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

- Power Line 3 kV to 35 kV
- Current Transformer or Rogowski Coil
- Rectifier
- Signal Conditioning
- ADC
- Power Management
- Battery
- Super Cap
- Processor
- Output
- LED
- Rotate Part
- RF

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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 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.

### Main Products Introduction

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Key Features</th>
<th>Benefits</th>
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<tbody>
<tr>
<td><strong>Power Management</strong></td>
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<tr>
<td>ADP5091</td>
<td>Ultralow power energy harvester PMU</td>
<td>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</td>
<td>Boost regulator with maximum power point tracking; RF transmission friendly</td>
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<tr>
<td><strong>Amplifiers</strong></td>
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<tr>
<td>ADA4051-x</td>
<td>Zero-drift, rail-to-rail op amps</td>
<td>Very low supply current: 13 μA; low offset voltage: 15 μV maximum; offset voltage drift: 20 nV/°C; V&lt;sub&gt;SUPPLY&lt;/sub&gt;: 1.8 V to 5.5 V</td>
<td>Rail-to-rail input/output; unity-gain stable; extended industrial temperature range: −40°C to +125°C.</td>
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<tr>
<td><strong>Processor</strong></td>
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<tr>
<td>ADuCM302x</td>
<td>Ultralow power ARM Cortex-M3 MCU</td>
<td>Up to 26 MHz ARM Cortex-M3 core with 64 kB, 256 kB flash, 4 kB cache; V&lt;sub&gt;SUPPLY&lt;/sub&gt;: 1.8 V to 3.6 V; active &lt; 38 μA/MHz; hibernate &lt; 750 nA; 8-channel, 1.8 MSPS, 12-bit SAR ADC; digital comparator; hardware crypto accelerator/CRC</td>
<td>Power supply monitor; LDO+ buck converter for improved efficiency; user code protection; dynamic/SW clock and power gating</td>
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<td><strong>Power Supervisor</strong></td>
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<tr>
<td>ADM861x</td>
<td>Ultralow power supervisory</td>
<td>Ultralow power consumption ICC = 92 nA; voltage monitoring range: 0.5 V to 4.63 V ±1.3% threshold accuracy; optional watchdog timer</td>
<td>Manual reset input; active low, open-drain RESET output; power supply glitch immunity</td>
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<tr>
<td><strong>RF Transceiver</strong></td>
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<tr>
<td>ADF7024</td>
<td>Sub-GHz, ISM/SDR, FSK/GFSK, transceiver</td>
<td>ISM bands: 431 MHz to 435 MHz/862 MHz to 928 MHz; data rates supported: 9.6 kbps to 300 kbps; V&lt;sub&gt;SUPPLY&lt;/sub&gt;: 2.2 V to 3.6 V; automatic frequency/gain control (AFG/GC); 11.75 μA autonomous Rx sniff using smart wake mode (SWM)</td>
<td>Ultralow power sleep modes; digital received signal strength indication (RSSI); highly linear/blocking/sensitivity; on-chip, 8-bit ADC</td>
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<td><strong>Voltage Comparator</strong></td>
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<tr>
<td>ADCMP380</td>
<td>Ultralow power voltage comparator</td>
<td>Ultralow power consumption with ICC = 92 nA; enable input; 23 μs typical propagation delay; open-drain type output</td>
<td>Comparator with on-chip reference; input glitch immunity</td>
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<tr>
<td><strong>Voltage Reference</strong></td>
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<tr>
<td>AD1S82</td>
<td>Micropower, precision series mode voltage reference</td>
<td>Low quiescent current: 70 μA maximum; current output capability: ±5 mA; wide supply range: V&lt;sub&gt;ref&lt;/sub&gt; = V&lt;sub&gt;out&lt;/sub&gt; + 200 mV to 12 V; wideband noise (10 Hz to 10 kHz): 50 μV rms</td>
<td>Patented temperature drift curvature correction design; industrial temperature range of −40°C to +125°C</td>
</tr>
</tbody>
</table>
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—
- AN-1317, Rolling Data Buffer on the ADF7024—

Design Tool
- EVAL-ADuC3029 EZ-KIT—

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

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