ADI Biochemistry Analyzer Solutions

Biochemistry Analyzer and Typical Architecture

Biochemical 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.

Biochemical 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 (temperature, pressure, 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.

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

Biochemistry Analyzer Design Considerations and Major Challenges

- System integration is complex because a biochemical analyzer is 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 system.
- Spectrophotometer.
  - Need low bias, high ZIN, low noise, and low offset op amps for I/V converters in photodiode input.
  - Fast, high precision, simultaneous sampling ADC.
  - Low noise and stable power supply.
  - Low noise, stable light source.
- Temperature control is very important for reagent and chemical reaction.
  - Enzymes are sensitive to temperature fluctuations.
  - Reaction rates are very sensitive to temperature.
  - The general temperature range is body temperature, and accuracy is up to ±0.1°C.
  - Heat/cooler equipment is sometimes integrated for smooth and stable temperature control.
- Automation control is necessary to improve executive efficiency.
  - 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 processing and classification.
  - High speed processor for multichannel data process.
  - DSP to accelerate complex analysis.
  - Provide an inspection report as soon as possible.

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.

Main Signal Chain

- The biochemistry analyzer is a very complex device that contains various technologies. The signal chain below diagrams the overall system, then provides an overview of each subsystem.

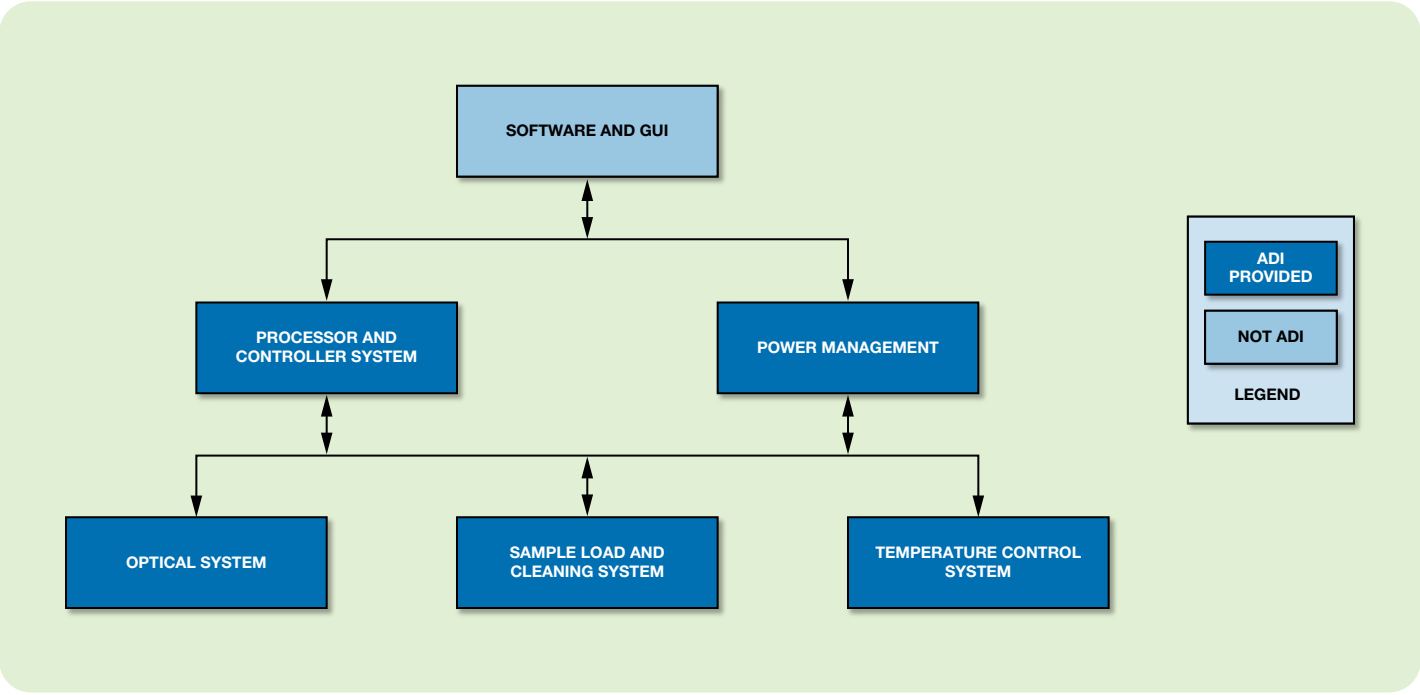

Figure 1. System diagram

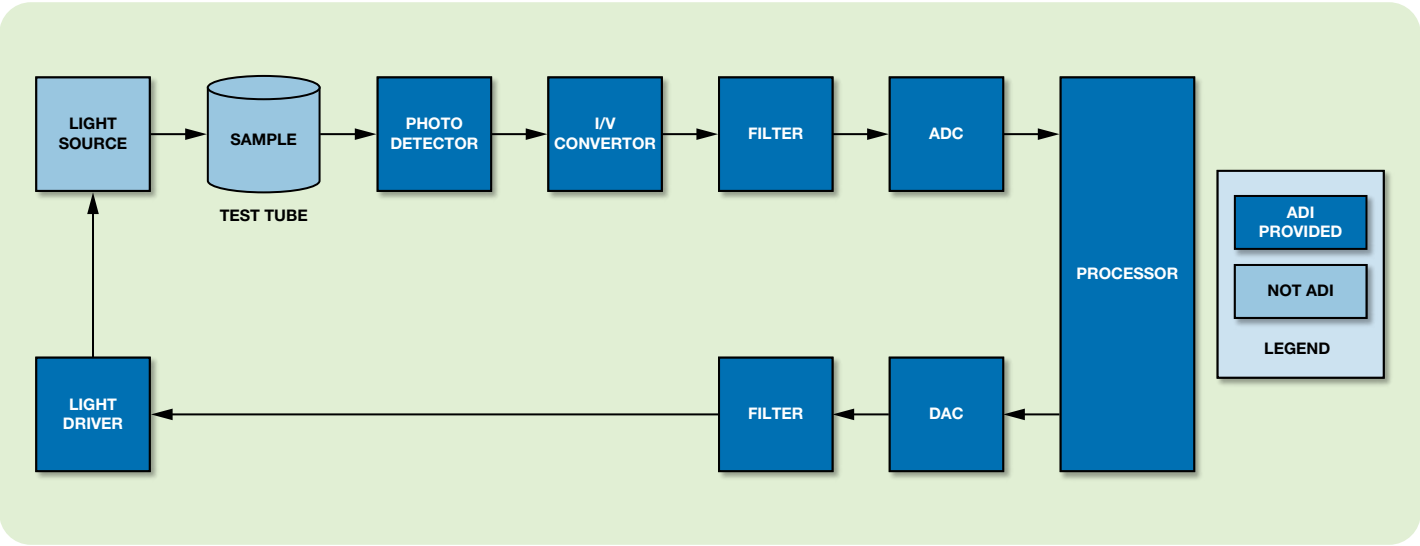

Figure 2. Spectrophotometer subsystem

Notes: The signal chains above are representative of a biochemistry 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.

I/V Convertor	Filter	Mux	DAC	ADC	Processor	Light Driver
AD549/AD8605/ AD8606/AD8608/ AD8661/AD8662/ AD8664/ADA4627-1/ ADA4637-1	AD8625/AD8626/ ADA4051-1/ADA4051-2/ ADA4528-1/ADA4528-2/ ADA4638-1/ADA4627-1/ ADA4092-4/ADA4610-2	ADG1408/ADG1434/ ADG1208/ADG509F	AD5693R/AD5686R/ AD5780/AD9122	ADAS1126/ADAS3023/ AD7982/AD7960/ AD7606/AD7190/ AD7176-2/AD7264/ AD7862	ADuCM350/ADuCM360/ ADUC7021/ADUC7022/ ADUC7023/ ADSP-BF512F/ ADSP-BF527C	ADP8866/ADP8140/ ADP2386/ADP2503/ AD5820

