI	PGA (1, 2, 4, 8, 10, 16, 20)	Int	0.03	13	—	6	SSOP-28	4.75
ADS7869	12	1000	12 Diff	Serial, SPI/P12	±2.5 at +2.5	Int	0.048	11	—	175	TQFP-100	14.56
ADS7810	12	800	1 SE	P12	±10	Int/Ext	0.018	12	71	225	SOIC-28	26.44
ADS7818	12	500	1 Diff	Serial, SPI	5	Int	0.024	12	70	11	PDIP-8, VSSOP-8	2.35
ADS7834	12	500	1 Diff	Serial, SPI	2.5	Int	0.024	12	70	11	VSSOP-8	2.33
ADS7835	12	500	1 Diff	Serial, SPI	±2.5	Int	0.024	12	72	17.5	VSSOP-8	2.65
ADS7852	12	500	8 SE	P12	5	Int/Ext	0.024	12	72	13	TQFP-32	3.25
ADS7861	12	500	2x2 Diff	Serial, SPI	±2.5 at +2.5	Int/Ext	0.024	12	70	25	SSOP-24	3.85
ADS7862	12	500	2x2 Diff	P12	±2.5 at +2.5	Int/Ext	0.024	12	71	25	TQFP-32	5.45
ADS7864	12	500	3x2 Diff	P12	±2.5 at +2.5	Int/Ext	0.024	12	71	52.5	TQFP-48	6.35
TLC2551	12	400	1 SE	Serial, SPI	V_{REF}	Ext	0.024	12	72	15	SOIC-8, VSSOP-8	3.72
TLC2552	12	400	2 SE	Serial, SPI	V_{REF}	Ext	0.024	12	72	15	SOIC-8, VSSOP-8	3.72
TLC2554	12	400	4 SE	Serial, SPI	4	Int/Ext	0.024	12	71	9.5	SOIC-16, TSSOP-16	5.04
TLC2555	12	400	1 Diff	Serial, SPI	V_{REF}	Ext	0.024	12	72	15	SOIC-8, VSSOP-8	3.72

[1]SE = Single Ended, Diff = Differential. [2]NMC = no missing code resolution.
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New devices are listed in **bold red**.

ADCs (Continued)

Device	Res. (Bits)	Sample Rate (kSPS)	Number of Input Channels[1]	Interface	Input Voltage (V)	V_{REF}	Linearity (%)	NMC[2] (Bits)	SINAD (dB)	Power (mW)	Package(s)	Price[3]
TLC2558	12	400	8 SE	Serial, SPI	4	Int/Ext	0.024	12	71	9.5	SOIC-20, TSSOP-20	5.02
ADS7800	12	333	1 SE	P8/P12	±5, 10	Int	0.012	12	72	135	CDIP SB-24, PDIP-24	28.60
ADS7816	12	200	1 Diff	Serial, SPI	V_{REF}	Ext	0.024	12	72	1.9	PDIP-8, SOIC-8, VSSOP-8	1.85
ADS7817	12	200	1 Diff	Serial, SPI	$\pm V_{REF}$ at $+V_{REF}$	Ext	0.024	12	71	2.3	SOIC-8, VSSOP-8	1.85
ADS7841	12	200	4 SE/2 Diff	Serial, SPI	V_{REF}	Ext	0.024	12	72	0.84	SSOP-16	2.49
ADS7842	12	200	4 SE	P12	V_{REF}	Ext	0.024	12	72	0.84	SSOP-28	2.93
ADS7844	12	200	8 SE/4 Diff	Serial, SPI	V_{REF}	Ext	0.024	12	72	0.84	SSOP-20	2.88
TLC2574	12	200	4 SE	Serial, SPI	+2, 4	Ext	0.024	12	79	29	SOIC-20, TSSOP-20	4.67
TLC2578	12	200	8 SE	Serial, SPI	V_{REF}	Ext	0.024	12	79	29	SOIC-24, TSSOP-24	5.14
TLV2541	12	200	1 SE	Serial, SPI	V_{REF}	Ext	0.024	12	72	2.8	SOIC-8, VSSOP-8	3.63
TLV2542	12	200	2 SE	Serial, SPI	V_{REF}	Ext	0.024	12	72	2.8	SOIC-8, VSSOP-8	3.63
TLV2544	12	200	4 SE	Serial, SPI	+2, 4	Int/Ext	0.024	12	70	3.3	SOIC-16, TSSOP-16	3.99
TLV2545	12	200	1 Diff	Serial, SPI	+5.5 ($V_{REF} = V_{DD}$)	Ext	0.024	12	72	2.8	SOIC-8, VSSOP-8	3.63
TLV2548	12	200	8 SE	Serial, SPI	+2, 4	Int/Ext	0.024	12	70	3.3	SOIC-20, TSSOP-20	4.59
TLV2553	12	200	11 SE	Serial, SPI	V_{REF}	Ext	0.024	12	—	2.43	SOIC-20, TSSOP-20	3.42
TLV2556	12	200	11 SE	Serial, SPI	V_{REF}	Int/Ext	0.024	12	—	2.43	SOIC-20, TSSOP-20	3.55
ADS7829	12	125	1 Diff	Serial, SPI	V_{REF}	Ext	0.018	12	71	0.6	QFN-8	1.40
ADS7804	12	100	1 SE	P8/P16	±10	Int/Ext	0.011	12	72	81.5	PDIP-28, SOIC-28	13.36
ADS7808	12	100	1 SE	Serial, SPI	+4, 10 , ±3.3, 5, 10	Int/Ext	0.011	12	73	81.5	SOIC-20	10.30
AMC7820	12	100	8 DAS	Serial, SPI	+5	Int	0.024	12	72 (typ)	40	TQFP-48	9.15
VECANA01	12	78	10 Diff	Serial x3	PGA (1, 1.25, 2.5, 5), ±2.5	Int	0.048	12	—	225	PLCC-68	24.03
ADS7822	12	75	1 Diff	Serial, SPI	V_{REF}	Ext	0.018	12	71	0.6	PDIP-8, SOIC-8, VSSOP-8,	1.46
ADS7823	12	50	1 SE	Serial, I²C	V_{REF}	Ext	0.024	12	71	0.75	VSSOP-8	2.71
ADS7828	12	50	8 SE/4 Diff	Serial, I²C	V_{REF}	Int/Ext	0.024	12	71	0.675	TSSOP-16	3.20
ADS7870	12	50	8 SE	Serial, SPI	PGA (1, 2, 4, 8, 10, 16, 20)	Int	0.06	12	72	4.6	SSOP-28	3.95
ADS7806	12	40	1 SE	Serial, SPI/P8	+4, 5, ±10	Int/Ext	0.011	12	73	28	PDIP-28, SOIC-28	12.06
ADS7812	12	40	1 SE	Serial, SPI	+4, 10, ±3.3, 5, 10	Int/Ext	0.012	12	74	35	PDIP-16, SOIC-16	11.23
ADS7824	12	40	4 SE	Serial, SPI/P8	±10	Int/Ext	0.012	12	73	50	PDIP-28, SOIC-28	12.44
ADS1286	12	37	1 Diff	Serial, SPI	V_{REF}	Ext	0.024	12	72	1	PDIP-8, SOIC-8	3.01
TLC1514	10	400	4 SE/3 Diff	Serial, SPI	+5.5 ($V_{REF} = V_{DD}$)	Int/Ext	0.012	10	60	10	SOIC-16, TSSOP-16	2.76
TLC1518	10	400	8 SE/7 Diff	Serial, SPI	+5.5 ($V_{REF} = V_{DD}$)	Int/Ext	0.012	10	60	10	SOIC-20, TSSOP-20	3.28
ADS7826	10	200	1 Diff	Serial, SPI	V_{REF}	Ext	0.0048	10	62	0.6	QFN-8	1.20
TLV1504	10	200	4 SE	Serial, SPI	+2, 4	Int/Ext	0.05	10	60	3.3	SOIC-16, TSSOP-16	2.51
TLV1508	10	200	8 SE	Serial, SPI	+2, 4	Int/Ext	0.05	10	60	3.3	SOIC-20, TSSOP-20	3.01
TLC1550	10	164	1 SE	P10	V_{REF}	Ext	0.05	10	—	10	PLCC-28, SOIC-24	3.71
TLC1551	10	164	1 SE	P10	V_{REF}	Ext	0.1	10	—	10	PLCC-28, SOIC-24	3.19
TLV1544	10	85	4 SE	Serial, SPI	V_{REF}	Ext	0.1	10	—	1.05	SOIC-16, TSSOP-16	1.85
TLV1548	10	85	8 SE	Serial, SPI	V_{REF}	Ext	0.1	10	—	1.05	CDIP-20, LCCC-20, SSOP-20	2.18
TLC1542	10	38	11 SE	Serial, SPI	V_{REF}	Ext	0.05	10	—	4	CDIP-20, LCCC-20, PDIP-20, PLCC-20, SOIC-20	2.38
TLV1543	10	38	11 SE	Serial, SPI	V_{REF}	Ext	0.1	10	—	2.64	CDIP-20, LCCC-20, PDIP-20, PLCC-20, SOIC-20, SSOP-20	2.05
TLV1549	10	38	1 SE	Serial, SPI	V_{REF}	Ext	0.1	10	—	1.32	PDIP-8, SOIC-8	1.72
TLC1541	10	32	11 SE	Serial, SPI	V_{REF}	Ext	0.1	10	—	6	PDIP-20, PLCC-20, SOIC-20	3.05
TLC0820A	8	392	1 SE	P8	V_{REF}	Ext	0.2	8	—	37.5	PLCC-20, SOIC-20, SSOP-20	1.79
ADS7827	8	250	1 Diff	Serial, SPI	V_{REF}	Ext	0.2	8	48	0.6	QFN-8	0.95
TLC545	8	76	19 SE	Serial, SPI	V_{REF}	Ext	0.2	8	—	6	PDIP-28, PLCC-28	2.94
TLC540	8	75	11 SE	Serial, SPI	V_{REF}	Ext	0.2	8	—	6	PDIP-20, PLCC-20, SOIC-20	1.74
TLV0831	8	49	1 SE	Serial, SPI	+3.6 ($V_{REF} = V_{DD}$)	Ext	0.2	8	—	0.66	PDIP-8, SOIC-8	1.32
TLC548	8	45.5	1 SE	Serial, SPI	V_{REF}	Ext	0.2	8	—	9	PDIP-8, SOIC-8	1.14
TLV0832	8	44.7	2 SE/1 Diff	Serial, SPI	V_{REF}	Ext	0.2	8	—	5	PDIP-8, SOIC-8	1.32
TLV0834	8	41	4 SE/2 Diff	Serial, SPI	V_{REF}	Ext	0.2	8	—	0.66	PDIP-14, SOIC-14, TSSOP-14	1.38
TLC541	8	40	11 SE	Serial, SPI	V_{REF}	Ext	0.2	8	—	6	PDIP-20, PLCC-20, SOIC-20	1.41
TLC549	8	40	1 SE	Serial, SPI	V_{REF}	Ext	0.2	8	—	9	PDIP-8, SOIC-8	0.90

[1]SE = Single Ended, Diff = Differential. [2]NMC = no missing code resolution.

