Plastic Optic Fiber for IIoT in Power Distribution

M. O'Gorman, D. Loughnan

Firecomms Ltd.

August 2019

Industrial Internet of Things (IIoT) is communication beyond the traditional Machine-to-Machine (M2M) model that operates within today's factories, machines and processes. It is a world of connected sensor devices collecting data on how machines are performing and then using that data to provide greater efficiency and cost savings. How then can such a network of connected sensors be safely integrated into a high-power distribution network?

Industrial Internet of Things (IIoT), is revolutionizing the power distribution industry. The ability of a power distribution network to provide uninterrupted supply is now dependent on a complex system of sensors connecting every part of the grid. Real-time monitoring and feedback provide a 21st -century service where power failure can be detected, root-caused and promptly repaired with the minimum of customer outage.

Outage Management Systems are designed to reduce outage duration by locating outages faster and providing the power grid manager with better information for directing the response. Thousands of IIoT sensors deployed across the grid provide a real-time network of information for accurately evaluating how an outage impacts the customer, how to prioritize responses, how to effectively assign crews and then better determine options for back-feeding power.

Clearly, digital technology is enhancing the modern power grid. However, interfacing a data communication network that uses low-power digital electronics with high-power distribution networks brings significant technical challenges.

An Ethernet network based on copper (CAT5, 6, or 7) generally does not have to concern itself with large ground currents. However, high voltage distribution transformer stations must pay very particular attention to grounding, isolation and safety issues. Faults of this type can cause significant damage to plant equipment and endanger personnel.

How then do we solve the problem of networking low-voltage sensors and their 5 V electronics, when they are located inside or in the vicinity of high-power equipment and plant with voltages from 10 kV to 35 kV?

Wireless connectivity is often proposed as a simple solution, but wireless has significant disadvantages when used in the vicinity of large metal infrastructure such as transformers and their associated plant. Wireless also has concerns with security, as people outside the facility can easily interfere with wireless technology by either sending malicious blocking signals or hacking the link and using this as an access point to the broader power distribution network. As a result, many governments have prohibited the use of wireless technology in critical power infrastructure.

Plastic Optic Fiber (POF) allows engineers to solve all of these issues with a well proven technology already used for many years in the power electronics industry. For over 30 years, POF has been used for isolation in the power switches at the core of power distribution. Low data rate transceivers invented by Hewlett Packard in the late 1970s and early 1980s have been used to control thyristors, isolated gate bi-polar transistors (IGBT) and more recently silicon carbide (SiC) based switches. Hundreds of thousands of these parts are used every year in, for example, high-voltage direct current (HVDC) installations. The POF used here has been proven to provide up to 50 kV of voltage isolation. The technology has also been shown to provide the twenty-year plus longevity required in the field for power distribution equipment.

Today, the lower speed RedLink® transceivers for POF are joined by high-speed versions that enable Fast Ethernet and EtherCAT links. With the same fiber that switches an IGBT at 25 kHz, an Ethernet signal can be sent around a HVDC plant or link all of the data gathering electronics and sensors in a transformer station. As the name POF implies the fibre is made of plastic which can support up to 50 kV of voltage isolation as well as preventing possible ground currents and shorting.

The design of the high-speed POF transceivers includes the latest integrated silicon technology where the photodiode is combined into the same silicon as the sensing electronics. Differential photodiode arrangements are used to provide even higher noise rejection and cancellation.

POF not only provides a technically robust solution for networking inside a power distribution plant, it also offers an ideal solution for interfacing the power system to a wider area datacom network without risking damage to either. The isolation provided by a POF link allows a safe interface to the existing local area network and is an ideal solution for upgrading existing field installations such as transformer distributions points in a city. With POF the existing transformer station can be upgraded with a new sensor technology and then safely interfaced to the local area network.

Firecomms OptoLock® Transceiver

As well as Ethernet over POF, the same fiber can be used for the distribution of RS-232/RS-485. This is very useful for connecting PLC's distributed throughout a substation to a networking infrastructure integrating the PLC's into a larger power grid network.

Collaboration between a national telecom's network provider and power distribution companies can provide a highly economic path for upgrading older installations into the power distribution network. POF is the critical link that ensures that both parties are safely isolated from each other but can enjoy a robust high-speed data interconnect.

