

ADI'S IN VITRO CHEMISTRY ANALYZER SOLUTIONS

Typical In Vitro Chemistry Analyzer Architecture

Life sciences and medical instrumentation includes variable systems like in vitro chemical analyzers, flow cytometers, infusion pumps, dialysis equipment, ventilators, catheters, and more. In vitro chemistry analyzers use many electrochemical and optical techniques to analyze blood, urine, cerebral spinal fluid, and other biological samples. The most widely used techniques are optically based measurements, and examples include colorimetric, absorption, spectrometric, and fluoroscopic detection methods. These processes can measure chemicals such as antigens, molecules, and proteins in body fluids. These techniques are widely used at all levels of hospitals, clinics, epidemic prevention stations, and family planning service providers because of their fast measurement ability, high sensitivity, and accuracy when detecting even small doses of chemicals.

In vitro chemistry analyzers are complex systems that are composed of an optical engine consisting of light sources, detectors and other optical elements, sample movement/fluidics, automation control and processing, power management, and environmental monitoring and control (such as for temperature, pressure, and humidity). For greater efficiency, biochemical analyzers have become highly automated. This technology automates sample loading, tube cleaning, mechanical control, and data processing. The operator just needs to insert the sample for analysis, choose the program, and start the instrument.

In vitro chemistry analyzers could be classified by processing capacity into large (600+ samples per hours), middle (300 to 600 samples per hours), and small (below 300 samples per hour) sizes. They can also be characterized by laboratory-based or point-of-care testers, which are deployed near patients for faster test turnaround time.

In Vitro Chemistry Analyzer Design Considerations and Major Challenges

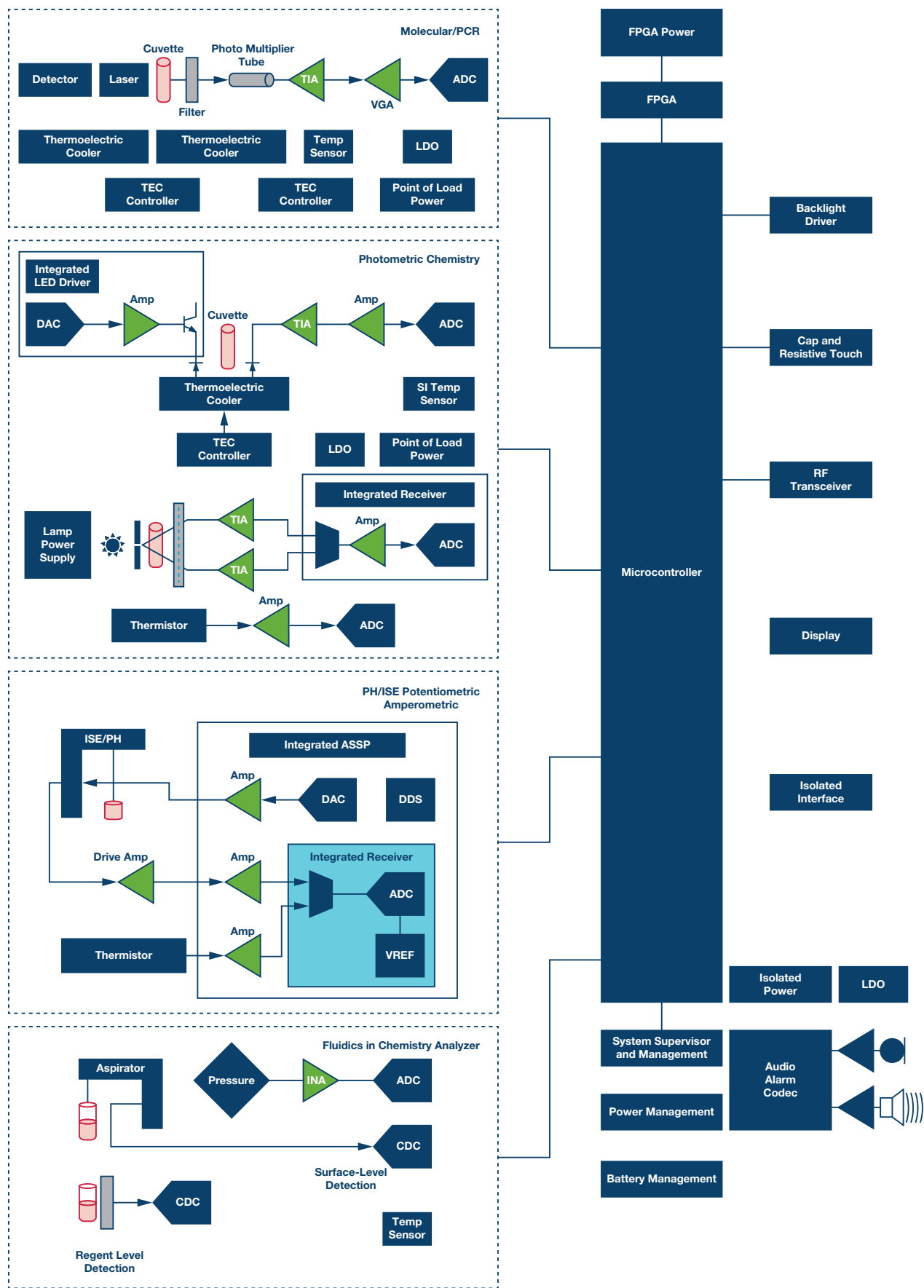
- ▶ System integration is complex because in vitro chemistry analyzers are composed of different technologies like a spectrophotometer, electrochemistry modules (ISE, PH), fluidic and sample handling features, automatic control, and data processing systems
 - Measurement speed is very important
 - Reagent volume control is important for cost and consistency
 - Optical system control and precision is critical in systems