Part Number	Description	Benefits
I/V Converter		
AD549	The AD549 is a monolithic electrometer operational amplifier with very low input bias current; input offset voltage and input offset voltage drift are laser trimmed for precision performance	Ultralow input bias current operational amplifier; ultralow current and voltage noise
AD8605	The AD8605 is a single rail-to-rail input and output, singlesupply amplifier; it feature very low offset voltage, low input voltage and current noise, and wide signal bandwidth; it use the ADI patented DigiTrim® trimming technique, which achieves superior precision without laser trimming	Precision, low noise, CMOS, RRIO op amp
Filter		
AD8625	The AD8625 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/amp	Precision, low power, single-supply, JFET amplifier
ADA4627-1	The ADA4627-1 is a wide bandwidth precision amplifier 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
Mux		
ADG1408	The ADG1408 monolithic *i*CMOS® analog multiplexer comprises eight single channels; the ADG1408 switches one of eight inputs to a common output, as determined by the 3-bit binary address lines, A0, A1, and A2	4 Ω, 4-channel/8-channel ±15 V, 12 V, ±5 V CMOS multiplexer
ADG509F	The ADG508F is a CMOS analog multiplexer and it comprises eight single channels; this multiplexer provides fault protection	8-channel/4-channel fault-protection analog multiplexer
DAC		
AD5693R	The AD5693R is a low power, single-channel, 16-bit buffered voltage out DAC	Tiny 16-bits *nanoDAC+*®, with ±2 (16-bits) LSB INL; 2 ppm/°C reference
AD5686R	The AD5686R *nano*DAC+ 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 *nanoDAC+* with 2 ppm/°C on-chip reference and SPI interface
ADC		
AD7960	The AD7960 is an 18-bit, 5 MSPS charge redistribution successive approximation (SAR), analog-to-digital converter (ADC); the SAR architecture allows unmatched performance both in noise and in linearity; the AD7960 contains a low power, high speed, 18-bit sampling ADC, an internal conversion clock, and an internal reference buffer	18-bit, 5 MSPS pulSAR® differential ADC
AD7606	The AD7606 is a 16-bit, 8-channel, simultaneous sampling analog-to-digital data acquisition system (DAS); it contains analog clamp protection, a 2nd order anti alias filter, a track and hold amplifier, a 16-bit charge redistribution successive approximation ADC, a flexible digital filter, a 2.5 V reference and reference buffer, and high speed serial and parallel interfaces	8-channel DAS with 16-bit, bipolar, simultaneous sampling ADC
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		
ADuCM350	The ADuCM350 is a complete, coin cell powered, high precision, meter on a 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 potentiostat, current, voltage, and impedance measurement capabilities	16-bit precision, low power meter on a chip with ARM® Cortex®-M3 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 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 peripheral like ADC, PWM, CAN, SPI, and more

Part Number	Description	Benefits
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

