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INNOVATIVE LINE SENSOR DESIGN WITH ADI ENERGY HARVESTING AND LOW POWER SIGNAL CHAIN

Fault Indicator Introduction

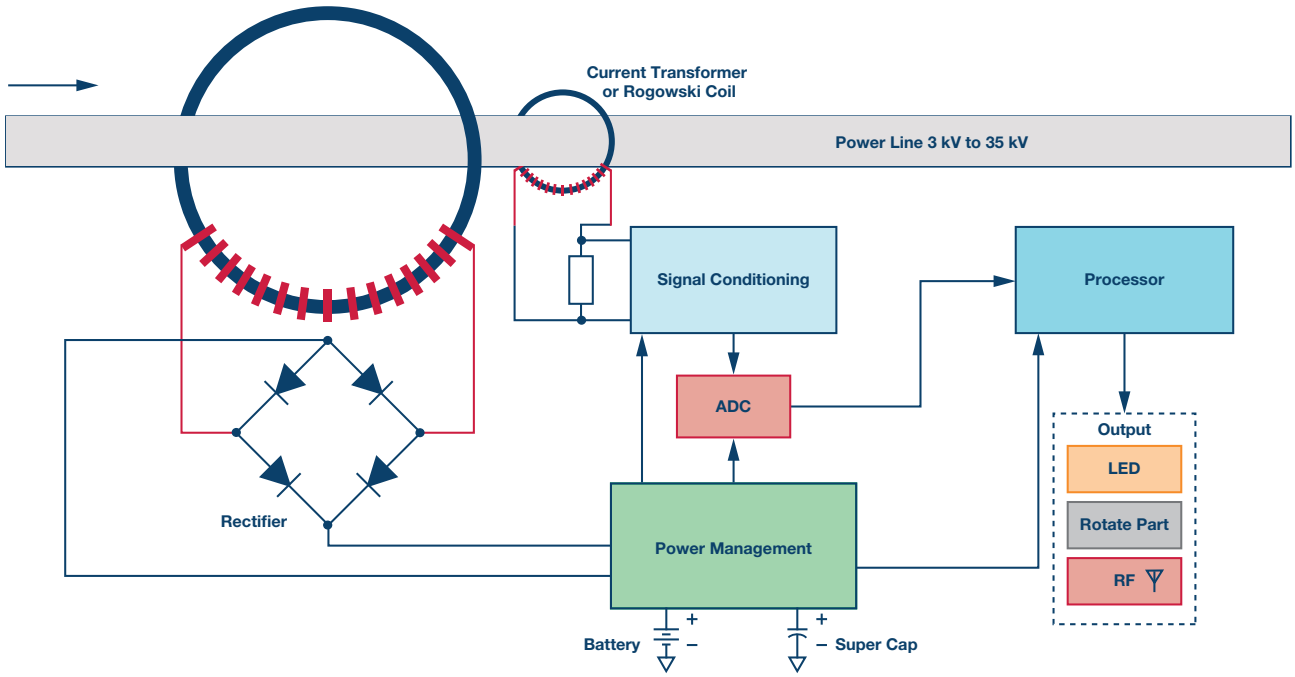
Power transmission and distribution (T&D) systems have evolved into vast interconnected power delivery networks that link multiple distributed power generators with different end user loads. A critical system requirement is to recover operation as quickly as possible whenever there is a fault condition that interrupts service. The system must monitor individual branches of the distribution grid, including overhead and underground power lines in urban and rural areas, and quickly locate a fault condition. This function, known primarily as fault indication (FI), and sometimes called line monitoring, faulting monitoring, or fault circuit indication, is growing because it is relatively easy to implement, achieves low cost, and requires little or no maintenance.

An FI system is composed of functional blocks such as energy harvesting, power management, processor, analog front-end (AFE) circuitry and communication interfaces. The most important requirements of an FI design are efficient energy harvesting and ultralow power consumption.

Design Considerations and Challenges

- Achieving very low power consumption (µA level) and meeting high efficiency for energy harvesting.
- Using a current transformer as both a sensor and a power source.
- Providing stable power delivery for the system by managing multiple power supplies and switching among them.
- Achieving long-term reliability over system lifetime while operating in a harsh field environment.
- Synchronizing wireless communication and networking while meeting low power.

