imaging

Texas Instruments

TI HealthTech

Engineering components for life.

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Overview

Medical imaging technology is continually evolving and advancing, all with the goal of enabling early diagnosis, prevention, and patient comfort. Medical imaging modalities such as ultrasound, x-ray and MRI all have complex processing and performance needs that push the limits of what is possible. By developing innovative ways to increase integration, lower noise, and lower power consumption, TI components make high performance medical imaging more flexible, affordable and accessible. Driven by the need for higher image quality, medical imaging applications require the highest performance including advanced integrated I/O and powerful data processing. Innovations often focus on integration, such as incorporating digital demodulation into the Analog Front End circuitry in order to decrease the FPGA processing load. A focus on decreasing power consumption and size also allows for the migration of hospital medical imaging equipment into field applications – effectively increasing the speed of delivery and availability of medical care worldwide. TI features a broad array of comprehensive system block diagrams, selection tables and key design tools to help you accelerate innovation. TI HealthTech's broad portfolio, backed by the resources of the TI global enterprise, is the world's largest producer of analog and embedded processors and the single most experienced source for healthcare components in medical imaging applications.

Ultrasound

Ultrasound systems

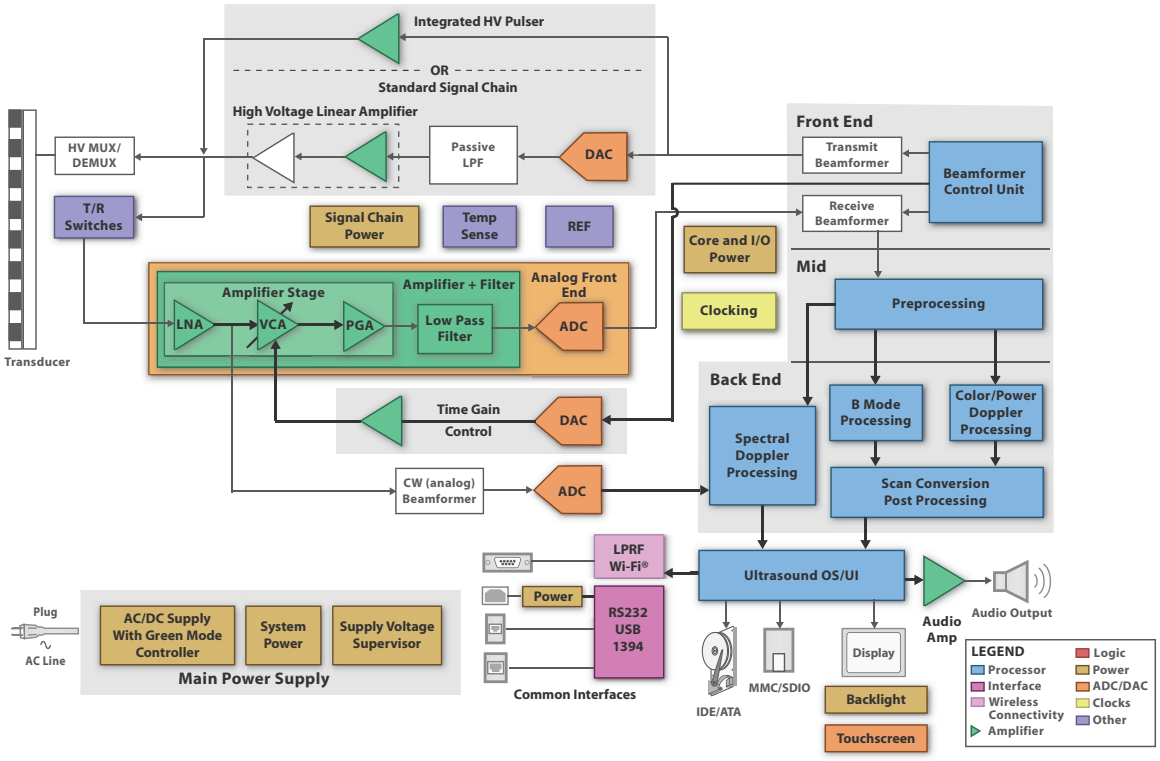
As ultrasound equipment becomes more compact and portable, it heralds a variety of health care applications that illustrate how advances in medical technology are bringing care to patients instead of requiring them to travel. TI's analog products and embedded processors facilitate advanced ultrasound system designs with low power consumption and high performance, yielding portability with high-quality images.

Medical and industrial ultrasound systems use focal imaging techniques to achieve imaging performance far beyond a single-channel approach. By using an array of receivers, TI's latest products for ultrasound enable high definition images through time shifting, scaling and intelligently summing echo energy. This makes it possible to focus on a single point in the scan region; by subsequently focusing on other 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 15MHz. As it does, the signal weakens rapidly, falling off as the square of the distance traveled. As the signal travels, portions of the wavefront energy are reflected back to the transducer/receiver.

Limits on the amount of energy that can be put into the body require that the industry 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. At focal points deep in the body, the receive echoes will be extremely weak and must be amplified by a factor of 1,000 or more. This region is referred to as the far field. These regions represent the two extremes in which the receive electronics must operate.

In the high-gain (far field) mode, the performance limit 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 the low-gain mode (near field), the performance limit is defined by the magnitude of the input signal. The ratio between these two signals defines the system's dynamic range. Many receive chains integrate the LNA with a voltage-controlled attenuator (VCA) and a programmable gain amplifier (PGA).



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

Ultrasound system block diagram.

Ultrasound

Low-pass filtering is typically used between the VCA/PGA and ADC as an anti-aliasing filter and to limit the noise bandwidth. Depending on the specific system, two- to five-pole filter linear phase topologies can be found there. 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. This reduction enables high system integration densities, which translates to smaller and lower cost PC boards — an essential part of portable imaging systems.

The front end of the digital part of the system takes in data from a number of ADCs, commonly referred to as the channel count. This number can vary from eight for ultra-portable systems to 512 for high-end devices. For 3-D and 4-D systems, this number can be even higher. The main function of the digital front end is to perform focusing at a given depth and direction. This beamforming is performed by resampling the ADC output at a higher rate, properly delaying the resampled data, multiplying by a weight (apodization factor), and then summing all the weighted and delayed outputs. Both the I/O and computational requirements for this process are extremely high.

Traditionally, FPGAs and custom ASICs have been used for digital beamforming, but today DSPs provide the ability to handle much of the required computational load. DSPs are also well suited to handle the real-time aspects of the beamforming controller, which may vary the delay and apodization profile required for beamforming based on the depth and direction of the beam.

The beamformed data is then passed through a mid-processing block where various filtering is performed to reduce noise and properly extract the ultrasound RF data. This is followed by demodulation to create complex baseband data. Adaptive processing based on the depth and angle of measurements is sometimes used to get an optimized ultrasound image.

The output from the mid-processing stage is handled in the back-end in various ways. For B-mode imaging, the data envelope is compressed to bring it to the dynamic range of the human eye. Additional image enhancement, noise reduction and speckle reduction algorithms are performed. The data is then scan converted to the final output display form and size. For Doppler processing, velocity and turbulence are estimated in the color flow mode, and power is estimated in the power Doppler mode. These estimates are again scan converted to the final output display form and size.

An assignment of color to the estimates is also necessary for proper display. In spectral Doppler mode, a windowed and overlapped FFT is taken to estimate the spectrum. It is also customary to present the Doppler data, after separation of forward and reverse flow, in the form of audio. All of these intensive signal processing computations are well suited for DSPs.

Product portfolio for ultrasound

Analog application-specific signal chain products

- The main function of a digital front end in an ultrasound system is to focus at a given depth and direction. The AFE58xx family of fully integrated analog front ends offers compact solutions, with low power and low noise for superior image quality.
- The transmit beamformer, high-voltage (HV) pulser TIR switch, and HV multiplexer form the transmit path responsible for the pulse-excitation of transducer elements. The LM965xx family offers these functions and are designed for low power, portable solutions.

Ultrasound

Fully Integrated 8-Channel Analog Front End with CW and Demodulation

NEW

AFE5809

Get samples, datasheets and evaluation modules at: **www.ti.com/sc/device/AFE5809**

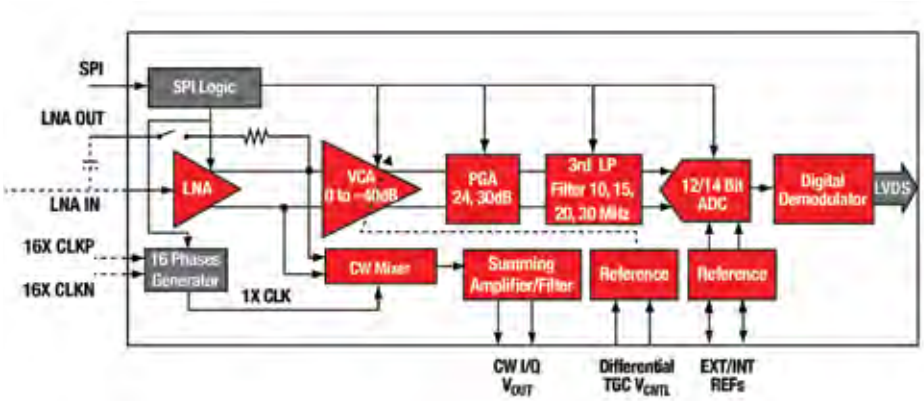
Key Features

- Digital in-phase and quadrature (I/Q) demodulator and a low-pass decimation filter to reduce the LVDS data rate and improve overall system power efficiency
- Integrated CW Doppler mixer and summing amplifier with a very low close-in phase noise better than –156dBc/Hz at 1KHz off a 2.5MHz carrier to ease design with CW beamforming
- Low-noise optimization of 0.75nV/rtHz, at 158mW/CH 65MSPS and a 14-bit ADC with 77dBFS SNR

Applications

- Ultrasound
- Non-destructive testing
- Sonar
- Radar

The AFE5809 consists of eight channels, including a low-noise amplifier, a voltage controlled attenuator, a programmable gain amplifier, a third order filter, and a 14-bit, analog-to-digital converter with LVDS output. It integrates a continuous wave Doppler mixer enabling ease of design for Spectral Doppler systems to measure blood flow velocity. The integrated CW mixer for CW beamforming has a very low close-in phase noise better than –156dBc/Hz at 1KHz off a 2.5MHz carrier. AFE5809 also includes a digital in-phase and quadrature (I/Q) demodulator and a low-pass decimation filter. The main purpose of the demodulation block is to reduce the LVDS data rate and improve overall system power efficiency. The I/Q demodulator can accept ADC output with up to 65MSPS sampling rate and 14-bit resolution. The AFE5809 is available in a small 15mm x 9mm 135-pin BGA package.



AFE5809 functional diagram.

Ultrasound

Fully Integrated 8-Channel Analog Front Ends with CW

AFE5807, AFE5808A

NEW

Get samples, datasheets and evaluation modules at: **www.ti.com/sc/device/afe5807** or **www.ti.com/sc/device/afe5808a**

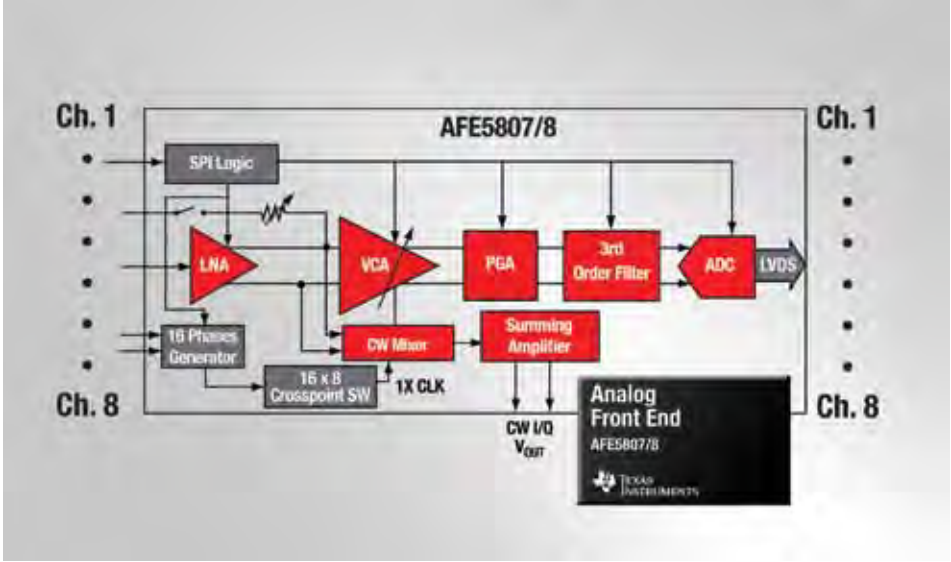
Key Features

- Integrated CW Doppler mixer and summing amplifier with a very low close-in phase noise better than –156dBc/Hz at 1KHz off a 2.5MHz carrier to ease design with CW beamforming
- AFE5807 is low-power, high sampling rate with 117mW/CH at 1.05nV/rtHz, 80MSPS
- AFE5808A is high-performance with low-noise optimization of 0.75nV/rtHz, at 158mW/CH 65MSPS and a 12/14-bit ADC with 77dBFS SNR

Applications

- Ultrasound
- Non-destructive testing
- Sonar
- Radar

The AFE5807 and AFE5808A consist of eight channels each, including a low-noise amplifier, a voltage controlled attenuator, a programmable gain amplifier, a third order filter, and a 14-bit, analog-to-digital converter with LVDS output. Most importantly, these products integrate the continuous wave Doppler mixer enabling ease of design for Spectral Doppler systems to measure blood flow velocity. The integrated CW mixer for CW beamforming has a very low close-in phase noise better than –156dBc/Hz at 1KHz off a 2.5MHz carrier. They are both available in a small 15mm x 9mm 135-pin BGA package.



AFE5807 and AFE5808A functional diagram.

Ultrasound

Fully Integrated 8-Channel Analog Front End

AFE5803

Get samples, datasheets and evaluation modules at: **www.ti.com/sc/device/afe5803**

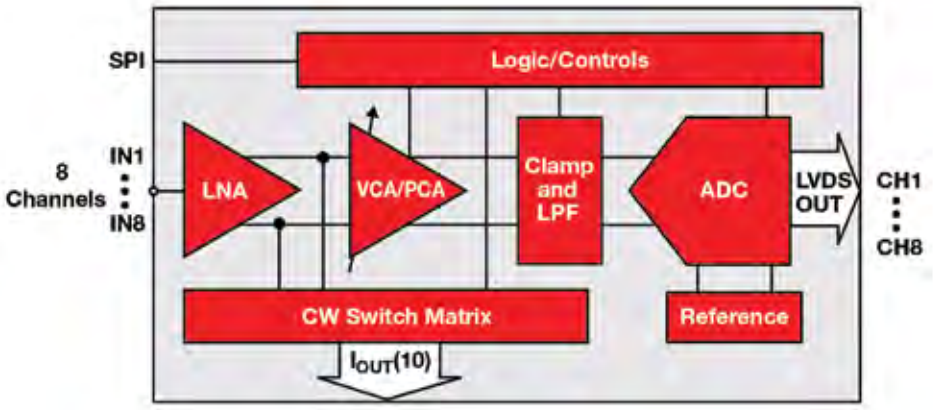
Key Features

- Integrated LNA, VCA, PGA, LPF, 14-bit ADC with LVDS output up to 65MSPS
- Low-noise optimization of 0.75nV/rtHz, 149mW/ch, 65MSPS and an ADC with 77dBFS SNR
- Total max gain: 54db and 0.25/0.5/1 V_{pp} linear input range
- Third order linear phase LPF with selectable bandwidth of 10, 15, 20, and 30MHz and 50, 100, 200 or 400Ω active termination
- Package: 135-pin 15mm x 9mm BGA

Applications

- Ultrasound
- Non-destructive testing
- Sonar
- Radar

The AFE5803 consists of eight channels, including a low-noise amplifier, a voltage controlled attenuator, a programmable gain amplifier, a third order filter, and a 14-bit, analog-to-digital converter with LVDS output. It has the best-in-class noise performance at 0.75nV/rtHz and is available in a small 15mm x 9mm 135-pin BGA package.



AFE5803 functional diagram.

Ultrasound

Octal, 12-/14-Bit, 80 MSPS ADC

ADS5292/ADS5294

Get samples, datasheets and evaluation modules at: **www.ti.com/sc/device/ads5292** or **ads5294**

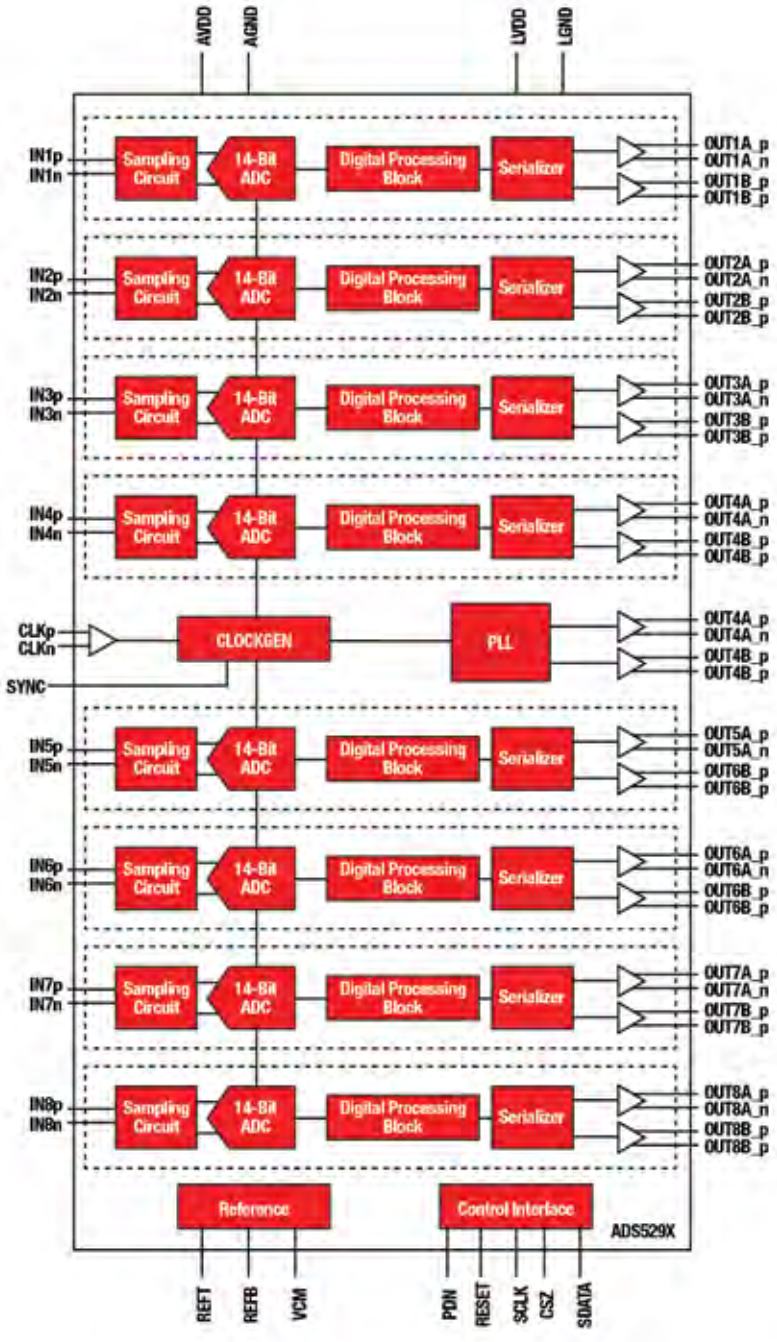
Key Features

- ADS5294 – 14-bit
  - 75.5dBFS SNR at 5MHz/80 MSPS
  - 78.2dBFS SNR at 5MHz and decimation filter
  - 84dBc SFDR at 5MHz/80MSPS
  - 77mW/ch at 80MSPS (2 LVDS wires/cH)
  - 58mW/ch at 50MSPS (1 LVDS wire/cH)
- ADS5292 – 12-bit
  - 70dBFS SNR at 5MHz/80MSPS
  - 71.5dBFS SNR at 5MHz and decimation filter
  - 85dBc SFDR at 5MHz/80MSPS
  - 54mW/ch at 65MSPS
  - 66mW/ch at 80MSPS (2 LVDS wires/ch)
- Digital processing block integrates several commonly used system functions such as two- or four-channel averaging and decimation by two, four or eight filters.
- Digital data can be output over one or two wires of LVDS pins per channel

Applications

- Ultrasound
- Non-destructive testing
- Radar
- Multi-channel data acquisition

The ADS5294 meets designers' needs for power-efficient, cost effective designs by delivering a best in class SNR of 75.5dBFS at 5MHz and a sampling frequency of up to 80MSPS. The ADS5292 offers low power consumption of 66mW/channel at 80MSPS. The ADS5292/4 allows engineers to design smaller, more compact systems than were previously possible with existing single-, dual-, or quad-channel devices.



ADS5292/4 functional diagram.

Ultrasound

Transmit Family

LM96530/50/70

Get samples, datasheets and evaluation modules at: **www.ti.com/sc/device/PARTnumber**
(Replace **PARTnumber** with **lm96530**, **lm96550**, or **lm96570**)

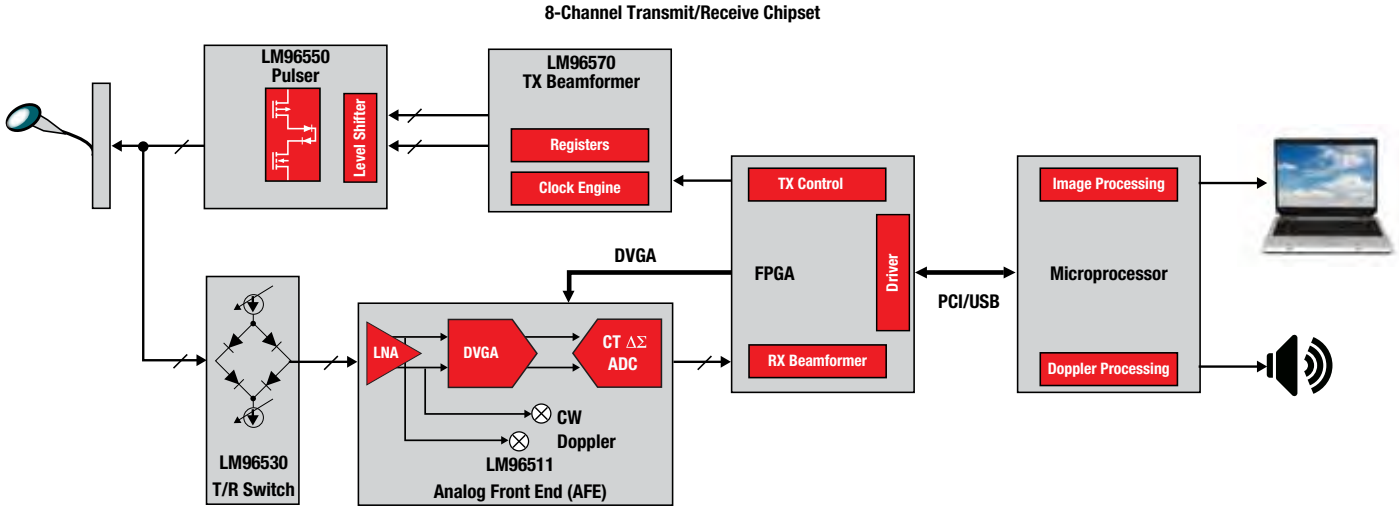
The LM965xx family offers a complete medical ultrasound transmit solution targeted for low power, portable systems. The family includes the T/R switch, the pulser, and the beamformer for pulse generators.

