The Next Generation of Line Sensors: Power Harvested, Connected, and Lower Maintenance

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Introduction

In today's ever changing energy landscape, power outages continue to cost businesses millions of dollars by interrupting critical operations such as manufacturing. In addition, some power grid equipment in operation throughout the world has reached old age and, in some regions, major storms are becoming more common. Faced with these serious challenges, utility companies can cope with the risk of future service outages in a variety of ways including modernizing distribution networks, managing foliage growth, and hiring more line repair crews. All of these options can be complex to evaluate because they have varying degrees of cost, technical risk, and societal benefits.

A recent focus for utility companies has been locating, hiring, and training more line repair personnel to improve outage responses and achieve better results for customers. But in many parts of the world, the aging workforce effect is well-known, as it is increasingly difficult to find skilled labor and fill vacant line crew positions. Faced with the prospect of prolonged service outages, unhappy customers, and the possibility of government intervention, utility companies need better solutions. What if it were possible to improve the line crew's work activity so that they allocate more time to actual repair and high priority maintenance and spend less time searching for broken wires?

Capturing Data at Power Grid Nodes Is Key

In the last few years, many countries have experienced prolonged power outages simply because the source of the problem was difficult to locate. But how do utility companies improve the distribution network architecture to achieve better outage response? The answer lies in taking advantage of better line sensor technology that enables lower system cost and deploys to more nodes within the power infrastructure. This technology features more integration, helps achieve better measurement accuracy, consumes less power, and needs less maintenance.

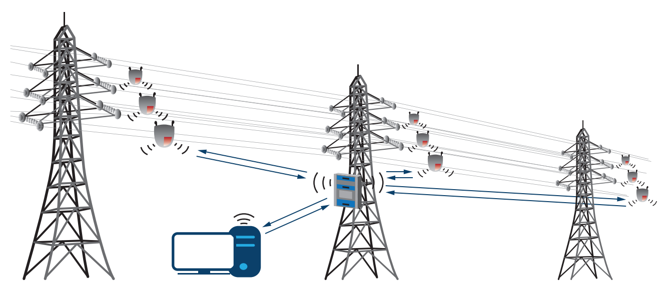

Figure 1. Node monitoring system known as a fault indicator.

One of the most common use cases for new line sensors is a node monitoring system known as a fault indicator that detects and sends an alert when problems occur so that line crews can service faulted equipment with minimal delay. The diagram in Figure 1 shows fault indicators in use on power distribution lines. There are many names used across different geographies and different suppliers to describe this same system including line monitor, fault monitor, and fault circuit indicator. Throughout this article, this author will use the general term fault indicator for the system and line sensor for the underlying technology used for detecting the physical state of power lines.

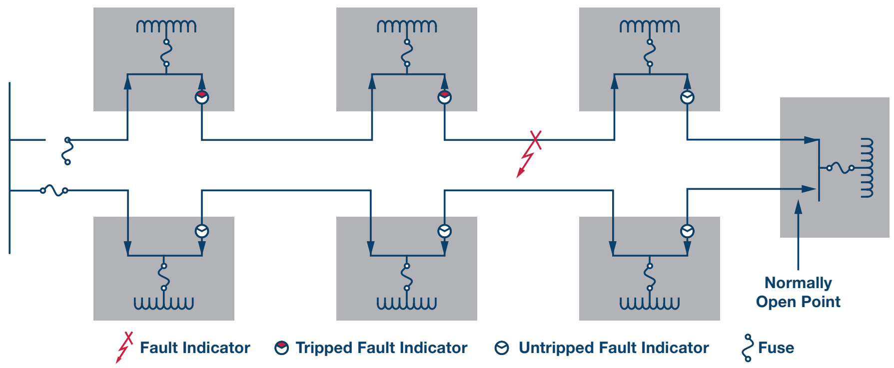

Figure 2. Line sensors for detecting the physical state of power lines.

In underground applications, a fault indicator is placed at cable terminations along each primary cable. The indicators upstream of the fault will trip, and the indicators downstream of the fault will remain in the nontripped position. As a result, the service team can easily identify the faulted section of cable or equipment without going through a time consuming isolation process. Underground applications can include transformers, switchgear, cabinets, junction boxes, and splices.

