ADI Energy—Protective Relay Platform for Power Distribution Systems

Power Distribution Application Theory and Typical Architecture

In the modern automatic power distribution system, more and more intelligent electronic devices are used to monitor the power quality and quickly isolate any fault from affecting the overall grid operation. The architecture of such devices is mostly composed of processor, multichannel ADC, signal condition circuit, power supply, and communication interfaces. Analog Devices, as the worldwide technical leader of mixed-signal processing, is the major electronic system solution supplier in this area.

- ADI's expertise in integrated energy measurement—300 million ADI metrology-based meters deployed.
- Precision measurement of current and voltage through highly accurate converters and amplifiers.
- Enable robust and reliable power networks using high performance processing technology.
- 50% of all electrical grid equipment worldwide uses ADI converters.
- Mixed-signal conversion and processing enable ease of design and reduced time to market.
- Enable system cost reductions through innovation, with integration of features such as additional channel count and on-board amplifiers.

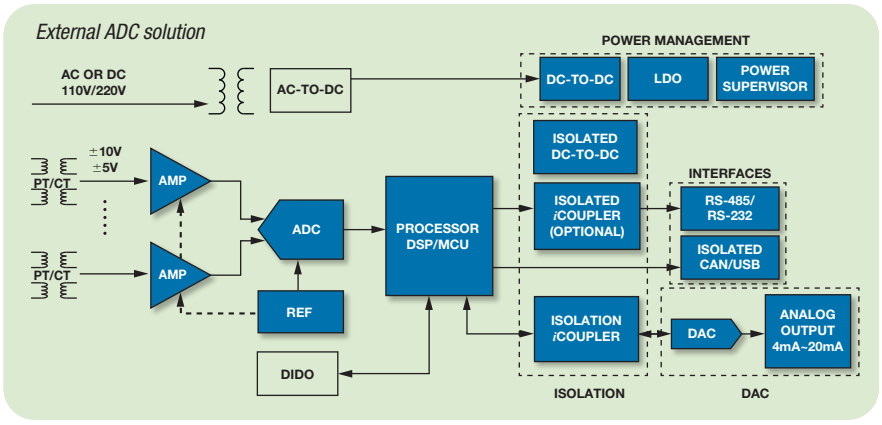
Main Challenges and System Considerations

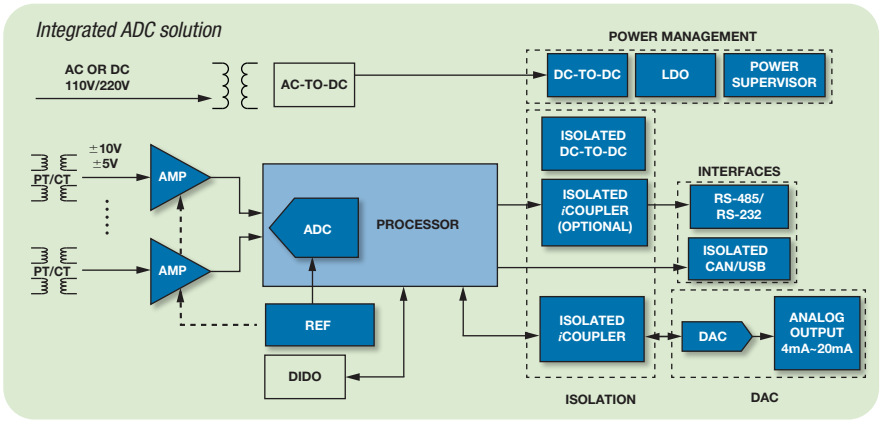
- Higher reliability and lower assembly/manufacturing costs.
- High signal dynamic range (up to 4000:1) and resolution (≥12 bits system ENOB) in some applications.
- Various requirements of system accuracy (protection up to 0.5%, measurement up to 0.1%).
- Multichannel (simultaneously as optional).
- Real-time processing (10 ms, 20 ms for all channels).
- System level connectivity: RS-232, RS-485, Ethernet, CAN, USB. In most cases, the communication interfaces also require isolation (≥ 500 V).
- Robustness requirements such as overvoltage protection, EMC/EMI, industry operation temperature range, long lifetime.
- To develop a low voltage device, the designer usually needs to consider different system requirements, including dynamic range, accuracy, bandwidth, channels, isolation, real-time processing, cost, and robustness.