Key Features

- LM96530: Ultrasound transmit/ receive switch
  - 8-channel high-voltage receive side switches without charge-injection
  - Can be used for receive protection and/or receive multiplexing with SPI™ compatible bus control
  - Channel bandwidth supports 1MHz to 20MHz transducers
  - Input accepts pulses and continuous-wave signals within ±60V
- LM96550
  - 8-channel high-voltage CMOS pulse generator
  - Output pulses with ±50V and 2A peak current
  - Active damper with built-in blocking diodes
  - Built-in floating supply voltages for output stage
- LM96570
  - Full control over selecting beam directions and pulse patterns by programming individual channel parameters
  - Outputs interface seamlessly with positive and negative inputs on octal high-voltage pulser ICs
  - Beamformer timing provides: Delay resolution of 0.78ns

Applications

- Ultrasound
- Radar
- Sonar



Transmit system block diagram.

Ultrasound

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Analog Front Ends				
AFE5807	8-Channel Integrated Analog LNA, VCA, PGA, LPF and 12-Bit, 80-MSPS ADC and CW	Low power solution with 117mW/ch at 1.05 nV/√Hz, 80MSPS. Low close-in phase noise better than –156dBc√Hz at 1KHz off a 2.5 MHz carrier.	Fully integrated AFE with CW mode to display blood flow velocity in Spectral Doppler ultrasound systems	AFE5808A
AFE5809	8-Channel Integrated Analog LNA, VCA, PGA, LPF and 14-Bit, 65-MSPS ADC and CW with demodulatation	Low-noise optimization of 0.75nV/√Hz, 149mW/ch, 65MSPS and an ADC with 77dBFS SNR. Low close-in phase at –156dBc√Hz at 1KHz off a 2.5 MHz carrier.	Fully integrated AFE with CW mode to display blood flow velocity in Spectral Doppler ultrasound systems	AFE5808A
AFE5808A	8-Channel Integrated Analog LNA, VCA, PGA, LPF and 14-Bit, 65-MSPS ADC and CW	Low-noise optimization of 0.75nV/√Hz, 158mW/ch, 65MSPS and an ADC with 77dBFS SNR. Low close-in phase at –156dBc√Hz at 1KHz off a 2.5 MHz carrier.	Fully integrated AFE with CW mode and digital demodulator to reduce overall system cost and power	AFE5807
AFE5803	8-Channel Integrated Analog LNA, VCA, PGA, LPF and 14-Bit, 65-MSPS ADC	Low-noise optimization of 0.75nV/√Hz, 158mW/ch, 65MSPS and an ADC with 77dBFS SNR.	Best in class noise at 0.75nV/√HzHz	AFE5805
LM96511	8-Channel Integrated Analog LNA, VCA, PGA, LPF and 12-Bit, 50-MSPS ADC and CW	110mW/channel low power, 0.9nV/√Hz low noise, 135-pin 15 x 9 BGA package	Enables portability, greater number of channels per system and maintains good image quality	AFE5805
AFE5801	8-Channel Integrated Analog VCA, PGA, LPF and 12-bit, 65 MSPS ADC	50mW/channel at 30MSPS, 58mW/channel at 50MSPS, 64-pin 9 x 9 QFN package	Low power enables handheld ultrasounds	AFE5851
AFE5804	8-Channel Integrated Analog LNA, VCA, PGA, LPF and 12-bit, 50-MSPS ADC	101mW/channel low power, 1.23nV/√Hz low noise, 135-pin 15 x 9 BGA package	Enables portability, greater number of channels per system and maintains good image quality	AFE5805, VCA8500 with ADS5281
AFE5805	8-Channel Integrated Analog LNA, VCA, PGA, LPF and 12-bit, 50-MSPS ADC	122mW/channel low power, 0.85nV/√Hz low noise, 135-pin 15 x 9 BGA package	Enables portability, greater number of channels per system and maintains good image quality	AFE5804
AFE5851	16-Channel Integrated Analog VCA, PGA, LPF and 12-bit, 65-MSPS ADC	39mW/channel at 32.5MSPS, 64-pin 9 x 9 QFN package	High channel count and low power allows increased channel density in handheld ultrasounds	AFE5801
Amplifiers				
LM324	Quadruple Operational Amplifier	Wide supply range 3V to 32V Supply current independent of supply voltage 0.8mA Low input bias 20nA	Excellent performance and reliability	
LM358	Dual Operational Amplifiers	Wide supply range 3V to 32 Supply current independent of supply voltage 0.7mA Low input bias 20nA	Excellent performance and reliability	LMV358
OPAx695	High-Speed Op Amp	G = +2 BW 1400MHz, G = +8 BW 450MHz, 4300V/µs SR	Ultra-wideband, current feedback	OPA2695 (dual)
OPAx832	Video Buffer Op Amp	G = +2 BW 80MHz, 3.9mA supply, 350V/µs SR	Low power, fixed gain	OPA2832 (dual)
OPA847	VFB Op Amp	3.9GHz GBW, 0.85nV/√Hz noise, 950V/µs SR	High DC accuracy, stable for gains ≥12V/V	
OPA211	Precision Op Amp	1.1nV/√Hz noise at 1kHz, ±2.25V to ±18V supply, 80MHz BW	Unity gain stable, RRO, wide supply range	OPA227
OPA369	Nanopower Zero-Crossover Op Amp	1.8V to 5.5V, 700nA I_Q, CMRR 114dB RRIO, 0.4µV/°C, V_{OS} drift	Zero-crossover input offers excellent CMRR over entire input range	OPA379, OPA349
LPV521	Nano Power Amplifier	1.6V, 345nA, RRIO, 120dB CMRR, 0.4µV/°C drift	Lowest power, high CMRR	LPV511, OPA369
OPA695	Ultra-Wideband, Current-Feedback Operational Amp	±4.2V output voltage swing, low disabled power of 0.5mW, ultra-high slew rate	Gives more than adequate 0.8ns rise time for a 2V output step for the highest speed video requirements	
OPA2695	Dual, Wideband, Current-Feedback Operational Amp	±4.2V output voltage swing, low quiescent current, low disable current	Optimized for high gain operation	
OPA2889	High-Speed Op Amp	460µA/channel quiescent current	Very low power	OPA2890
THS4131	High-Speed Op Amp	150MHz (–3dB) BW, 51V/µs SR, –100dB THD	Differential input/differential output	THS4120, THS4150
THS4304	High-Speed Op Amp	3GHz BW, 830V/µs SR, 2.4nV/√Hz noise, 7.5ns settling time (001%)	High bandwidth and fast settling time	
THS4509	High-Speed Op Amp	1900MHz BW, 6600V/µs SR, 2ns settling time (1%)	Low distortion, fully differential	THS4508, THS4511

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

Ultrasound

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers (continued)				
THS4524	Very Low Power Quad Channel Rail-to-Rail Output Fully Differential Amplifier	Fully differential, 1.14-mA/ch current consumption	Low power signal conditioning	THS4521
TPA2010D1	Analog-Input Class-D Amp	2.5W mono, fully differential, filter-free Class D, in WCSP	Loud audio, long battery life, small package size	TPA2031D1
TPA2013D1	Analog-Input Class-D Amp	2.7W constant output power, mono, Class D, integrated boost converter	Louder audio at low battery levels	TPA2014D1
TPA4411	Audio Headphone Amp	Audio headphone amp		TPA6130A2
TPA6205A1	Class-AB Audio Amp	1.25W mono, fully differential, Class AB	Loud audio, low cost	TPA6204A1
TPA6211A1	Class-AB Audio Amp	3.1W mono, fully differential, Class AB	Loud audio	
VCA2615	Dual, Low-Noise LNA and VCA	Very low noise: 0.7nV/$\sqrt{Hz}$	For high-end systems requiring high dynamic range and flexibility	VCA2611
VCA2617	Dual, Low-Power VCA	Differential I/O VCA, low power: 52mW/ch	Low-power, low-noise VCA to follow an off-chip LNA	VCA2614
VCA8500	8-Channel Ultrasound Front End	Complete with LNA, VCA and LPF; low noise and power: 0.8nV/$\sqrt{Hz}$ and 65mW/ch	Best-in-class noise-power combination	AFE5805
VCA8613	8-Channel Ultrasound Front End	Complete with LNA, VCA and LPF; low power: 75mW/ch	Best-in-class power	VCA8500
VCA8617	8-Channel Ultrasound Front End	Complete with LNA, VCA and LPF; low noise of 1.0nV/$\sqrt{Hz}$	Best-in-class noise	VCA8500
Data Converters				
ADS5292	High-Speed ADC	8-Channel, 12-bit 80MSPS, 78.2dBFS SNR at 5MHz and decimation filter	Best in class SNR performance improves systems sensitivity	ADS5294
ADS5294	High-Speed ADC	8-Channel, 14-bit 80MSPS, 54mW/ch at 65MSPS	Enables high density applications to increase channel count without increasing power	ADS5292
ADS1610	Delta-Sigma ADC	16-bit, 10MSPS, parallel interface	SYNC pin for simultaneous sampling	
ADS1605	Delta-Sigma ADC	16-bit, 5MSPS (10MSPS in 2x mode), 88dB SNR, –99dB THD	Selectable on-chip reference	
ADS5121	High-Speed ADC	8-channel, 10-bit, 40MSPS, 1.8V analog/digital supply	Low power, individual channel power down	ADS5122
ADS5232	High-Speed ADC	Dual 12-bit, 65MSPS, 3.3V analog/digital supply	Internal or external reference	
ADS5240	High-Speed ADC	4-channel, 12-bit, 65MSPS, 3.3V analog/digital supply	Serialzed LVDS outputs, integrated frame and bit patterns	ADS5242
ADS5281	High-Speed ADC	8-channel, ultra-low-power, 12- and 10-bit, 50 to 65MSPS analog-to-digital converter	77mW per channel, serialized LVDS outputs, 1/F noise-suppression	ADS5282, ADS5287
ADS5282	High-Speed ADC	Ultra-low-power, 8-channel, 12-bit, 65MSPS	77mW per channel, serialized LVDS outputs, 1/f noise suppression	ADS5281
ADS5287	High-Speed ADC	Ultra-low-power, 8-channel, 10-bit, 65MSPS	77mW per channel, serialized LVDS outputs, 1/f noise suppression	ADS5281
ADS5295	High-Speed ADC	8-channel, 12-bit, 100MSPS high-SNR and low-power ADC	Low power consumption and integration of multiple channels in a compact package make the device attractive for very high channel count data acquisition systems	UI
ADS7809	AR ADC	16-bit, 100kHz sample rate, 86dN SINAD with 20kHz input, serial ouput	Output sync pulse for ease of use with standard DSP processors	
ADS8284	SAR ADC	18-bit, 1MSPS, 4 MUX inputs, 98.5dB (typ) SNR at 10kHz	Integrated op amp, ultra-high DC and AC performance	
ADS8380	SAR ADC	18-bit, 600kHz sample rate, ±2 LSB (typ), pseudo-differential input	Zero latency, serial interface with clock up to 40MHz	
ADS8422	SAR ADC	16-bit, 4MSPS, parallel w/reference, pseudo bipolar, fully differential input	Low power	
ADS8484	High-Speed SAR	18-bit, 125MSPS, 98dB (typ) SNR, –110dB (typ) THD	Excellent drift performance	
ADS8519	Bipolar ADC	±10V bipolar, 16-bit, 250kSPS, 10mW at 250kSPS (typ)	Flexible voltage digital interface supports 1.8V I/O	
DAC2900	High-Speed DAC	10-bit, 125MSPS dual DAC	Supports 3.3/5V	DAC2902, DAC2904

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

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

Ultrasound

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Data Converters (continued)				
DAC7568	12-Bit Octal Channel, Ultra-Low Glitch, Voltage Output DAC With 2.5V, 2-ppm/°C Internal Reference	DSP-compatible 3-wire serial interface with power on reset and power down features	Useful for portable ultrasound data conversion	DAC8168, DAC8568
DAC8168	14-Bit Octal Channel, Ultra-Low Glitch, Voltage Output DAC With 2.5V, 2ppm/°C Internal Reference	DSP compatible 3-wire serial interface with power on reset and power down features	Useful for portable ultrasound data conversion	DAC7568, DAC8568
DAC8560	V_{OUT} DAC	16-bit, 0.15nV-s glitch, ±10µs to 0.003% FSR settling time	Small package, low power	DAC8554, DAC8551, DAC8552
DAC8568	16-Bit Octal Channel, Ultra-Low Glitch, Voltage Output DAC With 2.5V, 2ppm/°C Internal Reference	DSP compatible 3-wire serial interface with power on reset and power down features	Useful for portable ultrasound data conversion	DAC7568, DAC8168
DAC8330	Precision DAC	16-bit, V_{OUT}, 1LSB INL	Very low power, serial interface	DAC8331, DAC8830
DACx311	8 to 16-Bit, Single Channel, Low Power, Ultra-Low Glitch DAC	±2 LSB, scalable output range, SPI interface with 1.8V to 5.5V logic	Very low noise and fast settling time	
References				
LM4040x	Precision Micropower Shunt Voltage Reference	35µV_{RMS} typ, ABCD grade, 45µA (typ) to 15mA 2.048V, 2.5V, 3V, 4.096V, 5V, 8.192V, 10V	Highly precise with low output noise and a wide operating current range	
REF02	Precision V_{REF}	0.2% (max) initial accuracy, 10ppm/°C (max) drift, 1.4mA (max)	Excellent line/load regulation, low noise	REF5050
REF30xx	Low-Power, Low-Drift Series Reference	50µA, 0.2% initial accuracy, 50ppm/°C max drift, ±25mA output, 1.25V, 2.048V, 2.5V, 3.0V , 3.3V, 4.096V		REF31xx, REF33xx, REF29xx
REF31xx	Voltage Reference	15ppm/°C (max) drift, 5mV low dropout, 115µA (max) I_Q, 0.2% (max) accuracy, 1.25V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V	No load capacitor required	REF32xx, REF33xx
REF32xx	Low Drift, Bandgap	0.2% (max) accuracy, 7ppm/°C (max) drift, 0.1mA (max) I_Q	Multiple output voltages, SOT23-6	
REF33xx	Very-Low-Power Series Reference	5µA, 0.15% initial accuracy, 30ppm/°C max drift, ±5mA output, 1.25V, 1.8V, 2.048V, 2.5V, 3.0V, 3.3V	Preserves battery life, fits into physically constrained systems	REF30xx, REF31xx, REF29xx
REF5010	Low Noise, Very-Low-Drift, Precision Voltage Reference	0.05% initial accuracy, 3ppm/°C max drift, ±10mA output, 10V	Improves system accuracy	REF102
REF50xx	High-Precision, Very-Low-Drift Series Reference	0.05% initial accuracy, 3ppm/°C max drift, ±10mA output, 2.048V, 2.5V, 3.0V, 4.096V, 4.5V, 5.0V	Improves system accuracy	REF02
TL43x	Adjustable Precision Shunt Regulator	Output voltage V_{REF} to 36V, 0.2-Ω (typ), sink-current capability 1mA to 100mA	Easy to use, low output noise, great replacement for Zener Diodes	
Processors				
AM37x	Applications Processor	ARM® Cortex-A8 processor that nearly doubles graphics performance and overall system performance while providing a 30 percent decrease in power consumption	Laptop-like performance at handheld power levels	AM3715, AM3703
TMS320C6452	DSP	900MHz, 1.4MB L2 cache, 2x SGMII/Gigabit EMAC	High-performance DSP with improved system cost	
TMS320C6455	DSP	1.2GHz, SRIO, 2MB RA	High-performance, fixed-point 16-bit processor	TMS320C6454BZTZ
TMS320C6472	DSP	6x 700MHz C64x+ cores, 4.8MB RAM, SRIO, HPI	High-performance multiprocessor solution	
TMS320C6474	DSP	3x 1.2GHz C64x+ cores, 3MB RAM, SRIO	High-performance multiprocessor solution	
TMS320C6654	Industry's Most Efficient Floating-Point DSPs	850MHz, C66x single core, 2MB L2, 2W	Fixed and floating point DSP, 13.5 GFlops, 27 GMACS	
TMS320C6655	Industry's Most Efficient Floating-Point DSPs	1.0, 1.25 GHz, C66x single core, 2MB L2, 2.5W	Fixed and floating point DSP, 20 GFlops, 40 GMACS	
TMS320C6657	Industry's Most Efficient Floating-Point DSPs	1.0, 1.25 GHz, C66x dual core, 2MB L2, 3.5W	Fixed and floating point DSP, 40 GFlops, 80 GMACS	

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

Ultrasound

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Processors (continued)				
TMS320C6678	Industry's Highest Performance Floating-Point DSPs	1.0, 1.25 GHz, eight C66x cores, 8MB L2, 10W	High-performance fixed and floating point DSP, 160 GFlops, 320 GMACS	
TMS320C6745	DSP	1800MFLOPS, 256KB L2	Low cost floating point, combines C64x+ and C67x cores	TMS320C671x
TMS320C6747	Industry's Lowest Power Floating-Point DSPs	32-/64-bit accuracy, 1.8V to 3.3V I/O supply, low power and rich connectivity peripherals	Uses three times less power than existing floating-point DSPs	
TMS320DM355	Highly Integrated, Programmable Platform for Low Cost Portable Digital Video Apps	ARM926 at 216/270MHz; MPEG4 HD (720p) and JPEG up to 50M pixels per second	High quality, low-power consumption at low price	TMS320DM365, TMS320DM368
TMS320DM6446	Highly Integrated Video SoC	Robust operating systems support, rich user interfaces, high processing performance, and long battery life	High quality, low-power consumption at low price	TMS320DM6443, TMS320DM6441
TMS320F2802x/3x Piccolo™	32-Bit Microcontroller	Up to 60MHz C28x™ core with optional control law accelerator. Up to 128KB Flash, high resolution (150ps) PWMs, 4.6MSPS ADC, CAN/LIN, QEP.	With dedicated, high precision peripherals, Piccolo microcontrollers are the ultimate combination of performance, integration, size, and low cost. Ideal for precision sensing and control applications.	TMS320F283x Delfino, TMS320F280x
TMS320F283x Delfino™	32-Bit Floating-Point Microcontroller	Up to 300MHz C28x™ core. Up to 512KB Flash, high resolution (150ps) PWMs, 12MSPS ADC, CAN/LIN, QEP, external memory bus, DMA.	Delfino brings floating point and unparalleled performance to MCUs. Native floating point brings increased performance and quicker development. Ideal for precision sensing and control applications.	TMS320F2802x/3x Piccolo, TMS320F280x
Hercules RM48x	Safety Microcontroller	Up to 220MHz dual lockstep ARM® Cortex-R4 CPUs with floating point, up to 3MB Flash w/ECC, up to 256KB RAM w/ECC, USB host/device, Ethernet, CAN, SPI, UART, 12-bit ADC, NHET co-processor for PWM generation and input capture	Simplified development for safety critical applications, large integrated flash memory, rich peripherial set	
Interface				
SN65LVDS387	16-Channel LVDS Driver	630Mbps	High-density LVDS driver	SN65LVDS386
SN65LVDS93A	24-Bit RGB LVDS Serdes	10MHz-135MHz, BGA and TSSOP; supports 1.8V to 3.3V TTL i/p	Wide frequency range, saves space, no level shifter for 1.8V powered uP	SN75LVDS83B
SN65MLVD047	4-Channel M-LVDS Driver	Higher differential swing	Industry standard	SN65LVDS348
Clocking				
CDCE62005	Clock Generator	RMS jitter <1ps, recommended clocking solution for AFE580x and ADS528x/527x	Integrated VCO saves system cost	CDCE72010, CDCM7005
CDCE(L)949	Clock Synthesizer	Recommended clocking solution for TI DSPs	0ppm multiple-frequency generation	CDCE(L)937, CDCE(L)925
CDCE906	Clock Synthesizer	Recommended clocking solution for TI DSPs	0ppm multiple-frequency generation	CDCE706
Pulsers and Switchers				
TX810	8-Channel Integrated T/R Switch	Eight bias current settings; eight power/performance combinations; accepts 200V_{PP} input signals	Compact T/R switch; flexible programmability; easy power-up/down control; fast wake-up time; dual supply operation; optimized insertion loss	LM96530
TX517	2-Channel High-Voltage Pulse Generator	Output pulses with ±90V with Xformer and 2A peak current	Integrated transmitter for multi-level waveforms	
LM96530	8-Channel Integrated T/R Switch	Input accepts pulses and continuous-wave signals within ±60V	Can be used for receive protection and/or receive multiplexing with SPI™ compatible bus control	LM96550, LM96570
LM96550	8-Channel High-Voltage Pulse Generator	Output pulses with ±50V and 2A peak current	Integrated solution with active damping for low noise operation	LM96530, LM96570
LM96570	Configurable Transmit Beamformer	Full control over selecting beam directions and pulse patterns by programming individual channel parameters	Outputs interface seamlessly with positive and negative inputs on octal high-voltage pulser ICs	LM96530, LM96550
Temperature Sensor				
TMP441	±Temperature sensor with automatic beta compensation, series-R and n-Factor in a 8-pin SOT23	±1°C remote diode sensor with ±1°C local temp sensor	Recommended for FPGA temp monitoring in ultrasound	TMP421

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

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

Ultrasound

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
RF Transceivers				
CC2560	*Bluetooth*® v2.1 + EDR (Enhanced Data Rate)	Fully qualified *Bluetooth*® v2.1 + EDR, +10dBm Tx power with transmit power control, –93dBm received sensitivity, support for *Bluetooth*® power saving modes (sniff, hold), hardware and software pre-integration with TI's MSP430 and Stellaris platforms, FCC, CE and IC certified module options, Broad market offering with extensive documentation, sample software, and support forums	Supports replacement of serial cables for personal area networks, high throughput, robust connection with extended range, extended battery life and power efficiency reduced development time and costs, flexibility to use various MCUs	
CC2564	*Bluetooth*® v4.0	Fully qualified *Bluetooth*® v4.0 with dual mode capability, +10dBm Tx power with transmit power control, –93dBm received sensitivity, support for *Bluetooth*® power saving modes (sniff, hold), hardware and software pre-integration with TI's MSP430 and Stellaris platforms, FCC, CE and IC certified module options, Broad market offering with extensive documentation, sample software, and support forums, ability to connect to existing mobile devices without BLE and some newer devices with BLE	Supports replacement of serial cables for personal area networks, high throughput, robust connection with extended range, extended battery life and power efficiency reduced development time and costs, flexibility to use various MCUs and connect to any type of existing device	
RF Systems-on-Chip				
CC254x	2.4 GHz *Bluetooth*® low energy compliant RF System-on-Chip	Best-in-class System-on-chip *Bluetooth*® low energy solution enabling devices to connect to smartphone/ tablets with extremely low power. Able to run on coin cell battery	System-on-chip for quick time to market. Provides a robust and complete *Bluetooth*® low energy stack enabling extremely long battery life and ability to run on a single coin-cell	CC2590/91, CC2530ZNP
RF Network Processor				
CC3000	SimpleLink™ Wi-Fi® CC3000 Module	One step configuration with SmartConfig Technology, easy to use Wi-Fi® solution with compact code size to be used with microcontrollers, best-in-class link budget, precertified FCC/IC/CE module, small form factor module and $9.99 price point for 1k units, proven Wi-Fi® interoperability, broad market offering with extensive documentation, sample software, and support forums	Universal IP connectivity can be enabled on low memory, low-cost, low-power microcontroller systems, has low certification cost and is easy to use for development	
Toolkits				
STK-MED	A collection of several standard ultrasound algorithms optimized for TI's C64x+ DSP architecture	Standard APIs; tested, benchmarked and documented library modules	Shortens customer development time by providing highly opttimized C64x+ DSP source code of common ultrasound processing blocks	
DLP® LightCrafter™	A compact, versatile EVM for integrating light into medical applications	608x684 micromirror array, 7.6µm micromirror pitch, pattern rates up to 4000Hz, video display up to WVGA resolution	Has multiple industry standard interfaces including USB, mini-HDMI, and I^2C	

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

CT Scanners

Computed Tomography

Computed tomography (CT) is a medical imaging technique that produces three-dimensional images of internal human body parts from a large series of two-dimensional X-ray images (called profiles) taken in a single-axis rotating structure called a gantry. When compared to a conventional X-ray radiograph, which is an image of many planes superimposed on each other, a CT image exhibits significantly improved contrast.