System Block Diagram for FI General System Architecture



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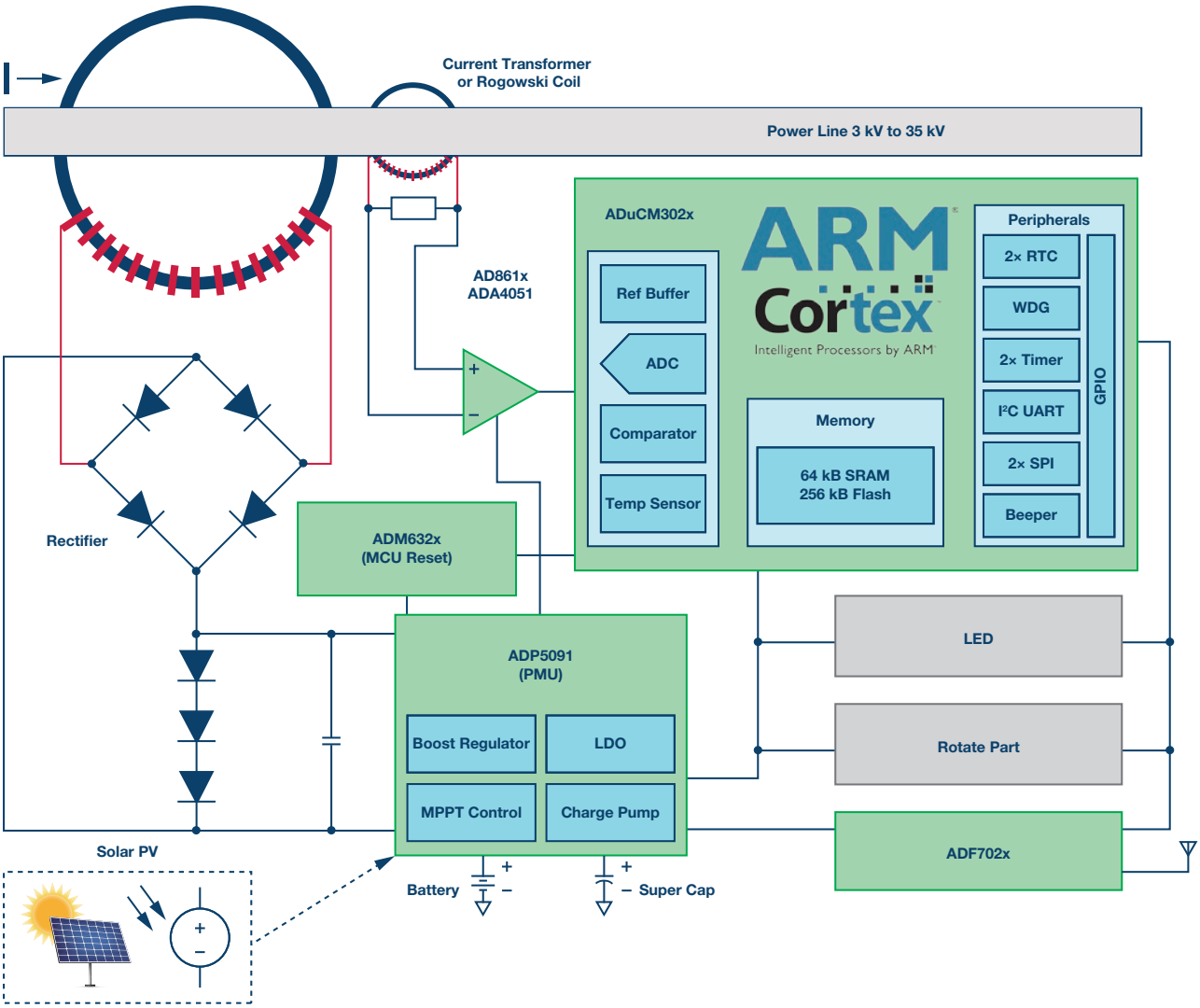
System Diagram for FI Low Power ADP5091 Architecture



The signal chain above is representative of a typical FI application design. The technical requirements of the blocks vary, but the products listed in the table on Page 3 are representative ADI's solutions that meet some of those requirements.