Typical Distribution System Categories

- Low voltage system: <35 kV, including 10 kV, 6 kV, 3 kV.
- Ultralow voltage system: 1 kV, 380 V, 220 V.

Typical Power Distribution Device Signal Chain





	ADI Recommended
Amplifier	OP2177, OP4177, AD8672, AD8674, ADA4077-2, AD8602, AD8604, AD8608
ADC	AD7606, AD7607, AD7658-1, AD7689, AD7327, AD7490, ADE7878
Reference	ADR421, ADR431, ADR3425
Processor	ADSP-BF51x, ADSP-21469
Isolation	Power isolation: ADuM5000 Signal isolation: ADuM141x
DAC	AD5422
Interface	RS-485: ADM487E, ADM2587E RS-232: ADM3251E Isolated CAN: ADM3053 Isolated USB: ADuM4160
Power Management	LDO: ADP125 DC-to-DC: ADP1612, ADP2301, ADP5034 Power supervisor: ADM6710

	ADI Recommended
Amplifier	AD8602, AD8604, AD8608, AD8618, AD8666
Reference	ADR3425
Processor	ADSP-BF506F, ADuC702x
Isolation	Power isolation: ADuM5000 Signal isolation: ADuM141x
DAC	AD5422
Interface	RS-485: ADM487E, ADM2587E RS-232: ADM3251E Isolated CAN: ADM3053 Isolated USB: ADuM4160
Power Management	LDO: ADP125 DC-to-DC: ADP5034 Power supervisor: ADM6710

The signal chain above is representative of a typical power distribution device. The technical requirements of the blocks vary, but the products listed in the table below representative ADI's key promotion parts for the power distribution application.