With the advent of diagnostic imaging systems like CT, where complex and intensive image processing is required, semiconductors play a very important role in developing systems with increased density, flexibility and high performance.

X-ray slice data is generated using an X-ray source that rotates around the object, with X-ray detectors positioned on the opposite side of the circle from the X-ray source. Many data scans are taken progressively as the object is gradually passed through the gantry. The newer helical or spiral CT machines that use faster computer systems and optimized software can continuously process the cross-section images while the object passes through the gantry at a constant speed.

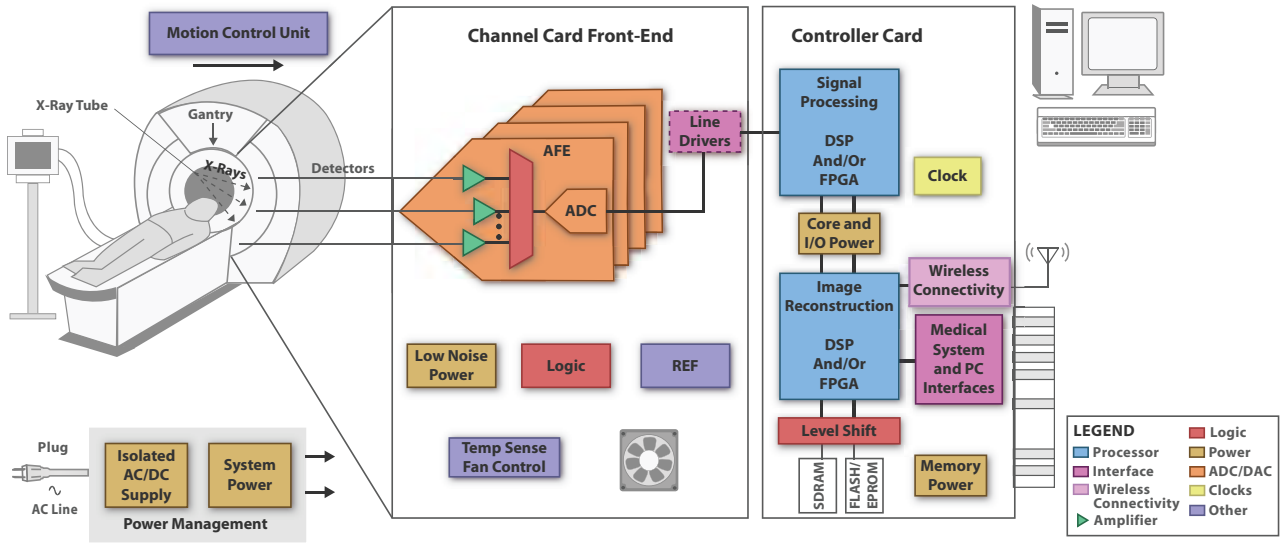
The detector system consists of a number of channel cards that have scintillator-photodiode solid state detectors. The X-rays interact with the scintillator and produce visible light, which is in turn converted into a current by the photodiode. The depth information along the direction of the X-ray beam that is lost in radiography is recovered by viewing the slide from many different directions.

The channel card has a front-end system where charge on the detectors are integrated, gained by amplifiers and converted to digital values by ADCs. The digital data from all channel cards is transferred by high-speed link to the controller card and onto the image conditioning cards. The image conditioning card is connected to the host computer where the CT images can be viewed. Here, the digital data are combined by the mathematical procedure known as tomographic reconstruction. Power supplies, clocks and clock distribution circuits, reference and reference buffers, logic, and interface products are some of the key blocks in the channel card subsystem.

Control cards can include DSPs and FPGAs, power supplies, clocks and clock distribution circuitry and interface blocks. DSPs can be used to provide accurate control of the gantry rotation, the movement of the table (up/down and in/out), tilting of the gantry for angled images, and other functions such as turning the X-ray beam on and off. Another important DSP control functionality is ECG gating used to reduce motion artifacts caused by heart movement. Here, the data acquisition is carefully synchronized with the heartbeat.

Product portfolio for CT scanners

- The DDC family are single-chip solutions for directly digitizing low-level currents from photodiode arrays in CT scanners.
- DSPs with TI's VelociTI™ VLIW architecture can provide accurate control of the gantry rotation, the movement of the table, the tilting of the gantry for angle images, and other real-time control and processing functions.
- Voltage supervisors, DC/DC converters, non-isolated power modules and low-dropout linear regulators to meet sequencing requirements.



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

CT scanner system block diagram.

CT Scanners

Dual, Current-Input, 20-Bit ADC

DDC264

Get samples, datasheets, application reports and evaluation modules at: **www.ti.com/sc/device/ddc264**

Key Features

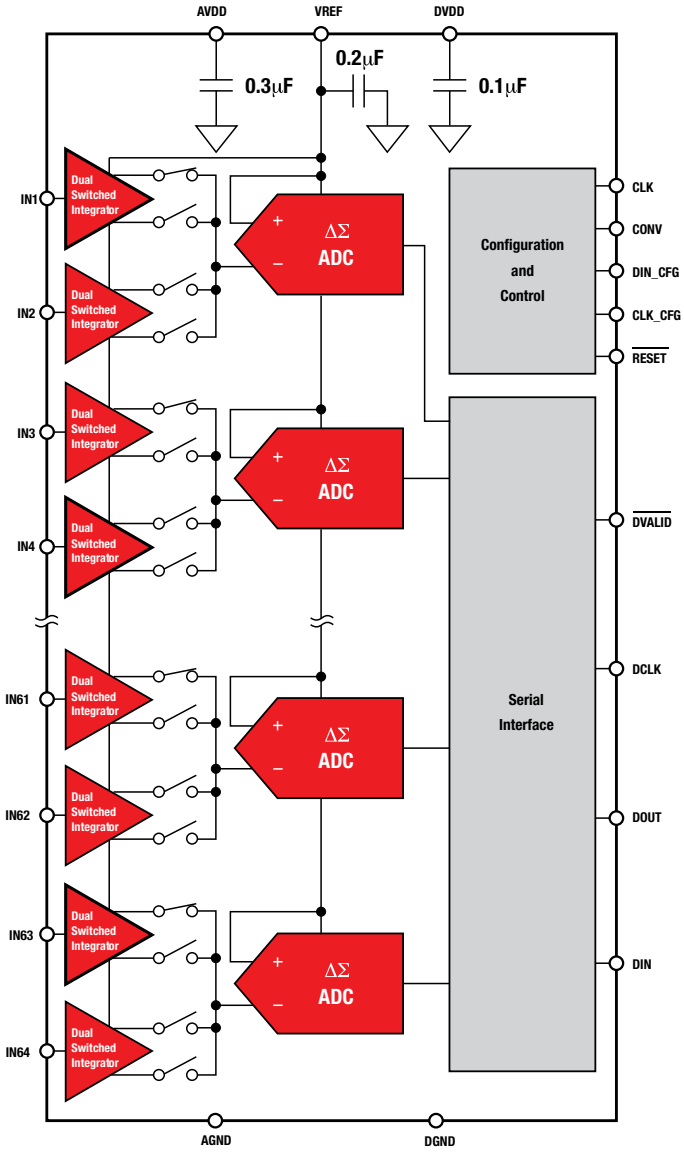
- Single-chip solution to directly measure 64 low-level currents
- Proven high-precision, true integrating architecture with 100% charge collection
- Easy upgrade for existing DDC family applications
- Very low power: 3mW/channel
- Extremely linear:
  INL = ±0.025% of reading ±1.0ppm of FSR
- Low noise: 6.3ppm of FSR
- Adjustable full-scale range

Applications

- CT scanners
- X-ray systems
- Photodiode sensor arrays

The DDC264 is a 20-bit, 64-channel, current-input analog-to-digital (A/D) converter. It combines both current-to-voltage and A/D conversion so that 64 separate low-level current output devices, such as photodiodes, can be directly connected to its inputs and digitized.

For each of the 64 inputs, the DDC264 uses the proven dual switched integrator front-end. This configuration allows for continuous current integration: while one integrator is being digitized by the onboard A/D converter, the other is integrating the input current. This architecture provides both a very stable offset and a loss-less collection of the input current. Adjustable integration times range from 16µs to 1s, allowing currents from fAs to µAs to be continuously measured with outstanding precision.



DDC264 functional diagram.

CT Scanners

Dual, Current-Input, 20-Bit ADC

DDC232

Get samples, datasheets, application reports and evaluation modules at: **www.ti.com/sc/device/ddc232**

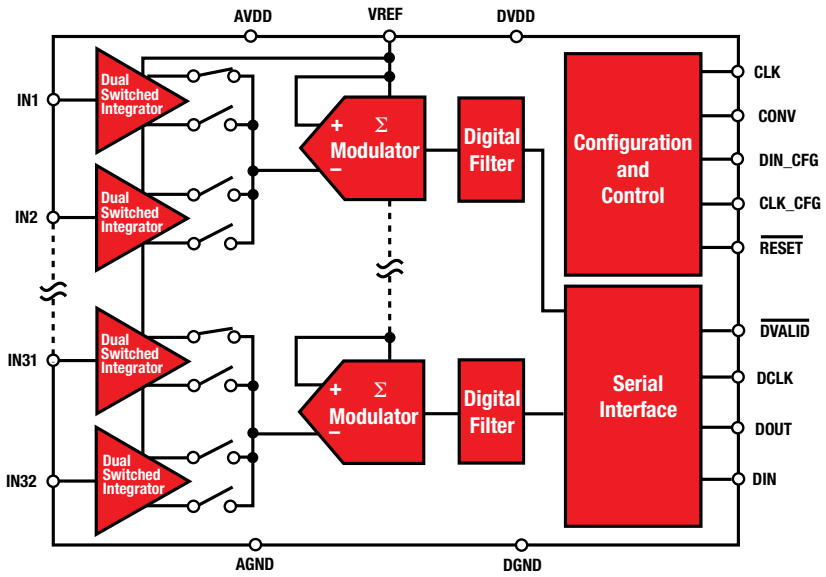
Key Features

- Complete solution for measuring 32 photodiodes with 20-bit resolution
- Continuous charge collection
- Adjustable integration time: 160µs to more than 1s
- Programmable full scale: 12.5pC up to 350pC
- Low noise: 5ppm, rms
- Integral nonlinearity: ±0.025% reading ±1ppm FSR
- Single supply with 7mW/channel power dissipation
- Serial digital interface with daisy chaining support
- Packaging: 8mm x 8mm BGA

Applications

- CT scanners
- X-ray systems
- Photodiode sensor arrays

The DDC products are single-chip solutions for directly digitizing low-level currents from photodiode arrays in CT scanners. The dual-integrator front-end provides continuous charge collection. While one integrator is collecting the photodiode current, the other is being measured by the onboard 20-bit ADC. Integration time is user-adjustable, and the output data is retrieved over a serial interface that can be daisy chained to minimize digital interconnects in high-channel-count systems.



DDC232 functional diagram.

CT Scanners

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifier				
LM324	Quadruple Operational Amplifier	Wide supply range 3V to 32V Supply current independent of supply voltage 0.8mA Low input bias 20nA	Excellent performance and reliability	
LM358	Dual Operational Amplifiers	Wide supply range 3V to 32 Supply current independent of supply voltage 0.7mA Low input bias 20nA	Excellent performance and reliability	LMV358
OPA2211	Lowest Power, 1.1nV/$\sqrt{Hz}$ Noise, Precision Operational Amplifier in DFN-8 (3 x 3mm) and SOIC-8	Extremely low voltage and low current noise, high speed and wide output swing	Allows 16-bit accuracy throughout 10V output swings	OPA627, OPA2111
OPA380	Transimpedance Amp	90MHz GBW, over 1MHz transimpedance BW, 25µV offset (max), 0.1µV/°C drift (max)	Precision, dynamic range 4 to 5 decades, excellent long term stability	OPA350, OPA335
OPA827	Precision JFET Op Amp	4nV/$\sqrt{Hz}$ noise at 1kHz, ±4V to ±18V supply, 15pA (typ) input bias current, 22MHz BW	High precision, low noise, low input bias, wide supply range	OPA177, OPA627,
Data Converters				
ADS8284	SAR ADC	18-bit, 1MSPS, 4 MUX inputs, 98.5dB (typ) SNR at 10kHz	Integrated op amp, ultra-high DC and AC performance	
ADS8317	SAR ADC, Serial	16-bit, 250kSPS, 2.7V to 5.5V, pseudo-bipolar, diff inputs	Excellent linearity, micropower, high speed	ADS8422
ADS8326	SAR ADC, Serial	16-bit, 250kSPS, 2.7V to 5.5V, pseudo-bipolar, diff inputs	Low noise, low power, high speed	ADS8325
ADS8482	SAR ADC	18-bit, 1MSPS, 2.25mW power, 99dB SNR, ±2.5 LSB (max) INL	Pseudo bipolar, internal or external reference	ADS8472, ADS8484
ADS8484	High-Speed SAR	18-bit, 125MSPS, 98dB (typ) SNR, –110dB (typ) THD	Excellent drift performance	
DDC112	2 Channels	50 to 100pC full-scale	Up to 3kSPS data rate, 40mW/Ch	SOIC-28 or TQFP-32
DDC114	4 Channels	12.5 to 350pC full-scale	Up to 3.1kSPS data rate, 13.5mW/Ch	QFN-48
DDC118	8 Channels	12.5 to 350pC full-scale	Up to 3kSPS data rate, 40mW/Ch	QFN-48
DDC232	32 Channels	12.5 to 350pC full-scale	Up to 6kSPS data rate, 7mW/Ch	BGA-64
DDC264	64 Channels	12.5 to 150pC full-scale	Up to 6kSPS data rate, 5.5mW/Ch	BGA-100
References				
LM4040x	Precision Micropower Shunt Voltage Reference	35µV_{RMS} typ, ABCD grade, 45µA (typ) to 15mA 2.048V, 2.5V, 3V, 4.096V, 5V, 8.192V, 10V	Highly precise with low output noise and a wide operating current range	
REF02	Precision V_{REF}	0.2% (max) initial accuracy, 10ppm/°C (max) drift, 1.4mA (max)	Excellent line/load regulation, low noise	REF5050
REF102	10V, Ultra Precision	0.05% (max) initial accuracy, 2.5ppm/°C (max) drift, 1.4mA (max)	Excellent stability and line/load regulation	REF5010
REF31xx	Voltage Reference	15ppm/°C (max) drift, 5mV low dropout, 115µA (max) I_Q, 0.2% (max) accuracy, 1.25V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V	No load capacitor required	REF3130, REF3120
REF32xx	Low Drift, Bandgap	0.2% (max) accuracy, 7ppm/°C (max) drift, 0.1mA (max) I_Q, 1.25V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V	Multiple output voltages, SOT23-6	
REF33xx	Very Low Power Series Reference	5µA, 0.15% initial accuracy, 30ppm/°C max drift, ±5mA output, 1.25V, 1.8V, 2.048V, 2.5V, 3.0V, 3.3V	Preserves battery life, fits into physically constrained systems	REF30xx, REF31xx, REF29xx
REF5010	Low Noise. Very Low Drift, Precision Voltage Reference	0.05% initial accuracy, 3ppm/°C max drift, ±10mA output, 10V	Improves system accuracy	REF102
REF50xx	High-Precision, Very Low Drift Series Reference	0.05% initial accuracy, 3ppm/°C max drift, ±10mA output, 2.048V, 2.5V, 3.0V, 4.096V, 4.5V , 5.0V	Improves system accuracy	REF02
TL43x	Adjustable Precision Shunt Regulator	Output voltage V_{REF} to 36V, 0.2-Ω (typ), sink-current capability 1mA to 100mA	Easy to use, low output noise, great replacement for Zener Diodes	

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CT Scanners

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Processors				
TMS320C-6455BZTZ	DSP	1.2GHz, SRIO, 2MB RAM	High-performance, fixed-point 16-bit processor	TMS320C6454BZTZ
TMS320F2808	Digital Signal Controller	100MIPS, 8KB ROM, 36KB RAM, 128KB flash, 12-bit ADC	I^2C, 4 SPI, 2 SCI, 2 CAN	
TMS320F2812	Digital Signal Controller	150MIPS, 8KB ROM, 36KB RAM, 256KB flash, 12-bit ADC	McBSP, 1 SPI, 2 SCI, 1 CAN	
TMS320F28015	Digital Signal Controller	60MIPS, 8KB ROM, 12KB RAM, 32KB flash, 12-bit ADC	I^2C, 1 SPI, 1 SCI	
TMS320F2802x/3x Piccolo™	32-Bit Microcontroller	Up to 60MHz C28x™ core with optional control law accelerator. Up to 128KB Flash, high resolution (150ps) PWMs, 4.6MSPS ADC, CAN/LIN, QEP.	With dedicated, high precision peripherals, Piccolo microcontrollers are the ultimate combination of performance, integration, size, and low cost. Ideal for precision sensing and control applications.	TMS320F283x Delfino, TMS320F280x
TMS320F283x Delfino™	32-Bit Floating-Point Microcontroller	Up to 300MHz C28x™ core. Up to 512KB Flash, high resolution (150ps) PWMs, 12MSPS ADC, CAN/LIN, QEP, external memory bus, DMA.	Delfino brings floating point and unparalleled performance to MCUs. Native floating point brings increased performance and quicker development. Ideal for precision sensing and control applications.	TMS320F2802x/3x Piccolo, TMS320F280x
Hercules RM48x	32-Bit Floating-Point Safety Microcontroller	Up to 220MHz Dual Lockstep ARM® Cortex-R4 CPUs with Floating Point, up to 3MB Flash w/ECC, up to 256KB RAM w/ECC, USB host/device, Ethernet, CAN, SPI, UART, 12-bit ADC, NHET co-processor for PWM generation and input capture	Simplified development for safety critical applications, large integrated flash memory, rich peripherial set	
TMS320C6474	DSP	3x 1GHz C64x+™ DSP cores, 3MB RAM, SRIO	High-performance multiprocessor solution	
TMS320C6655	Industry's Most Efficient Floating-Point DSPs	1.0, 1.25 GHz, C66x single core, 2MB L2, 2.5W	Fixed and floating point DSP, 20 GFlops, 40 GMACS	
TMS320C6657	Industry's Most Efficient Floating-Point DSPs	1.0, 1.25 GHz, C66x dual core, 2MB L2, 3.5W	Fixed and floating point DSP, 40 GFlops, 80 GMACS	
TMS320C6678	Industry's Highest Performance Floating-Point DSPs	1.0, 1.25 GHz, eight C66x cores, 8MB L2, 10W	High-performance fixed and floating point DSP, 160 GFlops, 320 GMACS	
Interface				
XIO1100	x1 PCIe PHY	Interface FPGA to PCIe fabric between channels	PCIe 1.1 compliant, flexible MAC interface	
TLK1221	Gigabit Ethernet Serdes	Power 250mW	Smallest package	TLK2208B
SN65LVCP40	Dual 1:2 Mux/ Buffer	Input EQ, output pre-emp	Improves signal range	
SN65LVDS93A	24-bit RGB LVDS Serdes	10MHz-135MHz, BGA and TSSOP; supports 1.8V to 3.3V TTL i/p	Wide frequency range, saves space, no level shifter for 1.8V powered uP	SN75LVDS83B
Clocking				
CDCLVP12xx/ 21xx	1:2/4/8/12/16 or Dual 1:2/4/6/8 Universal-to-LVPECL Clock Buffers	Very low additive jitter <100ps RMS; 2.5V / 3.3V operation	Improved clock signal quality by 10x; saves additional interface logic / external components	CDCLVP111, CDCLVP215
Analog Multiplexers				
TS3A5017	Dual SP4T 3.3-V/2.5-V Analog Multiplexer/ Demultiplexer	Low total harmonic distortion	Excellent signal integrity in both digital and analog applications	
TS3A5018	Quad SPDT 3.3V/2.5V Analog Switch	Low on state resistance and matching (R_{ON} = 10)	Minimizes signal loss and ensures less variance	

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Magnetic Resonance Imaging (MRI)

Magnetic Resonance Imaging (MRI)
Magnetic resonance imaging (MRI) is a non-invasive diagnostic technology that produces physiologic images of the human body. Powerful magnets create a field that forces hydrogen atoms in the body into a particular alignment. Radio frequency (RF) energy distributed throughout the body is interrupted by body tissue. The disruptions correspond to varying return signals which, when processed, create the image.