- ▶ Spectrophotometer
 - Need low bias, high Z_{in} , low noise, and low offset op amps for I/V converters with photodiode input
 - Fast, high precision, simultaneous sampling ADC
 - Low noise and stable power supply
 - Low noise and stable light source
- ▶ Temperature control is very important for reagent and chemical reactions
 - Enzymes are sensitive to temperature fluctuations
 - Reaction rates are very sensitive to temperature
 - The general temperature range is the human body temperature, with accuracy up to $\pm 0.1^\circ\text{C}$
 - Heating/cooling equipment is sometimes integrated for smooth and stable temperature control
- ▶ Automation control improves the efficiency of in vitro chemistry analyzers
 - Accurate step and position control
 - Multi-axis motor motion control for sample movement and transfer inside instrument
 - Accurate liquid level measurement
 - Pressure detection to detect blockages
 - Accurate and fast sample loading and cleaning
- ▶ Data process and classification
 - High speed processor for multichannel data process
 - DSP to accelerate complex analysis
 - Provide inspection report as soon as possible

In Vitro Chemistry Analyzer Total Solutions from ADI

ADI provides an extensive selection of amplifiers for I/V conversion, filter design, signal conditioning, and ADC drivers, as well as providing data conversion, signal processing, and power management solutions to maximize product quality and reliability for the biochemistry analyzer application. In addition, ADI provides evaluation boards, simulation tools, and applications expertise to support customer design and development efforts.

In Vitro Chemistry Analyzer Main Signal Chain



Notes: the signal chains above are representative of an in vitro chemistry analyzer system. The technical requirements of the blocks vary, but the products listed in the table are representative of ADI's solutions that meet some of those requirements.

Molecular/PCR

TIA	VGA	Mux	RMS Detector	ADC
ADA4896-2/ADA4897-1/ ADA4627-1/ADA4637-1/ ADA4817	AD8264/AD8331/AD8332/ AD8334/AD8337	ADG1408/ADG1208/ ADG509F/ADG5408/ADG5208/ ADGS1208/ADGS1209	AD8361/AD8362/AD8364	AD7760/AD7960/AD7606/ AD7626/AD9253-125