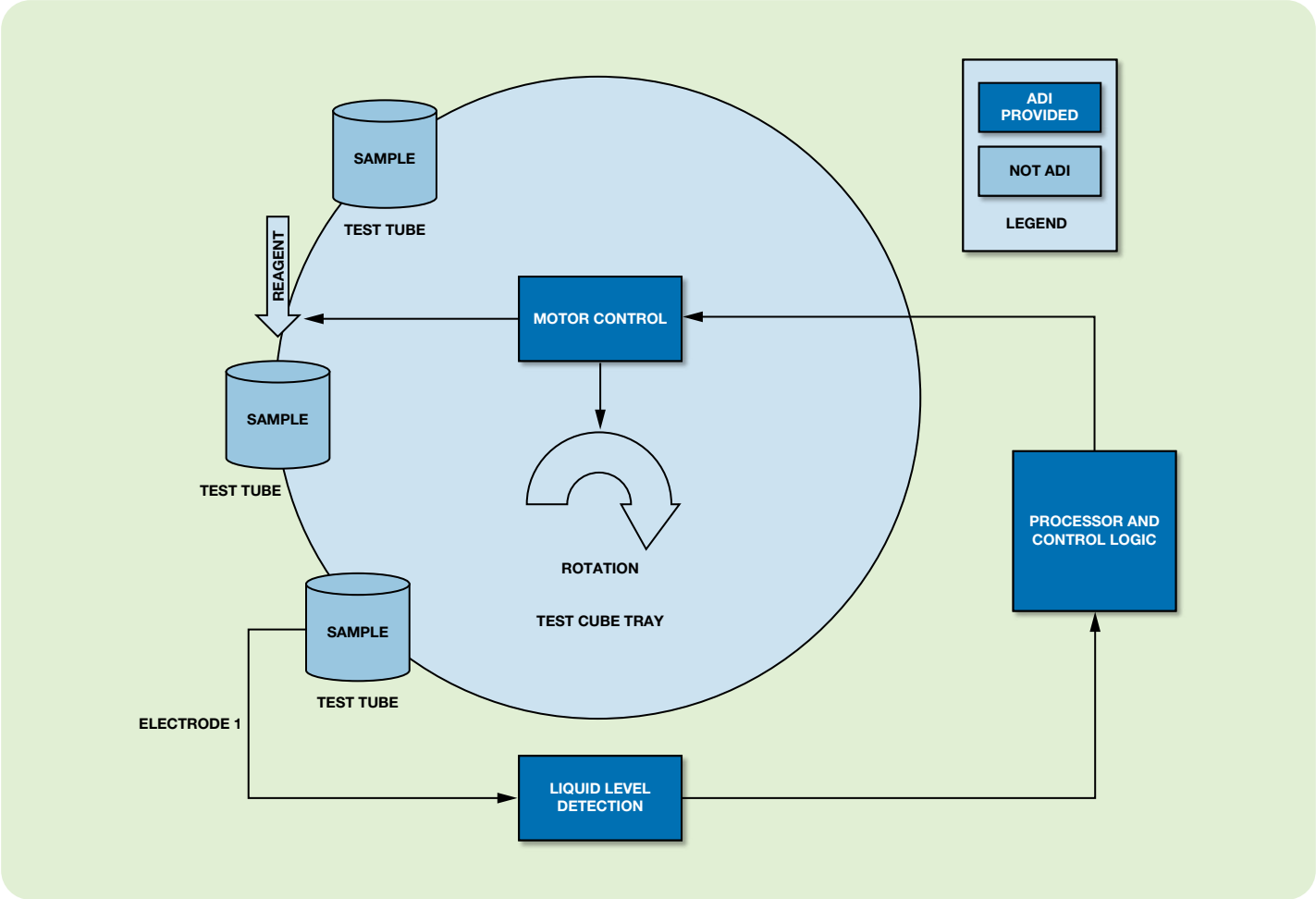

Figure 3. Sample movement/fluidics subsystem

Liquid Level Detection	Processor	Motor Control
AD7745/AD7747	ADUC7021/ADSP-BF512F/ADSP-BF527C	Refer to APM Motor Control

Part Number	Description	Benefits
Liquid Level Detection		
AD7745	The AD7745 is 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 (±0.01%), and high accuracy (±4 fF factory calibrated)	24-bit, 1-channel capacitance-to-digital converter