ADI Solutions for Line Sensor and Fault Indicator Applications

ADI provides an integrated solution that implements a full signal chain, reduces design complexity, results in a small form factor, and achieves very low power consumption.

- A highly integrated ASIC implements efficient energy harvesting and manages multiple power sources, while reducing BOM cost and simplifying PCB design.
- Our solution achieves over 90% power conversion efficiency with optimized maximum power point tracking (MPPT).
- The low power op amp with a wide dynamic range and high slew rate supports Rogowski coil architecture and minimizes magnetic field interference with the current measurement accuracy.
- The high performance, ultralow power ARM® Cortex®-M3 processor provides a rich of set of peripherals and also supports security features that improve system safety and reliability.
- The integrated ISM band transceiver performs RF communication and supports sensor network protocol.
- Additional power supervision and voltage comparator solutions are available.

Analog Devices is the worldwide leader in mixed-signal processing technology and provides solutions for FI applications.

- ADI is an expert in energy measurement. Over half of all electrical grid equipment worldwide uses ADI converters.
- ADI enables ease of design, cost saving, and long-term system reliability by combining high integration with excellent system performance.
- ADI technology for energy harvesting and power management leads the industry.
- ADI offers precision signal measurement through highly accurate converters and amplifiers.
- A complete family of ADCs, processors, and wireless transceivers covers an entire ultralow power signal chain.

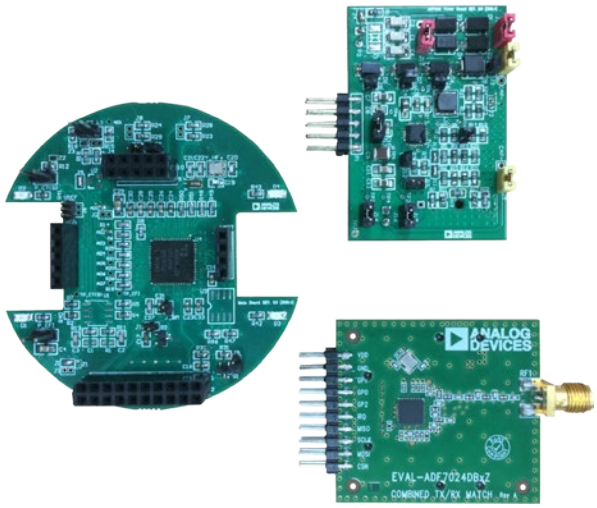
Products	ADI Recommended
Power Management	ADP5091
Signal Conditioning	Amplifiers: ADA4051-x/AD861x/AD850x
Processor	ADuCM302x
Power Supervisor	ADM861x
RF Transceiver	ADF702x
Voltage Comparator	ADCMP380
Voltage Reference	AD1582/ADR525