Spectrophotometric

TIA	Filter	Mux	DAC	ADC	Optical	Light Driver
AD549/ADA4530-1/ ADA4350/AD8605/ AD8606/AD8608/ AD8609/AD8661/ AD8662/AD8664/ ADA4627-1/ ADA4637-1/ADA4817	AD8625/AD8626/ ADA4051-1/ ADA4051-2/ ADA4528-1/ ADA4528-2/ ADA4638-1/ ADA4627-1/ ADA4092-4/ ADA4610-2	ADG1408/ADG1208/ ADG509F/ADG5408/ ADG5208/ADGS1208/ ADGS1209	AD5693R/AD5686R/ AD5780/AD9122/ LTC2620	AD7960/AD7606/ AD4003/AD4007/ AD4020/LTC238x	ADPD103/ADPD105/ ADPD107/ADPD1080/ ADPD2210/ADPD2211/ ADPD2212/ADPD2214	ADP8866/ADP8140/ LT3476

ISE/PH Potentiometric and Amperometric

ASSP	Amplifier	DDS	DAC	ADC	AFE	Voltage Reference
ADuCM350/AD5933	AD8625/AD8626/ AD549/AD8613/ AD8617/ADA4665-2/ AD8592	AD9837/AD9833/ AD9102	AD5422/AD5755-1/ LTC2620	AD7960/AD7606/ AD4003/AD4007/ AD4020/LTC238x	ADAS3022/ADAS3023	ADR45xx/ADR35xx/ LTC665x/LT1461

Fluidics

CDC	INA	ADC
AD7745/AD7747/AD7142/AD7147	AD8422/AD8426/AD8290	ADAQ7988/AD4003/AD4007/ AD7190/AD7191/AD7192/AD7193

Temperature Measurement and Control

Digital Temperature Sensor	Thermal Couple Amplifier	Signal Conditioning and Filter	ADC	TEC Control
ADT7320/ADT7420	AD590/AD8494	AD8625/AD8626/ AD8541/AD8542/AD8544 AD8505/AD8506 AD8613/AD8617/AD8619 ADA4505-1/ADA4505-2/ ADA4505-4	AD7091R/AD7656-1/AD7682/ AD7988-1/AD7684/AD7176-2	ADN8831

Power Management

Power Module	Switch Regulator	LDO	Power Supervisory
LTM4622A/LTM4631/LTM4643	LT8609S/LTC7149/LTC3853/ADP505x	ADM7151/LT3090/ LT308x/LT196x/LT176x	ADM6339/ADM13307/LTC2914

Processor/Isolated Interface/Backlit Driver/Audio Codec/RF Transceiver/Cap and Resistive Touch

Processor	Isolated Interface	Backlight Driver	Audio Codec	RF Transceiver	Cap and Resistive Touch
ADuCM350/ADuCM360/ ADuCM3029/ADuCM3027/ ADuCM4050/ ADSP-BF512F/ ADSP-BF527C	ADM2682E/ADM2484E/ ADM2491E	ADD5203/ADD5205/ ADD5211	ADAU1772/ADAU1781/ ADAU1761	ADF7241/ADF7242/ ADF7023/ADF7024	AD7873/AD7877/ AD7147A