Accurate signal processing is key to obtaining high-quality images. A key system consideration for the receive channel is high SNR. The return signals have narrow bandwidths, with an IF location dependent on the main magnet's strength. Some systems use high-speed pipeline ADCs with wide-band amplifiers to sample the IF, leaving large headroom for post-processing gain by a digital down converter or FPGA. Other systems mix the IF to baseband where lower speed, higher resolution SAR and delta-sigma ADCs can be used.

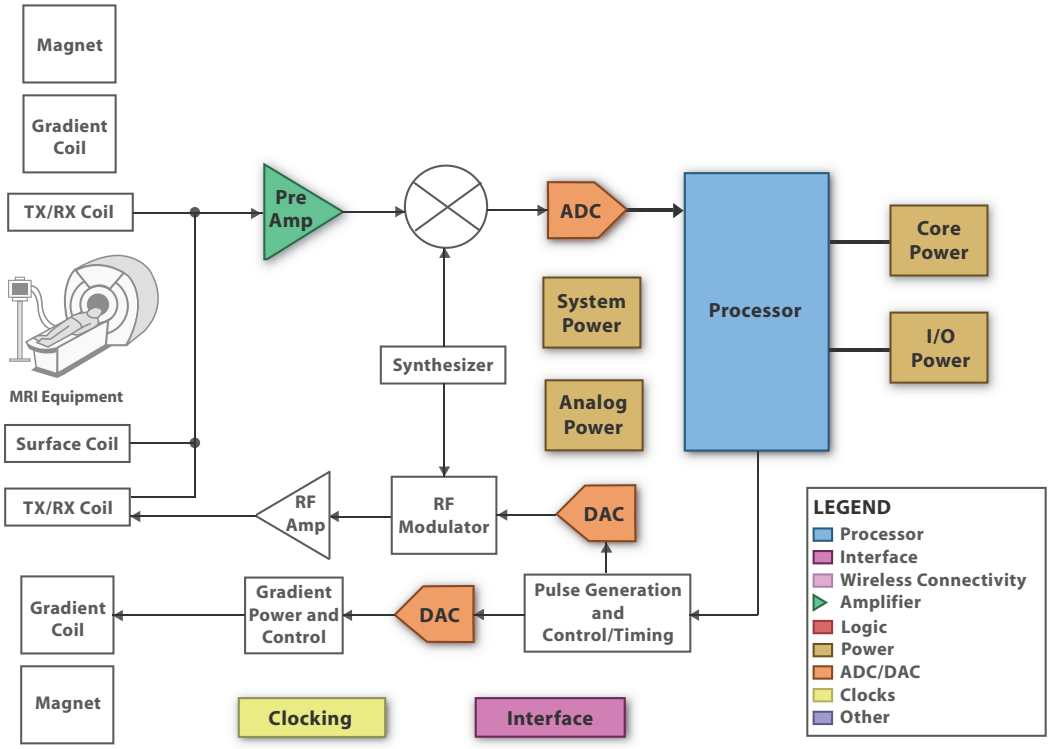
High-resolution, high-speed DACs are needed to control the magnetic and RF energy in the MRI. High resolution is required to accurately define the area of the patient to be scanned and high speed is needed to match the high IFs generated by the main magnet.

DSPs can be used to provide gradient processor control for properly controlling MRI system magnets. DSPs are also useful for implementing signal processing functionalities in MRI devices. MRI reconstruction is based mostly on 2-D Fourier transformation. In addition, functionalities like auto- and cross-correlation, curve fitting, combining sub-images and motion stabilization are required to pre- and post-process the image to reduce various artifacts.

Analog ICs and embedded processors are playing a key role in improving the delivery speed and crisp detail of magnetic resonance images, leading to more accurate diagnoses and effective treatments. Accurate signal processing is key to high-quality MRI images.

Product portfolio for MRIs

- Some systems use high-speed pipeline ADCs with wideband amplifiers to sample the intermediate frequency (IF) generated by the main magnet.
- Other systems mix the IF to baseband, allowing for the use of lower speed, higher resolution successive approximation registers (SARs) and delta-sigma ADCs.
- High-resolution DACs can control the magnetic and RF energy in an MRI.
- DSPs like the TMS320C6452 can provide gradient processor control for properly controlling the magnets and preprocess the signal before it reaches the image reconstruction engine.
- Other products for MRI systems and equipment manufacturers include operational amplifiers, clocking distribution, interface and power management devices.



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

Magnetic resonance imaging (MRI) system block diagram.

Magnetic Resonance Imaging (MRI)

Quad, 16-Bit, 100 MSPS ADC

ADS5263

NEW

Get samples, datasheets, evaluation modules and application reports at: **www.ti.com/sc/device/ads5263**

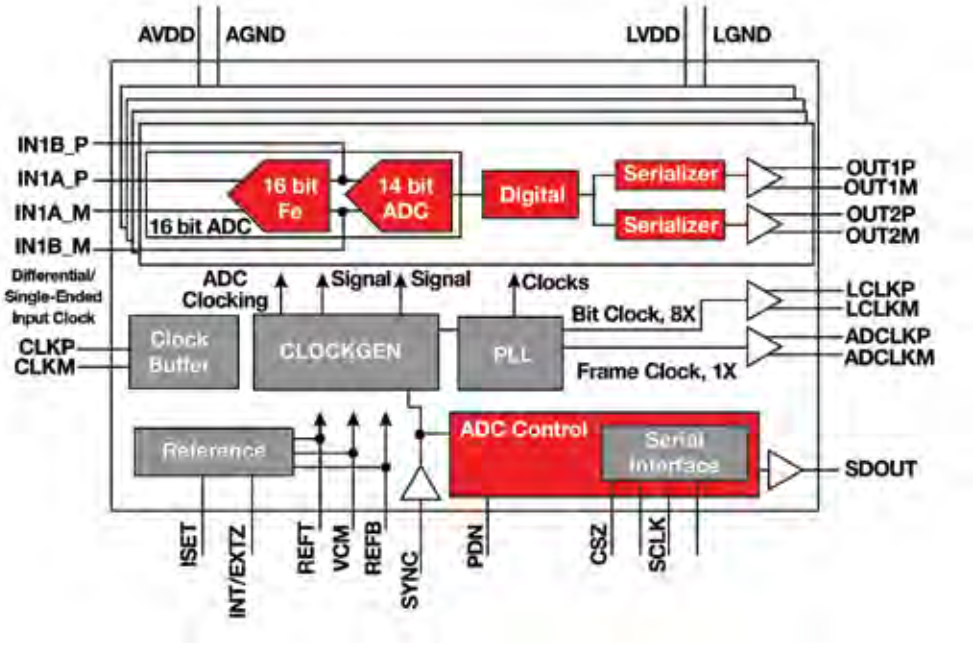
Key Features

- 16-bit resolution with up to 100MSPS sampling frequency for highest performance
- SNR of 84.6dBFS at 10MHz for best image quality
- Low-power consumption of 380mW/channel for compact medical imaging systems
- 14-bit and 16-bit resolution modes to switch between low-power and high-speed, high-resolution operation
- Quad-channel in 9mm x 9mm QFN package brings 50% board space savings
- Non-magnetic package option allows for operation in a strong magnetic field such as in magnetic resonance imaging (MRI) and other high-resolution applications

Applications

- MRI
- Radar

The ADS5263 delivers a very high SNR of 84.6dBFS, with 10MHz input and a sampling frequency up to 100MSPS. Together with up to $4V_{pp}$ full-scale input, this enables a very strong signal and a high-range of signal variations for best image clarity and contrast. The quad-channel architecture, the low power consumption of 380mW/channel and the small footprint of the ADS5263 allows system designers to design smaller, more compact systems than was previously possible with existing single or dual channel solutions. A non-magnetic package option allows for operation in a strong magnetic field, such as in MRI machines.



ADS5263 functional diagram.

Magnetic Resonance Imaging (MRI)

NEW

Non-Magnetic Packages

For more information visit **www.ti.com/nonmagnetic**

Key Features

- Removal of every magnetic component from silicon and package
- Allows for operation without distortion in strong magnetic fields
- Cost-effective design allows designers to remove shield previously needed

Applications

- MRI

TI's non-magnetic packages remove every magnetic component (such as nickel and iron) from its silicon and package. Non-magnetic package options allow for operation without distortion in strong magnetic fields. Non-magnetic packages allow engineers to design more compact, cost-effective designs, where previously designers had to design in shields around the components to protect them from the magnetic fields..

Non-magnetic components.

Non-Magnetic Components	
ADS5263IRGCT-NM	Analog-digital converter – 16-bit/14-bit ADC, 100 MSPS, BW>130MHz: QFN 9mm x 9mm 64-leads
TPS715A01DRBT-NM	80mA adjustable LDO 1.2V/15V: QFN 3mm x 3mm (DRB 8 leads)
TLC7701IDRBT-NM	Power management micro power supply voltage supervisor, QFN 3mm x 3mm (DRB 8 leads)
TS5A22362DRCT-NM	Analog switch – 0.65Ω dual SPDT analog switch, QFN 3mm x 3 mm (DRC 10 leads)
TPD2E001DRST-NM	15KV ESD diodes – 5V double I/O low cap IEC ESD diodes, QFN 3mm x 3mm (DRS 6-leads)
MSP430F2618TPMT-NM	Microcontroller – ultra-low-power microcontrollers, 64-LQFP 12mm x 12mm PM (S-PQFP-G64)

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

Magnetic Resonance Imaging (MRI)

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers				
LM324	Quadruple Operational Amplifier	Wide supply range 3V to 32V Supply current independent of supply voltage 0.8mA Low input bias 20nA	Excellent performance and reliability	
LM358	Dual Operational Amplifiers	Wide supply range 3V to 32 Supply current independent of supply voltage 0.7mA Low input bias 20nA	Excellent performance and reliability	LMV358
TPS715A01-NM	80mA Adjustable LDO 1.2V/15V	Non-magnetic package	Operation without shielding in strong magnetic field	
TLC7701-NM	Micro Power Supply Voltage Supervisor	Non-magnetic package	Operation without shielding in strong magnetic field	
TS5A22362-NM	0.65Ω Dual SPDT Analog Switch	Non-magnetic package	Operation without shielding in strong magnetic field	
TPD2E001-NM	5V Double I/O Low Cap IEC ESD Diode	Non-magnetic package	Operation without shielding in strong magnetic field	
MSP430F2618-NM	Ultra-Low-Power Microcontrollers	Non-magnetic package	Operation without shielding in strong magnetic field	
OPA861	Transconductance Amp	80MHz, open loop, G = +5BW, 900V/µs SR	95mA/V high transconductance, 5.4mA I_Q	
PGA870	Fully Differential PGA	650MHz BW, gain range: –11.5dB to +20dB, OIP3 +47dBm at 100MHz	Optimized for low distortion, accomodates varying signal levels	
THS4503	High-Speed Op Amp	370MHz BW, 3700V/µs SR, 5V, ±5V, 12V and 15V supply	Low distortion, fully differential	THS4504, THS4141
THS9000	Cascadeable Amp	50MHz to 400MHz, 50Ω input/output impedance	High dynamic range, single supply	
Data Converters				
ADS5263	High Speed ADC	Quad, 16bit/14bit, 100MSPS, 84.6dBFS	High performance for best image quality	
ADS1605	16-bit, 10-MSPS Delta-Sigma ADC	10 to 5MSPS, parallel interface with direct connection to TMS320 DSPs	Provides key system-level design advantages with respect to anti-aliasing filtering and clock jitter	ADS1610
ADS1610	Delta-Sigma ADC	16-bit, 10MSPS, parallel interface	SYNC pin for simultaneous sampling	ADS1605
ADS5281	High-Speed ADC	8-channel, ultra-low-power, 12- and 10-bit, 50 to 65MSPS analog-to-digital converter	77mW per channel, serialized LVDS outputs, 1/F noise-suppression	ADS5282, ADS5287
ADS5282/87	High-Speed ADC	Ultra-low-power, 8-channel, 12-bit, 65MSPS	77mW per channel, serialized LVDS outputs, 1/f noise suppression	ADS5281, ADS5287
ADS5423	High-Speed ADC	14-bit, 80MSPS, 74dBc at 80MSPS and 50MHz IF SNR	3.3V CMOS-compatible outputs, 2s-complement output format	ADS5424, ADS5433
ADS5545	High-Speed ADC	14-bit, 170MSPS, DDR LVDS/CMOS outputs	Programmable output clock position to ease data capture	ADS5546, ADS5547
ADS5547	High-Speed ADC	14-bit, 210MSPS, user-selectable DDR LVDS or CMOS parallel outputs	High performance	ADS5545, ADS5546
ADS5562	High-Speed ADC	Low-power, 16-bit ADC with up to 84dBFS SNR	High SNR, 1/f noise suppression with low power and small package ease data capture	ADS5560
ADS61xx/61Bxx	High-Speed ADC	11- /12- /14-bits, 65 to 250MSPS, 3.3V, 260 to 780mW per channel	High performance	ADS62xx, ADS62Pxx, ADS64xx
ADS62xx/62Pxx	High-Speed ADC	11- /12- /14-bits, 65 to 250MSPS, 3.3V, 260 to 780mW per channel	High performance	ADS61xx, ADS61Bxx, ADS64xx
ADS64xx	High-Speed ADC	11- /12- /14-bits, 65 to 250MSPS, 3.3V, 260 to 780mW per channel	High performance	ADS61xx, ADS61Bxx, ADS62xx, ADS62Pxx
ADS6425	High-Speed ADC	4-channel, 12-bit, 125MSPS, serial LVDS interface, 1.65W total power	High performance, multiple input option	
DAC904	High-Speed DAC	14-bit, 165MSPS DAC	Low-power DAC	
DAC5672	High-Speed DAC	14-bit, 275MSPS dual DAC	High sample rate with low power	DAC5662, DAC5652
DAC5681Z	High-Speed DAC	16-bit, 1GSPS 2x-4x interpolating DAC	High sample rate allows direct launch to low RF	DAC5681, DAC5682Z
DAC5687	High-Speed DAC	16-bit, 500MSPS interpolating with NCO	Digital integration and superior AC performance for flexible application and high-quality transmission	DAC5686
DAC7725	V_{OUT} DAC	Quad, 12-bit, 250mW (max) power, 10µs to 0.012% settling time	Double-buffered data inputs	DAC7724, DAC902, DAC900

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

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

Magnetic Resonance Imaging (MRI)

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
References				
LM4040x	Precision Micropower Shunt Voltage Reference	35µV_{RMS} typ, ABCD grade, 45µA (typ) to 15mA 2.048V, 2.5V, 3V, 4.096V, 5V, 8.192V, 10V	Highly precise with low output noise and a wide operating current range	
REF02	Precision V_{REF}	0.2% (max) initial accuracy, 10ppm/°C (max) drift, 1.4mA (max)	Excellent line/load regulation, low noise	REF5050
REF102	10 V, Ultra Precision	0.05% (max) initial accuracy, 2.5ppm/°C (max) drift, 1.4mA (max)	Excellent stability and line/load regulation	REF5010
REF31xx	Voltage Reference	15ppm/°C (max) drift, 5mV low dropout, 115µA (max) I_Q, 0.2% (max) accuracy, 1.25V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V	No load capacitor required	REF31xx, REF32xx, REF33xx
REF32xx	Low Drift, Bandgap	0.2% (max) accuracy, 7ppm/°C (max) drift, 0.1mA (max) I_Q, 1.25V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V	Multiple output voltages, SOT23-6	
REF33xx	Very Low Power Series Reference	5µA, 0.15% initial accuracy, 30ppm/°C max drift, ±5mA output, 1.25V, 1.8V, 2.048V, 2.5V, 3.0V, 3.3V	Preserves battery life, fits into physically constrained systems	REF30xx, REF31xx, REF29xx
REF5010	Low Noise, Very Low Drift, Precision Voltage Reference	0.05% initial accuracy, 3ppm/°C max drift, ±10mA output, 10V	Improves system accuracy	REF102
REF50xx	High-Precision, Very Low Drift Series Reference	0.05% initial accuracy, 3ppm/°C max drift, ±10mA output, 2.048V, 2.5V, 3.0V, 4.096V, 4.5V, 5.0V	Improves system accuracy	REF02
TL43x	Adjustable Precision Shunt Regulator	Output voltage V_{REF} to 36V, 0.2-Ω (typ), sink-current capability 1mA to 100mA	Easy to use, low output noise, great replacement for Zener Diodes	
Processors				
AM37x	Applications Processor	ARM® Cortex-A8 processor that nearly doubles graphics performance and overall system performance while providing a 30 percent decrease in power consumption	Laptop-like performance at handheld power levels	AM3715, AM3703
TMS320C6452/55	DSP	900MHz, 1.4MB L2 cache, 2 x SGMII/Gigabit EMAC	High-performance DSP with improved system cost	TMS320C6414, TMS320C6455, TMS320C6454, TMS320C6747
TMS320C-6455BZTZ	DSP	1.2GHz, SRIO, 2MB RAM	High-performance, fixed-point 16-bit processor	TMS320C6454BZTZ
TMS320C6655	Industry's Most Efficient Floating-Point DSPs	1.0, 1.25 GHz, C66x single core, 2MB L2, 2.5W	Fixed and floating point DSP, 20 GFlops, 40 GMACS	
TMS320C6657	Industry's Most Efficient Floating-Point DSPs	1.0, 1.25 GHz, C66x dual core, 2MB L2, 3.5W	Fixed and floating point DSP, 40 GFlops, 80 GMACS	
TMS320C6678	Industry's Highest Performance Floating-Point DSPs	1.0, 1.25 GHz, eight C66x cores, 8MB L2, 10W	High-performance fixed and floating point DSP, 160 GFlops, 320 GMACS	
TMS320F2808	32-Bit MCU	100MIPS, 8KB ROM, 36KB RAM, 128KB flash, 12-bit ADC	I^2C, 4 SPI, 2 SCI, 2 CAN	
TMS320F28015	32-Bit MCU	60MIPS, 8KB ROM, 12KB RAM, 32KB flash, 12-bit ADC	I^2C, 1 SPI, 1 SCI	
TMS320F28234	32-Bit MCU	150MIPS, 8KB ROM, 68KB RAM, 256KB flash, 12-bit ADC	McBSP, 1 SPI, 2 SCI, 2 CAN	
TMS320F283x Delfino™	32-Bit Floating-point Microcontroller	Up to 300MHz C28x™ core. Up to 512KB Flash, high resolution (150ps) PWMs, 12MSPS ADC, CAN/LIN, QEP, external memory bus, DMA.	Delfino brings floating point and unparalleled performance to MCUs. Native floating point brings increased performance and quicker development. Ideal for precision sensing and control applications.	TMS320F2802x/3x Piccolo, TMS320F280x
Hercules RM48x	32-Bit Floating-Point Safety Microcontroller	Up to 220MHz Dual Lockstep ARM® Cortex-R4 CPUs with Floating Point, up to 3MB Flash w/ECC, up to 256KB RAM w/ECC, USB host/device, Ethernet, CAN, SPI, UART, 12-bit ADC, NHET co-processor for PWM generation and input capture	Simplified development for safety critical applications, large integrated flash memory, rich peripherial set	
TMS320C6474	DSP	3 x 1GHz C64x+ cores, 3MB RAM, SRIO	High-performance multiprocessor solution	

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

Magnetic Resonance Imaging (MRI)

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Interface				
SN65MLVD128	1:8 Fanout Buffer	200Mbps	Standardized M-LVDS	SN65MLVD2
SN65LVDS93A	24-Bit RGB LVDS Serdes	10MHz-135MHz, BGA and TSSOP; supports 1.8V to 3.3V TTL i/p	Wide frequency range, save space, no level shifter for 1.8V powered uP	SN75LVDS83B
Clocking				
CDCE62005	Clock Generator	rms jitter <1ps, recommended clocking solution for AFE580x and ADS528x/527x	Integrated VCO saves system cost	CDCE72010, CDCM7005
CDCE(L)949	Clock Synthesizer	Recommended clocking solution for TI DSPs	0ppm multiple-frequency generation	CDCE(L)937, CDCE(L)925, CDCE(L)913
CDCE906	Clock Synthesizer	Recommended clocking solution for TI DSPs	0ppm multiple-frequency generation	CDCE706

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Digital X-Ray

Digital X-rays are revolutionizing diagnostic radiology and spurring innovative new applications, such as their use in surgical procedures. A key benefit of digital X-rays is the ability to store and transfer the digital images, allowing for the outsourcing of radiological services or easy access to remote and/or specialized analysis.

A conventional X-ray system captures less than 40 percent of the original image information. By adding a digital detector to digital X-ray imaging, it is possible to capture more than 80 percent of the original image information and use a wide range of post-processing tools to further improve the image.