Main Products Introduction

Part Number	Description	Key Features	Benefits
Power Management			
ADP5091	Ultralow power energy harvester PMU	Input voltage: 80 mV to 3.3 V; fast cold start from 380 mV; 150 mA regulated output from 1.5 V to 3.6 V; programmable voltage monitor of charging storage and backup cell battery	Boost regulator with maximum power point tracking; RF transmission friendly
Amplifier			
ADA4051-x	Zero-drift, rail-to-rail op amps	Very low supply current: 13 µA; low offset voltage: 15 µV maximum; offset voltage drift: 20 nV/°C; V_{SUPPLY}: 1.8 V to 5.5 V	Rail-to-rail input/output; unity-gain stable; extended industrial temperature range: –40°C to +125°C.
Processor			
ADuCM302x	Ultralow power ARM Cortex-M3 MCU	Up to 26 MHz ARM Cortex-M3 core with 64 kB, 256 kB flash, 4 kB cache; V_{SUPPLY}: 1.8 V to 3.6 V; active < 38 µA/MHz, hibernate < 750 nA; 8-channel, 1.8 MSPS, 12-bit SAR ADC; digital comparator; hardware crypto accelerator/CRC	Power supply monitor; LDO+ buck converter for improved efficiency; user code protection; dynamic/SW clock and power gating
Power Supervisor			
ADM861x	Ultralow power supervisory	Ultralow power consumption ICC = 92 nA; voltage monitoring range: 0.5 V to 4.63 V, ±1.3% threshold accuracy; optional watchdog timer	Manual reset input; active low, open-drain RESET output; power supply glitch immunity
RF Transceiver			
ADF7024	Sub-GHz, ISM/SRD, FSK/GFSK, transceiver	ISM bands: 431 MHz to 435 MHz/862 MHz to 928 MHz; data rates supported: 9.6 kbps to 300 kbps; V_{SUPPLY}: 2.2 V to 3.6 V; automatic frequency/gain control (AFC/AGC); 11.75 µA autonomous Rx sniff using smart wake mode (SWM)	Ultralow power sleep modes; digital received signal strength indication (RSSI); highly linear/blocking/sensitivity; on-chip, 8-bit ADC
Voltage Comparator			
ADCMP380	Ultralow power voltage comparator	Ultralow power consumption with ICC = 92 nA; enable input; 23 µs typical propagation delay; open-drain type output	Comparator with on-chip reference; input glitch immunity
Voltage Reference			
AD1582	Micropower, precision series mode voltage reference	Low quiescent current: 70 µA maximum; current output capability: ±5 mA; wide supply range: $V_{IN} = V_{OUT}$ + 200 mV to 12 V; wideband noise (10 Hz to 10 kHz): 50 µV rms	Patented temperature drift curvature correction design; industrial temperature range of –40°C to +125°C

Design Resource

Reference Design/Demo Design



Application Notes/Articles

- EE-388, *Power Optimization Guide for ADuCM302x Processors*—
  www.analog.com/media/en/technical-documentation/application-notes/EE388v01.pdf
- EE-381, *Using the ADuCM302x Processor Boot Kernel*—
  www.analog.com/media/en/technical-documentation/application-notes/EE381v01.pdf
- AN-1315, *Autonomous IR Calibration on the ADF7024*—
  www.analog.com/media/en/technical-documentation/application-notes/AN-1315.pdf
- AN-1317, *Rolling Data Buffer on the ADF7024*—
  www.analog.com/media/en/technical-documentation/application-notes/AN-1317.pdf

Design Tool

- EVAL-ADuCM3029 EZ-KIT—
  www.analog.com/en/design-center/evaluation-hardware-and-software/evaluation-boards-kits/eval-aducm3029-ezkit.html

ADI Contact

- If you need more ADI energy applications and products information, please visit: *www.analog.com/en/energy*.

Customer Interaction Center

Asia: *cic.asia@analog.com*

North America: *cic.americas@analog.com*

Europe: *cic@analog.com*

EngineerZone™

ez.analog.com

Free Samples

analog.com/sample

Analog Devices, Inc.
Worldwide Headquarters

Analog Devices, Inc.
One Technology Way
P.O. Box 9106
Norwood, MA 02062-9106
U.S.A.
Tel: 781.329.4700
(800.262.5643, U.S.A. only)
Fax: 781.461.3113

Analog Devices, Inc.
Europe Headquarters

Analog Devices GmbH
Otl-Aicher-Str. 60-64
80807 München
Germany
Tel: 49.89.76903.0
Fax: 49.89.76903.157

Analog Devices, Inc.
Japan Headquarters

Analog Devices, KK
New Pier Takeshiba
South Tower Building
1-16-1 Kaigan, Minato-ku,
Tokyo, 105-6891
Japan
Tel: 813.5402.8200
Fax: 813.5402.1064

Analog Devices, Inc.
Asia Pacific Headquarters

Analog Devices
5F, Sandhill Plaza
2290 Zuchongzhi Road
Zhangjiang Hi-Tech Park
Pudong New District
Shanghai, China 201203
Tel: 86.21.2320.8000
Fax: 86.21.2320.8222

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