ADI Products

Part Number	Description	Key Features	Benefits
Amplifier			
OP2177/OP4177	Precision low noise op amp	V_{os} = 60 µV (max), drift = 0.7 mV/°C, V_{noise} = 8 nV/√Hz @ 1 kHz, V_{supply} = ±2.5 V to ±15 V	Low noise, low offset and offset drift, no phase reversal
ADA4077-2	Precision low noise op amp	V_{os} = 25 µV (B-grade), drift = 0.15 µV/°C, V_{noise} = 8 nV/√Hz, V_{supply} = ±2.5 V to ±15 V	Very low offset voltage drift and low input bias current
AD8604	Precision CMOS single supply op amp	V_{os} = 500 µV (max), V_{supply} = 2.7 V to 5.5 V, wide bandwidth: 8 MHz	RRIO, low cost 4 amplifier
ADC			
AD7490	16-channel, 12-bit non-simultaneous ADC	0 to V_{REF}/2x V_{REF} uni-polar single-ended analog input, SPI interface, 1 MSPS, SINAD > 69 dB	Low cost, 16-channel, 12-bit ADC
AD7689/AD7699	8-channel, 16-bit non-simultaneous ADC	0 to V_{REF} unipolar/differential analog input, SPI interface, 250 kSPS (AD7689)/ 500 kSPS (AD7699) , SINAD = 92.5 dB	8-channel, 16-bit ADC, low cost
AD7606/AD7607	8-channel, 16-bit/14-bit simultaneous ADC	True bipolar analog input ranges: ±10 V, ±5 V, single 5 V analog supply, 2.3 V to +5 V VDRIVE, 1 MΩ analog input impedance, analog input clamp protection	8-channel simultaneous sampling, single 5 V supply
Reference			
ADR421	Voltage reference	Initial accuracy ≤ 0.05% with drift ≤ 3 ppm/°C, high output current: 10 mA, different output voltage option 2.5 V, low noise (0.1 Hz to 10.0 Hz): 1.75 μV_{p-p} @ 2.5 V output	High performance (3 ppm), high output current: 10 mA
ADR3425	Voltage reference	Initial accuracy: ±0.1% (maximum), maximum temperature coefficient: 8 ppm/°C, operating temperature range: −40°C to +125°C	Low cost, SOT-23 package, 10 mA source and 3 mA sink reference
Processor			
ADSP-BF51x	DSP	300 MHz/400 MHz DSP, 116 kB on-chip RAM, on-chip RTC, ethernet Mac (10/100) with IEEE 1588 supported	400 MHz DSP, IEEE 1588 supported
ADSP-BF506F	Embedded ADC DSP	300 MHz/400 MHz Blackfin core, embedded 12-bit ADC and 4 MB flash, 6-pair PWM output and multi-interface	12-bit ADC and >300 MHz core
ADuC702x	Precision Analog Microcontroller	41 MHz ARM7 core and embedded 12-bit ADC, 3-pair PWM output, 32 kB or 64 kB flash	Processor with embedded 12-bit ADC
Isolation			
ADuM5000/ ADuM6000	Isolated dc-to-dc	*iso*Power® integrated isolated dc-to-dc converter, up to 500 mW output power, thermal overload protection	Isolated dc-to-dc
ADuM141x	Quad channel digital isolator	High data rate: dc to 10 Mbps (NRZ), high common-mode transient immunity: >25 kV/µs, low power operation and bidirectional communication	Long lifetime, easy to select different direction
Interface			
ADuM2587E	Isolated RS-485/RS-422 transceiver	Half or full duplex, 500 kbps, 5 V or 3.3 V operation	RS485 with integrated isolated dc-to-dc converter, ±15 kV ESD protection
ADM3053	Isolated CAN transceiver	Signal and power isolated CAN transceiver, complies with ISO 11898 standard, high speed data rates up to 1 Mbps	CAN bus interface with integrated isolated dc-to-dc
Power Management			
ADP5034	Multi-output dc-to-dc regulator	Dual 1.2 A bucks and dual 300 mA LDOs in LFCSP; up to 96% buck power efficiency	4-channel output PMU, single part power chain solution
ADP1612	Step-up (boost) regulator	V_{IN} 1.8 V to 5.5 V, V_{OUT} adjustable up to 20 V, 1.4 A	1.4 A step up dc-to-dc with pin selectable 650 kHz or 1.3 MHz PWM frequency, soft start
ADP2301	Step-down (buck) switch regulator	V_{IN} 3.0 V to 20 V, output voltage from 0.8 V to 0.85 × V_{IN}, 1.2 A, high efficiency up to 91%, current-mode control architecture	Integrated high side MOSFET, integrated bootstrap diode, internal compensation, and soft start

Circuits from the Lab™ Reference Circuits for Energy Management

Reference circuits are subsystem-level building blocks that have been engineered and tested for quick and easy system integration.

- *Layout Considerations for an Expandable Multichannel Simultaneous Sampling Data Acquisition System (DAS) Based on the AD7606 16-Bit, 8-Channel DAS* (CN0148)—*www.analog.com/CN0148*
- *A Low Cost, 8-Channel, Simultaneously Sampled, Data Acquisition System with 84 dB SNR and Excellent Channel-to-Channel Matching* (CN0175)—*www.analog.com/CN0175*
- *24-Bit, 4-Channel, High Dynamic Range, 156 KSPS per Channel Simultaneous Sampling Data Acquisition System* (CN0157)—*www.analog.com/CN0157*
- *Half-Duplex, Isolated RS-485 Interface* (CN0031)—*www.analog.com/CN0031*
- More reference circuits are available at *www.analog.com/circuits*

Reference Design for Low Voltage Energy Distribution System

(Design by ADI third party - Beijing Eflag)

Main Features

- 2 × AD7606 as analog front, with no amplifier
- ADSP-BF51x can run RTOS, protection algorithm, and communication stack in the same time
- ADSP-BF518 has IEEE 1588, which is required by digital substation applications
- Free schematics, PCB, software (OS, drivers, etc), and documents are provided

If you need more information about ADI energy applications and products, please visit: *energy.analog.com*

Customer Interaction Center *cic.asia@analog.com*
Engineer Zone *ez.analog.com*
Free Sample *www.analog.com/sample*

Printed in China BR10138-.5-8/11

ANALOG DEVICES