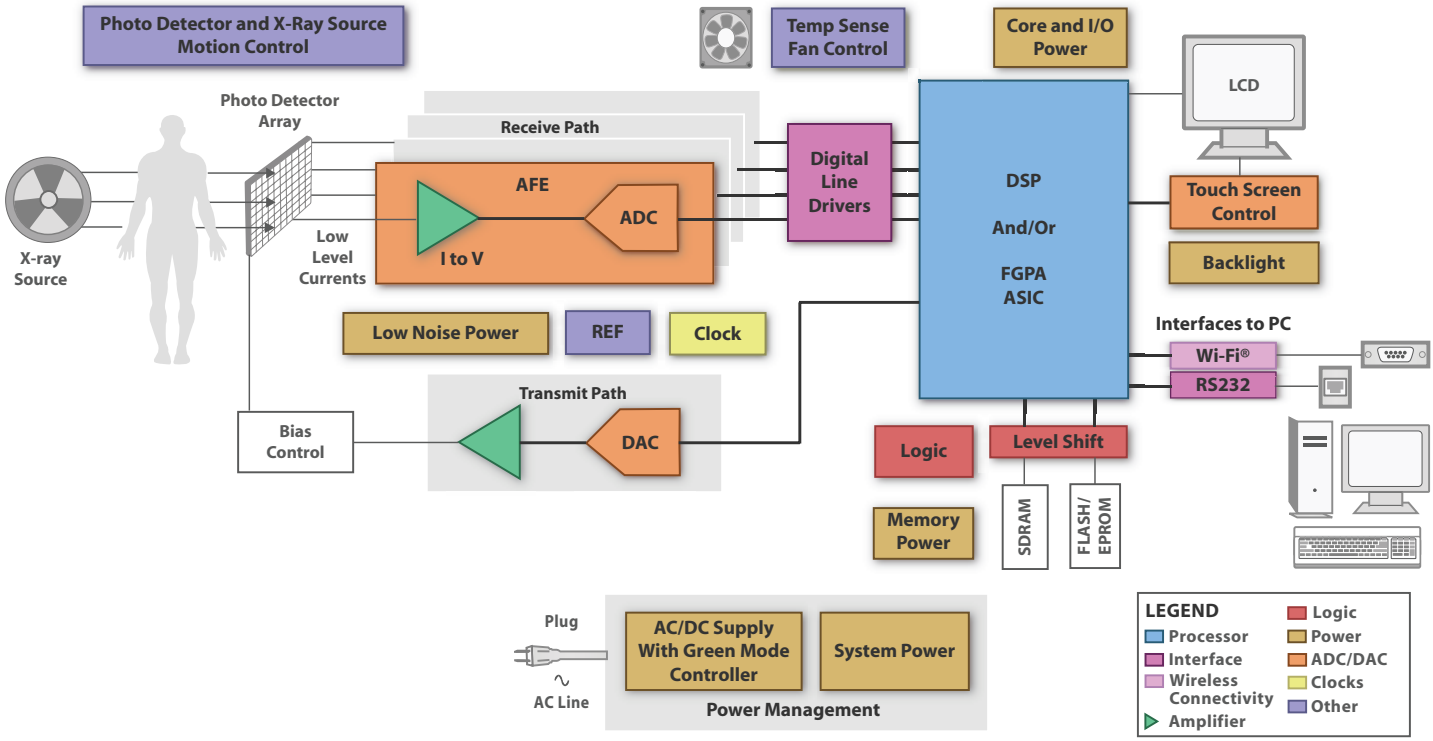
Other digital X-ray technology advances made possible by semiconductor technology include:

- Faster diagnoses by eliminating photographic processing time and facilitating quick transmission over network connections.
- Reduced costs by eliminating photographic processing film and chemicals.
- Processing only the image data that highlights regions of interest, suppressing irrelevant information.
- Combining image data with other pertinent radiology information system (RIS) and hospital information system (HIS) records.
- Archiving all relevant information efficiently.

There are two different approaches to digital X-ray technology: computed radiology (CR) and digital radiography (DR). Computed radiology involves trapping electrons on an imaging plate (IP) containing photo-stimulated-phosphor (PSP) and exposing them to generate image data. The IP is then moved to a CR reader, where it is scanned using a laser beam.

The second approach, digital radiography, uses both direct and indirect conversion. In direct conversion, flat-panel selenium detectors absorb X-rays directly and convert them into individual pixel electric charges. In indirect conversion, X-ray signals are converted to light, and then converted to electric charges. Both tiled charge-coupled device (CCD) arrays and computed tomography use indirect conversion technology. Tiled CCD transitional technology employs multiple CCDs coupled to a scintillator plate via fiber optics.

Computed tomography involves trapping electrons on photo-stimulated plates and exposing them to generate image data. In both approaches, charges



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

Digital X-ray system block diagram.

Digital X-Ray

proportional to X-ray intensity seen by the pixel are stored in the thin film transistor (TFT) storage cap. A number of such pixels form the flat detector panel (FDP). The charges are deciphered by read-out electronics from the FDP and transformed into digital data.

The block diagram shows the readout electronics required for direct imaging to convert the charge in the FDP to digital data. It has two chains: the acquisition and the biasing chain. At the beginning of the acquisition chain, an analog front-end is capable of multiplexing the charges on different FDP (channels) storage caps and converting those charges into voltage. The biasing chain generates bias voltages for the TFT array through intermediate bias-and-gate control circuitry. Digital control and data conditioning are controlled by a DSP, an FPGA, an ASIC or a combination of these. These processors also manage high-speed serial communications with the external image processing unit through a high-speed interface (serialized, LVDS, optical).

Temperature sensors, DACs, amplifiers and high-input voltage-capable switching regulators are other key system blocks. Each block must have an enable pin and synchronize frequencies to avoid crosstalk with other blocks in the acquisition chain. The number of FDP pixels determines the number of ADC channels versus ADC speed. Static or dynamic acquisition also determines ADC speed. While static acquisition means a single image in less than 1 s, dynamic means an image is refreshed at 30 Hz for more specific cardiovascular, fluoroscopic or related applications that require much faster data conversion with the same number of channels. An ADC in the range of 2 MSPS or more with excellent DC performance will work well.

For indirect conversion, the CCD output requires correlated double sampling (CDS). The signal level's reset voltages and image signal level are converted to digital data by an analog front end (AFE). The AFE's sampling speed is determined by the number of pixels in the CCD array and the frame rate. In addition, the AFE corrects sensor errors such as dark current correction, offset voltages and defective pixels. Depending on the signal level, the presence of programmable gain amplifiers (PGAs), the linearity of the PGAs and the range of gains available may also be important. During digitization, the number of bits determines image contrast. Typically, digitizing the initial data with two to four bits more precision than desired in the final image is recommended. For example, if 8 bits of final image data are required, initially digitize to 10 bits to allow for rounding errors during image processing.

The main metric for image quality is detection quantum efficiency (DQE), a combination of contrast and SNR expressed in percentage. The higher the contrast and lower the noise, the higher the DQE. Contrast is the number of shades of gray determined by the ADC's output resolution. Generally, 14 or 16 bits are suitable for the application.

SNR indicates not only SNR from the ADC, but system SNR impact from X-ray dose, pixel size and all electronic components. SNR can be improved by increasing X-ray dose and photodiode spacing and decreasing electronics noise. Increasing the X-ray dose is not suitable for patients or operators. Increasing photodiode spacing may not be suitable because this decreases spatial resolution. Decreasing the noise from the system's electronics is the main challenge.

Total system noise is the root-square-sum of all noise contributions over the signal chain, assuming all are uncorrelated. This means all parts have to be ultra-low-noise or heavily filtered, when applicable, including ADCs, op amps and references. Stability over temperature is another important challenge. Internal temperature increases, due to power dissipation, may offset gray levels and distort an image, especially during dynamic acquisitions. Therefore, temperature stability of ADCs, op amps and references should be high.

The digital X-ray data undergoes several processing steps before it is presented to the display for viewing. The first step, called shading, is where the non-idealities in the detector pixels are corrected. Next, the unexposed area is determined in the detector so that it is not used in subsequent processing. Histogram equalization is then carried out on the useful data. Finally, several image enhancement techniques are used for noise reduction, contrast improvement and edge enhancement.

Product portfolio for digital X-rays

- Analog front ends (AFEs) capable of multiplexing the charges on different flat detector panels (FDPs), storage caps (channels) and converting these charges into voltage for direct conversion X-rays. AFEs also convert the signal level and its reset voltages to digital data and correct sensor errors in indirect conversion X-rays.
- High-performance DSPs for control functions and signal conditioning to acquire and improve the clarity of the image.
- Temperature sensors, DACs, amplifiers and high-input voltage-capable switching regulators are other key system blocks.

Digital X-Ray

64-Channel AFE

AFE0064

NEW

Get samples, datasheets, evaluation modules and application reports at: **www.ti.com/afe0064**

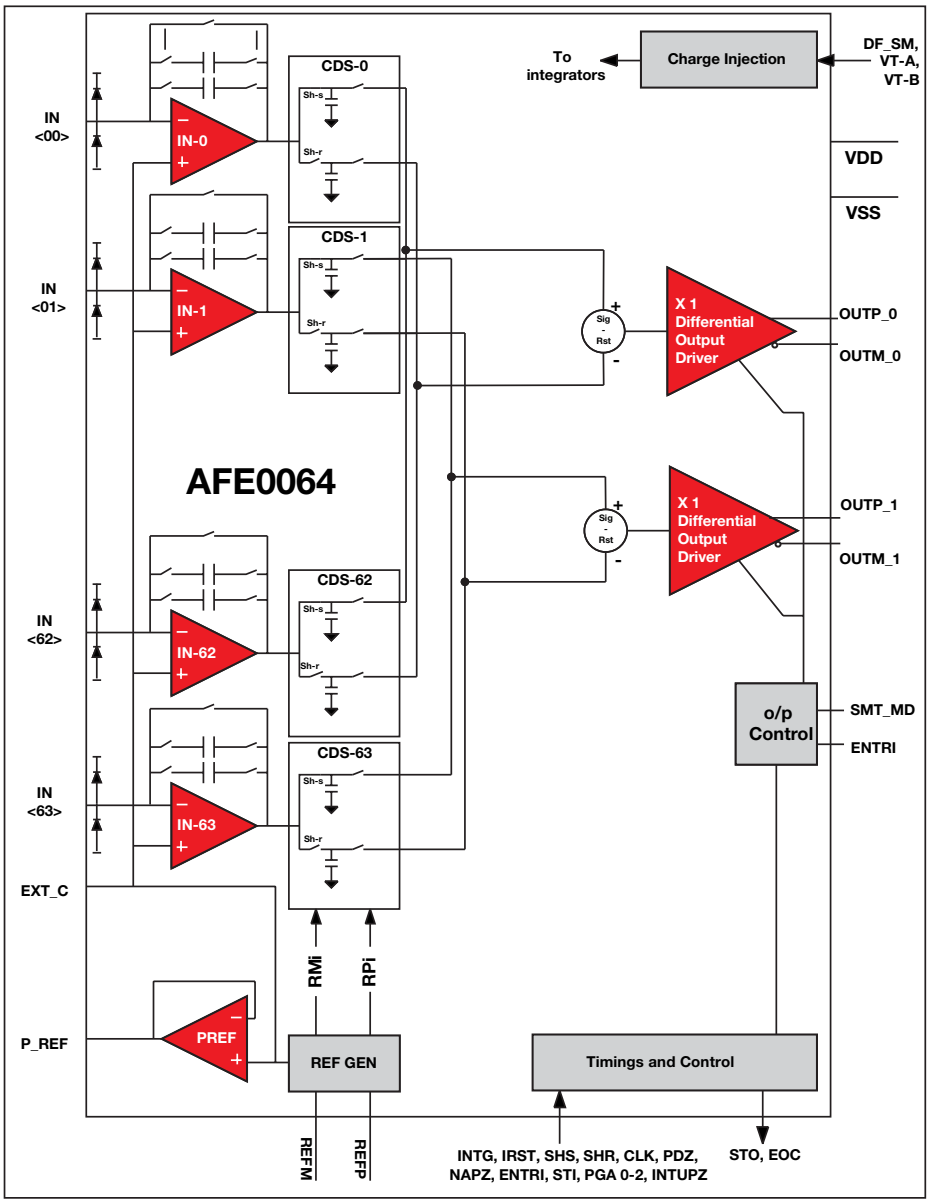
Key Features

- 64 channels
- 28.32µSec min scan time (including integration and data transfer for all 64 channels)
- 7.5MHz Max data transfer rate
- Noise 824 e-RMS with 30pF sensor capacitor in 1.2pC range
- Integral nonlinearity: ±0.006% of FSR
- Eight adjustable full scale ranges (0.13pC min to 9.5pC max)
- Built in CDS (signal sample – offset sample)
- Selectable integration up/down mode
- Low power: 175mW
- NAP mode: 49.5mW
- 14mm × 14mm 128 pin TQFP package

Applications

- Digital radiography
- Baggage scanners
- Infrared spectroscopy

The AFE0064 is a 64-channel analog front end designed to suit the requirements of flat panel detector-based digital X-ray systems. The device includes 64 integrators, a PGA for full scale charge level selection, correlated double sampler, 64 as to 2 multiplexer, and two differential output drivers. Hardware selectable integration polarity allows integration of a positive or negative charge and provides more flexibility in system design. In addition, the device features TFT (Thin Film Transistor from Flat Panel Detector) charge injection compensation. This feature helps maximize the usable signal charge range of the device.



AFE0064 functional diagram.

Digital X-Ray

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers				
AFE0064	64-Channel AFE	64 channel, 2.2 mW/ch, 14-15-bit linearity	Single ended integrator, ADC driver shared for 32 channels, external ADC	Glueless with external ADC
LM324	Quadruple Operational Amplifier	Wide supply range 3V to 32V Supply current independent of supply voltage 0.8mA Low input bias 20nA	Excellent performance and reliability	
LM358	Dual Operational Amplifiers	Wide supply range 3V to 32 Supply current independent of supply voltage 0.7mA Low input bias 20nA	Excellent performance and reliability	LMV358
OPA211	Precision Op Amp	1.1nV/$\sqrt{Hz}$ at 1kHz noise, 3.6mA/ch supply, 80MHz BW	Unity gain stable, RRO, shutdown	OPA227
OPA141	Precision Op Amp	10MHz, 6.5nV/$\sqrt{Hz}$, ±4.5V to ±18V, 1.8mA typical, FET input: I_B = 20pA max	Common mode voltage range includes GND	OPA827
OPA277	Precision Op Amp	10µV offset, ±0.1µV/°C drift, 134dB open-loop gain		OPA4277 (quad)
OPA827	Precision JFET Op Amp	4nV/$\sqrt{Hz}$ noise at 1kHz, ±4V to ±18V supply, 15pA (typ) input bias current, 22MHz BW	High precision, low noise, low input bias, wide supply range	OPA177, OPA627, OPA141
OPAx890	High-Speed Op Amp	Wide output swing of ±4.1 (V_S = ±5V)	Minimizes distortion when used as an ADC driver	OPA2890 (dual) OPA2889 (dual)
THS403x	High-Speed Op Amp	100MHz, 1.6nV/$\sqrt{Hz}$ noise, 100V/µs SR, 90mA output	Low distortion	THS4051, THS4081
THS413x	High-Speed Op Amp	150MHz (–3dB) BW, 51 V/µs SR, –100dB THD at 250kHz	Differential input/differential output	THS4120, THS4150
THS4520	High-Speed Op Amp	Fully differential, RRO	Minimizes distortion when used as an ADC driver	
Data Converters				
ADS8413	SAR ADC	16-bit, 2MSPS, serial LVDS	LVDS, serial interface, daisy-chain capable	ADS8410, ADS8406
ADS8422	SAR ADC	16-bit, 4MSPS, int. ref and ref buffer	Zero latency	ADS8412, ADS8472
DAC8814	Multiplying DAC	16-bit, 0.5µs settling time, –105dB THD, 1 LSB (max) relative ac-curacy	Double-buffered serial data interface	DAC7715, DAC8811
VSP2562	12-Bit, 36MSPS, 1-Channel Analog Front End	Low noise, OB correct 2X 8b DAC, PGA amplifier	Better image quality; corrects for sensor dark current offset; used for system tuning and control of analog functions. Programmable gain supports wide range of light conditions.	
VSP2582	12-Bit, 36MSPS, 1-Channel Analog Front End	Low noise, OB correct PGA amplifier	Better image quality; corrects for sensor dark current offset. Programmable gain supports wide range of light conditions.	
Interface				
SN65EL11	PECL/ECL 1:2 fanout Buffer	Differential 1:2 PECL/ECL fanout buffer	Maintains a known logic level when inputs are in an open condition	SN65MLVD047
SN65ELT20	5 V TTL to Differential PECL Translator	1.25ns max prop delay	Built-in temperature compensation	SN65ELT21
SN65LV1023A	10:1 LVDS Serdes	Embedded clock	Smallest package	SN65LV1224B
SN65LVDS31	4-Channel LVDS Driver	400Mbps	Industry standard	SN65LVDS32
TLK6201EA	PC Board Equalizer	Up to 6.25Gbps operation, low power, high-input dynamic range	CML data outputs	
Clocking				
CDCLVP12xx/ 21xx	1:2/4/8/12/16 or Dual 1:2/4/6/8 Universal-to-LVPECL Clock Buffers	Very low additive jitter <100ps RMS; 2.5V / 3.3V operation	Improved clock signal quality by 10x; saves additional interface logic / external components	CDCLVP111, CDCLVP215
Temperature Sensor				
TMP175	Digital Temp Sensor	27 addresses, ±1.5°C (max) accuracy, 50µA I_Q, 9- to 12-bit resolution	Two-wire interface, serial output	TMP75
TMP275	Digital Temp Sensor	8 addresses, ±0.5°C (max) accuracy, 50µA I_Q, 9- to 12-bit resolution	Two-wire interface, serial output	

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

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

Digital X-Ray

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Processors				
AM3354	Applications Processor	ARM® Cortex-A8, graphics accelerators, touch screen controller	ARM Cortex-A8 performance at power levels of an ARM9	AM3352, AM3356, AM3357, AM3358, AM3359
AM3517	Applications Processor	ARM® Cortex-A8, graphics accelerators, Ethernet, CAN	High performance at handheld power levels	AM3505
AM37x	Applications Processor	ARM® Cortex-A8 processor that nearly doubles graphics performance and overall system performance while providing a 30 percent decrease in power consumption	Laptop-like performance at handheld power levels	AM3715, AM3703
TMS320C-6455BZTZ	DSP	1.2GHz, SRIO, 2MB RAM	High-performance, fixed-point 16-bit processor	TMS320C6454BZTZ
TMS320C6472	DSP	6 x 700MHz C64x+ cores, 4.8MB RAM, SRIO, HPI	High-performance multiprocessor solution	
TMS320C6474	DSP	3 x 1GHz C64x+ cores, 3MB RAM, SRIO	High-performance multiprocessor solution	
TMS320C6655	Industry's Most Efficient Floating-Point DSPs	1.0, 1.25 GHz, C66x single core, 2MB L2, 2.5W	Fixed and floating point DSP, 20 GFlops, 40 GMACS	
TMS320C6657	Industry's Most Efficient Floating-Point DSPs	1.0, 1.25 GHz, C66x dual core, 2MB L2, 3.5W	Fixed and floating point DSP, 40 GFlops, 80 GMACS	
TMS320C6678	Industry's Highest Performance Floating-Point DSPs	1.0, 1.25 GHz, eight C66x cores, 8MB L2, 10W	High-performance fixed and floating point DSP, 160 GFlops, 320 GMACS	
TMS320F2810	DSP	150MIPS, controller area network (CAN) peripheral	CAN for board-level communication, combination of DSP performance and MCU integration	
TMS320DM-6446BZWT	DSP	C64x+™, ARM9, video accelerators	Image processing, display	TMS320DM6441, TMS320DM6437
RF Network Processor				
CC3000	SimpleLink™ Wi-Fi® CC3000 Module	One step configuration with SmartConfig Technology, easy to use Wi-Fi® solution with compact code size to be used with microcontrollers, best-in-class link budget, precertified FCC/IC/CE module, small form factor module and $9.99 price point for 1k units, proven Wi-Fi® interoperability, broad market offering with extensive documentation, sample software, and support forums	Universal IP connectivity can be enabled on low memory, low-cost, low-power microcontroller systems, has low certification cost and is easy to use for development	
References				
LM4040x	Precision Micropower Shunt Voltage Reference	35µV_{RMS} typ, ABCD grade, 45µA (typ) to 15mA 2.048V, 2.5V, 3V, 4.096V, 5V, 8.192V, 10V	Highly precise with low output noise and a wide operating current range	
REF50xx	High-Precision, Very-Low-Drift Series Reference	0.05% initial accuracy, 3ppm/°C max drift, ±10mA output, 2.048V, 2.5V, 3.0V, 4.096V, 4.5V, 5.0V, 10V	Improves system accuracy	REF02
TL43x	Adjustable Precision Shunt Regulator	Output voltage V_{REF} to 36V, 0.2-Ω (typ), sink-current capability 1mA to 100mA	Easy to use, low output noise, great replacement for Zener Diodes	

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

Positron Emission Tomography (PET) Scanners

Positron emission tomography (PET) is a non-invasive diagnostic technology. Used to identify growing cancer cells, for example, a PET scan uses radiation emissions from the body (generated by radioactive chemical elements consumed by the patient) to produce physiologic images of specific organs or tissues.

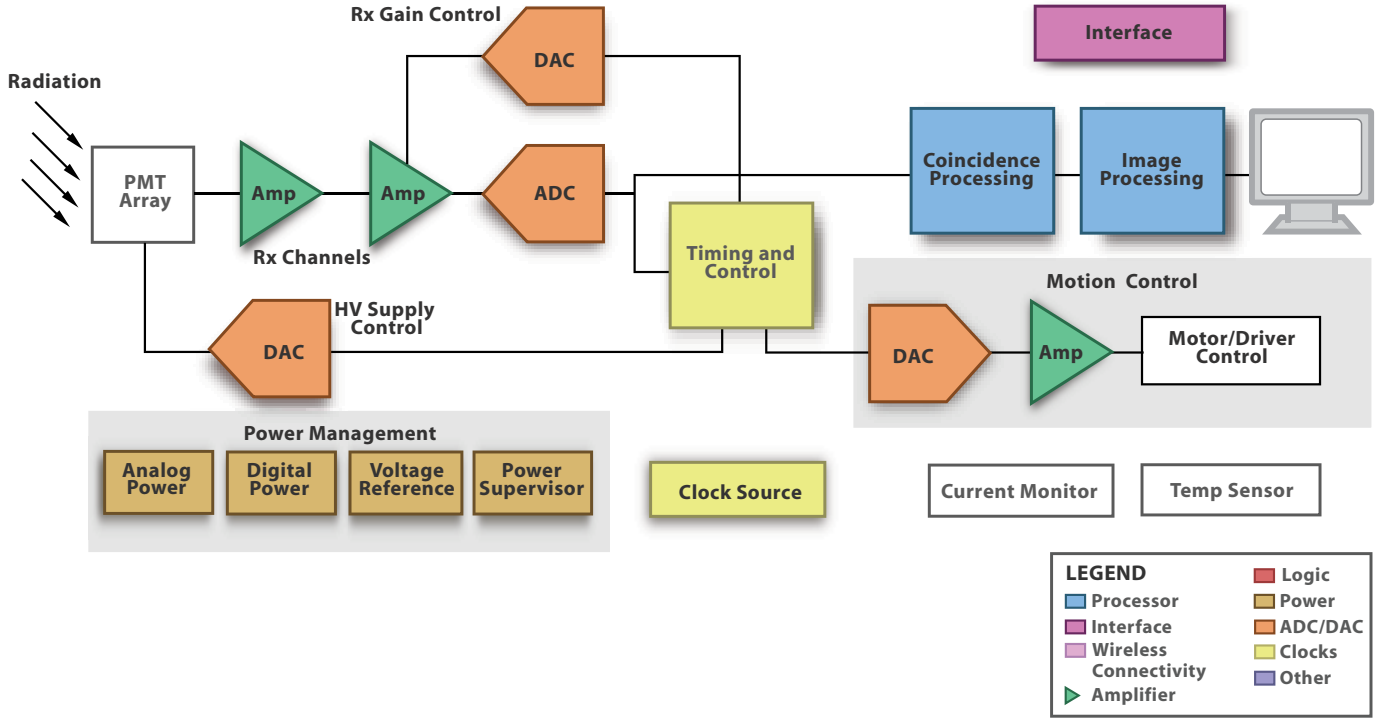
The radioactive emissions are converted to light via a scintillation crystal detector and are amplified and converted to an output current by a photomultiplier tube (PMT). The PMT's current output is then converted to a voltage that is amplified and filtered before being converted to a digital signal by an ADC.