Part	Descriptions	Benefits
<i>Optical</i>		
ADPD1080	Photometric front end; integrated 14-bit ADC and a 20-bit burst accumulator enabling 20 bits per sample period that works with flexible LED drivers; flexible sampling frequency ranging from 0.122 Hz to 2700 Hz	Multifunction photometric front end with low power ambient light rejection capability without the need for photodiode optical filters
ADPD105	Photometric front end; integrated 14-bit ADC and a 20-bit burst accumulator enabling 20 bits per sample period that works with flexible LED drivers; flexible sampling frequency ranging from 0.122 Hz to 3820 Hz	Multifunction photometric front end with low power ambient light rejection capability without the need for photodiode optical filters
ADPD2210	Ultralow noise, low power current amplifier; 80 fA/√Hz (typical) noise floor, current gain: 24	Very low power consumption provides the system sensitivity of a smaller photodiode
ADPD2214	Low noise, high sensitivity optical sensor with green band-pass filter; 90 fA/√Hz (typical) ultralow noise floor; SNR is near shot noise limit; BW: 75 kHz typical	Very low power consumption, ultrahigh detectivity photodetector
<i>ASSP</i>		
ADuCM350	The ADuCM350 is a complete, coin cell powered, high precision, meter-on-chip for portable device applications such as point-of-care diagnostics and body-worn devices for monitoring vital signs; the ADuCM350 is designed for high precision potentiometric, current, voltage, and impedance measurement capabilities	16-bit precision, low power meter on a chip with Cortex®-M3 and connectivity
AD5933	The AD5933 is a high precision impedance converter system solution that combines an on-board frequency generator with a 12-bit, 1 MSPS, ADC; the frequency generator allows an external complex impedance to be excited with a known frequency; the response signal from the impedance is sampled by the on-board ADC and a DFT is processed by an on-board DSP engine	Programmable output peak-to-peak excitation voltage, impedance measurement, internal temperature sensor, phase measurement
<i>TIA</i>		
AD549	Ultralow input bias current operational amplifier; input bias current: 60 fA max, offset voltage: 500 μV max, offset voltage drift: 15 μV/°C typical, input voltage noise: 4 μV (typ) p-p over 0.1 Hz to 10 Hz	Ultralow input bias current; ultralow current and voltage noise
ADA4530-1	Femtoampere input bias current electrometer amplifier; input bias current: ±20 fA max, offset voltage: 50 μV, offset voltage drift: ±0.13 μV/°C max, input voltage noise: 14 nV/√Hz at 10 kHz	Ultralow input bias current; ultralow current and voltage noise; ultralow offset voltage and drift
ADA4817	Low noise, 1 GHz FastFET™ operational amplifier; –3 dB bandwidth (G = 1, RL = 100 Ω): 1050 MHz; low distortion: –90 dBc at 10 MHz; input bias current: 2 pA typical, input voltage noise: 4 nV/√Hz at 100 kHz, input current noise: 2.5 fA/√Hz at 100 kHz	Suitable for wideband I to V conversion with low input capacitance, low noise, and low offset voltage
ADA4897/ ADA4896	Low wideband noise : 1 nV/√Hz and 2.8 pA/√Hz; low 1/f noise: 2.4 nV/√Hz @ 10 Hz, 80 mA output current, rail-to-rail output	Suitable for wideband I to V conversion low input noise
<i>AFE</i>		
ADA4350	FET input AFE integrates a FET input amplifier, a switching network, and an ADC driver; input bias current: ±0.25 pA, input voltage noise: 5 nV/√Hz typical at 100 kHz at ±5 V, switch off leakage: ±0.5 pA typical	Suitable for I to V conversion, suitable for chemistry analyzer
<i>Filter</i>		
AD8625	The AD862x is a precision JFET input amplifier; it features true single-supply operation, low power consumption, and rail-to-rail output; the outputs remain stable with capacitive loads of over 500 pF; the supply current is less than 630 μA/amplifier	Precision, low power, single-supply, JFET amplifier
ADA4627-1	The ADA4627-1/ADA4637-1 are wide bandwidth precision amplifiers featuring low noise, very low offset, drift, and bias current; the parts operate from ±5 V to ±15 V dual supply	36 V, 19 MHz, low noise, low bias current, JFET op amp
<i>Drive Amplifier</i>		
AD8592	Dual op amp with ±250 mA output current and shutdown mode; BW: 3 MHz, low bias current: 5 pA typical	Low power, low input bias current high output current
<i>Mux</i>		
ADGS1208	SPI, low C _{ON} and Q _{INJ} , ±15 V/+12 V, 1.8 V logic control, 8:1 mux; <1 pC charge injection over full signal range, 1 pF off capacitance	Ultralow on capacitance (C _{ON}) and exceptionally low charge injection (Q _{INJ})
ADG509F	The ADG508F and ADG509F are CMOS analog multiplexers, with the ADG508F comprising eight single channels and the ADG509F comprising four differential channels; these multiplexer provide fault protection	8-channel/4-channel fault-protection analog multiplexer