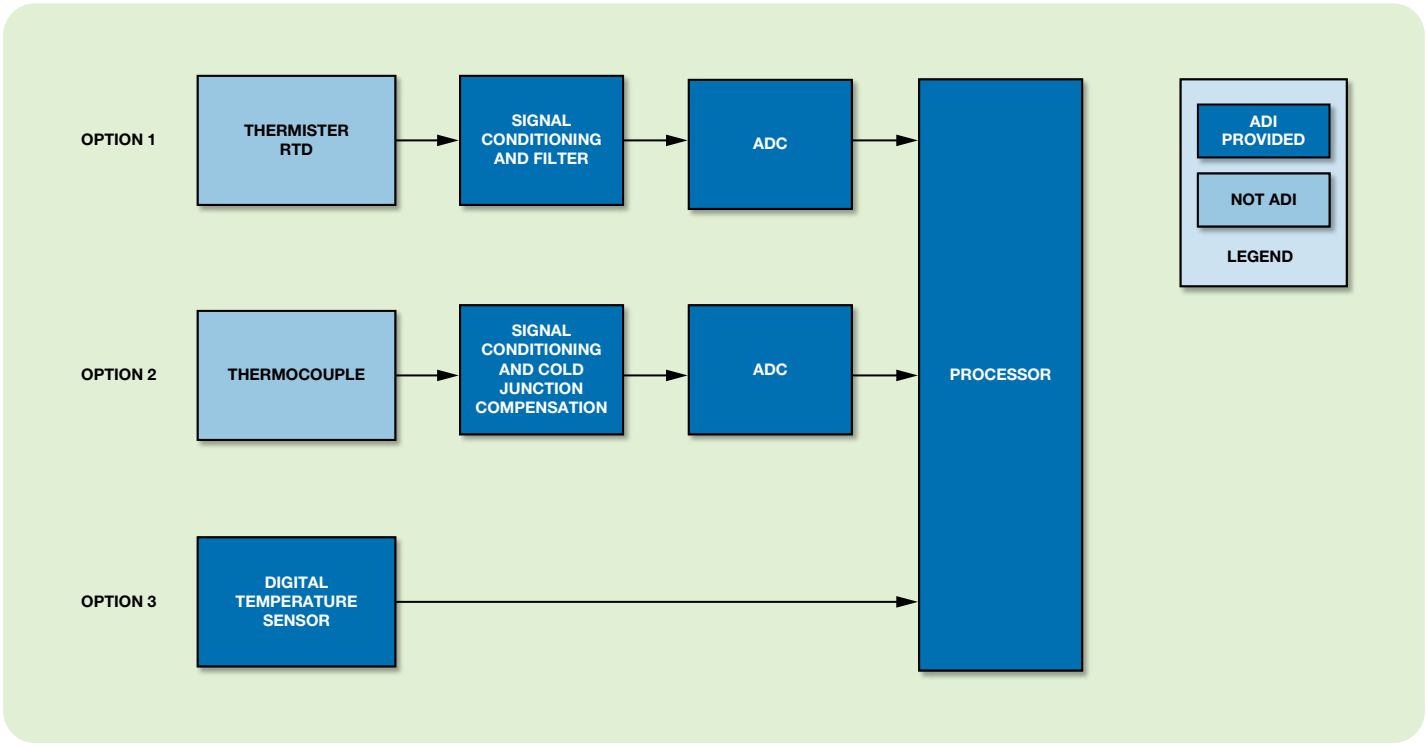

Figure 4. Temperature control subsystem

Digital Temperature Sensor	Thermal Couple Amplifier	Signal Conditioning and Filter	ADC	Processor
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	ADUC7021/ADUC7022/ ADUC7023/ADUC7121/ ADUC7124/ADUC7126/ ADuCM350/ADuCM360

Part Number	Description	Benefits
Digital Temperature Sensor		
ADT7320	The ADT7320 is a high accuracy digital temperature sensor that offers breakthrough performance over a wide industrial temperature range, housed in a 4 mm × 4 mm LFCSP package; it contains an internal band gap reference, a temperature sensor, and a 16-bit analog-to-digital converter (ADC) to monitor and digitize the temperature to a resolution of 0.0078°C	±0.25°C accurate, 16-bit digital SPI temperature sensor
Signal Conditioning and Cold Junction Compensation		
AD590	The AD590 is a 2-terminal integrated temperature transducer; high impedance, constant current regulator passing 1 μA/K for supply voltages between 4 V and 30 V	Excellent linearity, wide temperature range of −55°C to +150°C, laser trimmed to ±0.5°C calibration accuracy
AD8494	The AD494 is a precision instrumentation amplifier with thermocouple cold junction compensators on an integrated circuit; it produces a high level (5 mV/°C) output directly from a thermocouple signal by combining an ice point reference with a precalibrated amplifier	Full J-type range 0°C to 50°C thermocouple amplifier with cold junction compensation
Signal Conditioning and Filter		
AD8625	The AD8625 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/amp	Precision, low power, single-supply, JFET amplifier
AD8541	The AD8541 is a single rail-to-rail input and output single-supply amplifier featuring very low supply current and 1 MHz bandwidth; it is guaranteed to operate from a 2.7 V single supply as well as a 5 V supply; this part provides 1 MHz bandwidth at a low current consumption of 45 μA per amplifier	Low cost, general-purpose CMOS single rail-to-rail amplifier