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

[3]Suggested resale price in U.S. dollars in quantities of 1,000. For current pricing, visit **www.ti.com** *or* **dataconverter.ti.com**

Data Converters

ADCs (Continued)

Device	Res. (Bits)	Sample Rate (kSPS)	Number of Input Channels[1]	Interface	Input Voltage (V)	V_{REF}	Linearity (%)	NMC[2] (Bits)	SINAD (dB)	Power (mW)	Package(s)	Price[3]
TLV0838	8	37.9	8 SE/4 Diff	Serial, SPI	V_{REF}	Ext	0.2	8	—	0.66	PDIP-20, SOIC-20, TSSOP-20	1.38
TLC0831	8	31	1 Diff	Serial, SPI	V_{REF}	Ext	0.2	8	—	3	PDIP-8, SOIC-8	1.32
TLC542	8	25	11 SE	Serial, SPI	V_{REF}	Ext	0.2	8	—	6	PDIP-20, PLCC-20, SOIC-20	1.42
TLC0832	8	22	2 SE/1 Diff	Serial, SPI	V_{REF}	Ext	0.2	8	—	12.5	PDIP-8, SOIC-8	1.32
TLC0834	8	20	4 SE/2 Diff	Serial, SPI	V_{REF}	Ext	0.2	8	—	3	PDIP-14, SOIC-14	1.38
TLC0838	8	20	8 SE/4 Diff	Serial, SPI	V_{REF}	Ext	0.2	8	—	3	PDIP-20, SOIC-20, TSSOP-20	1.38
TLC7135	4.5 Dig	0.003	1 SE	MUX BCD	$\pm V_{REF}$	Ext	0.005	4.5 Dig	—	5	PDIP-28, SOIC-28	1.89

[1]SE = Single Ended, Diff = Differential. [2]NMC = no missing code resolution.
New devices are listed in **bold red**.
[3]Suggested resale price in U.S. dollars in quantities of 1,000. For current pricing, visit **www.ti.com** *or* **dataconverter.ti.com**

Intelligent ADCs

Device	ADC Resolution (Bits)	Sample Rate (kSPS)	Number of Input Channels	Input Voltage (V)	V_{REF}	CPU Core	Program Memory (KB)	Program Memory Type	SRAM (KB)	Power (mW/V)	DAC Output (Bits)	Price[3]
MSC1200Y2	24	1	8 Diff / 8 SE	PGA (1-128), ± 2.5	Int	8051	4	Flash	0.1	4 / 2.7-5.25	8-bit IDAC	5.95
MSC1200Y3	24	1	8 Diff / 8 SE	PGA (1-128), ± 2.5	Int	8051	8	Flash	0.1	4 / 2.7-5.25	8-bit IDAC	6.45
MSC1210Y2	24	1	8 Diff / 8 SE	PGA (1-128), ± 2.5	Int	8051	4	Flash	1.2	4 / 2.7-5.25	16-bit PWM	8.95
MSC1210Y3	24	1	8 Diff / 8 SE	PGA (1-128), ± 2.5	Int	8051	8	Flash	1.2	4 / 2.7-5.25	16-bit PWM	9.49
MSC1210Y4	24	1	8 Diff / 8 SE	PGA (1-128), ± 2.5	Int	8051	16	Flash	1.2	4 / 2.7-5.25	16-bit PWM	10.74
MSC1210Y5	24	1	8 Diff / 8 SE	PGA (1-128), ± 2.5	Int	8051	32	Flash	1.2	4 / 2.7-5.25	16-bit PWM	12.26
MSC1211Y2[1]	24	1	8 Diff / 8 SE	PGA (1-128), ± 2.5	Int	8051	4	Flash	1.2	4 / 2.7-5.25	4x16-bit I/VDAC[2]	16.65
MSC1211Y3[1]	24	1	8 Diff / 8 SE	PGA (1-128), ± 2.5	Int	8051	8	Flash	1.2	4 / 2.7-5.25	4x16-bit I/VDAC[2]	17.20
MSC1211Y4[1]	24	1	8 Diff / 8 SE	PGA (1-128), ± 2.5	Int	8051	16	Flash	1.2	4 / 2.7-5.25	4x16-bit I/VDAC[2]	18.45
MSC1211Y5[1]	24	1	8 Diff / 8 SE	PGA (1-128), ± 2.5	Int	8051	32	Flash	1.2	4 / 2.7-5.25	4x16-bit I/VDAC[2]	19.95
MSC1212Y2[1]	24	1	8 Diff / 8 SE	PGA (1-128), ± 2.5	Int	8051	4	Flash	1.2	4 / 2.7-5.25	4x16-bit I/VDAC[2]	16.15
MSC1212Y3[1]	24	1	8 Diff / 8 SE	PGA (1-128), ± 2.5	Int	8051	8	Flash	1.2	4 / 2.7-5.25	4x16-bit I/VDAC[2]	16.70
MSC1212Y4[1]	24	1	8 Diff / 8 SE	PGA (1-128), ± 2.5	Int	8051	16	Flash	1.2	4 / 2.7-5.25	4x16-bit I/VDAC[2]	17.95
MSC1212Y5[1]	24	1	8 Diff / 8 SE	PGA (1-128), ± 2.5	Int	8051	32	Flash	1.2	4 / 2.7-5.25	4x16-bit I/VDAC[2]	19.45

[1]MSC1211 includes four 16-bit DACs.
New devices are listed in **bold red**.
[2]All four DACs default to "voltage out" or alternately up to two DACs can be configured as "current out".
[3]Suggested resale price in U.S. dollars in quantities of 1,000.
For current pricing, visit **dataconverter.ti.com**

High-Speed DACs

Device	Resolution (Bits)	Number of Output DACs	Interface	Update Rate (MSPS)	DNL (±LSB)	INL (±LSB)	Supply Voltage (V)	Power (mW)	Package	Price[1]
DAC2902	12	2	Parallel	125	2.5	3	3.0 to 5.5	310	TQFP-48	10.70
DAC902	12	1	Parallel	200	1.75	2.5	2.7 to 5.5	170	SO-28, TSSOP-28	5.95
DAC2932	12	2	Parallel	40	0.5	2	2.7 to 3.3	25	TQFP-48	8.35
DAC2900	10	2	Parallel	125	1	1	3.0 to 5.5	310	TQFP-48	7.60
DAC900	10	1	Parallel	200	0.5	1	2.7 to 5.5	170	SO-28, TSSOP-28	4.20
DAC908	8	1	Parallel	200	0.5	0.5	2.7 to 5.5	170	SO-28, TSSOP-28	3.15

[1]Suggested resale price in U.S. dollars in quantities of 1,000.
For current pricing, visit **dataconverter.ti.com**

DACs

Device	Architecture	Res. (Bits)	Settling Time (µs)	Number of Output DACs	Interface	Output (V)	V_{REF}	Linearity (%)	Monotonic (Bits)	Power (mW) (typ)	Package(s)	Price[1]
DAC7731	R-2R	16	5	1	Serial, SPI	+10, ±10	Int/Ext	0.0015	16	100	SSOP-24	7.80
DAC7741	R-2R	16	5	1	P16	±10	Int/Ext	0.0015	16	100	LQFP-48	8.30
DAC712	R-2R	16	10	1	P16	±10	Int	0.003	15	525	PDIP-28, SOIC-28	2.53
DAC714	R-2R	16	10	1	Serial, SPI	±10	Int	0.0015	16	525	PDIP-16, SOIC-16	12.53
DAC715	R-2R	16	10	1	P16	+10	Int	0.003	16	525	PDIP-28, SOIC-28	12.53
DAC716	R-2R	16	10	1	Serial, SPI	+10	Int	0.003	16	525	PDIP-16, SOIC-16	12.53
DAC7631	R-2R	16	10	1	Serial, SPI	$+V_{REF}$, $\pm V_{REF}$	Ext	0.0015	15	1.8	SSOP-20	5.57
DAC7632	R-2R	16	10	2	Serial, SPI	$+V_{REF}$, $\pm V_{REF}$	Ext	0.0015	15	2.5	LQFP-32	9.94
DAC7634	R-2R	16	10	4	Serial, SPI	$+V_{REF}$, $\pm V_{REF}$	Ext	0.0015	15	7.5	SSOP-48	18.98
DAC7641	R-2R	16	10	1	P16	$+V_{REF}$, $\pm V_{REF}$	Ext	0.0015	15	1.8	TQFP-32	5.99
DAC7642	R-2R	16	10	2	P16	$+V_{REF}$, $\pm V_{REF}$	Ext	0.0015	15	2.5	LQFP-32	10.04
DAC7643	R-2R	16	10	2	P16	$+V_{REF}$, $\pm V_{REF}$	Ext	0.0015	15	2.5	LQFP-32	10.04
DAC7644	R-2R	16	10	4	P16	$+V_{REF}$, $\pm V_{REF}$	Ext	0.0015	15	7.5	SSOP-48	18.98
DAC7734	R-2R	16	10	4	Serial, SPI	$+V_{REF}$, $\pm V_{REF}$	Ext	0.0015	16	50	SSOP-48	29.94
DAC7742	R-2R	16	10	1	P16	±10	Int/Ext	0.0015	16	100	LQFP-48	8.30
DAC7744	R-2R	16	10	4	P16	$\pm V_{REF}$	Ext	0.0015	16	50	SSOP-48	29.94
DAC8501	String	16	10	1	Serial, SPI	$+V_{REF}$/MDAC	Ext	0.0987	16	0.72	VSSOP-8	2.83
DAC8531	String	16	10	1	Serial, SPI	$+V_{REF}$	Ext	0.0987	16	0.72	VSSOP-8	2.83
DAC8532	String	16	10	2	Serial, SPI	$+V_{REF}$	Ext	0.0987	16	1.35	VSSOP-8	5.32
DAC8534	String	16	10	4	Serial, SPI	$+V_{REF}$	Ext	0.0987	16	0.42	VTSSOP-16	9.75
DAC8541	String	16	10	1	P16	$+V_{REF}$	Ext	0.096	16	0.72	TQFP-32	2.85
DAC8571	String	16	10	1	Serial, I^2C	$+V_{REF}$	Ext	0.0987	16	0.42	VSSOP-8	2.83
DAC8574	String	16	10	4	Serial, I^2C	$+V_{REF}$	Ext	0.0987	16	2.7	TSSOP-16	9.75
DAC7800	R-2R	12	0.8	2	Serial, SPI	1 mA	Ext	0.012	12	1	PDIP-16, SOIC-16	11.90
DAC7801	R-2R	12	0.8	2	P12	1 mA	Ext	0.012	12	1	PDIP-24, SOIC-24	15.26
DAC7802	R-2R	12	0.8	2	P12	1 mA	Ext	0.012	12	1	PDIP-24, SOIC-24	12.32
DAC7541	R-2R	12	1	1	P12	±1 mA	Ext	0.012	12	30	PDIP-18, SOP-18	6.40
DAC8043	R-2R	12	1	1	Serial, SPI	1 mA	Ext	0.012	12	2.5	SOIC-8	7.54
TLV5610	String	12	1	8	Serial, SPI	$+V_{REF}$	Ext	0.4	12	18	SOIC-20, TSSOP-20	9.41
TLV5613	String	12	1	1	P8	$+V_{REF}$	Ext	0.1	12	1.2	SOIC-20, TSSOP-20	2.70
TLV5619	String	12	1	1	P12	$+V_{REF}$	Ext	0.08	12	4.3	SOIC-20, TSSOP-20	2.70
TLV5630	String	12	1	8	Serial, SPI	$+V_{REF}$	Int/Ext	0.4	12	18	SOIC-20, TSSOP-20	9.02
TLV5633	String	12	1	1	P8	+2, 4	Int/Ext	0.08	12	2.7	SOIC-20, TSSOP-20	4.46
TLV5636	String	12	1	1	Serial, SPI	+2, 4	Int/Ext	0.1	12	4.5	SOIC-8, VSSOP-8	3.82
TLV5638	String	12	1	2	Serial, SPI	+2, 4	Int/Ext	0.1	12	4.5	SOIC-8, CDIP-8, LCCC-20	3.92
TLV5639	String	12	1	1	P12	+2, 4	Int/Ext	0.1	12	2.7	SOIC-20, TSSOP-20	3.58
DAC7545	R-2R	12	2	1	P12	±1 mA	Ext	0.012	12	30	SOIC-20	5.00
TLV5618A	String	12	2.5	2	Serial, SPI	$+V_{REF}$	Ext	0.08	12	1.8	CDIP-8, PDIP-8, SOIC-8, LCCC-20	4.25
TLV5614	String	12	3	4	Serial, SPI	$+V_{REF}$	Ext	0.1	12	3.6	SOIC-16, TSSOP-16	7.74
TLV5616	String	12	3	1	Serial, SPI	$+V_{REF}$	Ext	0.1	12	0.9	VSSOP-8, PDIP-8, SOIC-8	2.70
DAC811	R-2R	12	4	1	P12	+10, ±5, 10	Int	0.006	12	625	CDIP SB-28, PDIP-28, SOIC-28	10.92
DAC813	R-2R	12	4	1	P12	+10, ±5, 10	Int/Ext	0.006	12	270	PDIP-28, SOIC-28	10.96
DAC7512	String	12	10	1	Serial, SPI	$+ V_{CC}$	Ext	0.38	12	0.345	VSSOP-8, SOT23-6	1.37
DAC7513	String	12	10	1	Serial, SPI	V_{REF}	Ext	0.38	12	0.3	VSSOP-8, SSOP-8	1.37
DAC7571	String	12	10	1	Serial, I^2C	$+V_{REF}$	Ext	0.096	12	0.85	PLCC-8	1.37
DAC7574	String	12	10	4	Serial, I^2C	$+V_{REF}$	Ext	0.096	12	0.85	SSOP-14	4.86
DAC7611	R-2R	12	10	1	Serial, SPI	+4	Int	0.012	12	5	PDIP-8, SOIC-8	2.39
DAC7612	R-2R	12	10	1	Serial, SPI	+4	Int	0.012	12	3.5	SOIC-8	2.57
DAC7613	R-2R	12	10	1	P12	$+V_{REF}$, $\pm V_{REF}$	Ext	0.012	12	1.8	SSOP-24	2.16