This type of collaboration is now in place in European countries where Firecomms media converters have been used to make a safe Ethernet link between the transformer substation monitoring computer and the local area network run by a national network provider. This link provides all of the technical benefits discussed above; high voltage isolation, immunity to EMI/EMC, high-speed Ethernet communication and it also provides significant operational benefits. As POF provides complete voltage isolation, technicians from both companies can work on their own side of the link without needing to have special safety procedures or working arrangements in place. The telecom's staff does not need the power distribution company present when they are working on their side of the link, as there is no risk from the power plant and vice-versa. This is a significant time and cost-saving in day-to-day operations.

Fiber solutions often raise flags among field technicians as they are generally not equipped to deal with the complexity of glass fiber installation and maintenance. However, POF combined with Firecomms patented bare fiber connector, the OptoLock®, has simplified installation and maintenance. No specialized tooling is required nor complex fiber termination. In fact, termination is achieved with a simple razor blade cut of the POF, its subsequent insertion and clamping in the OptoLock® connector. The transceiver supports 100 Base-FX communication as per the IEEE802.3 standard. POF provides standard Fast Ethernet at 100 Mbps, and the transceivers also support real-time Ethernet standards for example EtherCAT.

For existing installations not equipped with fiber transceivers, Firecomms media converter takes care of all of the conversion required to switch from copper (Cat 5,6,7) to POF. It sits neatly behind rack mounted PC's and DIN rail mounted versions are also available. The media converters can be powered from a 5 V power source such as a spare USB port and the DIN rail version can be wired to the local 48/24/12 V power supply.

Isolation of RS-232 or RS-485 is also easily achieved with a POF link. Options are available for the OptoLock® enabling bare fiber termination, but also for traditional simple Plastic Optic Fiber plugs. PLC's can be linked in a daisy chain or a star network as required by the installation.

For further information see:
www.firecomms.com

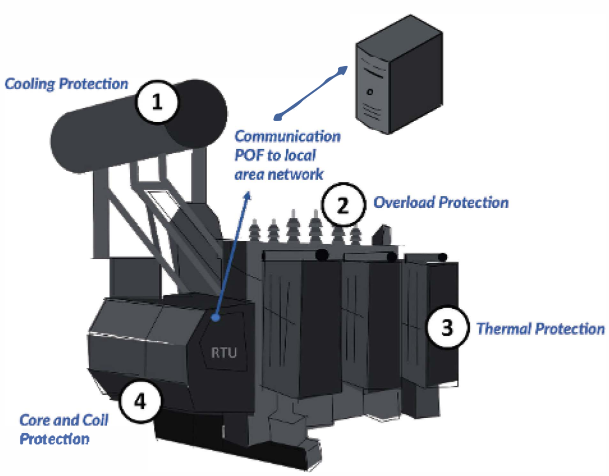

FIGURE 1. Sensors distributed across a high-power transformer connected to a local area networks via a POF link

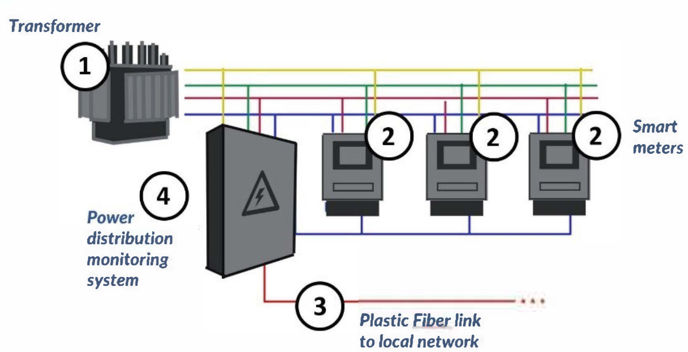

FIGURE 2. Interface of the power distribution network to the local area network over a POF link

Firecomms
enlightened innovation
www.firecomms.com

Copyright (c) 2019 Firecomms Ltd. Firecomms assumes no responsibility for inaccuracies or omissions in the information contained in this document. Specifications are subject to change without notice. No patent rights are granted to any of the circuits described herein.