Part	Descriptions	Benefits
DAC		
AD5693R	The AD5693R/AD5692R/AD5691R/AD5693, members of the <i>nanoDAC+</i> [®] family are low power, single-channel, 16-/14-/12-bit buffered voltage out DACs	Tiny, 16-bit <i>nanoDAC+</i> , with $\pm 2(16 \text{ bits})$ LSB INL and 2 ppm/°C reference
AD5686R	The AD5686R <i>nanoDAC+</i> is a quad, 16-bit, rail-to-rail, voltage output DAC; the device includes a 2.5 V, 2 ppm/°C internal reference (enabled by default) and a gain select pin giving a full-scale output of 2.5 V (gain = 1) or 5 V (gain = 2)	Quad, 16-bit <i>nanoDAC+</i> with 2 ppm/°C on-chip reference and SPI
LTC2620	The LTC2600/LTC2610/LTC2620 are octal 16-/14-/12-bit, 2.5 V to 5.5 V rail-to-rail voltage output DACs	Low power, high rail-to-rail output drive, ultralow crosstalk
ADC		
AD4020	20-bit, 1.8 MSPS, precision SAR, differential ADC; SNR: 100.5 dB typical at 1 kHz, THD: -123 dB typical at 1 kHz	Low noise, low power, high speed, very good SNR
LTC2387-18	18-bit, 15 MSPS SAR ADC, 95.7 dB SNR (typ) at $f_{IN} = 1 \text{ MHz}$ 102 dB SFDR (typ) at $f_{IN} = 1 \text{ MHz}$	Low noise, high speed
AD7960	The AD7960 is an 18-bit, 5 MSPS SAR ADC; unmatched performance both in noise and in linearity; integrated internal conversion clock and an internal reference buffer	18-bit, 5 MSPS PULSAR [®] differential ADC
AD4003	The AD4003/AD4007 are low noise, low power, high speed, 18-bit, 2 MSPS/1 MSPS SAR ADCs; SNR: 100.5 dB typical at 1 kHz, THD: -123 dB typical at 1 kHz	Low power, high SNR, low distortion
AD7176-2	The AD7176-2 is a fast settling, highly accurate, high resolution, multiplexed, 24-bit, Σ - Δ ADC for low bandwidth input signals with a fully flexible ODR (output data rate) between 5 SPS and 250 kSPS	24-bit, 250 kSPS Σ - Δ ADC with 20 μs settling
Processor		
ADuCM3029	Ultralow power ARM [®] Cortex-M3 MCU with integrated power management and 256 kB of embedded flash memory; an analog subsystem that provides clocking, reset, and an ADC subsystem	Ultralow power microcontroller systems with integrated power management for processing, control, and connectivity
ADuCM360	The ADuCM360 is a fully integrated, 3.9 kSPS, 24-bit data acquisition system that incorporates dual high performance, multichannel Σ - Δ (Σ - Δ) analog-to-digital converters (ADCs), a 32-bit ARM Cortex-M3 processor, and Flash [®] /EE memory on a single chip	Low power precision analog microcontroller, ARM Cortex-M3 with dual Σ - Δ
ADSP-BF512F	The ADSP-BF512F is the low cost entry point into the Blackfin [®] processor family; it offers an optimal balance between performance, peripheral integration, and price and is well suited for the most cost-sensitive applications including portable test equipment, embedded modems, biometrics, and consumer audio	Optimal balance between performance and cost, digital signal processor with rich peripherals like ADCs, PWM, CAN, SPI, and more
Light Driver		
ADP8866	The ADP8866 combines a programmable backlight LED charge pump driver with automatic blinking functions; nine LED drivers can be independently programmed at currents up to 25 mA; the current level, fade time, and blinking rate can be programmed once and executed autonomously on a loop	Charge pump driven 9-channel LED driver with automated LED lighting effects
ADP8140	The ADP8140 provides high current control of up to four LED drivers; each driver can sink up to 500 mA; the sink current is programmed for all four drivers with one external resistor	4-channel high current LED driver with adaptable power control
LT3476	High current quad output LED driver; V_{IN} range: 2.8 V to 16 V, up to 5000:1 dimming ratio, frequency adjust pin: 200 kHz to 2 MHz, high efficiency conversion = up to 96%	Open LED protection, high efficiency conversion
Digital Temperature Sensor		
ADT7420	Digital I ² C temperature sensor with $\pm 0.25^\circ\text{C}$ accuracy from -20°C to 105°C , 16-bit resolution (0.0078°C), ADT7320 is the SPI version	No calibration required, over/under temperature interrupt
CDC		
AD7745	The AD7745/AD7746 are a high resolution, Σ - Δ capacitance-to-digital converter (CDC); the capacitance to be measured is connected directly to the device inputs; the architecture features inherent high resolution (24-bit no missing codes, up to 21-bit effective resolution), high linearity ($\pm 0.01\%$), and high accuracy ($\pm 4 \text{ fF}$ factory calibrated)	24-bit, 1-channel capacitance to digital converter