[1] *Suggested resale price in U.S. dollars in quantities of 1,000.*
For current pricing, visit **dataconverter.ti.com**

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

Data Converters

DACs (Continued)

Device	Architecture	Res. (Bits)	Settling Time (µs)	Number of Output DACs	Interface	Output (V)	V_{REF}	Linearity (%)	Monotonic (Bits)	Power (mW) (typ)	Package(s)	Price[1]
DAC7614	R-2R	12	10	4	Serial, SPI	$+V_{REF}$, $\pm V_{REF}$	Ext	0.012	12	15	PDIP-16, SOIC-16, SSOP-20	6.38
DAC7615	R-2R	12	10	4	Serial, SPI	$+V_{REF}$, $\pm V_{REF}$	Ext	0.012	12	15	PDIP-16, SOIC-16, SSOP-20	6.38
DAC7616	R-2R	12	10	4	Serial, SPI	$+V_{REF}$, $\pm V_{REF}$	Ext	0.012	12	2.4	SOIC-16, SSOP-20	5.75
DAC7617	R-2R	12	10	4	Serial, SPI	$+V_{REF}$, $\pm V_{REF}$	Ext	0.012	12	2.4	SOIC-16, SSOP-20	5.75
DAC7621	R-2R	12	10	1	P12	+4	Int	0.012	12	2.5	SSOP-20	2.62
DAC7624	R-2R	12	10	4	P12	$\pm V_{REF}$	Ext	0.012	12	15	PDIP-28, SOIC-28	9.26
DAC7625	R-2R	12	10	4	P12	$\pm V_{REF}$	Ext	0.012	12	15	PDIP-28, SOIC-28	9.26
DAC7714	R-2R	12	10	4	Serial, SPI	$\pm V_{REF}$	Ext	0.012	12	45	SOIC-16	10.88
DAC7715	R-2R	12	10	4	Serial, SPI	$\pm V_{REF}$	Ext	0.012	12	45	SOIC-16	10.88
DAC7724	R-2R	12	10	4	P12	$\pm V_{REF}$	Ext	0.012	12	45	PLCC-28, SOIC-28	11.85
DAC7725	R-2R	12	10	4	P12	$\pm V_{REF}$	Ext	0.012	12	45	PLCC-28, SOIC-28	11.85
TLV5637	String	10	0.8	2	Serial, SPI	+2, 4	Int/Ext	0.1	10	4.2	SOIC-8	4.30
TLV5608	String	10	1	8	Serial, SPI	$+V_{REF}$	Ext	0.4	10	18	SOIC-20, TSSOP-20	4.74
TLV5631	String	10	1	8	Serial, SPI	$+V_{REF}$	Int/Ext	0.4	10	18	SOIC-20, TSSOP-20	5.12
TLV5617A	String	10	2.5	2	Serial, SPI	$+V_{REF}$	Ext	0.1	10	1.8	SOIC-8	2.90
UCC5950	String	10	2.5	1	Serial, SPI	+1.1, 3.2	Int	0.2	10	7.5	PDIP-8, SOIC-8	1.39
TLV5604	String	10	3	4	Serial, SPI	$+V_{REF}$	Ext	0.05	10	3	SOIC-16, TSSOP-16	3.86
TLV5606	String	10	3	1	Serial, SPI	$+V_{REF}$	Ext	0.15	10	0.9	SOIC-8, VSSOP-8	1.35
TLC5615	String	10	12.5	1	Serial, SPI	$+V_{REF}$	Ext	0.1	10	0.75	PDIP-8, SOIC-8, VSSOP-8	1.85
TLC7524	R-2R	8	0.1	1	P8	1mA	Ext	0.2	8	5	PDIP-16, PLCC-20, SOIC-16, TSSOP-16	1.44
TLC7528	R-2R	8	0.1	2	P8	1mA	Ext	0.2	8	7.5	PDIP-20, PLCC-20, SOIC-20, TSSOP-20	1.52
TLC7628	R-2R	8	0.1	2	P8	2mA	Ext	0.2	8	20	SOIC-20, PDIP-20	1.36
TLV5626	String	8	0.8	2	Serial, SPI	+2, 4	Int/Ext	0.4	8	4.2	SOIC-8	2.22
TLV5624	String	8	1	1	Serial, SPI	+2, 4	Int/Ext	0.2	8	0.9	SOIC-8, VSSOP-8	1.65
TLV5629	String	8	1	8	Serial, SPI	$+V_{REF}$	Ext	0.4	8	18	SOIC-20, TSSOP-20	2.99
TLV5632	String	8	1	8	Serial, SPI	+2, 4	Int/Ext	0.4	8	18	SOIC-20, TSSOP-20	3.19
TLV5627	String	8	2.5	4	Serial, SPI	$+V_{REF}$	Ext	0.2	8	3	SOIC-16, TSSOP-16	2.69
TLV5623	String	8	3	1	Serial, SPI	$+V_{REF}$	Ext	0.2	8	2.1	SOIC-8, VSSOP-8	1.15
TLV5625	String	8	3	2	Serial, SPI	$+V_{REF}$	Ext	0.2	8	2.4	SOIC-8	1.74
TLC7225	R-2R	8	5	4	P8	$+V_{REF}$	Ext	0.4	8	75	SOIC-24	2.20
TLC7226	R-2R	8	5	4	P8	$+V_{REF}$	Ext	0.4	8	90	PDIP-20, SOIC-20	2.11
TLC5620	String	8	10	4	Serial, SPI	$+V_{REF}$	Ext	0.4	8	8	PDIP-14, SOIC-14	1.42
TLC5628	String	8	10	8	Serial, SPI	$+V_{REF}$	Ext	0.4	8	15	PDIP-16, SOIC-16	2.32
TLV5620	R-2R	8	10	4	Serial, SPI	$+V_{REF}$	Ext	0.2	8	6	PDIP-14, SOIC-14	1.00
TLV5621	R-2R	8	10	4	Serial, SPI	$+V_{REF}$	Ext	0.4	8	3.6	SOIC-14	1.74
TLV5628	String	8	10	8	Serial, SPI	$+V_{REF}$	Ext	0.4	8	12	PDIP-16, SOIC-16	2.32

[1]Suggested resale price in U.S. dollars in quantities of 1,000.
For current pricing, visit **dataconverter.ti.com**

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

Voltage References

Voltage References

Device	Description	Output (V)	Initial Accuracy (%) (max)	Drift (ppm/°C) (max)	Long-Term Stability (ppm/kHr) (typ)	Noise 0.1 Hz to 10 Hz (µVp-p) (typ)	I_Q (mA) (max)	Temperature Range (°C)	Package(s)	Price[1]
REF29xx	Micropower bandgap	1.25, 2.048, 2.5, 3.0, 3.3, 4.096	2.00%	100	24	20 - 45	0.05	–40 to +125	SOT23-3	0.49
REF30xx	Micropower bandgap	1.25, 2.048, 2.5, 3.0, 3.3, 4.096	0.20%	50	24	20 - 45	0.05	–40 to +125	SOT23-3	0.59
REF31xx	Precision micropower	1.25, 2.048, 2.5, 3.0, 3.3, 4.096	0.20%	15	24	15 - 30	0.1	–40 to +125	SOT23-3	1.10
REF02A/B	Low drift, low noise, buried Zener	5.0	0.19%/0.13%	10/5	50	4	1.4	–25 to +85	PDIP-8, SOIC-8	1.65/2.27
REF102A/B/C	Low drift, low noise, buried Zener	10.0	0.1%/0.05%/ 0.025%	10/5/2.5	20	5	1.4	–25 to +85	PDIP-8, SOIC-8	1.65/4.15/ 4.85
REF200	Dual current reference with current mirror	Two 100 µA	±1 µA	25 (typ)	—	—	—	–25 to +85	PDIP-8, SOIC-8	2.54

[1]Suggested resale price in U.S. dollars in quantities of 1,000. For a complete product listing visit **amplifier.ti.com**
For current pricing and complete product listing, visit **dataconverter.ti.com**

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

Microcontrollers

MSP430 Ultra-Low-Power Microcontrollers

Device[1]	Program	SRAM	I/O	LCD Seg	Watch-dog 16-Bit	Timer_A 16-Bit No. of C/C[2]	Timer_B 16-Bit No. of C/C[2]	USART	I^2C	SVS	Brown-Out Reset	MPY	Comp_A	ADC	Additional Analog	Pins/Packages	Price[3]
Flash/ROM-Based F1xx Family V_{CC} 1.8 to 3.6 V																	
MSP430F1101A	1 KB	128	14	—	✔	3	—	—	—	—	—	—	✔	slope	—	20 DGV, DW, PW, 24 RGE	0.99
MSP430C1101	1 KB	128	14	—	✔	3	—	—	—	—	—	—	✔	slope	—	20 DGV, DW, PW, 24 RGE	0.60
MSP430F1111A	2 KB	128	14	—	✔	3	—	—	—	—	—	—	✔	slope	—	20 DGV, DW, PW, 24 RGE	1.35
MSP430C1111	2 KB	128	14	—	✔	3	—	—	—	—	—	—	✔	slope	—	20 DGV, DW, PW, 24 RGE	1.10
MSP430F1121A	4 KB	256	14	—	✔	3	—	—	—	—	—	—	✔	slope	—	20 DGV, DW, PW, 24 RGE	1.70
MSP430C1121	4 KB	256	14	—	✔	3	—	—	—	—	—	—	✔	slope	—	20 DGV, DW, PW, 24 RGE	1.35
MSP430F1122	4 KB	256	14	—	✔	3	—	—	—	—	✔	—	—	5-ch ADC10	—	20 DW, PW, 32 RHB	2.00
MSP430C1122	4 KB	256	14	—	✔	3	—	—	—	—	✔	—	—	5-ch ADC10	—	20 DW, PW	1.50
MSP430F1132	8 KB	256	14	—	✔	3	—	—	—	—	✔	—	—	5-ch ADC10	—	20 DW, PW, 32 RHB	2.25
MSP430C1132	8 KB	256	14	—	✔	3	—	—	—	—	✔	—	—	5-ch ADC10	—	20 DW, PW	1.70
MSP430F122	4 KB	256	22	—	✔	3	—	1	—	—	—	—	✔	slope	—	28 DW,PW, 32 RHB	2.15
MSP430F123	8 KB	256	22	—	✔	3	—	1	—	—	—	—	✔	slope	—	28 DW,PW, 32 RHB	2.30
MSP430F1222	4 KB	256	22	—	✔	3	—	1	—	—	✔	—	—	8-ch ADC10	—	28 DW, PW, 32 RHB	2.40
MSP430F1232	8 KB	256	22	—	✔	3	—	1	—	—	✔	—	—	8-ch ADC10	—	28 DW,PW, 32 RHB	2.50
MSP430F133	8 KB	256	48	—	✔	3	3	1	—	—	—	—	✔	8-ch ADC12	—	64 PM, RTD, PAG	3.00
MSP430C1331	8 KB	256	48	—	✔	3	3	1	—	—	—	—	✔	slope	—	64 PM, RTD	2.00
MSP430F135	16 KB	512	48	—	✔	3	3	1	—	—	—	—	✔	8-ch ADC12	—	64 PM, RTD, PAG	3.60
MSP430C1351	16 KB	512	48	—	✔	3	3	1	—	—	—	—	✔	slope	—	64 PM, RTD	2.30
MSP430F147	32 KB	1024	48	—	✔	3	7	2	—	—	—	✔	✔	8-ch ADC12	—	64 PM, RTD, PAG	5.05
MSP430F1471	32 KB	1024	48	—	✔	3	7	2	—	—	—	✔	✔	slope	—	64 PM, RTD	4.60
MSP430F148	48 KB	2048	48	—	✔	3	7	2	—	—	—	✔	✔	8-ch ADC12	—	64 PM, RTD, PAG	5.75
MSP430F1481	48 KB	2048	48	—	✔	3	7	2	—	—	—	✔	✔	slope	—	64 PM, RTD	5.30
MSP430F149	60 KB	2048	48	—	✔	3	7	2	—	—	—	✔	✔	8-ch ADC12	—	64 PM, RTD, PAG	6.05
MSP430F1491	60 KB	2048	48	—	✔	3	7	2	—	—	—	✔	✔	slope	—	64 PM, RTD	5.60
MSP430F155	16 KB	512	48	—	✔	3	3	1	✔	✔	✔	—	✔	8-ch ADC12	(2) DAC12	64 PM	4.95
MSP430F156	24 KB	1024	48	—	✔	3	3	1	✔	✔	✔	—	✔	8-ch ADC12	(2) DAC12	64 PM	5.35

[1]C = ROM, F = Flash.
[2]C/C = Capture/Compares.
[3]Suggested resale price in U.S. dollars in quantities of 1,000.
All devices support industrial temperature range.