Signal processing is needed for detector signal processing of the receive channels and for a number of control functions. DSPs, microcontrollers and digital-to-analog converters are used in this application for functions such as varying input amplifier gain, controlling the PMT high-voltage power supply, and motion control for the detector ring assembly and patient entry/exit.

DSPs can be used for PET scanner control and signal processing units. Filtered back-projection algorithms can be used in image reconstruction. Several iterative techniques have also been proposed for PET image reconstruction. Additional signal pre-conditioning may be necessary to correct various artifacts like attenuation variations, detector geometry and efficiency variations, random and scatter coincidences, etc.

Product portfolio for PET scanners

- Amplifiers, power management products and other analog parts are suitable for converting radioactive emissions to light and reconstruct and correct images.
- DSPs such as the TMS320C6455 can handle tasks such as varying input amplifier gain and controlling the photomultiplier tube (PMT) high-voltage power supply and motion control for detector ring assembly and patient entry/exit. DSPs are also suitable for PET scanner control and signal processing units.



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

PET scanner system block diagram.

Positron Emission Tomography (PET) Scanners

8-Channel, Ultra-Low-Power, 12- and 10-Bit, 50 to 65MSPS Analog-to-Digital Converters with Serialized LVDS Interface

ADS5281, ADS5282, ADS5287

Get samples, datasheets and evaluation modules at: **www.ti.com/sc/device/PARTnumber**
(Replace **PARTnumber** with **ads5281**, **ads5282** or **ads5287**)

Key Features

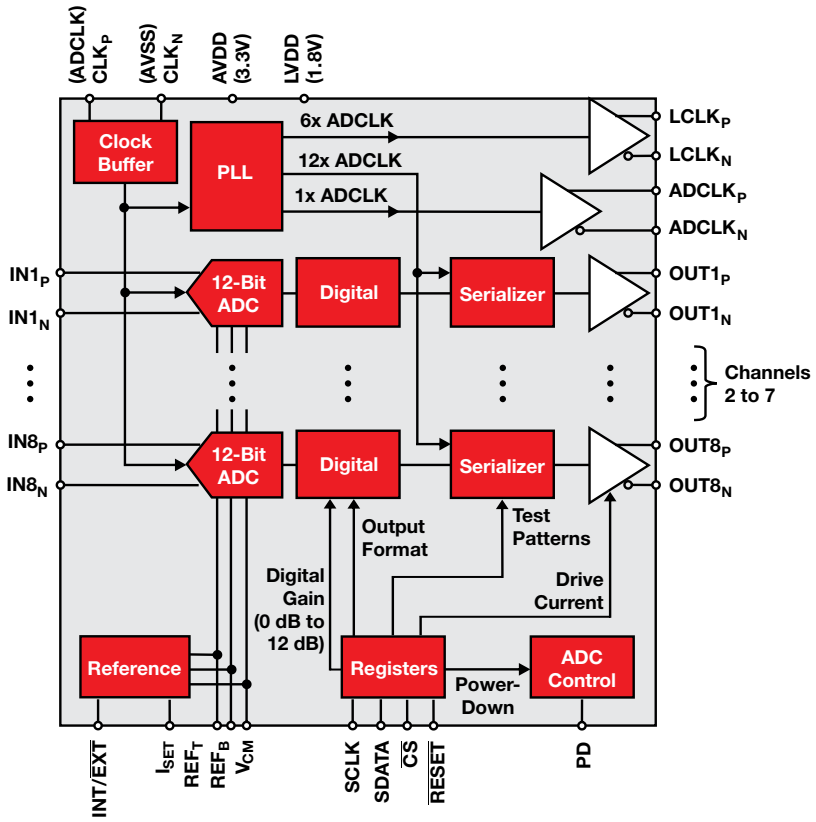
- 8-channel 12- or 10-bit ADCs in one small 64-pin QFN package
  - ADS5281 also available in 80-pin TQFP pin-compatible to ADS527x
- 77mW per channel at 65MSPS; 64mW per channel at 50MSPS
- 70dB SNR for 12-bits at 10MHz IF
- 1/f (flicker) noise suppression
- Up to 6dB overload recovery in one clock cycle
- Individual channel power down
- Direct interface with VCA8500 8-channel variable-gain amplifier
- Xilinx-supported deserializer code

Applications

- Medical and other imaging:
  - Ultrasound
  - MRI
  - PET

The ADS5281 family provides eight high-performance ADCs in a small 64-pin QFN package, making it possible to implement high channel counts in high-performance ultrasound and other medical imaging systems. The low power dissipation per channel aids in making compact ultrasound equipment where space and battery life are at a premium, and in conjunction with the VCA8500 offers a high-performance LNA-to-digital solution for less than 130mW per channel in ultrasound applications.

The ADS5281 family also incorporates advanced features to optimize system performance, including programmable gain from 0 to 12dB in 1dB steps, 1/f (flicker) noise suppression and 6dB input overload recovery within one clock cycle. Available with 12-bit resolution at 50 and 65MSPS and 10-bit resolution at 65MSPS, the ADS5281 family has the flexibility to offer an optimal solution for the entire spectrum of imaging systems.



ADS5281/2/7 functional diagram.

Positron Emission Tomography (PET) Scanners

Wideband, >40dB Gain Adjust Range Variable-Gain Amplifier

VCA821

Get samples, datasheets and evaluation modules at: **www.ti.com/sc/device/vca821**

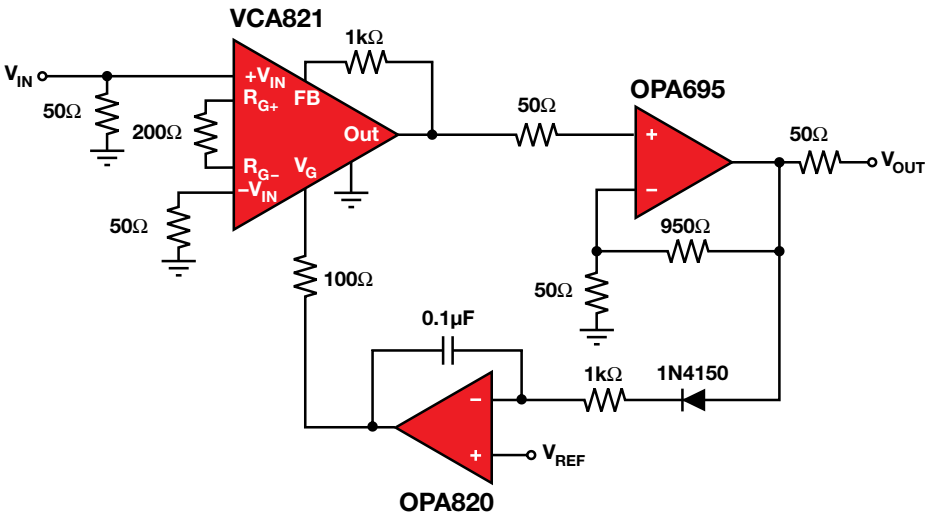
Key Features

- >40dB gain adjust range
- High gain accuracy: 20dB ±0.4dB
- Small signal bandwidth (G = +2): 710MHz (VCA821/824), 150MHz (VCA820/822)
- Slew rate: 2500V/µs (VCA821/824), 1700V/µs (VCA820/822)
- Output current: ±160mA (VCA820/822), ±90mA (VCA821/824)
- Voltage noise: 8.2nV/√Hz (VCA820/822), 6nV/√Hz (VCA821/824)
- Packaging: MSOP-10, SO-14

Applications

- AGC receivers with RSSI (VCA820/821)
- Pulse amplitude compensation
- Differential line receivers
- Differential equalizers (VCA822/824)
- Voltage-tunable active filters
- Variable attenuators

The VCA821 is a DC-coupled, wideband, variable-gain amplifier with linear gain adjustment control for >40dB gain range. This amplifier provides a differential input to single-ended conversion with a high-impedance gain-control input used to vary the gain with linear in dB gain adjust. The output voltage of ±3.9V and current capability of ±90mA helps drive a large variety of loads. Also available from this variable-gain family are the VCA820, offering linear in dB gain adjust, and the VCA822 and VCA824, offering linear in V/V gain adjust.



Variable-gain amplifier with AGC loop.

Positron Emission Tomography (PET) Scanners

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers				
LM324	Quadruple Operational Amplifier	Wide supply range 3V to 32 Supply current independent of supply voltage 0.8mA Low input bias 20nA	Excellent performance and reliability	
LM358	Dual Operational Amplifiers	Wide supply range 3V to 32 Supply current independent of supply voltage 0.7mA Low input bias 20nA	Excellent performance and reliability	LMV358
OPA657	High-Speed Op Amp	FET-Input, 1.6GHz GBW, 4.8nV/√Hz noise, 70mA output	High dynamic range, fast overdrive recovery	
OPA860	Transconductance Amp	80MHz, open loop, G = +5 BW, 900V/µs SR	95mA/V high transconductance, buffer	
OPA827	Precision JFET Op Amp	4nV/√Hz noise at 1kHz, ±4V to ±18V supply, 15pA (typ) input bias current, 22MHz BW	High precision, low noise, low input bias, wide supply range	OPA141, OPA177, OPA627
OPA211	Precision Op Amp	1.1nV/√Hz noise at 1kHz, ±2.25V to ±18V supply, 80MHz BW	Unity gain stable, RRO, wide supply range	OPA227
OPA2690	VFB Op Amp	Dual, 220MHz, G = 2 BW, 1800V/µs SR, 190mA output	+5V supply, disable	OPA2691
THS4130	High-Speed Op Amp	150MHz BW (–3dB), 51V/µs slew rate, –100dB THD at 250kHz	High-speed, fully differential I/O	
THS7530	High-Speed VGA	1.1nV/√Hz noise, 300MHz BW, 11.6dB to 46.5dB continuously variable gain	High-speed, fully differential	
VCA810	Voltage-Controlled Amp	±40dB high gain adjust range, 2.4nV/√Hz noise, ±60mA output current	Differential in/single-ended out	
VCA821	Voltage-Controlled Amp	>40dB gain adjust range with high gain accuracy	Adds flexibility and accuracy to design	VCA820
Data Converters				
ADS5240	High-Speed ADC	4-channel, 12-bit, 40MSPS, serial LVDS interface	Integrated frame and bit pattern, 4 current modes for LVDS	ADS5242, ADS5525
ADS5272	High-Speed ADC	8-channel, 12-bit, 65MSPS, 3.3-V analog/digital supply	Serialized LVDS outputs, integrated frame and bit patterns	
ADS5281	High-Speed ADC	8-channel, ultra-low-power, 12- and 10-bit, 50 to 65MSPS analog-to-digital converter	77mW per channel, serialized LVDS outputs, 1/F noise-suppression	ADS5282, ADS5287
ADS5282	High-Speed ADC	Ultra-low-power, 8-channel, 12-bit, 65MSPS	77mW per channel, serialized LVDS outputs, 1/f noise suppression	ADS5281, ADS5287
ADS5287	High-Speed ADC	Ultra-low-power, 8-channel, 10-bit, 65MSPS	77mW per channel, serialized LVDS outputs, 1/f noise suppression	ADS5281, ADS5282
ADS5525	High-Speed ADC	12-bit, 170MSPS, DDR/LVDS CMOS outputs	Programmable gain up to 6dB for SNR/SFDR trade-off at high IF	ADS5527, ADS5545
ADS5527	High-Speed ADC	12-bit, 210MSPS, DDR/LVDS CMOS outputs	Internal/external reference support	ADS5545, ADS5440
ADS5562	High-Speed ADC	Low-power, 16-bit ADC with up to 84dBFS SNR	High SNR, 1/f noise suppression with low power and small package	ADS5560
DAC2900	High-Speed DAC	10-bit, 125MSPS dual DAC	Supports 3.3/5V	DAC2902, DAC2904
DAC5652	High-Speed DAC	10-bit, 275MSPS dual DAC	High sample rate with low power	DAC5662, DAC5672
DAC7554	V_{OUT} DAC	Quad, 12-bit, 2.7V to 5.5V supply, 5µs settling time	Ultra-low glitch, ultra-low crosstalk	DAC7614, DAC7615
DAC7731	V_{OUT} DAC	16-bit, 150mW (max) low power, 5µs settling time, +10V int. reference	Unipolar or bipolar operation	DAC8811
References				
LM4040x	Precision Micropower Shunt Voltage Reference	35µV_{RMS} typ, ABCD grade, 45µA (typ) to 15mA 2.048V, 2.5V, 3V, 4.096V, 5V, 8.192V, 10V	Highly precise with low output noise and a wide operating current range	
REF02	Precision V_{REF}	0.2% (max) initial accuracy, 10ppm/°C (max) drift, 1.4mA (max)	Excellent line/load regulation, low noise	REF5050
REF102	10V, Ultra Precision	0.05% (max) initial accuracy, 2.5ppm/°C (max) drift, 1.4mA (max)	Excellent stability and line/load regulation	REF5010
REF31xx	Voltage Reference	15-ppm/°C (max) drift, 5mV low dropout, 115µA (max) I_Q, 0.2% (max) accuracy, 1.25V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V	No load capacitor required	REF3130, REF3120
REF32xx	Low Drift, Bandgap	0.2% (max) accuracy, 7ppm/°C (max) drift, 0.1mA (max) I_Q, 1.25V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V	Multiple output voltages, SOT23-6	

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

Positron Emission Tomography (PET) Scanners

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
REF33xx	Very-Low-Power Series Reference	5µA, 0.15% initial accuracy, 30ppm/°C max drift, ±5mA output, 1.25V, 1.8V, 2.048V, 2.5V, 3.0V, 3.3V	Preserves battery life, fits into physically constrained systems	REF30xx, REF31xx, REF29xx
REF5010	10V, High-Precision, Very-Low-Drift Series Reference	0.05% initial accuracy, 3ppm/°C max drift, ±10mA output, 10V	Improves system accuracy	REF102
REF50xx	High-Precision, Very-Low-Drift Series Reference	0.05% initial accuracy, 3ppm/°C max drift, ±10mA output, 2.048V, 2.5V, 3.0V, 4.096V, 4.5V, 5.0V	Improves system accuracy	REF02
TL43x	Adjustable Precision Shunt Regulator	Output voltage V_{REF} to 36V, 0.2-Ω (typ), sink-current capability 1mA to 100mA	Easy to use, low output noise, great replacement for Zener Diodes	
Interface				
SN65EL11	PECL/ECL 1:2 Fanout Buffer	Differential 1:2 PECL/ECL fanout buffer	Maintains a known logic level when inputs are in an open condition	SN65MLVD047
SN65LVCP40	Dual 1:2 Mux/Buffer	Input EQ, output pre-emp	Improves signal range	SN65LVCP404
SN65LVDS93A	24-Bit RGB LVDS Serdes	10MHz-135MHz, BGA and TSSOP; supports 1.8V to 3.3V TTL i/p	Wide frequency range, saves space, no level shifter for 1.8V powered uP	SN75LVDS83B
TLK1221	Gigabit Ethernet Serdes	Power 250mW	Smallest package	TLK2208B
Clocking				
CDCE62005	Clock Generator	rms jitter <1ps, recommended clocking solution for AFE580x and ADS528x/527x	Integrated VCO saves system cost	CDCE72010, CDCM7005
CDCE(L)949	Clock Synthesizer	Recommended clocking solution for TI DSPs	0ppm multiple-frequency generation	CDCE(L)937, CDCE(L)925, CDCE(L)913
CDCE906	Clock Synthesizer	Recommended clocking solution for TI DSPs	0ppm multiple-frequency generation	CDCE706
CDCLVP12xx/ 21xx	1:2/4/8/12/16 or Dual 1:2/4/6/8 Universal-to-LVPECL Clock Buffers	Very low additive jitter <100ps RMS; 2.5V/3.3V operation	Improved clock signal quality by 10x; saves additional interface logic / external components	CDCLVP111, CDCLVP215
Processors				
TMS320C6452	DSP	900MHz, 1.4MB L2 cache, 2 x S GMII/Gigabit EMAC	High-performance DSP with improved system cost	
TMS320C-6455BZTZ	DSP	1.2GHz, SRIO, 2MB RAM	High-performance, fixed-point 16-bit processor	TMS320C6454BZTZ
TMS320C6472	DSP	6 x 700Mhz C64x+™ cores, 4.8MB RAM, SRIO, HPI	High-performance multiprocessor solution	
TMS320C6474	DSP	3 x 1GHz C64x+ cores, 3MB RAM, SRIO	High-performance multiprocessor solution	
TMS320C6452	DSP	900MHz, 1.4MB L2 cache, 2 x S GMII/Gigabit EMAC	High-performance DSP with improved system cost	
TMS320C-6455BZTZ	DSP	1.2GHz, SRIO, 2MB RAM	High-performance, fixed-point 16-bit processor	TMS320C6454BZTZ
TMS320C6472	DSP	6 x 700Mhz C64x+™ cores, 4.8MB RAM, SRIO, HPI	High-performance multiprocessor solution	
TMS320C6474	DSP	3 x 1GHz C64x+ cores, 3MB RAM, SRIO	High-performance multiprocessor solution	
TMS320C6655	Industry's Most Efficient Floating-Point DSPs	1.0, 1.25 GHz, C66x single core, 2MB L2, 2.5W	Fixed and floating point DSP, 20 GFlops, 40 GMACS	
TMS320C6657	Industry's Most Efficient Floating-Point DSPs	1.0, 1.25 GHz, C66x dual core, 2MB L2, 3.5W	Fixed and floating point DSP, 40 GFlops, 80 GMACS	
TMS320C6678	Industry's Highest Performance Floating-Point DSPs	1.0, 1.25 GHz, eight C66x cores, 8MB L2, 10W	High-performance fixed and floating point DSP, 160 GFlops, 320 GMACS	

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

Optical 3-D Surface Scanners

DLP® technology facilitates 3D measurement by utilizing a DMD (Digital Micromirror Device) as a spatial light modulator. The DMD achieves high quality, fast, and flexible sequential pattern illumination of the subject field. Typically, solid state (LED) illumination is used to provide monochrome or multi-color, high brightness illumination within the visible to NIR wavelength range.

Example uses for 3D imaging in the medical industry include scanners for: dental scanners, inner-ear scanners for hearing aids, foot scanners for podiatrists, limb scanners for prosthetics, skin measurement for wound healing and cosmetics, and face/body scanning for plastic surgery.

A synchronized camera of sufficient resolution, sensitivity, and capture frame rate is required to complete the 3D measurement loop. The DMD controller provides a SYNC output to trigger the camera shutter for capturing each pattern in sequence.

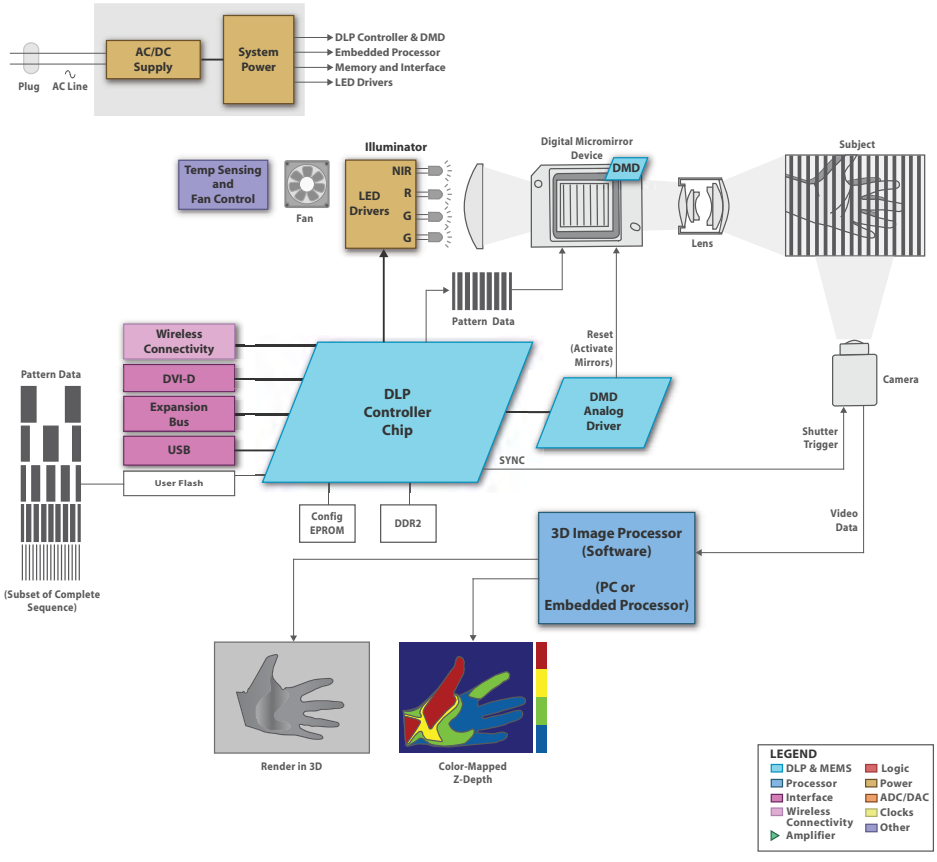
The 3D measurement depends on the principle of geometric triangulation. This requires a certain amount of baseline offset between the pattern projection lens and the camera lens, with both lenses aimed at the subject field. Provision should be made for securely locating the projection and camera optics so that measurement calibration can be established and maintained.

The chosen measurement algorithm determines the type and number of patterns used. Patterns may be binary or “gray scale” (the operation of the two is somewhat different). The essential principal is multi-scale (coarse to fine) image analysis. The measurement algorithm, and the type and number of patterns used will affect the speed, resolution, and accuracy of the measurements.

The measurement algorithm is implemented in software and executed on a PC or embedded processor. The output of the measurement algorithm can take several forms. One example is a color-coded z-depth map. Another is a point cloud (set of measurements) which can be processed by 3D visualization programs, such as MeshLab.

The sequence of patterns required for a full measurement take a finite period of time to occur. The subject must be held immobile (still) during the measurement time in order to avoid blurring, striping, and measurement errors. Faster pattern rates allow for fewer motion artifacts and errors.

The speed and effectiveness of the 3D measurement system depend on illumination brightness and ambient light levels. In general, brighter illumination allows for faster measurements. The LED illuminators (and electrical drivers) require sufficient consideration of power and thermal factors to allow for proper operation and reliability for the expected environmental conditions.



DLP® 3D Biometrics system block diagram.