Part	Descriptions	Benefits
<i>Isolated Interface</i>		
ADM2682E	16 Mbps, 5 kV rms signal and power isolated RS-485 transceiver with ± 15 kV ESD protection	Suitable for medical instrumentation, 5 kV isolation
<i>Audio Codec</i>		
ADAU1781	SigmaDSP® low noise stereo audio codec; programmable SigmaDSP core for audio processing, 24-bit stereo audio ADC and DAC, 400 mW speaker amplifier	Low noise DAC and ADC support sample rates from 8 kHz to 96 kHz
<i>RF Transceiver</i>		
ADF7241	Low power IEEE 802.15.4 zero-IF 2.4 GHz transceiver; low power IEEE 802.15.4 zero-IF 2.4 GHz transceiver	Highly integrated, low power, and high performance
<i>Voltage Reference</i>		
ADR4540	The ADR4520/ADR4525/ADR4530/ADR4533/ADR4540/ADR4550 devices are high precision, low power, low noise voltage references featuring $\pm 0.02\%$ maximum initial error, maximum temperature coefficient (TCV_{OUT}): 2 ppm/°C	High accuracy, low power, low noise
LTC6655	Low drift precision references; low noise: 0.25 ppm p-p (0.1 Hz to 10 Hz); low drift: 2 ppm/°C max, high accuracy: $\pm 0.025\%$ max	High accuracy, low drift, low noise
<i>Power Module</i>		
LTM4622A	Dual, ultrathin 2 A or single 4 A step-down dc-to-dc μ Module® regulator; input voltage range: 3.6 V to 20 V, 1.5 V to 12 V output voltage	Tiny, wide input range, fast transient response, stable
LTM4631	Dual, ultrathin 10 A or single 20 A dc-to-dc μ Module regulator; input voltage range: 4.5 V to 15 V, output voltage range: 0.6 V to 1.8 V	High output current, small size, stable
LTM4643	Quad, ultrathin μ Module regulator with configurable 3 A output array input voltage range: 4 V to 20 V, 0.6 V to 3.3 V output voltage	Small size, stable, high efficiency
<i>Switch Regulator</i>		
LT8609S	42 V, 2 A/3 A peak synchronous step-down regulator with 2.5 μ A quiescent current input voltage range: 3.0 V to 42 V, >93% efficiency at 1 A, 12 V_{IN} to 5 V_{OUT} , output ripple <10 mV p-p	Ultralow EMI/EMC emissions on any PCB, low noise, high efficiency
LTC3853	Triple output, multiphase synchronous step-down controller; high efficiency: up to 92%, V_{IN} range: 4.5 V to 24 V	Low noise, high efficiency
LTC7149	60 V, 4 A synchronous step-down regulator for inverting outputs; V_{IN} range: 3.4 V to 60 V, V_{OUT} range: 0 V to -28 V, 92% efficiency with 12 V_{IN} and $-5 V_{OUT}$	Low noise, high efficiency, negative output
<i>LDO</i>		
LT3083	Adjustable 3 A single resistor low dropout regulator; input voltage range: 1.2 V to 23 V, low dropout voltage: 310 mV, output adjustable to 0 V, low output noise: 40 μ V rms (10 Hz to 100 kHz)	Low dropout voltage, low noise
LT3090	-36 V, 600 mA negative linear regulator with programmable current limit; low dropout voltage: 300 mV, low output noise: 18 μ V rms (10 Hz to 100 kHz), input voltage range: -1.5 V to -36 V, rail-to-rail output voltage range: 0 V to -32 V	Low noise, low dropout voltage, rail-to-rail negative output
LT1963A	1.5 A, low noise, fast transient response LDO regulators; dropout voltage: 340 mV, low noise: 40 μ Vrms (10 Hz to 100 kHz), adjustable output from 1.21 V to 20 V	Low noise, low dropout voltage
<i>Power Supervisory</i>		
ADM6339	Quad voltage microprocessor supervisory circuit can monitor: -5.0 V, $+1.8$ V, $+2.5$ V, $+3.0$ V, $+3.3$ V, and $+5.0$ V supply voltages; tolerance levels of $\pm 5\%$ and $\pm 10\%$ are available; the device is also available with one to three adjustable threshold options; the adjustable voltage threshold options are $+1.23$ V, $+0.62$ V, and -0.5 V	Quad voltage microprocessor supervisory circuit
LTC2914	Quad UV/OV positive/negative voltage monitor adjustable UV and OV trip values, guaranteed threshold accuracy: $\pm 1.5\%$, input glitch rejection, monitors up to two negative voltages	Quad adjustable voltage monitoring supervisory circuit