Microcontrollers

MSP430 Ultra-Low-Power Microcontrollers (Continued)

Device[1]	Program	SRAM	I/O	LCD Seg	Watch-dog 16-Bit	Timer_A 16-Bit No. of C/C[2]	Timer_B 16-Bit No. of C/C[2]	USART	I^2C	SVS	Brown-Out Reset	MPY	Comp_A	ADC	Additional Analog	Pins/Packages	Price[3]
Flash/ROM-Based F1xx Family V_{CC} 1.8 to 3.6 V (Continued)																	
MSP430F157	32 KB	1024	48	—	✔	3	3	1	✔	✔	✔	—	✔	8-ch ADC12	(2) DAC12	64 PM	5.85
MSP430F167	32 KB	1024	48	—	✔	3	7	2	✔	✔	✔	✔	✔	8-ch ADC12	(2) DAC12	64 PM	6.75
MSP430F168	48 KB	2048	48	—	✔	3	7	2	✔	✔	✔	✔	✔	8-ch ADC12	(2) DAC12	64 PM	7.45
MSP430F169	60 KB	2048	48	—	✔	3	7	2	✔	✔	✔	✔	✔	8-ch ADC12	(2) DAC12	64 PM	7.95
MSP430F1610	32 KB	5120	48	—	✔	3	7	2	✔	✔	✔	✔	✔	8-ch ADC12	(2) DAC12	64 PM	8.25
MSP430F1611	48 KB	10240	48	—	✔	3	7	2	✔	✔	✔	✔	✔	8-ch ADC12	(2) DAC12	64 PM	8.65
MSP430F1612	55 KB	5120	48	—	✔	3	7	2	✔	✔	✔	✔	✔	8-ch ADC12	(2) DAC12	64 PM	8.95
Flash/ROM-Based F4xx Family With LCD Driver V_{CC} 1.8 to 3.6 V																	
MSP430F412	4 KB	256	48	96	✔	3	—	—	—	✔	✔	—	✔	slope	—	64 PM, RTD	2.60
MSP430C412	4 KB	256	48	96	✔	3	—	—	—	✔	✔	—	✔	slope	—	64 PM, RTD	1.90
MSP430F413	8 KB	256	48	96	✔	3	—	—	—	✔	✔	—	✔	slope	—	64 PM, RTD	2.95
MSP430C413	8 KB	256	48	96	✔	3	—	—	—	✔	✔	—	✔	slope	—	64 PM, RTD	2.10
MSP430F423	8 KB	256	14	128	✔	3	—	1	—	✔	✔	—	—	(3) SD16	—	64 PM	4.50
MSP430F425	16 KB	512	14	128	✔	3	—	1	—	✔	✔	—	—	(3) SD16	—	64 PM	4.95
MSP430F427	32 KB	1024	14	128	✔	3	—	1	—	✔	✔	—	—	(3) SD16	—	64 PM	5.40
MSP430F435	16 KB	512	48	128/160	✔	3	3	1	—	✔	✔	—	✔	8-ch ADC12	—	80 PN, 100 PZ	4.45
MSP430F436	24 KB	1024	48	128/160	✔	3	3	1	—	✔	✔	—	✔	8-ch ADC12	—	80 PN, 100 PZ	4.70
MSP430F437	32 KB	1024	48	128/160	✔	3	3	1	—	✔	✔	—	✔	8-ch ADC12	—	80 PN, 100 PZ	4.90
MSP430F447	32 KB	1024	48	160	✔	3	7	2	—	✔	✔	✔	✔	8-ch ADC12	—	100 PZ	5.75
MSP430F448	48 KB	2048	48	160	✔	3	7	2	—	✔	✔	✔	✔	8-ch ADC12	—	100 PZ	6.50
MSP430F449	60 KB	2048	48	160	✔	3	7	2	—	✔	✔	✔	✔	8-ch ADC12	—	100 PZ	7.05

[1]*C = ROM, F = Flash.*
[2]*C/C = Capture/Compares.*
[3]*Suggested resale price in U.S. dollars in quantities of 1,000.*
All devices support industrial temperature range.

Digital Temperature Sensors

Digital Temperature Sensors

Device	Supply Voltage (V)	Interface	–25 to 85°C Accuracy (°C max)[1]	Quiescent Current (µA max)	Resolution (Bits)	Programmable Temp Alert	Max Operating Temp (°C)	Package	Price[2]
TMP100	2.7 to 5.5	2-wire	±2	45	9 to 12	—	150	SOT23	0.75
TMP101	2.7 to 5.5	2-wire	±2	45	9 to 12	✔	150	SOT23	0.80
TMP121	2.7 to 5.5	SPI	±1.5	50	12	—	150	SOT23	0.90
TMP122	2.7 to 5.5	SPI	±1.5	50	9 to 12	✔	150	SOT23	0.99
TMP123	2.7 to 5.5	SPI	±1.5	50	12	—	150	SOT23	0.90
TMP124	2.7 to 5.5	SPI	±1.5	50	12	—	150	SO-8	0.80
TMP75	2.7 to 5.5	2-wire	±1.5	50	9 to 12	✔	127	SO-8	0.70
TMP175	2.7 to 5.5	2-wire	±1.5	50	9 to 12	✔	127	SO-8	0.80

[1]*All digital temp sensors have ±0.5°C typical accuracy.*
[2]*Suggested resale price in U.S. dollars in quantities of 1,000.*

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

LVDS Line Drivers and Receivers

Device	Max Drvr/Rcvr t_{pd} (ns)	Max Speed (Mbps)	Max Supply Current (mA)	HBM ESD Protection (kV)	# Inputs	# Outputs	Output Skew (ps)[1]	Pulse Skew (ps)[1]	Package Options	Comments	Price[2]
SN65LVDS1	3.1	630	8	15	1 LVTTL	1 LVDS	–	300 typ	5-pin SOT-23, 8-pin SOIC	Single driver	0.66
SN65LVDS2	3.6	400	7	15	1 LVDS	1 LVTTL	–	600 max	5-pin SOT-23, 8-pin SOIC	Single receiver	0.66
SN65LVDS22	6	400	20	12	2 LVDS	2 LVDS	–	200 typ	16-pin SOIC, TSSOP	2:2 MUX (crosspoint)	3.01
SN65LVDS31	2.5	400	35	8	4 LVTTL	4 LVDS	300 max	300 max	16-pin SOIC, TSSOP	Quad driver	1.85
SN65LVDS32[3]	3	400	18	8	4 LVDS	4 LVTTL	300 max	400 max	16-pin SOIC, TSSOP	Quad receiver	1.85
SN65LVDS33[3]	6	400	23	15	4 LVDS	4 LVTTL	150 typ	200 typ	16-pin SOIC, TSSOP	Quad receiver	2.22
SN65LVDS047	2.8	400	26	8	4 LVTTL	4 LVDS	300 max	300 max	16-pin SOIC, TSSOP	Quad driver	1.83
SN65LVDS048A	3.7	400	15	10	4 LVDS	4 LVTTL	500 max	450 max	16-pin SOIC, TSSOP	Quad receiver	1.83
SN65LVDS386[3]	4	300	70	4	16 LVDS	16 LVTTL	400 max	600 max	64-pin TSSOP	16-ch. receiver	5.55
SN65LVDS387	2.9	630	95	15	16 LVTTL	16 LVDS	150 max	500 max	64-pin TSSOP	16-ch. receiver	5.55
SN75LVDS388A[3]	4	300	40	4	8 LVDS	8 LVTTL	400 max	600 max	38-pin TSSOP	Octal receiver	3.25
SN65LVDS389	2.9	300	70	4	8 LVTTL	8 LVDS	150 max	500 max	38-pin TSSOP	Octal driver	3.25

[1]*R_L = 100 Ω, C_L = 10 pF with max. spec.*
[2]*Suggested resale price in U.S. dollars in quantities of 1,000.*
[3]*Integrated termination option.*

UARTs

Device	Channels	FIFOs (Bytes)	Baud Rate (Mbps) (max)	Voltage (V)	Pins/Package(s)	Description	Price[1]
TL16C450	1	0	0.256	5	40PDIP, 44PLCC	Single UART without FIFO	1.50
TL16C451	1	0	0.256	5	68PLCC	Single UART with parallel port and without FIFO	2.50
TL16C452	2	0	0.256	5	68PLCC	Dual UART with parallel port and without FIFO	2.55
TL16C550C	1	16	1	5, 3.3	48LQFP, 40PDIP, 44PLCC, 48TQFP	Single UART with 16-byte FIFOs and auto flow control	1.75
TL16C552/552A	2	16	1	5	68PLCC	Dual UART with 16-byte FIFOs and parallel port	3.85
TL16C554/554A	4	16	1	5	80LQFP, 68PLCC	Quad UART with 16-byte FIFOs	6.05
TL16C750	1	16 or 64	1	5, 3.3	64LQFP, 44PLCC	Single UART with 64-byte FIFOs, auto flow control, low-power modes	3.70
TL16C752B	2	64	3	3.3	48LQFP	Dual UART with 64-byte FIFO	3.10
TL16C754B	4	64	5V-3, 3.3V-2	5, 3.3	80LQFP, 68PLCC	Quad UART with 64-byte FIFO	8.35
TL16PC564B/BLV	1	64	1	5, 3.3	100BGA, 100LQFP	Single UART with 64-byte FIFOs, PCMCIA interface	5.90
TL16PIR552	2	16	1	5	80QFP	Dual UART with 16-byte FIFOs, selectable IR and 1284 modes	6.10
TIR1000	0	None	0.115	2.7 to 5.5	8SOP, 8TSSOP	Stand-alone IrDA encoder and decoder	1.15
TUSB3410	0	None	0.922	3.3	32LQFP	RS232/IrDA serial-to-USB converter	2.50

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

USB Hub Controllers

Device	Speed	Ports	I^2C	Voltage (V)	Package	Description	Price[1]
TUSB2036	Full (1.1)	2	No	3.3	32 LQFP	2/3-port hub for USB with optional serial EEPROM interface	1.15
TUSB2046B	Full (1.1)	4	No	3.3	32 LQFP	4-port hub for USB with optional serial EEPROM interface supporting Windows® 95/DOS mode	1.20
TUSB2077A	Full (1.1)	7	No	3.3	48 LQFP	7-port USB hub with optional serial EEPROM interface	1.95
TUSB2136	Full (1.1)	2	Yes	3.3	64 LQFP	2-port hub with integrated general-purpose function controller	3.25
TUSB5052	Full (1.1)	5	Yes	3.3	100 LQFP	5-port hub with integrated bridge to two serial ports	5.10

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

USB Peripherals

Device	Speed	Voltage (V)	Remote Wakeup	Package	Description	Price[1]
TUSB3210	Full	3.3	Yes	64 LQFP	USB full-speed general-purpose device controller	2.50
TUSB3410	Full	3.3	Yes	32 LQFP	RS232/IrDA serial-to-USB converter	2.25
TUSB6250	Full, High	3.3	Yes	80 TQFP	USB 2.0 high-speed ATA/ATAPI bridge solution	3.00