Part Number	Description	Benefits
ADC		
AD7091R	The AD7091R is a 12-bit successive approximation analog-to-digital converter (ADC) that offers ultralow power consumption (typically 349 µA at 3 V and 1 MSPS) while achieving fast throughput rates (1 MSPS with a 50 MHz SCLK); the AD7091R uses advanced design and process techniques to achieve this very low power dissipation at high throughput rates; the part also features an on-chip, accurate 2.5 V reference	Lowest power 12-bit SAR ADC available; 349 µA typical at 3 V and 1 MSPS; 264 nA typical at 3 V in power-down mode; ±1 LSB max INL
AD7656-1	The AD7656-1 contain six 16-bit, fast, low power successive approximation ADCs in a package designed on the *i*CMOS® process (industrial CMOS); *i*CMOS is a process combining high voltage silicon with submicron CMOS and complementary bipolar technologies; it enables the development of a wide range of high performance analog ICs capable of 33 V operation in a footprint that no previous generation of high voltage parts could achieve; unlike analog ICs using conventional CMOS processes, *i*CMOS components can accept bipolar input signals while providing increased performance, which dramatically reduces power consumption and package size	Six 16-bit, 250 kSPS ADCs on board; six true bipolar, high impedance analog inputs; high speed parallel and serial interfaces; reduced decoupling requirements and reduced bill of materials cost compared with the AD7656
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