In overhead applications, the easy to spot displays on fault indicators lead the line crew to the problem section of line. Overhead applications can include unfused taps, long feeders with midline reclosers, sectioning switchgear, transitions, and feeders.

Two of the biggest challenges associated with existing fault indicators are 1) they can be expensive to purchase in volume and 2) they require recurring maintenance in order to keep functioning properly. Cumulative purchase cost and recurring maintenance are two primary reasons why utility companies with limited budgets and resources are unable to deploy more fault indicators within their vast power infrastructure.

Improving Fault Indicators Through More Advanced Power Management

To address these challenges, Analog Devices developed a new line sensor architecture for fault indicators that harvests power at high efficiency and requires less maintenance (Figure 3).

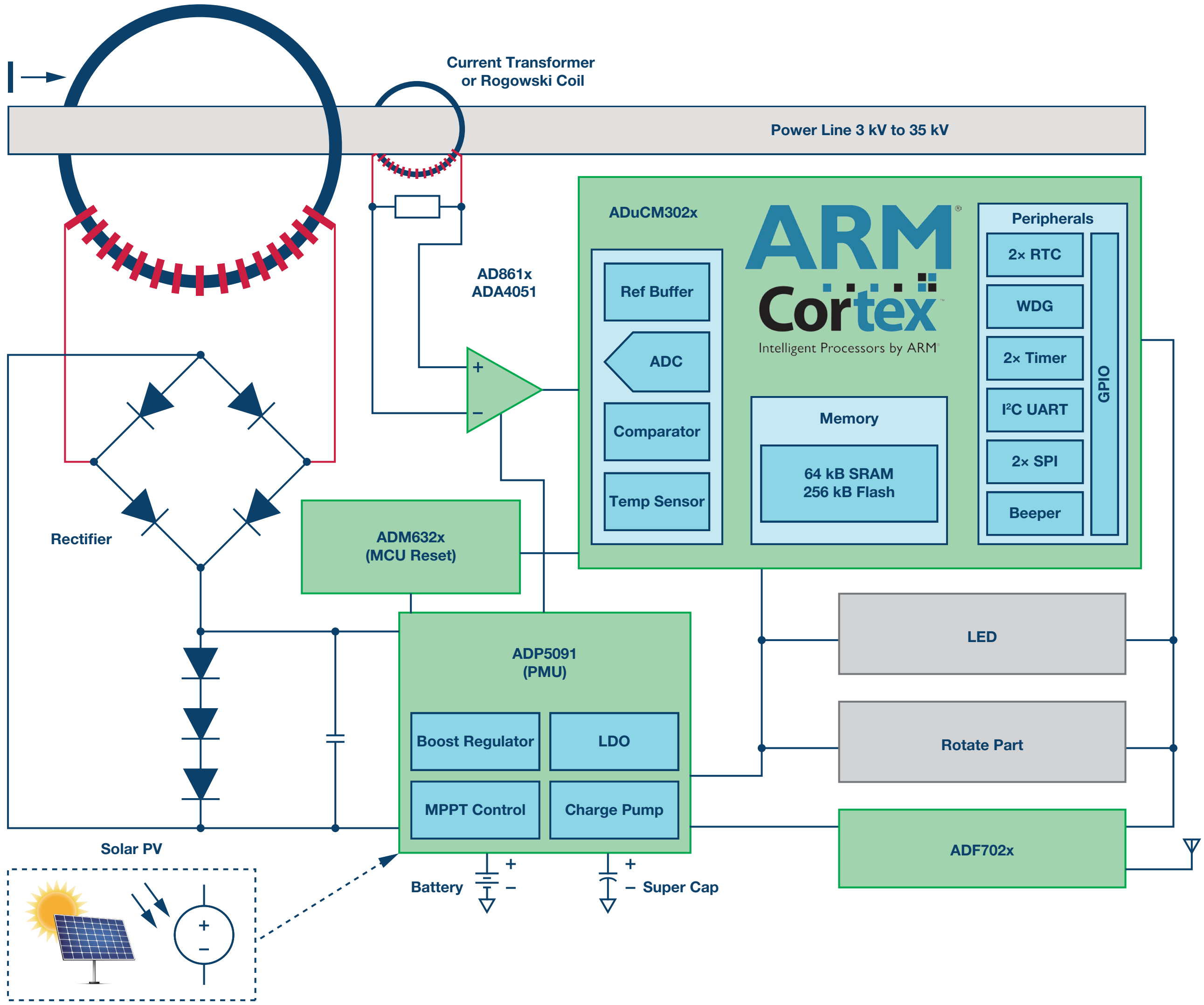

Figure 3. Power harvested fault indicator design.

While basic functions may seem simple, a power harvested fault indicator design is quite complex, particularly the power supply architecture. Not only are there three independent power sources (the power line sensor, a rechargeable battery, and a super capacitor), but there must also be a control algorithm that knows how to balance changing supply conditions with changing load conditions—all while guaranteeing always-on operation. The key innovation is a new technique for multiple power path designs that enables faster startups, lower power consumption, and smoother operation for the system. By employing better power management, fault indicators will need less maintenance because line crews can replace batteries less often and they can perform fewer system checks.

New fault indicator designs can also leverage more sophisticated data collection and more robust wireless communications to boost performance. They can capture more granularity by using high speed precision converters to collect power line information at data rates that are much higher than electrical power frequencies. Integrating wireless communications such as shortwave radio and GSM protocols also improve the reach of these devices. Fault indicators can transmit data and communicate their status so that line crews spend less time searching for faults and more time troubleshooting them.