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

Interface

SerDes (Serial Gigabit Transceivers)

Device	Function	Data Rate	Serial I/F[1]	Parallel I/F	Power	Special Features	Price[2]
TLK1501	Single-Ch. 16:1 SerDes	0.6-1.5 Gbps	1 CML	16 LVTTL	200 mW	Built-In Testability	8.00
TLK2501	Single-Ch. 16:1 SerDes	1.6-2.5 Gbps	1 CML	16 LVTTL	300 mW	Built-In Testability	12.00
TLK2701	Single-Ch. 16:1 SerDes	1.6-2.5 Gbps	1 CML	16 LVTTL	300 mW	Built-In Testability and K Character Control	12.00
TLK2711	Single-Ch. 16:1 SerDes	1.6-2.5 Gbps	1 VML	16 LVTTL	350 mW	MicroStar Junior™ BGA Packaging	12.00
TLK3101	Single-Ch. 16:1 SerDes	2.5-3.125 Gbps	1 VML	16 LVTTL	350 mW	Built-In Testability	16.00
TLK1201A	Single-Ch. 10:1 Gigabit Ethernet Xcvr Gbps	0.6-1.3	1 LVPECL	10 LVTTL	200 mW	Industrial Temperature	3.95
TLK2201	Single-Ch.	1.0-1.6 Gbps	1 LVPECL	10 LVTTL	200 mW	JTAG; 5-Bit DDR Mode	3.95
TLK2201I	Single-Ch. 10:1 Gigabit Ethernet Xcvr	1.2-1.6 Gbps	1 LVPECL	10 LVTTL	200 mW	JTAG; 5-Bit DDR Mode, Industrial Temperature Qualified	4.74
TLK2201JR	Single-Ch. 10:1 Gigabit Ethernet Xcvr	1.0-1.6 Gbps	1 LVPECL	10 LVTTL	200 mW	MicroStar Junior 5 mm x 5 mm LGA	3.95
TLK1002	Two-Ch. Gigabit Signal Ethernet Conditioner	1.0-1.3 Gbps	2 VML	N/A	<300 mW	High Input Jitter Tolerance <0.75 UI	Preview
TLK2521	Single-Ch. 18:1 SerDes	1.0-2.5 Gbps	1 VML	18 LVTTL	<550 mW	Low Power and Built-in Equalization	18.00
TLK1521	Single-Ch. 18:1 SerDes	0.6-1.3 Gbps	1 VML	18 LVTTL	<350 mW	Low Power and Built-in Equalization	10.00
TLK4120	Four-Ch. 18:1 Serdes	0.5-1.3 Gbps	4 VML	18 LVTTL	<350 mW	Four-Channel Version of TLK1521	24.00
TLK4250	Four-Ch. 18:1 Serdes	1.0-2.5 Gbps	4 VML	18 LVTTL	<550 mW	Four-Channel Version of TLK2521	28.00
TLK2208B	Eight-Ch. of 10:1 Gigabit Ethernet Xcvr	1.0-1.3 Gbps	8 CML	4/5-Bit/Ch (Nibble DDR Mode), 8/10-Bit/Ch (Multiplex Ch Mode)	1 W	JTAG, MDIO Supported	30.00
TLK2206	Six-Ch. 16:1 Gigabit Ethernet Xcvr	1.0-1.3 Gbps	6 VML	4/5-Bit RTBI or 8/10-Bit DDR Channel Mode	<1 W	MDIO Supported	20.00
TLK3104SA	Four-Ch. of 10/8:1 Xcvr	2.5-3.125 Gbps	4X 3.125 Gbps LVPECL (XAUI)	4X 10/8-Bit SSTL/HSTL	700 mW/ch.	JTAG; Programmable Pre-Emphasis and XAUI I/F	55.00
TLK3104SC	Four-Ch. of 4.1: Xcvr	3.0-3.125 Gbps	4X LVPECL	20X622 LVDS Lines	700 mW/ch.	JTAG, 8b/10b On/Off	120.00
TLK3114SC	Four-Ch. of 10/8:1: Xcvr	2.5-3.125 Gbps	4X 3.125 Gbps LVPECL (XAUI) (XGMII)	4X 10/8-Bit SSTL/HSTL	600 mW/ch.	IEEE 802.3ae Backplane Transceiver Compliant	55.00
TLK3118	Four Ch. 10/8:1 Xcvr w/ (XAUI) Full Redundancy	2.5-3.125 Gbps/ch.	4X 3.125 LVPECL (XAUI)	8/10 HSTLx4 (XGMII)	<2 W	Full Redundancy for Four Channels (XAUI)	Web
TLK4015	Four-Ch. of 16:1 Xcvr	0.6-1.5 Gbps/ch.	4X CML	16 LVTTL/ch.	1 W	Four-Channel Version of TLK1501	28.00
SLK2501/2511	Single-Ch. 4:1 Multirate SONET Xcvr with CDR	OC-3/12/24/48	1 LVPECL	4X622 LVDS	900 mW	Auto-Rate Detection, Local and Remote Loop Back	40.00
SLK2701/2721	Single-Ch. 4:1 Multirate SONET Xcvr with CDR	OC 3/12/24/48	PECL	4 x LVDS	900 mW	FEC Rate Compatible, SLK2721 is Optimized for Jitter Tolerance	40.00
SN65LVDS93/94	Four-Ch. 28:4 TX/RX Chipset	140-455 Mbps/ch.	4 LVDS	28 LVTTL	250 mW/chip	Supports up to 1.82 Gbps Throughout	3.73
SN65LVDS95/96	Three-Ch. 21:3 TX/RX Chipset	140-455 Mbps/ch.	4 LVDS	28 LVTTL	250 mW/chip	Supports up to 1.82 Gbps Throughout	3.73
SN65LV1021/1212	Single-Ch. 10:1 TX/RX Chipset	100-400 Mbps	1 LVDS	10 LVTTL	<400 mW Total	Low Power Solution	5.00
SN65LV1023/1024[3]	Single-Ch. 10:1 TX/RX Chipset	300-660 Mbps	1 LVDS	10 LVTTL	<400 mW Total	Low Power Solution	5.20

[1] CML = Current Mode Logic; VML = Voltage Mode Logic.
[2] Suggested resale price in U.S. dollars in quantities of 1,000.
[3] 'A' revision will support 100 to 660 Mbps.

Preview devices are listed in **bold blue**.

Interface

PCI CardBus Controllers

Device	Voltage (V)	D3 Cold Wake	Integrated 1394	Integrated ZV	Pin/ Package(s)	Description	Price[1]
PCI1510	3.3	Yes	No	No	144BGA, 144LQFP	Single Slot PC CardBus Controller	3.60
PCI1520	3.3	Yes	No	No	209BGA, 208LQFP	PC Card Controller	4.35
PCI1620	1.8, 3.3, 5	Yes	No	No	209BGA, 208LQFP	PC Card, Flash Media, and Smart Card Controller	7.35
PCI4510	3.3	Yes	Yes	No	209BGA, 208LQFP	PC Card and Integrated 1394a-2000 OHCI Two-Port-PHY/Link-Layer Controller	8.00
PCI4520	3.3	Yes	Yes	No	257BGA	Two Slot PC Card and Integrated 1394a-2000 OHCI Two-Port-PHY/Link-Layer Controller	9.15
PCI6420	3.3	Yes	No	No	288BGA	Integrated 2-Slot PC Card and Dedicated Flash Media Controller	9.50
PCI6620	3.3	Yes	No	No	288BGA	Integrated 2-Slot PC Card with Smartcard and Dedicated Flash Media Controller	10.50
PCI7410	3.3	Yes	Yes	No	209BGA, 208LQFP	PC Card, Flash Media, Integrated 1394a-2000 OHCI 2-Port PHY/Link-Layer Controller	11.00
PCI7420	3.3	Yes	Yes	No	288BGA	Integrated 2-Slot PC Card, Dedicated Flash Media Socket and 1394a-2000 OHCI 2Port-PHY/Link-Layer Controller	12.00
PCI7510	3.3	Yes	Yes	No	209BGA, 208LQFP	Integrated PC Card, Smart Card and 1394 Controller	11.00
PCI7610	3.3	Yes	Yes	No	209BGA, 208LQFP	Integrated PC Card, Smart Card, Flash media ,1394a-2000 OHCI 2-Port-PHY/ Link-Layer Controller	12.00
PCI7620	3.3	Yes	Yes	No	288BGA	Integrated 2-Slot PC Card w/Smart Card, Flash Media, 1394a-2000 OHCI 2Port-PHY/Link-Layer Controller	13.00

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

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

PCI Bridges

Device	Intel® Compatible Part Number	Speed (MHz)	Expansion Interface (Bits)	Hot Swap	MicroStar BGA™ Packaging	Voltage(s) (V)	Pin/ Package	Description	Price[1]
HPC3130	—	33	32	—	No	3.3	128LQFP, 120QFP	Hot Plug Controller	10.95
HPC3130A	—	66	64	—	No	3.3	128LQFP, 144LQFP, 120QFP	Hot Plug Controller	10.95
PCI2040	—	—	—	Friendly	Yes	3.3, 5	144BGA, 144LQFP	PCI-to-DSP Bridge Controller, Compliant to CompactPCI Hot Swap Specification 1.0	10.55
PCI2050	21150ab/ac	33	32	Friendly	Yes	3.3, 5	209BGA, 208LQFP	32-Bit, 33 MHz PCI-to-PCI Bridge, Compact PCI Hot-Swap Friendly, 9-Master, MicroStar BGA Packaging	8.20
PCI2050B	21150bc	66	32	Friendly	Yes	3.3, 5	257BGA, 208LQFP, 208QFP	PCI-to-PCI Bridge	9.50
PCI2250	21152ab	33	32	Friendly	No	3.3, 5	176LQFP, 160QFP	32-Bit, 33 MHz PCI-to-PCI Bridge, Compact PCI Hot-Swap Friendly, 4-Master	6.10

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

Power Management

Switching DC/DC Controllers

Device	V_{IN} (V)	V_O (V) (max)	V_O (V) (min)	V_{REF} Tol (%)	Driver Current (A)	Output Current (A)[1]	Multiple Outputs	Protection[2]	Comments	Price[3]
Performance Processor Power Supply Controllers										
TPS40000	2.25 to 5.5	4	0.7	1.5	1	15	No	OCP, UVLO	300-kHz low input sync buck, source only	0.99
TPS40050	8 to 40	30	0.7	1	1	20	No	OCP, UVLO	Wide input range sync buck, source only	1.32
TPS40060	10 to 55	40	0.7	1	1	10	No	OCP, UVLO	Wide input range sync buck, source only	1.32
High-Performance Portable and System Power Supply Controllers										
TPS5103	4.5 to 25	24	1.2	1.5	1.5	20	No	OCP, UVLO	Wide input voltage controller	1.60
TPS5120	4.5 to 28	26	0.9	1.5	1.5	15 (each)	Yes	OCP, UVLO, PG, OVP	Dual 180 degree out-of-phase operation	2.66
General-Purpose Power Supply Controllers										
UC3572	4.75 to 30	0	–48	2	0.5	5	No	OCP, UVLO	PWM simple inverting	1.00
UC3573	4.75 to 30	24	1.5	2	0.5	5	No	OCP, UVLO	PWM simple buck	1.00

[1]*Current levels of this magnitude and beyond can be supported.*
[2]*OCP = Over-current protection; UVLO = under-voltage lockout; PG = power good; OVP = over-voltage protection.*
[3]*Suggested resale price in U.S. dollars in quantities of 1,000.*

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

Power Management

DC/DC Converters (Integrated FETs)