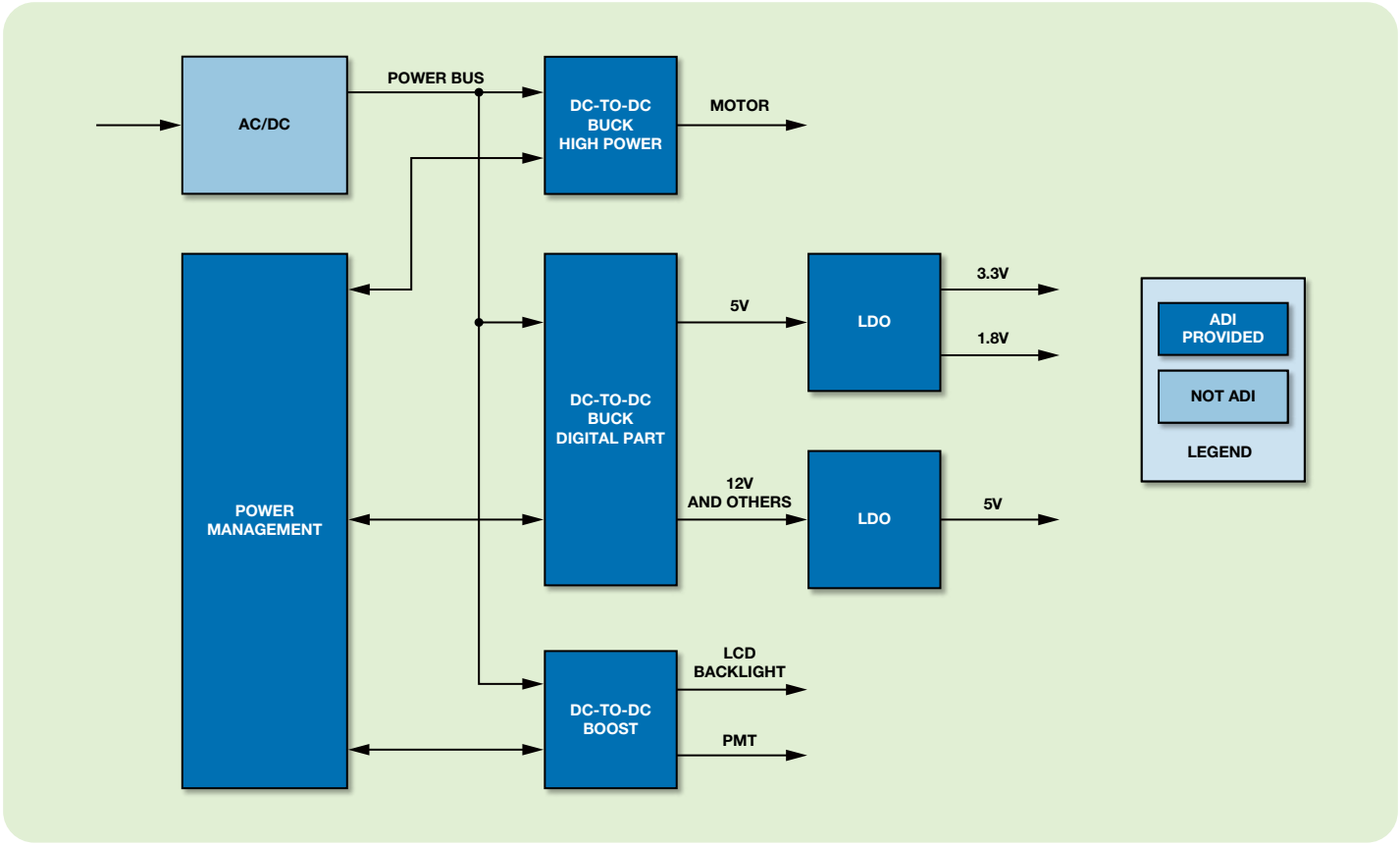

Figure 5. Power supply subsystem

DC/DC Buck	DC/DC Boost	LDO	Power Management
ADP1821/ADP1822/ADP1823/ ADP1828/ADP1829	ADP2384/ADP1621/ADP2503	ADP7102/ADP150/ADP160	ADM6339/ADM13307

Part Number	Description	Benefits
DC/DC Buck		
ADP1821	ADP1821 is a versatile and inexpensive, synchronous, pulse-width modulated (PWM), voltage mode, step-down controller; it drives an all N-channel power stage to regulate an output voltage as low as 0.6 V; the ADP1821 can be configured to provide output voltages from 0.6 V to 85% of the input voltage and is sized to handle large MOSFETs for point-of-load regulators	Precision, low power, single-supply, JFET amplifier
ADP2114	2.75 to 5.5V input, configurable, dual 2 A/single 4 A, synchronous step-down dc-to-dc regulator; pin-pin compatible with dual 3 A version: ADP2116	Full J-type range 0°C to 50°C thermocouple amplifier with cold junction compensation

Part Number	Description	Benefits
DC/DC Boost		
ADP2503	The ADP2503 is a high efficiency, low quiescent current step-up/step-down dc-to-dc converter that can operate at input voltages greater than, less than, or equal to the regulated output voltage; the power switches and synchronous rectifiers are internal to minimize external part count	600 mA, 2.5 MHz buck-boost dc-to-dc converter
ADP2384	4.5 V to 20 V input, 4 A output current, synchronous step-down dc-to-dc regulator; pin-pin compatible with 6 A version: ADP2386	High efficiency, accurate current limit allow the use of smaller inductor
LDO		
ADP7102	3.3 V to 20 V input, 300 mA output current, 200 mV low dropout voltage LDO with low noise performance, 15 μV rms for fixed voltage output, high PSRR 60 dB at 10 kHz, reverse current protection; pin-pin compatible with 500 mA version: ADP7104	Improves performance of noise sensitive loads and low dropout
ADP160	The ADP160 is an ultralow quiescent current, low dropout, linear regulator that operates from 2.2 V to 5.5 V and provides up to 150 mA of output current; the low 195 mV dropout voltage at 150 mA load improves efficiency and allows operation over a wide input voltage range	Ultralow quiescent current 150 mA, CMOS linear regulator
Power Management		
ADM6339	The ADM6339 incorporates a variety of internally pretrimmed undervoltage threshold options for monitoring −5.0 V, +1.8 V, +2.5 V, +3.0 V, +3.3 V, and +5.0 V, supply voltages; tolerance levels of ±5% and ±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; see the ordering guide section for a list and description of all available options	Quad voltage microprocessor supervisory circuit