Design Resources

Circuits from the Lab®

- ▶ A 16-Bit, 6 MSPS SAR ADC System with Low Power Input Drivers and Reference Optimized for Multiplexed Applications (CN-0307)—
analog.com/en/cn-0307
- ▶ Extending the Capacitive Input Range of the AD7745/AD7746 Capacitance-to-Digital Converter (CN-0129)—
analog.com/en/cn-0129
- ▶ Single Supply, Micropower Toxic Gas Detector Using an Electrochemical Sensor (CN-0234)—analog.com/en/cn-0234
- ▶ Dual-Channel Colorimeter with Programmable Gain Transimpedance Amplifiers and Synchronous Detectors (CN-0312)—
analog.com/en/cn-0312
- ▶ High Accuracy Impedance Measurements Using 12-bit Impedance Converters (CN-0217)—analog.com/en/cn-0217
- ▶ Precision 24-bit, 250 kSPS Single-Supply Σ - Δ ADC System for Industrial (CN-0310)—analog.com/en/cn-0310
- ▶ 16-Bit, 1.33 MSPS, 16-Channel Data Acquisition System (CN-0260)—
analog.com/en/cn-0260

Application Notes/Articles

- ▶ ADA4530-1 Femtoampere Level Input Bias Current Measurement (AN-1373)—analog.com/en/an-1373
- ▶ Amperometric/Potentiostat Measurements Using the ADuCM350 (AN-1281)—analog.com/en/an-1281
- ▶ High Speed Converters: An Overview of What, Why, and How (MS-2629)—analog.com/en/ms-2629

Design Tools/Forums

- ▶ ADC
 - VisualAnalog™ software—analog.com/en/visualanalog
 - SPIController: ADC SPI software—
analog.com/en/spicontroller
 - Virtual Eval Tool—Beta data converter tools—
analog.com/en/virtualeval
- ▶ DSP
 - Software Development Kit (SDK)—
analog.com/en/software_development_kit_downloads
- ▶ Amplifier
 - Analog Photodiode Wizard: Photodiode Circuit Design Wizard—
analog.com/en/photodiode
 - Analog Filter Wizard: Filter Circuit Design Wizard—
analog.com/en/filterwizard
 - DiffAmpCalc™: Differential amplifier calculator—
analog.com/en/diffampcalc
- ▶ Circuit and Power Design Simulation
 - LTspice®: Circuit Design Simulation Tool—
analog.com/en/ltspice
 - ADIsimPower™: Voltage Regulator Design Tool—
analog.com/en/ADIsimPower

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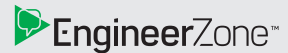
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