Device	V_{IN} (V)	Output Current (A)	V_{OUT} (V)	Package	Price[1]
Buck (Step Down)					
TPS62200/1/2/3/4/5/6	2.5 to 6.0	0.3	Adj.,1.5, 1.8, 3.3, 1.6, 2.5, 2.6	SOT 23-5	1.29
TPS62000/1/2/3/4/5/6/7/8	2.0 to 5.5	0.6	Adj., 0.9, 1.0,1.2, 1.5, 1.8, 2.5, 3.3, 1.9	MSOP-10	1.49
TPS62051/2/3/4/5	2.7 to 10	0.8	Adj., 1.5, 1.8, 3.3	MSOP-10	1.74
TPS54310/1/2/3/4/5/6	3.0 to 6.0	3	Adj., 0.9, 1.2, 1.5, 1.8, 2.5, 3.3	HTSSOP-20	3.45
TPS54610/1/2/3/4/5/6	3.0 to 6.0	6	Adj., 0.9, 1.2, 1.5, 1.8, 2.5, 3.3	HTSSOP-28	4.65
TPS54810	4.0 to 6.0	8	Adj. to 0.9	HTSSOP-28	4.90
TPS54910	3.0 to 4.0	9	Adj. to 0.9	HTSSOP-28	5.20
Inverter					
TPS6755	2.7 to 9.0	0.2	Adj. from –1.25 to –9.3	SOIC-8	1.25
TL497A	4.5 to 12	0.5	Adj. from –1.2 to –25	TSSOP-14	1.33

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

Supervisory Circuits

Device	Number of Supervisors	Supervised Voltages (V)	I_{DD} (µA)	Time Delay (ms)	Manual Reset	Reset Output Topology[1]	Packages	Price[2]
TPS3809	1	2.5, 3.0, 3.3, 5.0	9	200	—	PP	SOT23	0.29
TPS3808	1	Adj., 0.9, 1.0, 1.2, 1.5, 1.6, 1.8, 2.5, 3.0, 3.3, 5.0	3	Adj.	✔	OD	SOT23/QFN	0.47
TPS3823	1	2.5, 3.0, 3.3, 5.0	15	200	✔	PP	SOT23	0.61
TPS3836/8	1	1.8, 2.5, 3.0, 3.3	0.25	10/200	✔	PP/OD	SOT23	0.79
TPS3305	2	1.8, 2.5, 3.3, 5.0	15	200	✔	PP	SO-8, MSOP-8	0.91
TPS3307	3	Adj., 1.8, 2.5, 3.3, 5.0	15	200	✔	PP	SO-8, MSOP-8	0.99
TPS3510	3	3.3, 5.0, 12.0	1 mA	300	—	OD	SO-8, DIP-8	0.52

[1] *PP = Push-Pull; OD = Open Drain.*
[2] *Suggested resale price in U.S. dollars in quantities of 1,000.*

PWM Power Supply Control (Single Output)

Device	Typical Power Level (W)	Max Practical Frequency	Start-Up Current	Operating Current	Supply Voltage (V)	UVLO: On/Off (V)	V_{REF} (V)	V_{REF} Tol. (%)	Max Duty Cycle (%)	E/A	Voltage Feed-Forward	Internal Drive (Sink/Source) (A)	Package(s)	Price[1]
Peak Current Mode Controllers														
UCC38C40	10 to 250	1 MHz	50 µA	2.3 mA	6.6 to 20	7.0/6.6	5	2	100	Yes	Yes	1/1	SOIC-8, PDIP-8, MSOP-8	0.99
UCC38C41	10 to 250	1 MHz	50 µA	2.3 mA	6.6 to 20	7.0/6.6	5	2	50	Yes	Yes	1/1	SOIC-8, PDIP-8, MSOP-8	0.99
UCC38C42	10 to 250	1 MHz	50 µA	2.3 mA	9 to 20	14.5/9	5	2	100	Yes	Yes	1/1	SOIC-8, PDIP-8, MSOP-8	0.99
UCC38C43	10 to 250	1 MHz	50 µA	2.3 mA	7.6 to 20	8.4/7.6	5	2	100	Yes	Yes	1/1	SOIC-8, PDIP-8, MSOP-8	0.99
UCC38C44	10 to 250	1 MHz	50 µA	2.3 mA	9 to 20	14.5/9	5	2	50	Yes	Yes	1/1	SOIC-8, PDIP-8, MSOP-8	0.99
UCC38C45	10 to 250	1 MHz	50 µA	2.3 mA	7.6 to 20	8.4/7.6	5	2	50	Yes	Yes	1/1	SOIC-8, PDIP-8, MSOP-8	0.99

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

Low Dropout Regulators (LDOs)

Device	I_O (mA)	V_{DO} @ I_O (mV)	Iq (µA)	Output Options: Voltage (V)	Output Options: Adj.	Min V_{IN}	Max V_{IN}	Accuracy (%)	Packages: SC70	SOT23	MSOP	SO8	SOT223	TO220	TO263/ DDPAK	Features[1]	CO[2]	Comments	Price[3]
TPS797xx	10	105	1.2	1.8, 3.0, 3.3	—	1.8	5.5	4	✔	—	—	—	—	—	—	PG	0.47 µF C	MSP430; lowest Iq	0.32
TPS715xx	50	415	3.2	2.5, 3.0, 3.3, 5	1.2 - 15	2.5	24	4	✔	—	—	—	—	—	—	—	0.47 µF C	V_{IN} up to 24 V	0.32
TPS722xx	50	50	80	1.5, 1.6, 1.8	1.2 - 2.5	1.8	5.5	3	—	✔	—	—	—	—	—	/EN, BP	0.1 µF C	Low noise, V_{IN} down to 1.8 V	0.39
REG101	100	60	400	2.5, 2.8, 2.85, 3.0, 3.3, 5	2.5 - 5.5	2.6	10	1.5	—	✔	—	✔	—	—	—	EN, BP	—	Low noise, capacitor free	0.88
TPS792xx	100	38	185	2.5, 2.8, 3.0	1.2 - 5.5	2.7	5.5	2	—	✔	—	—	—	—	—	EN	1 µF C	RF very low noise, high PSRR	0.38
TPS731xx	150	60	450	1.5, 1.8, 2.5, 3.0, 3.3, 5.0	1.2 - 5.5	1.8	5.5	2	—	✔	—	—	—	—	—	EN, PG	No Cap	Reverse leakage protection	0.45
TPS771xx	150	75	90	1.5, 1.8, 2.7, 2.8, 3.3, 5	1.5 - 5.5	2.7	10	2	—	—	—	✔	—	—	—	/EN, SVS	10 µF C	Low noise	0.56
TPS794xx	250	145	172	1.8, 2.5, 2.8, 3.0, 3.3	1.2 - 5.5	2.7	5.5	2	—	—	✔	—	✔	—	—	EN, BP	2.2 µF C	RF very low noise, high PSRR	0.62
REG102	250	150	400	2.5, 2.8, 2.85, 3.0, 3.3, 5	2.5 - 5.5	1.8	10	2	—	✔	—	✔	✔	—	—	EN, BP	No Cap	Capacitor free, DMOS	1.00
TPS795xx	500	105	265	1.6, 1.8, 2.5, 3.0, 3.3	1.2 - 5.5	2.7	5.5	3	—	—	—	—	✔	—	—	EN, BP	2.2 µF C	RF very low noise, high PSRR	0.95
REG103	500	115	500	2.5, 2.7, 3.0, 3.3, 5	2.5 - 5.5	2.1	15	2	—	—	—	✔	✔	—	✔	EN, PG	—	Capacitor free, DMOS	2.00
TPS777xx	750	260	85	1.5, 1.8, 2.5, 3.3	1.5 - 5.5	2.7	10	2	—	—	✔	—	✔	—	—	/EN,SVS	10 µF T	Fast transient response	0.92
TPS725xx	1000	170	75	1.5, 1.6, 1.8, 2.5	1.2 - 5.5	1.8	6	2	—	—	—	✔	✔	—	✔	EN, SVS	No Cap	V_{IN} down to 1.8 V, low noise	1.04
TPS786xx	1500	390	310	1.8, 2.5, 2.8, 3.0, 3.3	1.2 - 5.5	2.7	5.5	3	—	—	—	—	✔	—	✔	EN, BP	1 µF C	RF very low noise, high PSRR	1.28
UCCx83-x	3000	400	400	3.3, 5	1.2 - 8.5	1.8	9	2.5	—	—	—	—	—	✔	✔	/EN	22 µF T	Reverse leakage protection	2.57
UCx85-x	5000	350	8 mA	1.5, 2.1, 2.5	1.2 - 6	1.7	7.5	1	—	—	—	—	—	✔	✔	—	100 µF T	Fast LDO with reverse leak.	3.00

[1]PG = PowerGood, EN = Active High Enable, /EN = Active Low Enable, SVS = Supply Voltage Supervisor, BP = Bypass Pin for noise reduction capacitor.
[2]C = Ceramic, T = Tantalum, No Cap = Capacitor Free LDO.
[3]Suggested resale price in U.S. dollars in quantities of 1,000.

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

Dual-Output LDOs

Device	I_{O1} (mA)	I_{O2} (mA)	V_{DO1} @ I_{O1} (mV)	V_{DO2} @ I_{O2} (mV)	Iq @ I_O (µA)	Output Options: Voltage (V)	Output Options: Adj.	Accuracy (%)	PWP Package	Min V_O	Max V_O	Features: /EN	PG	SVS	Seq	Low Noise	Min V_{IN}	Max V_{IN}	CO[1]	Description	Price[2]
TPS707xx	250	150	83	—	95	3.3/2.5, 3.3/1.8, 3.3/1.5, 3.3/1.2	✔	2	✔	1.2	5	✔	✔	✔	✔	✔	2.7	5.5	10 µF T	Dual-output LDO with sequencing	1.10
TPS708xx	250	150	83	—	95	3.3/2.5, 3.3/1.8, 3.3/1.5, 3.3/1.2	✔	2	✔	1.2	5	✔	✔	✔	—	✔	2.7	5.5	10 µF T	Dual-output LDO with independent enable	1.10
TPS701xx	500	250	170	—	95	3.3/2.5, 3.3/1.8, 3.3/1.5, 3.3/1.2	✔	2	✔	1.2	5	✔	✔	✔	✔	✔	2.7	5.5	10 µF T	Dual-output LDO with sequencing	1.40
TPS702xx	500	250	170	—	95	3.3/2.5, 3.3/1.8, 3.3/1.5, 3.3/1.2	✔	2	✔	1.2	5	✔	✔	✔	—	✔	2.7	5.5	10 µF T	Dual-output LDO with independent enable	1.40
TPS767D3xx	1000	1000	230	—	170	3.3/2.5 3.3/1.8	✔	2	✔	1.2	5	✔	—	✔	—	—	2.7	10	10 µF T	Dual-output fast LDO with integrated SVS	1.87
TPPM0110	1500	300	1000	2500	1000	3.3/1.8	—	2	—	1.8	3.3	—	—	—	—	—	4.7	5.3	100 µF T	Outputs track within 2 V	1.50
TPPM0111	1500	300	1000	2800	1000	3.3/1.5	—	2	—	1.5	3.3	—	—	—	—	—	4.7	5.3	100 µF T	Outputs track within 2 V	1.50
TPS703xx	2000	1000	160	—	185	3.3/2.5, 3.3/1.8, 3.3/1.5, 3.3/1.2	✔	2	✔	1.2	5	✔	✔	✔	✔	✔	2.7	5.5	22 µF T	Dual-output LDO with sequencing	2.20
TPS704xx	2000	1000	160	—	185	3.3/2.5, 3.3/1.8, 3.3/1.5, 3.3/1.2	✔	2	✔	1.2	5	✔	✔	✔	—	✔	2.7	5.5	22 µF T	Dual-output LDO with independent enable	2.20

[1]T = Tantalum.
[2]Suggested resale price in U.S. dollars in quantities of 1,000.