Hyperspectral Imaging

Hyperspectral imaging employs a dispersive optical element to spread the spectrum of light into spatially separated wavelengths. The dispersive element is usually a diffraction grating, which can be optimized for different spectral regions (UV, visible, NIR, etc.).

The Hyperspectral application illustrated in the diagram shows an external scene being focused by an imaging lens (like that used in an ordinary camera) on a DLP® Digital Micromirror Device (DMD). The DMD is used to decompose the image by turning on a single mirror at a time, until the entire image has been examined. The light reflected from each mirror (corresponding to each "pixel" in the scene) is collected and shined on a diffraction grating, which spreads the light out into a precisely dispersed spectrum of different wavelengths. The dispersed light is detected by a CCD (or CMOS) sensor array similar to that used in a camera, but in this case it is capturing the spectrum of each pixel, rather than capturing a broad-spectrum image of the 2 dimensional scene all at once. There is no correspondence between points in the scene, and points in the sensor array. The points in the sensor array correspond to each specific wavelength dispersed by the diffraction grating.

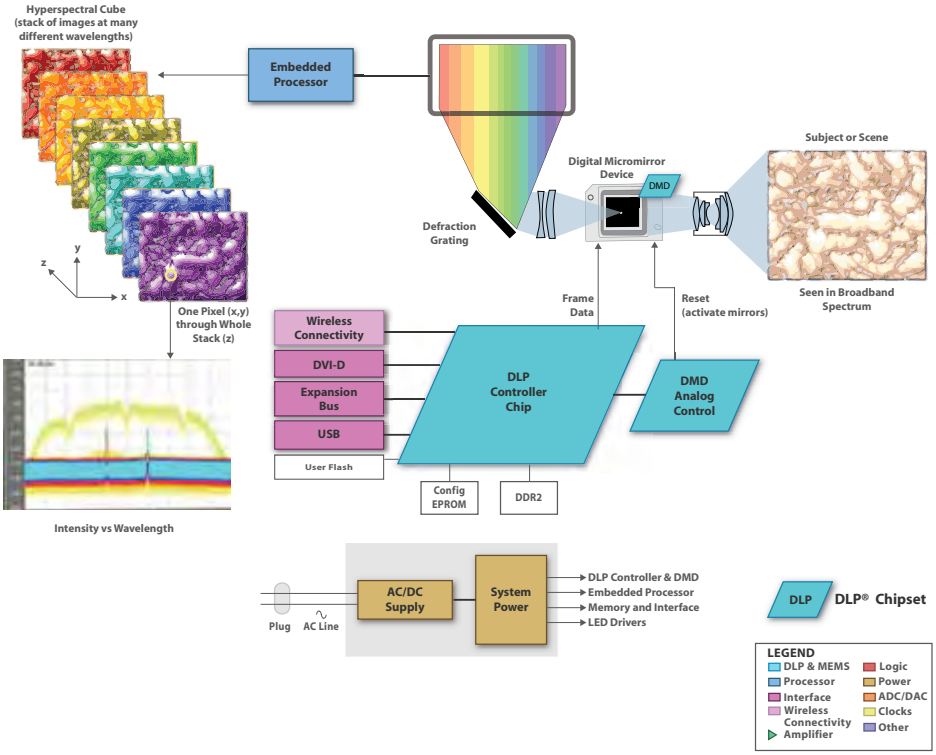
The embedded processor has two functions. The first is to send the commands to the DMD controller to turn on only the precise mirror at each instant to scan (or decompose) the image and send each pixel of the image to the diffraction grating. The second function of the embedded processor is to collect the data from the sensor and assemble the data into the Hyperspectral cube as the entire scene is scanned.

It is interesting to note that the data in the Hyperspectral cube can be viewed as a graph of the light intensity vs. wavelength at each point in the scene. Just as with traditional spectroscopy, the distinctive shape of this curve constitutes a spectral signature of the material being examined. By comparing the spectral signature of the sample to stored reference signatures, it is possible to ascertain the physical and chemical composition of the sample.

The diagram shows a DLP chipset, which includes the DMD, and a DMD Controller chip, plus a DMD Analog Control chip (depending on the specific DLP chipset). Choosing a DLP chipset will depend on the Hyperspectral imaging system's specifications, such as the range of wavelengths to be measured, the resolution of the image needed, the speed of acquisition of a Hyperspectral cube, etc.

The choice of sensor array device will depend, again, on the range of wavelengths to be measured. Other considerations for the sensor include the required sensitivity, speed of acquisition, noise, temperature range, interface requirements, cost, and other factors.

The system control and signal processing is accomplished by the Embedded Processor (Such as TI OMAP®). Power is provided by TI Power devices. An actual product will require additional optical components and optical design in order to achieve full functionality.



Hyperspectral Imaging system block diagram.

Endoscopes

In medicine, an endoscope is used to look inside the body to examine organs. Through a small incision, endoscopes can examine gastrointestinal, respiratory and urinary tracts, as well as internal organs. An endoscope captures images through its long tube, which can be rigid or flexible. Additional instruments for cutting, grasping and other functions are often attached to the endoscope to permit minimally invasive procedures that improve patient care and minimize recovery time.

When used in a technical application to inspect confined spaces, the tool is often referred to as a borescope. Borescopes are used to inspect machinery interiors, building walls and to search for victims in collapsed buildings.

Endoscopes and borescopes have four basic requirements:

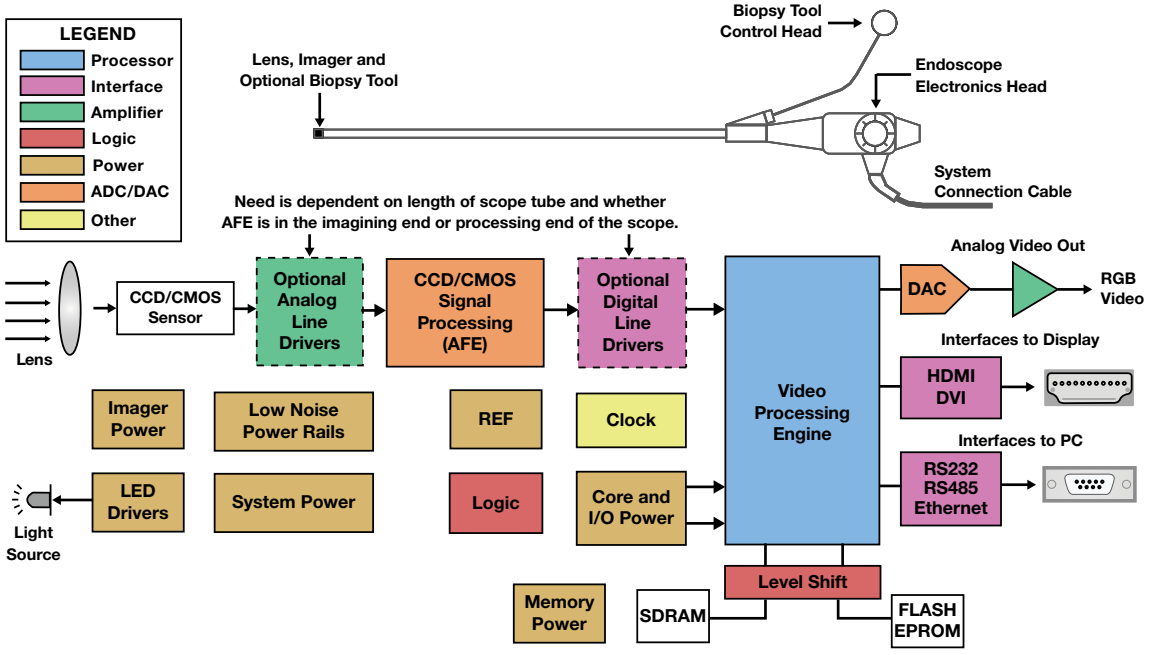
- A light source to illuminate the subject
- A tube to guide the light to the subject
- A lens or fiber optic system to capture light reflected from the subject
- An image-capture system to capture, process and store or display the image

TI's broad product portfolio supports the entire image chain including generating light, capturing an image, signal conditioning and image processing. LED drivers supply a bright light source with excellent directionality and minimal waste heat. These drivers are versatile and permit LED selection optimized for an application's spectral requirements. The resolution of current steps impacts illumination control precision: PWM and analog dimming available from TI LED drivers allow for precise illumination level and timing control.

The image sensor detects reflected light and converts the light to an analog electrical signal. Depending on the image sensor's location, low-noise line drivers may be needed to transmit the signal over the light tube's length. Critical considerations for line drivers are low power, noise immunity and data rate. LVDS technology provides up to 800 Mbps with voltage swings of a few tenths of a volt and high rejection of common-mode noise.

Essential to final image quality is the analog front end (AFE). The AFE conditions the sensor's analog electrical signal and converts image information to a digitized representation. Critical to AFE selection is the ability to condition the signal to correct sensor-induced distortions such as dark current cancellation, reset level variations, defective pixel correction and DC offset variations. Depending on the signal level, the presence of programmable gain amplifiers (PGAs), PGA linearity and the range of available gains may also be important. During digitization, the number of bits determines image contrast. Typically, digitizing the initial data with two to four bits more precision than desired in the final image is recommended. For example, if 8 bits of final image data are required, initially digitize to 10 bits to allow for rounding errors during image processing. When color reproduction is critical, differential non-linearity (DNL) and integral non-linearity (INL) should be minimized.

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



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

Endoscope system block diagram.

Endoscopes

Digital Media System-on-Chip

TMS320DM368

For more information, visit: **www.ti.com/sc/device/tms320dm368**

Key Features

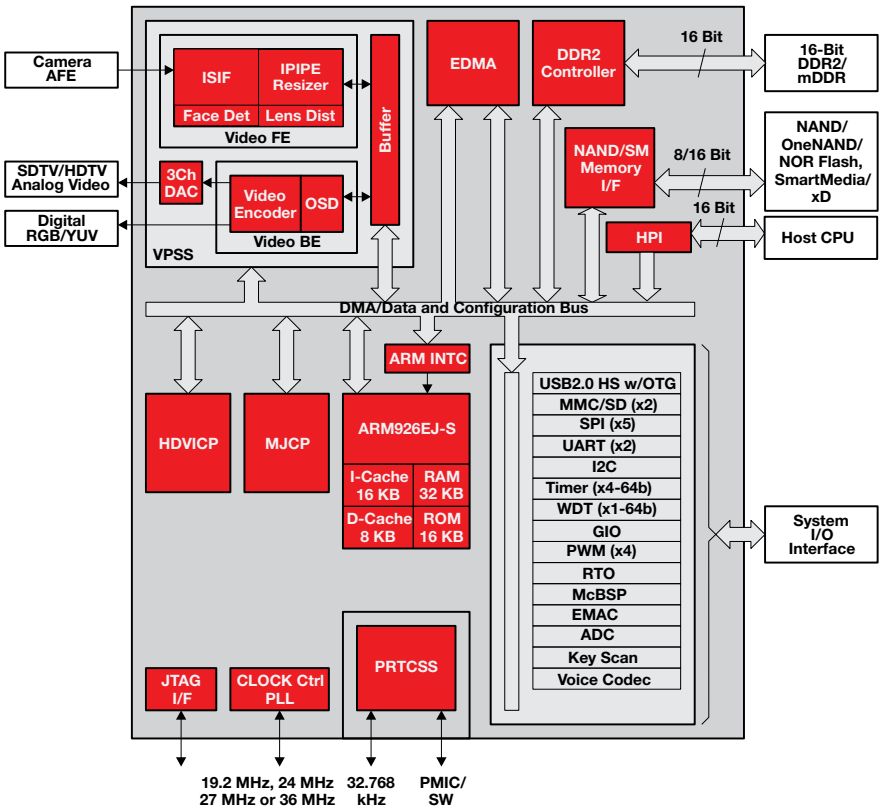
- HD video processing at 1080p 30 fps H.264
- 432-MHz ARM926EJ-S clock rate
- Two video image co-processor (HDVICP, MJCP) engines
- 3.3-V and 1.8-V I/O, 1.35-V core
- Extended temperatures available

Applications

- DLP® spectroscopy
- Endoscope

Developers can now deliver crystal clear multi-format video at up to 1080p H.264 at 30 fps (encode and closed-looped decode) in their designs without concerns of video format support, constrained network bandwidth, limited system storage capacity or cost with the new TMS320DM368 DaVinci™ video processor from Texas Instruments.

The DM368 is capable of achieving HD video processing at 1080p 30fps H.264 and is completely pin-to-pin compatible with the DM365 processors, using the same ARM926EJ-S core running at 432 MHz. This ARM9-based DM368 device supports production-qualified H.264BP/MP/HP, MPEG-4, MPEG-2, MJPEG and VC1/WMV9 codecs, providing customers with the flexibility to select the right video codec for their application.



TMS320DM368 system block diagram.

Endoscopes

16-Bit Ultra-Low-Power MCU

MSP430F4481

For more information, visit: **www.ti.com/sc/device/msp430f4481**

Key Features

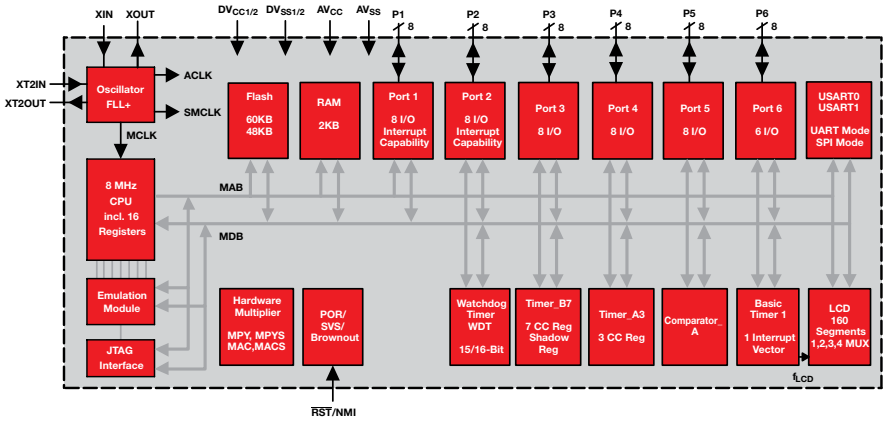
- Low supply-voltage range, 1.8 V to 3.6 V
- Ultra-low-power consumption
- 2-bit A/D converter with internal reference
- 16-bit RISC architecture
- Supply voltage supervisor/monitor with programmable level detection

Applications

- Endoscope

The device architecture, combined with five low-power modes, is optimized to achieve extended battery life in portable measurement applications. The device features a powerful 16-bit RISC CPU, 16-bit registers, and constant generators that contribute to maximum code efficiency. The digitally controlled oscillator (DCO) allows wake-up from low-power modes to active mode in less than 6 µs.

The MSP430F4481 has a configuration with two built-in 16-bit timers, one or two universal serial synchronous/asynchronous communication interfaces (USART), 48 I/O pins, and a liquid crystal driver (LCD) with up to 160 segments.



MSP430F4481 system block diagram.

Endoscopes

5-Channel Power Mgmt IC

TPS65053

For more information, visit: **www.ti.com/sc/device/tps65053**

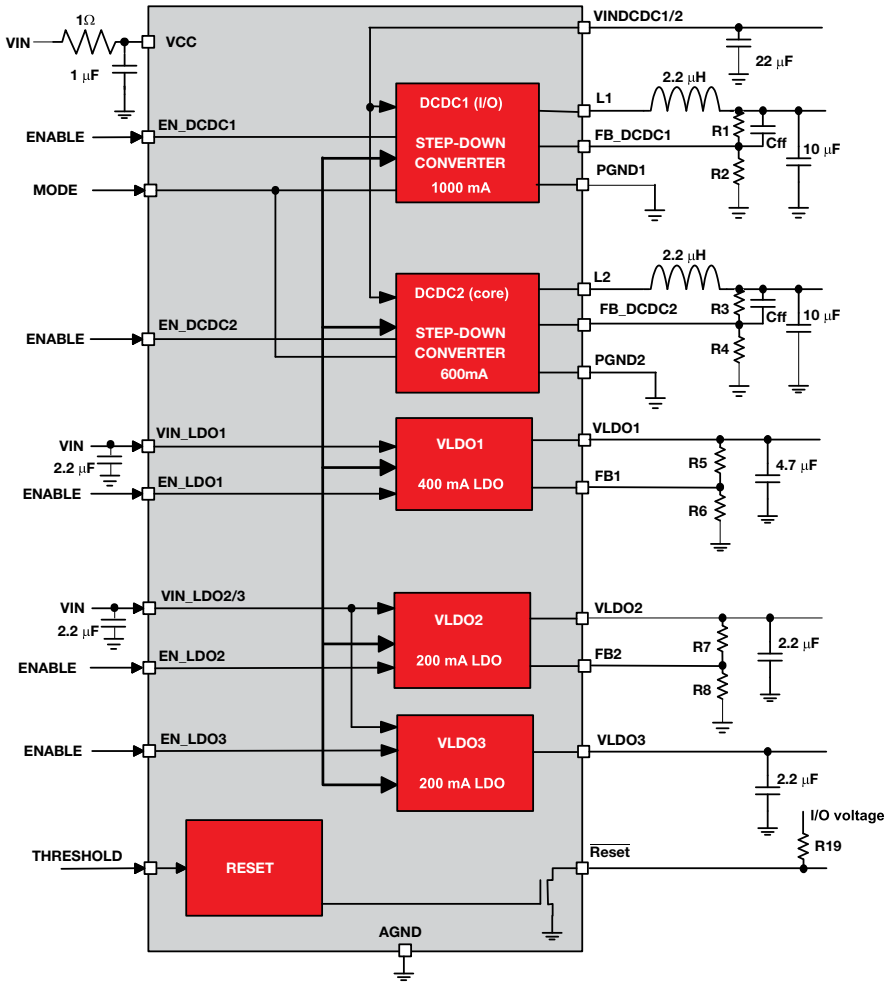
Key Features

- Up to 95% efficiency
- 2.5 V to 6 V V_{IN} range for DC/DC converters
- 2.25-MHz fixed frequency operation
- Output current of up to 1 A on the DC/DC1 converter
- 180° out-of-phase operation
- Output voltage accuracy in PWM mode ±1%
- Total typical 32-µA quiescent current for both DC/DC converters
- 100% duty cycle for lowest dropout

Applications

- Oscilloscope
- Pulse oximetry

The TPS65053 is an integrated Power Management IC for applications powered by one Li-Ion or Li-Polymer cell, which require multiple power rails. The device provides two highly efficient, 2.25 MHz step-down converters targeted at providing the core voltage and I/O voltage in a processor based system. Both step-down converters enter a low power mode at light load for maximum efficiency across the widest possible range of load currents. For low noise applications the devices can be forced into fixed frequency PWM mode by pulling the MODE pin high. Both converters allow the use of small inductors and capacitors to achieve a small solution size. TPS65053 provides an output current of up to 1 A on the DC/DC1 converter and up to 0.



TPS65053 system block diagram.

Endoscopes

1A SIMPLE SWITCHER® Nano Module

LMZ10501

For more information, visit: **www.ti.com/sc/device/lmz10501**

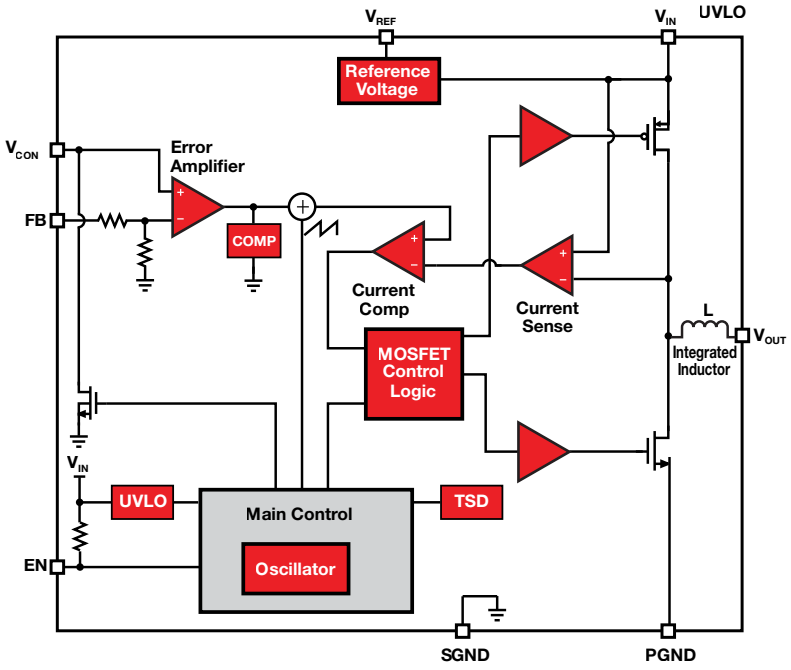
Key Features

- Easy-to-use step-down DC/DC solution
- Drive up to 1 A load
- Point-of-load conversions from 3.3 V and 5 V rails

Applications

- Endoscope
- Low output noise applications
- Space constrained applications

The LMZ10501 SIMPLE SWITCHER® nano module is an easy-to-use step-down DC/DC solution capable of driving up to 1 A load in space-constrained applications. Only an input capacitor, an output capacitor, a small V_{CON} filter capacitor, and two resistors are required for basic operation. The nano module comes in 8-pin LLP footprint package with an integrated inductor. Internal current limit based soft-start function, current overload protection, and thermal shutdown are also provided.



LMZ10501 system block diagram.

Endoscopes

525 kHz/1.6 MHz Constant Current Boost and SEPIC LED Driver

LM3410

For more information, visit: **www.ti.com/sc/device/lm3410**

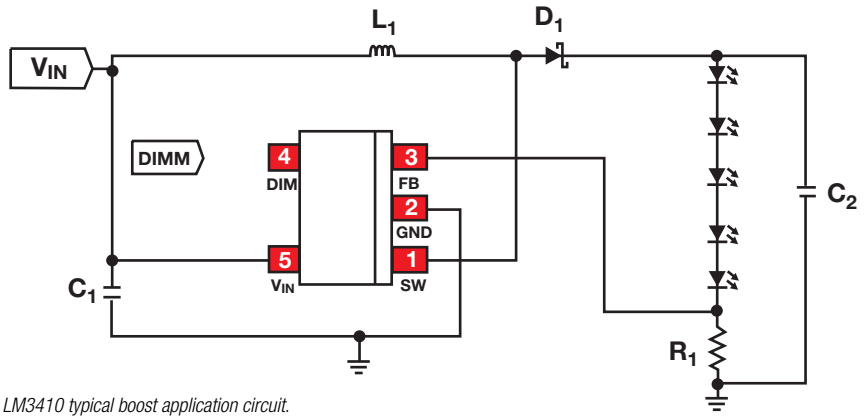
Key Features

- Input voltage range of 2.7 V to 5.5 V
- Output voltage range of 3 V to 24 V
- 2.8 A typical switch current
- High switching frequency
- Thermal shutdown
- 190 mV internal voltage reference

Applications

- Endoscope

The LM3410 constant current LED driver is a monolithic, high frequency, PWM DC/DC converter in 5-pin SOT23, 6-pin LLP, & 8-pin eMSOP packages. With a minimum of external components the LM3410 is easy to use. It can drive 2.8A typical peak currents with an internal 170 mΩ NMOS switch. Switching frequency is internally set to either 525 kHz or 1.60 MHz, allowing the use of extremely small surface mount inductors and chip capacitors. Even though the operating frequency is high, efficiencies up to 88% are easy to achieve. External shutdown is included, featuring an ultra-low standby current of 80 nA. The LM3410 utilizes current-mode control and internal compensation to provide high-performance over a wide range of operating conditions. Additional features include dimming, cycle-by-cycle current limit, and thermal shutdown.



