MOTORS & DRIVES

Wastewater Treatment Facility Upgrades Monitoring of VFD Systems

Ground fault detectors provide economic efficiency by improving operational availability.

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In the wastewater treatment industry, it is commonly accepted that 90 percent of electrical faults begin as ground faults. Early detection of ground faults and deteriorating equipment integrity can minimize equipment damage, enable predictive maintenance, prevent escalation to a dangerous arc fault scenario and, ultimately, ensure the protection of personnel.

An ungrounded power system has no point of the system intentionally bonded to ground. An optimal ground fault detection solution is found in the insulation monitoring device (IMD), offering low-level (Mega-ohm and below) detection of early-stage faults, including when only a single fault is present.

In grounded power systems, typically the system wye-point or artificially derived neutral is bonded to ground, either solidly grounded or impedance grounded. In this system type, optimal ground fault detection solutions use ground fault current sensors with low-level (sub-ampere) detection of early-stage faults.

A variable frequency drive (VFD) creates a mixed alternating current/direct current (AC/DC) system by rectifying an AC voltage to DC, then inverting the DC voltage to AC. The output is controlled to manage the connected load. A ground fault in such a system can be AC, DC or a combination of both.

A ground fault at the drive output terminals, in the cable to the motor or in the motor itself, will have a fundamental frequency equal to the drive-output operating frequency. Electrical noise resulting from the power-electronics switching may also be superimposed. Additionally, a VFD's operating (carrier) frequency may inadvertently impress harmonics onto the system. Ground fault detectors must overcome these challenges and still perform with precision.

One of the largest wastewater treatment facilities in British Columbia presented such a challenging environment. The facility required a solution for detecting AC and DC faults, operating while the system was both online and offline, and remaining immune to VFD harmonics. When implemented, the solution would allow maintenance personnel to find and correct insulation deterioration in the early stages, reducing the opportunities for further damage and avoiding expensive and unscheduled stoppages.

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Case Study

The facility currently has one of the highest levels of process treatment automation in the industry and treats more than 40 billion gallons of wastewater every year. It provides secondary treatment to wastewater for more than 1 million residents in 14 municipalities.

The focus of the metro Vancouver federation regulating the wastewater facility is to maximize the economic efficiency of their pumps and filters that play a key role in water treatment while maintaining a strict standard of electrical safety throughout the facility. It also specified that they did not want to experience an unanticipated drive failure at any time over the next 15 years of operation at the treatment facility.

To achieve this, technology enabling them to monitor the safety level of their electrical systems associated with the plant's pumps and filters was required. Using a ground fault detector, the facility has increased its economic efficiency by improving operational availability through optimized maintenance, while ensuring the safety of plant personnel and equipment.

The wastewater facility underwent substantial upgrades to ensure it remained online and was fully prepared to continue 24/7 operation for years to come. The upgrades focused on replacing seven VFDs with three 1,200-horsepower (hp) units for an influent pumping station and four 684-hp units for trickling filter pumps.

The upgrade was designed to ensure a minimum of 15 additional years without failure. High operational availability is paramount for a plant with an increasing wastewater treatment demand and for the surrounding municipalities that rely on its services.

Possible Challenges

Insulation failure can result from a wide number of factors in a wastewater treatment facility, including humidity, moisture, exposure to gases and mechanical stresses. In an ungrounded system, there is no deliberate connection from line to ground. A single ground fault does not generate significant leakage current and allows the system to continue operation. If the ground fault is identified and corrected in time, the system can remain online. This feature presents obvious advantages for applications that demand continuous operation.

Harmonics generated from VFDs presented additional challenges. To mitigate the effect of harmonics in the system, the plant had implemented 12-pulse input and 18-pulse input VFDs to operate their pumps and filters.

A 12-pulse input VFD is fed by a transformer with two secondary windings. An 18-pulse input VFD is fed by a transformer with three secondary windings. These configurations result in phase-shifted outputs, allowing for more pulses to be created. In theory, the increase in total pulses reduce the total harmonic distortion (THD) from input to output. In practice, however, some harmonics remain due to high-speed output switching.

To accurately monitor VFDs while online and offline, all input secondary transformers and the output filter to the motor must be monitored with an IMD. However, only one IMD may operate on a system at any given time. Multiple IMDs on the same system may see each other as a ground fault due to their connections to ground and their internal resistances.

The solution was found in one device that could handle all these challenges with the required functionality, reliability and affordability. One ground fault detector was chosen to monitor the entire system, including the transformer secondary windings, the VFD and the motor. The ground fault detector has the ability to detect AC and DC faults while remaining immune to harmonics, and has the ability to coordinate with other IMDs in the same circuit.

One feature allows internal separation between IMDs in the monitored system. When the system is energized, only one IMD remains active to monitor the entire circuit while the others remain on standby.

When the system is de-energized, three IMDs are required for the 12-pulse input (one for each transformer winding and one for the motor) and four IMDs are required for the 18-pulse input systems. The increase in IMDs is due to the presence of the diodes in the rectifier circuit, which do not allow for the flow of current when the system is offline.

Industrial communication and building automation networks are used more frequently in many industries, including wastewater treatment. Relay outputs and two-way fieldbus communication are available for connection to a programmable logic controller (PLC) or other controller.

Additionally, a built-in web server is available to read device values and configure settings in real-time. In this application, maintenance personnel use the web server to get the most up-to-date information on the status of their electrical systems.

The improved operational availability and economic efficiencies experienced at the prominent wastewater treatment facility is a significant demonstration of the versatility and functionality of deploying powerful ground fault monitoring technology in an ungrounded system. ■

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