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

Digital Signal Processors

These DSP selection guides are a sampling of the industry's most complete DSP product line. See **dsp.ti.com** for complete product trees, parametric sorts and application information. A complete DSP selection guide is available at **www.ti.com/dsp**

TMS320C67x™ DSP Generation Products – Floating-Point DSPs

Device	RAM (Bytes) Data/Prog	McBSP	DMA	COM	MHz	Cycle (ns)	MFLOPS	Typical Activity Total Internal Power (W) (Full Device Speed)	Voltage (V) Core	Voltage (V) I/O	Packaging	Price[1]
TMS320C6712DGDP150	4K/4K/64K[2]	2	16[3]	—	150	6.7	900	0.7	1.26	3.3	272 BGA, 27 mm	15.26
TMS320C6711DGDP200	4K/4K/64K[2]	2	16[3]	HPI/16	200	5	1200	0.9	1.26	3.3	272 BGA, 27 mm	21.55
TMS32C6711DGDPA167[4]	4K/4K/64K[2]	2	16[3]	HPI/16	167	6	1000	0.9	1.26	3.3	272 BGA, 27 mm	21.55
TMS32C6713BPYPA167[4]	4K/4K/256K[2]	2[5]	16[3]	HPI/16	167	6	1000	1.0	1.2	3.3	208 TQFP, 28 mm	22.18
TMS32C6713BPYP200	4K/4K/256K[2]	2[5]	16[3]	HPI/16	200	5	1200	1.0	1.2	3.3	208 TQFP, 28 mm	22.18
TMS32C6713BGDPA200[4]	4K/4K/256K[2]	2[5]	16[3]	HPI/16	200	5	1200	1.2	1.26	3.3	272 BGA, 27 mm	29.14
TMS320C6713BGDP225	4K/4K/256K[2]	2[5]	16[3]	HPI/16	225	4.4	1350	1.2	1.26	3.3	272 BGA, 27 mm	29.14
TMS320C6701GJC150	64K/64K	2	4	HPI/16	150	6.7	900	1.3	1.8	3.3	352 BGA, 35 mm	82.24
TMS320C6701GJCA120[4]	64K/64K	2	4	HPI/16	120	8.3	720	1.3	1.8	3.3	352 BGA, 35 mm	94.28
TMSC6701GJC16719V	64K/64K	2	4	HPI/16	167	6	1000	1.4	1.9	3.3	352 BGA, 35 mm	124.66

[1]Suggested resale price in U.S. dollars in quantities of 1,000. Prices represent year 2004 suggested resale pricing.
[2]Format represents cache memory architecture: [data cache] / [program cache] / [unified cache].
[3]Enhanced DMA.
[4]Extended temperature device, –40 to 105°C case temperature operation.
[5]The C6713 DSP can be configured to have up to three serial ports in various McASP/McBSP combinations by not utilizing the HPI. Other configurable serial options include I^2C and additional GPIO.
Notes: All devices include two timers. Enhanced plastic and military DSP versions are available for selected DSPs.

TMS320C64x™ DSP Generation Products – Fixed-Point DSPs

Device	Internal RAM (Bytes) L1 Program Cache/ L1 Data Cache/ L2 Unified RAM/Cache	McBSP	Enhanced DMA (Channels)	COM[1]	Timers	MHz	MIPS	Power (W)[2] CPU and L1	Power (W)[2] Total	Voltage (V) Core	Voltage (V) I/O	Packaging	Price[3]
Performance Value													
TMS320C6410GTS400	16K/16K/1M	2	64	HPI 32/16	3	400	3200	0.4	1.0	1.2	3.3	288 BGA, 23 mm	20.28
TMS320C6413GTS500	16K/16K/2M	2	64	HPI 32/16	3	500	4000	0.4	1.0	1.2	3.3	288 BGA, 23 mm	32.71
TMS320C6412GDK500[4]	16K/16K/256K	2	64	PCI/HPI/EMAC[5]	3	500	4000	0.4	1.0	1.2	3.3	548 BGA, 23 mm	45.14
TMS320C6412GNZ500[4]	16K/16K/256K	2	64	PCI/HPI/EMAC[5]	3	500	4000	0.4	1.0	1.2	3.3	548 BGA, 27 mm	45.14
TMS320C6412GDK600[4]	16K/16K/256K	2	64	PCI/HPI/EMAC[5]	3	600	4800	0.6	1.5	1.4	3.3	548 BGA, 23 mm	50.79
TMS320C6412GNZ600[4]	16K/16K/256K	2	64	PCI/HPI/EMAC[5]	3	600	4800	0.6	1.5	1.4	3.3	548 BGA, 27 mm	50.79
Video Application Specific													
TMS320DM640GDK400[6]	16K/16K/128K	1	64	EMAC	3	400	1600	0.4	1.0	1.0	3.3	548 BGA, 23 mm	22.54
TMS320DM640GNZ400[6]	16K/16K/128K	1	64	EMAC	3	400	1600	0.4	1.0	1.0	3.3	548 BGA, 27 mm	22.54
TMS320DM641GDK500[6]	16K/16K/128K	2	64	HPI 16/EMAC	3	500	4000	0.4	1.0	1.2	3.3	548 BGA, 23 mm	36.89
TMS320DM641GNZ500[6]	16K/16K/128K	2	64	HPI 16/EMAC	3	500	4000	0.4	1.0	1.2	3.3	548 BGA, 27 mm	36.89
TMS320DM641GDK600[6]	16K/16K/128K	2	64	HPI 16/EMAC	3	600	4800	0.6	1.5	1.4	3.3	548 BGA, 23 mm	42.33
TMS320DM641GNZ600[6]	16K/16K/128K	2	64	HPI 16/EMAC	3	600	4800	0.6	1.5	1.4	3.3	548 BGA, 27 mm	42.33
TMS320DM642GDK500[4]	16K/16K/256K	2[7]	64	PCI/HPI 32/EMAC[5]	3	500	4000	0.4	1.0	1.2	3.3	548 BGA, 23 mm	45.14
TMS320DM642GNZ500[4]	16K/16K/256K	2[7]	64	PCI/HPI 23/EMAC[5]	3	500	4000	0.4	1.0	1.2	3.3	548 BGA, 27 mm	45.14
TMS320DM642GDK600[4]	16K/16K/256K	2[7]	64	PCI/HPI 32/EMAC[5]	3	600	4800	0.6	1.5	1.4	3.3	548 BGA, 23 mm	50.79
TMS320DM642GNZ600[4]	16K/16K/256K	2[7]	64	PCI/HPI 32/EMAC[5]	3	600	4800	0.6	1.5	1.4	3.3	548 BGA, 27 mm	50.79

[1]HPI is selectable, 32-bit or 16-bit.
New devices are listed in ***bold red****.*
[2]Assumes 60% CPU utilization, 50% EMIF utilization (133 MHz for 1.4 V, 100 MHz for 1.2 V), 50% writes, 64 bits, 50% bit switching, two 2-MHz McBSPs at 100% utilization, and two 75-MHz timers at 100% utilization. For details, see TI Application Report SPRA811C.
[3]Suggested resale price in U.S. dollars in quantities of 1,000. Prices represent year 2004 suggested resale pricing.
[4]Experimental units (TMX) available now. Production units (TMS) available 3Q04.
[5]The C6412, DM640, DM641 and DM642 can be configured to have either a 32-bit PCI or 32-bit HPI, or a 16-bit HPI with Ethernet MAC.
[6]Experimental units (TMX) available now. Production units (TMS) available 3Q04.
[7]The DM642 can be configured to have up to three serial ports in various video/McASP/McBSP combinations.
Note: Enhanced plastic and military DSP versions are available for selected DSPs.

TMS320C64x™ DSP Generation Products – Fixed-Point DSPs (Continued)

Device	Internal RAM (Bytes) L1 Program Cache/ L1 Data Cache/ L2 Unified RAM/Cache	McBSP	Enhanced DMA (Channels)	COM[1]	Timers	MHz	MIPS	Power (W)[2] CPU and L1	Power (W)[2] Total	Voltage (V) Core	Voltage (V) I/O	Packaging	Price[3]
High Performance													
TMS32C6414DGLZ5E0	16K/16K/1M	3	64	HPI 32/16	3	500	4000	0.4	1.0	1.2	3.3	532 BGA, 23 mm	82.37
TMS32C6414DGLZA5E0[8]	16K/16K/1M	3	64	HPI 32/16	3	500	4000	0.4	1.0	1.25	3.3	532 BGA, 23 mm	98.84
TMS32C6414TDGLZ6E3	16K/16K/1M	3	64	HPI 32/16	3	600	4800	0.6	1.5	1.1	3.3	532 BGA, 23 mm	98.48
TMS32C6414TDGLZ7E3	16K/16K/1M	3	64	HPI 32/16	3	720	5760	0.6	1.7	1.2	3.3	532 BGA, 23 mm	128.49
TMS32C6414TDGLZ1	16K/16K/1M	3	64	HPI 32/16	3	1000	8000	TBD	TBD	1.2	3.3	532 BGA, 23 mm	213.63
TMS32C6415DGLZ5E0	16K/16K/1M	2+Utopia[9]	64	PCI/HPI 32/16	3	500	4000	0.4	1.0	1.2	3.3	532 BGA, 23 mm	86.70
TMS32C6415DGLZA5E0[8]	16K/16K/1M	2+Utopia[9]	64	PCI/HPI 32/16	3	500	4000	0.4	1.0	1.25	3.3	532 BGA, 23 mm	104.04
TMS32C6415TDGLZ6E3	16K/16K/1M	2+Utopia[9]	64	PCI/HPI 32/16	3	600	4800	0.6	1.5	1.1	3.3	532 BGA, 23 mm	104.05
TMS32C6415TDGLZ7E3	16K/16K/1M	2+Utopia[9]	64	PCI/HPI 32/16	3	720	5760	0.6	1.7	1.2	3.3	532 BGA, 23 mm	135.26
TMS32C6415TDGLZ1	16K/16K/1M	2+Utopia[9]	64	PCI/HPI 32/16	3	1000	8000	TBD	TBD	1.2	3.3	532 BGA, 23 mm	224.87
TMS32C6416DGLZ5E0	16K/16K/1M	2+Utopia[9]	64	PCI/HPI 32/16	3	500	4000[10]	0.4	1.0	1.2	3.3	532 BGA, 23 mm	95.37
TMS32C6416DGLZA5E0[8]	16K/16K/1M	2+Utopia[9]	64	PCI/HPI 32/16	3	500	4000[10]	0.4	1.0	1.25	3.3	532 BGA, 23 mm	114.44
TMS32C6416TDGLZ6E3	16K/16K/1M	2+Utopia[9]	64	PCI/HPI 32/16	3	600	4800[10]	0.6	1.5	1.1	3.3	532 BGA, 23 mm	114.45
TMS32C6416TDGLZ7E3	16K/16K/1M	2+Utopia[9]	64	PCI/HPI 32/16	3	720	5760[10]	0.6	1.7	1.2	3.3	532 BGA, 23 mm	148.78
TMS32C6416TDGLZ1	16K/16K/1M	2+Utopia[9]	64	PCI/HPI 32/16	3	1000	8000[10]	TBD	TBD	1.2	3.3	532 BGA, 23 mm	247.36

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

[1]HPI is selectable, 32-bit or 16-bit.
[2]Assumes 60% CPU utilization, 50% EMIF utilization (133 MHz for 1.4 V, 100 MHz for 1.2 V), 50% writes, 64 bits, 50% bit switching, two 2-MHz McBSPs at 100% utilization, and two 75-MHz timers at 100% utilization. For details, see TI Application Report SPRA811C.
[3]Suggested resale price in U.S. dollars in quantities of 1,000. Prices represent year 2004 suggested resale pricing.
[8]Extended temperature device, –40 to 105°C case temperature operation.
[9]UTOPIA pins muxed with a third McBSP.
[10]Plus on-chip Turbo (TCP) and Viterbi (VCP) coprocessors.
Note: Enhanced plastic and military DSP versions are available for selected DSPs.