Design Resources

Circuits from the Lab®

- *USB Based Temperature Monitor Using the ADuC7061 Precision Analog Microcontroller and an External RTD* (CN0075)—*www.analog.com/CN0075*
- *A 16-Bit, 6 MSPS SAR ADC System with Low Power Input Drivers and Reference Optimized for Multiplexed Applications* (CN0307)—*www.analog.com/CN0307*
- *Extending the Capacitive Input Range of the AD7745/AD7746 Capacitance-to-Digital Converter* (CN0129)—*www.analog.com/CN0129*
- *Single Supply, Micropower Toxic Gas Detector Using an Electrochemical Sensor* (CN0234)—*www.analog.com/CN0234*
- *Dual-Channel Colorimeter with Programmable Gain Transimpedance Amplifiers and Synchronous Detectors* (CN0312)—*www.analog.com/CN0312*
- *High Accuracy Impedance Measurements Using 12-Bit Impedance Converters* (CN0217)—*www.analog.com/CN0217*
- *16-Bit, 100 kSPS Low Power Successive Approximation ADC System with Optimum Low Power Drive Amplifier for Sub-Nyquist Input Signals Up to 1 kHz* (CN0306)—*www.analog.com/CN0306*
- *24-Bit, 250 kSPS Single-Supply Data Acquisition System* (CN0310)—*www.analog.com/CN0310*
- *Sensing Low-g Acceleration Using the ADXL345 Digital Accelerometer Connected to the ADuC7024 Precision Analog Microcontroller* (CN0133)—*www.analog.com/CN0133*

Application Notes/Articles

- AN-737 Application Note, *How ADIsimADC Models an ADC*—*www.analog.com/AN-737*
- AN-1168 Application Note, *Designing an Inverting Power Supply Using the ADP2384/ADP2386 Synchronous Step-Down DC-to-DC Regulators*—*www.analog.com/AN-1168*
- *Designing Power Supplies for High Speed ADC* (MS-2210)—*www.analog.com/MS-2210*
- *High Speed Converters: An Overview of What, Why, and How* (MS-2629)—*www.analog.com/MS-2629*
- *Precision 24-Bit, 250 kSPS Single-Supply Sigma-Delta ADC System for Industrial* (CN0310)—*www.analog.com/CN0310*
- *CN0269: 18-Bit, 1.33 MSPS, 16-Channel Data Acquisition System* (CN0269)—*www.analog.com/CN0269*

Design Tools/Forums

- ADC
  - VisualAnalog™ software—*www.analog.com/VisualAnalog*
  - ADC SPI interface software (SPIController)

- ADIsimADC modeling tool—*www.analog.com/ADIsimADC*

- DSP
  - VISUALDSP++ DOWNLOADS AND UPDATES—*www.analog.com/en/processors-dsp/sharc/adsp-21371/products/visualdsp_tools_upgrades/fca.html*
  - SOFTWARE DEVELOPMENT KIT (SDK)—*www.analog.com/en/processors-dsp/software-and-reference-designs/content/software_development_kit_downloads/fca.htmlC*
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  - ADIsimPLL™: PLL design and simulation—*www.analog.com/ADIsimPLL*
  - AD951x/AD952x evaluation software and board
- Amplifier
  - ADIsimOpAmp™: amplifier parametric evaluation tool—*www.analog.com/ADIsimOpAmp*
  - DiffAmpCalc™: differential amplifier calculator—*www.analog.com/diffampcalc*
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  - ADIsimPower™: power design tools—*www.analog.com/ADIsimPower*
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