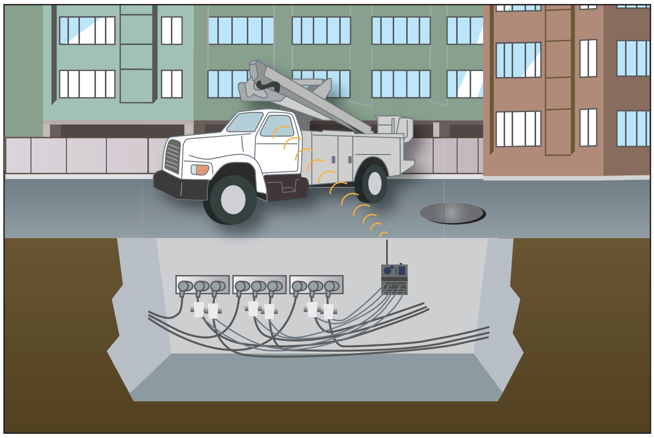

Figure 4. Communicating subsurface fault indicator status to street level.

Opportunities for Big Data Analytics that Drive Better Energy Intelligence

Fault indicators that take advantage of advanced line sensor technology present an opportunity to transform the way in which utility companies operate. By collecting data at the node that is more granular, better connected, and less expensive to maintain, utilities can identify and respond to outages faster and with higher confidence. But there are other possibilities to consider. For example, an entire population of fault indicators can provide historical data and alerts so that utilities can apply machine learning algorithms and analytics to drive more efficient line crew activity, lower operating expenses, and achieve better business outcomes.

Conclusion

Utility customers continue to experience prolonged power outages because problems are difficult to locate. One way to overcome this scenario is broader adoption of fault indicators. But two of the biggest drawbacks associated with today's fault indicators are their high price tag for volume purchases and their periodic maintenance needs.

There is a new line sensor technology for fault indicators that overcomes these challenges by harvesting power at high efficiency and requiring less maintenance. In the future, utility companies can take advantage of next-generation fault indicators and benefit from shorter outages, lower operating expenses, and more satisfied customers

About the Author

Swarnab Banerjee (B.S.E.E.) is a system engineering manager in the Energy Management Products Group of Analog Devices, Inc. (ADI). Banerjee is responsible for addressing the growing technology needs for power delivery and power conversion equipment that target the smart grid. Prior to ADI, he served in technical leadership roles at Core Innovation, Boulder Wind Power, and Princeton Power Systems, and he developed a variety of power transmission and distribution systems. He has two granted, and three pending, patents.

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