TMS320C55x™ DSP Generation Products

Device	RAM (Bytes)	ROM (Bytes)	Security	DAT/PRO (ADDR) (Words)	USB	ADC	UART	I^2C	RTC	McBSP[1]	MMC/SD	Voltage (V) Core	Voltage (V) I/O	COM	Timers[2]	Cycles (ns)	MIPS	Packaging	Price[3]
TMS320VC5501GZZ3[4]	32K	32K	—	8M	—	—	✔	✔	—	2	—	1.26	3.3	HPI16/8	3[5]	3.3	600	201 BGA[6]	5.37
TMX320VC5501PGF3[4]	32K	32K	—	8M	—	—	✔	✔	—	2	—	1.26	3.3	HPI16/8	3[5]	3.3	600	176 LQFP	6.44
TMS320VC5502GZZ2[4]	64K	32K	—	8M	—	—	✔	✔	—	3	—	1.26	3.3	HPI16/8	3[5]	5	400	201 BGA[6]	7.91
TMX320VC5502PGF2[4]	64K	32K	—	8M	—	—	✔	✔	—	3	—	1.26	3.3	HPI16/8	3[5]	5	400	176 LQFP	9.49
TMS320VC5502GGW3[4]	64K	32K	—	8M	—	—	✔	✔	—	3	—	1.26	3.3	HPI16/8	3[5]	3.3	600	176 BGA[6]	10.17
TMX320VC5502PGF3[4]	64K	32K	—	8M	—	—	✔	✔	—	3	—	1.26	3.3	HPI16/8	3[5]	3.3	600	176 LQFP	12.20
TMS320VC5509GHH31	256K	64K	✔[7]	8M	✔	✔	—	✔	✔	3	✔	1.6	3.3	HPI16	2[5]	6.9	288	179 BGA[6]	18.65
TMS320VC5509PGE31	256K	64K	✔[7]	8M	✔	✔	—	✔	✔	3	✔	1.6	3.3	HPI16	2[5]	6.9	288	144 LQFP	18.65
TMS320VC5509AGHH2[8]	256K	64K	✔[7]	8M	✔	✔	—	✔	✔	3	✔	1.6	3.3	HPI16	2[5]	5	400	179 BGA[6]	18.19
TMX320VC5509APGE2[8]	256K	64K	✔[7]	8M	✔	✔	—	✔	✔	3	✔	1.6	3.3	HPI16	2[5]	5	400	144 LQFP	21.83
TMS320VC5510AGGWA1[4]	320K	32K	—	8M	—	—	—	—	—	3	—	1.6	3.3	HPI16	2	6.25	320	240 BGA[6]	21.90
TMS320VC5510AGGWA2[4]	320K	32K	—	8M	—	—	—	—	—	3	—	1.6	3.3	HPI16	2	5	400	240 BGA[6]	25.70
TMS320VC5510AGGW1	320K	32K	—	8M	—	—	—	—	—	3	—	1.6	3.3	HPI16	2	6.25	320	240 BGA[6]	18.25
TMS320VC5510AGGW2	320K	32K	—	8M	—	—	—	—	—	3	—	1.6	3.3	HPI16	2	5	400	240 BGA[6]	21.47

[1]Multichannel buffered serial port (McBSP).
[2]3 = Two general-purpose timers and one 32-bit DSP/BIOS™ kernel counter; 2 = Two general-purpose timers.
[3]Suggested resale price in U.S. dollars in quantities of 1,000. Prices represent year 2004 suggested resale pricing.
[4]Extended temperature device, –40 to 85°C case temperature operation.
[5]Plus one additional programmable watchdog timer.
[6]MicroStar BGA™ package.
[7]8-Kword secure ROM and JTAG disconnect option.
[8]Initial experimental (TMX) devices available now. Qualified (TMS) units available in 2Q04.
Notes: All devices include 6-channel DMA and software PLL. Enhanced plastic and military DSP versions are available for selected DSPs.

Digital Signal Processors

TMS320C28x™ DSP Generation Products

Device[1]	MIPS	Boot ROM[2] (words)	RAM[2] (16-bit words)	Flash[2] (16-bit words)	Timers	Comp/ PWM	CAP/ QEP	# PWM Channels	A/D[3] Chs/ Conversion Time (ns)[4]	EMIF	WD Timer	McBSP	SPI	SCI	CAN	I/O Pins	Core Voltage (V)	Packaging	Price[5]
TMS320F2810-PBKA/S[4]	150	4K	18K	64K	7	16	9/6	16	16 ch/80	—	✔	✔	✔	✔	✔	56	1.9	128 LQFP	14.53
TMS320F2811-PBKA/S[4]	150	4K	18K	128K	7	16	9/6	16	16 ch/80	—	✔	✔	✔	✔	✔	56	1.9	128 LQFP	15.50
TMS320F2812-GHHA/S[4]	150	4K	18K	128K	7	16	9/6	16	16 ch/80	✔	✔	✔	✔	✔	✔	56	1.9	179 BGA[6]	16.47
TMS320F2812-PGFA/S[4]	150	4K	18K	128K	7	16	9/6	16	16 ch/80	✔	✔	✔	✔	✔	✔	56	1.9	176 LQFP	16.47

[1]A = –40° to 85°C; S = –40 to 125°C (10% price adder). *New devices are listed in* ***bold red****.*
[2]1 word = 2 bytes.
[3]Dual sample/hold.
[4]12-bit.
[5]Suggested resale price in U.S. dollars in quantities of 1,000. Prices represent year 2004 suggested resale pricing.
[6]MicroStar BGA™ package.
Note: Enhanced plastic and military DSP versions are available for selected DSPs.

TMS320C24x™ DSP Generation Products

Device	RAM[1] (16-bit words)	ROM[1] (16-bit words)	Flash[1] (16-bit words)	Boot[1] ROM (words)	EMIF	General-Purpose Timers	Watchdog Timer	PWM Channels	SPI	SCI	CAN	A/D Channels[2] Conversion Time (ms)	I/O Pins	Voltage (V)	MIPS	Packaging	Price[3]
TMS320LC2401AVFA[4,5]	1K	8K	—	—	—	2	✔	7	—	✔	—	5 ch 0.5	13	3.3	40	32 LQFP	1.99[4]
TMS320LC2402APGA[4,5]	544	6K	—	—	—	2	✔	8	—	✔	—	8 ch 0.425	21	3.3	40	64 PQFP	2.95[4]
TMS320LC2404APZA[4,5]	1.5K	16K	—	—	—	4	✔	16	✔	✔	—	16 ch 0.375	41	3.3	40	100 LQFP	4.90[4]
TMS320LC2406APZA[4,5]	2.5K	32K	—	—	—	4	✔	16	✔	✔	✔	16 ch 0.375	41	3.3	40	100 LQFP	5.47[4]
TMS320LF2401AVFA[5]	1K	—	8K	256	—	2	✔	7	—	✔	—	5 ch 0.5	13	3.3	40	32 LQFP	3.49
TMS320LF2402APAGA[5]	1K	—	8K	256	—	2	✔	8	—	✔	—	8 ch 0.5	21	3.3	40	64 PQFP	7.88
TMS320LF2403APAGA[5]	1K	—	16K	256	—	2	✔	8	✔	✔	✔	8 ch 0.5	21	3.3	40	64 LQFP	8.73
TMS320LF2406APZA[5]	2.5K	—	32K	256	—	4	✔	16	✔	✔	✔	16 ch 0.5	41	3.3	40	100 LQFP	8.86
TMS320LF2407APGEA[5]	2.5K	—	32K	256	✔	4	✔	16	✔	✔	✔	16 ch 0.5	41	3.3	40	144 LQFP	9.39
TMS320F243PGEA[5]	544	—	8K	—	✔	2	✔	8	✔	✔	✔	8 ch 0.9	32	5	20	144 LQFP	13.99
TMS320C242PGA[5,6]	544	4K	—	—	—	2	✔	8	—	✔	—	8 ch 0.9	26	5	20	64 PQFP	3.69[4]
TMS320C242FNA[5,6]	544	4K	—	—	—	2	✔	8	—	✔	—	8 ch 0.9	26	5	20	38 PLCC	3.69[4]
TMS320F241PGA[5]	544	—	8K	—	—	2	✔	8	✔	✔	✔	8 ch 0.9	26	5	20	64 PQFP	12.37
TMS320F241FNA[5]	544	—	8K	—	—	2	✔	8	✔	✔	✔	8 ch 0.9	26	5	20	38 PLCC	13.36
TMS320F240PQA[5]	544	—	16K	—	✔	3	✔	12	✔	✔	—	16 ch 6.1	28	5	20	132 PQFP	16.21

[1]1 word = 2 bytes.
[2]10-bit.
[3]Suggested resale price in U.S. dollars in quantities of 1,000. Prices represent year 2004 suggested resale pricing.
[4]Minimum volume for LC240xA devices is 10,000 units with NRE of $9,000.
[5]Available in industrial temperature range (A = –40 to 85°C) or automotive temperature range (S = –40 to 125°C) (with 10% price adder).
[6]Pricing based on 5,000 units minimum requirements due to factory ROM code.
Standard lead times are 5 weeks for Flash parts and 10 weeks for ROM-coded parts.
Note: Enhanced plastic and military DSP versions are available for selected DSPs.

Application Reports

Below you'll find a sampling of the design tools TI offers to simplify your design process. To access any of the following application reports, type the URL **www-s.ti.com/sc/techlit/*litnumber*** and replace *litnumber* with the number in the Lit Number column.
For a complete list of analog application reports, visit: **analog.ti.com/appnotes**
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Title	Lit Number
Amplifiers	
Single-Supply Operation of Isolation Amplifiers	SBOA004
Very Low Cost Analog Isolation with Power	SBOA013
Boost Instrument Amp CMR with Common-Mode Driven Supplies	SBOA014
DC Motor Speed Controller: Control a DC Motor without Tachometer Feedback	SBOA043
PWM Power Driver Modulation Schemes	SLOA092
Thermo-Electric Cooler Control Using a TMS320F2812 DSP and a DRV592 Power Amplifier	SPRA873
Isolation Amps Hike Accuracy and Reliability	SBOA064
Make a –10V to +10V Adjustable Precision Voltage Source	SBOA052
±200V Difference Amplifier with Common-Mode Voltage Monitor	SBOA005
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Level Shifting Signals with Differential Amplifiers	SBOA038
Photodiode Monitoring with Op Amps	SBOA035
Single-Supply Operation of Isolation Amplifiers	SBOA004
Precision IA Swings Rail-to-Rail on Single 5V Supply	SBOA033
Pressure Transducer to ADC Application	SLOA056
Buffer Op Amp to ADC Circuit Collection	SLOA098
Amplifiers and Bits: An Introduction to Selecting Amplifiers for Data Converters	SLOA035B
Diode-Connected FET Protects Op Amps	SBOA058
Signal Conditioning Piezoelectric Sensors	SLOA033A
Diode-Based Temperature Measurement	SBOA019
Single-Supply, Low-Power Measurements of Bridge Networks	SBOA018
Thermistor Temperature Transducer to ADC Application	SLOA052
Signal Conditioning Wheatstone Resistive Bridge Sensors	SLOA034
Low-Power Signal Conditioning For a Pressure Sensor	SLAA034
Interfacing the MSP430 and TMP100 Temperature Sensor	SLAA151
Data Converters	
Interfacing the ADS8361 to the TMS320F2812 DSP	SLAA167
Interfacing the TLC2552 and TLV2542 to the MSP430F149	SLAA168
MSC1210 In-Application Flash Programming	SBAA087
Pressure Transducer to ADC Application	SLOA056
Measuring Temperature with the ADS1216, ADS1217, or ADS1218	SBAA073
SPI-Based Data Acquisition/Monitor Using the TLC2551 Serial ADC	SLAA108A
Implementing a Direct Thermocouple Interface with MSP430x4xx and ADS1240	SLAA125A
Using the ADS7846 Touch Screen Controller with the Intel SA-1110 StrongArm Processor	SBAA070
Complete Temp Data Acquisition System from a Single +5V Supply	SBAA050
Interfacing the ADS1210 with an 8xC51 Microcontroller	SBAA010
Programming Tricks for Higher Conversion Speeds Utilizing Delta Sigma Converters	SBAA005
Retrieving Data from the DDC112	SBAA026
Selecting an ADC	SBAA004
Synchronization of External Analog Multiplexers with the ΔΣ ADCs	SBAA013

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Data Converters (Continued)	
The DDC112's Test Mode	SBAA025
Understanding the DDC112's Continuous and Non-Continuous Modes	SBAA024
Thermistor Temperature Transducer to ADC Application	SLOA052
Low-Power Signal Conditioning for a Pressure Sensor	SLAA034
Signal Acquisition and Conditioning with Low Supply Voltages	SLAA018
An Optical Amplifier Pump Laser Reference Design Based on the AMC7820	SBAA072
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Programming a Flash-Based MSP430 Using the JTAG Interface	SLAA149
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CAN	
A System Evaluation of CAN Transceivers	SLLA109
Introduction to the Controller Area Network	SLOA101
Using CAN Arbitration for Electrical Layer Testing	SLLA123
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Recommendations for Phy Layout	SLLA020A
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TI IEEE 1394A Cable Transceiver/Arbiter FAQ	SLLA087
TSB12LV32 (GP2Lynx)/TSB41LV03 Reference Schematic	SLLA044
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PCI1520 Implementation Guide	SCPA033
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DC Brush Motor Control using the TPIC2101	SLIT110
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Technical Review of Low Dropout Voltage Regulator Operation and Performance	SLVA072
ESR, Stability, and the LDO Regulator	SLVA115
Extending the Input Voltage Range of an LDO Regulator	SLVA119
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