LM3410 typical boost application circuit.

Endoscopes

Three 10-Bit Video DAC

THS8135

For more information, visit: **www.ti.com/sc/device/ths8135**

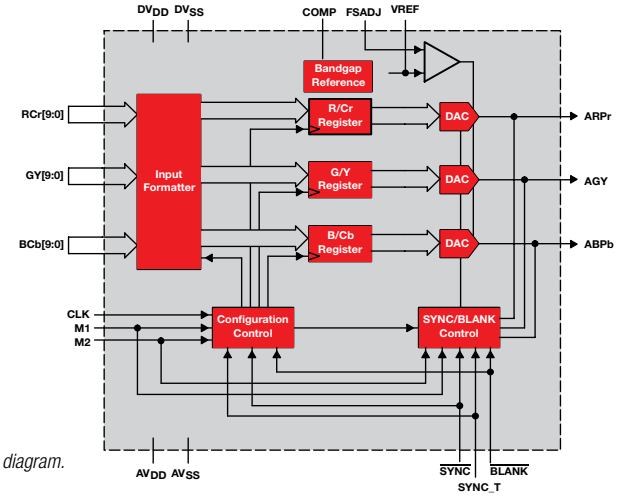
Key Features

- Operates from 3.3-V analog and 1.8-V digital supplies
- 240-MSPS operation
- Three 10-bit D/A converters
- YPbPr/RGB configurable blanking levels
- Integrated sync-on-green/luminance or sync-on-all composite sync insertion
- Internal voltage reference
- Low-power operation From 3.3-V analog and 1.8-V digital supply levels

Applications

- Endoscope

The THS8135 is a general-purpose triple high-speed D/A converter optimized for use in video/graphics applications. The device operates from 3.3-V analog and 1.8-V digital supplies. The THS8135 performance is assured at a sampling rate up to 240 MSPS. The THS8135 consists of three 10-bit D/A converters and additional circuitry for bi-level/tri-level sync and blanking level generation. By providing a DC offset for the lowest video amplitude output in video DAC mode, the device can insert a (negative) bi-level or (negative/positive) tri-level sync on either only the green/luminance (sync-on-green/sync-on-Y) channel or on all channels for video applications. A generic DAC mode avoids this dc offset, making this device suitable for non-video applications as well.



THS8135 system block diagram.

3G/HD/SD Video Clock Generator with Audio Clock

LMH1983

For more information, visit: **www.ti.com/sc/device/lmh1983**

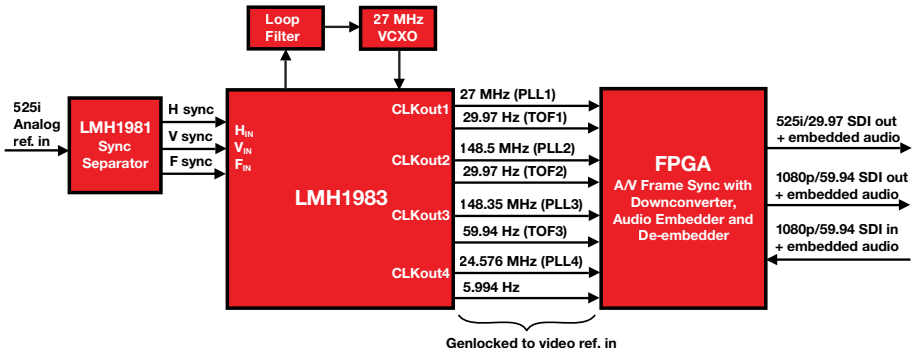
Key Features

- Four PLLs for simultaneous A/V clock generation
- 3.3 V single supply operation
- Flexible PLL bandwidth to optimize jitter performance and lock time
- 3 x 2 Video clock crosspoint

Applications

- Endoscope

The LMH1983 is a highly-integrated programmable audio/video (A/V) clock generator. It can replace multiple PLLs and VCXOs used in applications supporting SMPTE serial digital video (SDI) and digital audio AES3/EBU standards. It offers low-jitter reference clocks for any SDI transmitter to meet stringent output jitter specifications without additional clock cleaning circuits.



LMH1983 typical application.

Endoscopes

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Analog Front Ends				
VSP2582	CCD/CMOS AFE	36MSPS, 12-bits (parallel output), CDS	Low noise, low power, smallest footprint	
VSP2562	CCD/CMOS Analog Front End	36MSPS, 12-bits (parallel output), CDS, w/two 8-bit DACs	Low noise, low power, small footprint, includes two 8-bit DACs to simplify system design	
VSP2566	CCD/CMOS Analog Front End	36MSPS, 16-bits (parallel output), CDS, w/two 8-bit DACs	Higher resolution, low noise, low power, small footprint, includes two 8-bit DACs to simplify system design	
Amplifiers				
LM324	Quadruple Operational Amplifier	Wide supply range 3V to 32V Supply current independent of supply voltage 0.8mA Low input bias 20nA	Excellent performance and reliability	
LM358	Dual Operational Amplifiers	Wide supply range 3V to 32 Supply current independent of supply voltage 0.7mA Low input bias 20nA	Excellent performance and reliability	LMV358
LMH6683	Video Amp	190MHz single supply triple op amps	Provides excellent differential gain and phase combined with output current drive, making it ideal for video processing	
LMH6733	Video Amp	Single-Supply 1GHz low power triple op amps	Offers single/split supply operation, wide gain range, and stability without external compensation at unity gain	
LMH6738	Video Amp	Wideband low distortion triple op amps	Offers single/split supply operation, wide gain range, and stability without external compensation at unity gain	
OPA360	Video Amp	3V video amplifier with low pass filter, internal G=2 and SAG correction in SC70	Designed to work with video processors	OPA361, THS7303
OPA3693	Video Amp	Triple,ultra-wideband, fixed gain, video buffer w/disable	Designed to work with video processors	OPA3832
OPA830	Buffer Amp	250MHz (G = +1) BW, 550V/µs slew rate, 9.2nV/$\sqrt{Hz}$ noise, 3.9mA supply current, single/dual supply	Ideal input buffer stage	OPA2830, OPA847
Data Converters				
THS8135	Video DAC	Triple 10-bit 240MSPS video DAC with tri-level sync and video-compliant (ITU-R.BT601) full-scale range		
THS8200	Video DAC	Triple 10-bit all-format video DAC		
Interface/Video/Clock				
LMH1983	3G/HD/SD Video Clock Generator with Audio Clock	3.3 V single supply operation, 3 x 2 video clock crosspoint	It offers low-jitter reference clocks for any SDI transmitter to meet stringent output jitter specifications without additional clock cleaning circuits.	
LMK03806	High Performance, Ultra Low Jitter Clock Generator with 14 Programmable Outputs	High performance clock generator delivers ultra low RMS jitter < 150 fs and generates multiple clocks from low cost crystal/external clock	Reduces board area and BOM cost by 50% against competing approach	
LMK04100	Precision Clock Jitter Cleaner with Cascaded PLLs	High performance clock jitter cleaner provides jitter cleaning, clock multiplication, and distribution without the need for high-performance VCXO modules & generates 5 ultra low jitter clocks in LVCMOS, LVDS, or LVCPECL formats	Delivers high performance and significantly reduces BOM cost	
LMH6738	Buffer Amp	2.5MHz (G = +1) BW, 550V/µs slew rate, 9.2nV/$\sqrt{Hz}$ noise, 3.9mA supply current, single/dual supply	Ideal input buffer stage	OPA2830, OPA847
SN65LVDS93A	24-bit RGB LVDS Serdes	10MHz-135MHz, BGA and TSSOP; supports 1.8V to 3.3V TTL i/p	Wide frequency range, saves space, no level shifter for 1.8V powered µP	SN75LVDS83B
Processors				
AM3354	Applications Processor	ARM® Cortex-A8, graphics accelerators, touch screen controller	ARM Cortex-A8 performance at power levels of an ARM9	AM3352, AM3356, AM3357, AM3358, AM3359
OMAP3530	Applications Processor	ARM® Cortex-A8, C64x+™, graphics accelerator, video accelerators	Laptop-like performance at handheld power levels	OMAP3503, OMAP3515, OMAP3525
TMS320DM355	Digital Media System-on-Chip	64-channel EDMA, 135/216/270MHz ARM926EJ-S clock rate	Encode/decode up to 720p H.264; optimized for power, cost, and efficiency, and is even suitable for three Li-ion AA battery inputs	
TMS320DM365	Digital Media System-on-Chip	64-channel EDMA, 216/270/300MHz ARM926EJ-S clock rate	Encode/decode up to 1080p H.264; high-performance ARM® and video processing capabilities	
TMS320DM368 *Page 140	Digital Media System-on-Chip	HD video processing at 1080p, 432-MHz ARM926EJ-S clock rate	Deliver crystal clear multi-format video at up to 1080p H.264 at 30 fps	
TMS320DM6437	Digital Media Processor	64-channel EDMA, 400/500/600/660/700MHz C64x+™ clock rate	DSP architecture means programmable solution, Benefit from H.264 encode (D1)	
TMS320DM6446	Digital Media System-on-Chip	64-channel EDMA, 513/594MHz C64x+ clock rate	Encode/decode up to 720p MPEG-4, programmable DSP, with GUI and other processing offloaded to the ARM® for greater efficiency and scalability	

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

Endoscopes

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Processors (continued)				
TMS320DM6467	Digital Media System-on-Chip	64-channel EDMA, 594/729/1000MHz C64x+™ clock rate	Encode/decode up to 1080p H.264; high-performance programmable DSP and ARM	
TMS320C6654	Industry's Most Efficient Floating-Point DSPs	850MHz, C66x single core, 2MB L2, 2W	Fixed and floating point DSP, 13.5 GFlops, 27 GMACS	TMS320C6655
TMS320C6747	Industry's Lowest Power Floating-Point DSP	32-/64-bit accuracy, 1.8V to 3.3V I/O supply, low power and rich connectivity peripherals.	Uses three times less power that existing floating-point DSPs	
Microcontrollers				
MSP430F4481	16-Bit Ultra-Low-Power MCU	1.8 V to 3.6 V supply voltage, ultra-low-power consumption, 16-bit RISC architecture	Optimized to achieve extended battery life in portable measurement applications	
LED Drivers				
DRV777	Integrated Motor and Load Driver	7-Channel, 1.8V, 3.3V, 5V CMOS, low output VOL 0.4V Very low input leakage (<20uA)	Easy to use and low noise with Inductive kickback protection	
ULN2003LV	Low Power 3.3V and 5V Relay Driver	7-Channel, 1.8V, 3.3V, 5V CMOS, switching at 8V, low output VOL of 0.4V, delay time 80ns (typ)	Easy to use and low power dissipation	ULN2003A, ULN2003V12, ULN2004A, ULN2803A
ULN2003V12	Low Power Relay Driver	7-Channel, 1.8V, 3.3V, 5V CMOS, Switching at 16V low output VOL of 0.4V, delay time 80ns (typ)	Easy to use and low power dissipation	
RF Transceivers				
CC2560	*Bluetooth*® v2.1 + EDR (Enhanced Data Rate)	Fully qualified *Bluetooth*® v2.1 + EDR, +10dBm Tx power with transmit power control, –93dBm received sensitivity, support for *Bluetooth*® power saving modes (sniff, hold), hardware and software pre-integration with TI's MSP430 and Stellaris platforms, FCC, CE and IC certified module options, broad market offering with extensive documentation, sample software, and support forums	Supports replacement of serial cables for personal area networks, high throughput, robust connection with extended range, extended battery life and power efficiency reduced development time and costs, flexibility to use various MCUs	
CC2564	*Bluetooth*® v4.0	Fully qualified *Bluetooth*® v4.0 with dual mode capability, +10dBm Tx power with transmit power control, –93dBm received sensitivity, support for *Bluetooth*® power saving modes (sniff, hold), hardware and software pre-integration with TI's MSP430 and Stellaris platforms, FCC, CE and IC certified module options, broad market offering with extensive documentation, sample software, and support forums, ability to connect to existing mobile devices without BLE and some newer devices with BLE	Supports replacement of serial cables for personal area networks, high throughput, robust connection with extended range, extended battery life and power efficiency reduced development time and costs, flexibility to use various MCUs and connect to any type of existing device	
RF Systems-on-Chip				
CC254x	2.4 GHz *Bluetooth*® Low Energy Compliant RF System-on-Chip	Best-in-class System-on-chip *Bluetooth*® low energy solution enabling devices to connect to smartphone/tablets with extremely low power. Able to run on coin cell battery.	System-on-chip for quick time to market. Provides a robust and complete *Bluetooth*® low energy stack enabling extremely long battery life and ability to run on a single coin-cell.	CC2590/91
RF Network Processor				
CC3000	SimpleLink™ Wi-Fi® CC3000 Module	One step configuration with SmartConfig Technology, easy to use Wi-Fi® solution with compact code size to be used with microcontrollers, best-in-class link budget, precertified FCC/IC/CE module, small form factor module and $9.99 price point for 1k units, proven Wi-Fi® interoperability, broad market offering with extensive documentation, sample software, and support forums	Universal IP connectivity can be enabled on low memory, low-cost, low-power microcontroller systems, has low certification cost and is easy to use for development	

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

DLP® Technology

DLP & MEMS

DLP® Discovery™ 4100

For more information, visit **www.ti.com/dlplightcrafter**

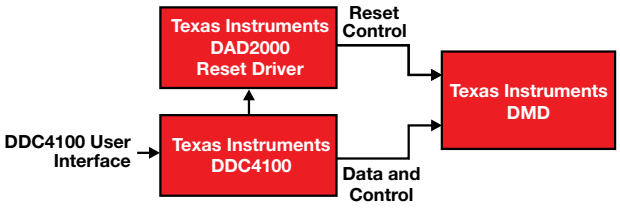
Key Features

- ±12° mirror operation
- Fill factor > 91percent
- Works with visible, near-infrared and ultraviolet light
- DMD: Options include 0.95" 1080p, 0.7" XGA
- DAD2000 power and reset driver
  - Generates reset control of 16 banks of DLP mirrors
- DDC4100 digital controller
  - Provides high-speed (400MHz) LVDS data and control interface and provides mirror reset and timing information to the DAD2000
  - Supports random row addressing

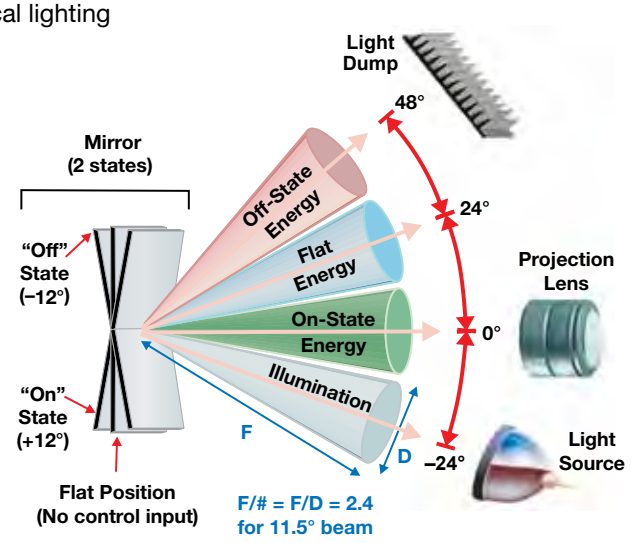
Applications

- Vascular imaging
- Phototherapy
- Chemical analysis
- Micro-array development
- 3-D metrology
- Genomics
- Surgical lighting

DLP® Discovery 4100 is capable of extremely fast switching speeds and offers high resolution performance in Spatial Light Modulation (SLM). Unlike DLP solutions optimized for projection display, the D4100 kit delivers maximum flexibility in formatting and sequencing light patterns and provides developers a robust platform to design industrial, medical and scientific products using the proven reliability of DLP technology. Digital micromirror device (DMD) options include XGA (1024 x 768) and 1080p (1920 x 1080) resolutions that can operate with UV and visible light spectrums. Design flexibility is enabled with interfaces such as: USB 2.0, Avent EXP, 64-bit DDR2 SODIMM DRAM, and many multipurpose I/O.



DLP Discovery 4100 chipset block diagram.



How the light is steered.

DLP Discovery 4100 starter kit.

DLP® Technology

DLP® LightCrafter™
DLPLIGHTCRAFTER

For more information, visit **www.ti.com/dlplightcrafter**

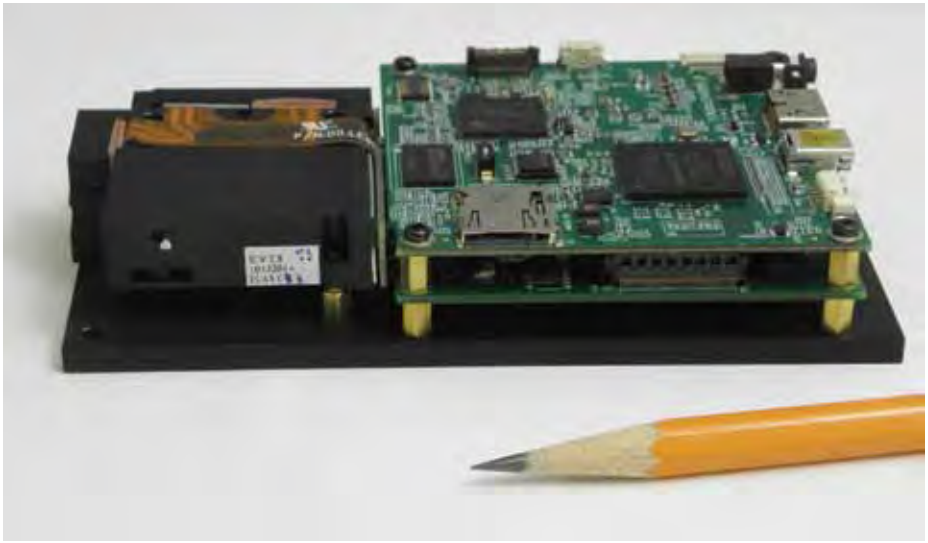
Key Features

- 608 x 684 micromirror array
- 7.6µm micromirror pitch
- Pattern rates up to 4000Hz
- Video display up to WVGA resolution

Applications

- Dental scanning
- Skin measurement
- Augmented reality/Information overlay
- Microscopy
- Portable imaging devices

DLP® LightCrafter™ is a compact, versatile EVM for integrating light into industrial, medical, and scientific applications. Featuring the DLP 0.3 WVGA chipset, the module includes a 20L RGB LED light engine (>50L with additional cooling). Developers can store 100+ patterns onboard and display high-speed sequences (up to 4kHz) with the easy-to-use GUI. DLP LightCrafter has multiple industry standard interfaces including USB, mini-HDMI, and I²C. It also features TI's powerful TMS320DM365 digital media processor running embedded Linux and a MSP430™ microcontroller. A configurable I/O trigger allows for convenient synchronization with cameras, sensors, motors, or other peripheral devices.



DLP® LightCrafter™ EVM.

Module Specifications	
RGB LED light engine	20L continuous light output Capable 50L continuous light output with additional cooling 36cm to 2m focus range
Pattern rates	Up to 4000Hz binary, up to 120Hz 8-bit grayscale
Input video resolutions	Native (608 x 684), WVGA (854 x 480), VGA (640 x 480), QVGA (320 x 240)
Onboard processing	TMS320DM365 digital media processor MSP430 microcontroller Application FPGA
Interfaces	USB for GUI/API commands and pattern download Mini-HDMI for video input I²C for programming DLPC300
Configurable I/O trigger	3.3V output with programmable delay, polarity and pulse width 3.3V input to advance patterns
Miscellaneous	65mm x 116.5mm x 23mm dimensions 128MB NAND flash memory holds 80+ 24-bit patterns

Medical Imaging Toolkit

TI Embedded Processor Software Toolkit for Medical Imaging (STK-MED)

Get more information at: **www.ti.com/medicaltoolkit**
View the “Ultrasound Scan Conversion Demo on OMAP3530” video at: **www.ti.com/stkvideo**

Key Features

- Common medical imaging algorithms optimized for the C64x+™ DSP architecture
- Standard APIs
- Tested, benchmarked, documented library modules

Applications

- Medical imaging
- Medical diagnostic ultrasound
- Optical Coherence Tomography (OCT)

Demos/Open source site

www.ti.com/ultrasounddemo

- Demo of scan conversion module running on OMAP3530
- Open Source of OMAP3530 demo’s software framework

The STK-MED is a collection of several standard medical imaging algorithms optimized for TI’s C64x+ DSP architecture. The algorithms showcase how developers can leverage the C64x+ DSP architecture for efficient performance and power consumption in real-time medical imaging applications such as diagnostic ultrasound and optical coherence tomography (OCT). The goal of the STK-MED is to shorten customer development time by providing highly optimized C64x+ DSP source code of common ultrasound processing blocks.

Medical imaging processing functions in STK-MED

- B-Mode processing
  - Doppler processing (color flow, power estimator, wall filter)
- RF demodulation and decimation
- DAS beamforming
- Scan conversion
- Optimized math utilities
  - 3D rendering
  - Real-time imaging processing for optical coherence tomography (OCT)

Enhanced Products/Die and Wafer Sales Solutions

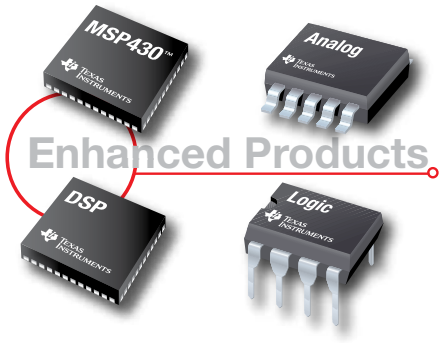
Enhanced Products

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

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

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

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



Expected from TI's EP line:

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

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

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

TI Die/Wafer Solutions

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

TI offers three categories of die screening:

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

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- Mount and bond diagrams
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