Capture Vital Substation Data Using the SEL Digital Fault Recorder (DFR) System

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INTRODUCTION

When the power system fails, recording oscillography and operational data before, during, and after the event is vital for determining root cause. DFR systems play an important role in the substation because they capture necessary information to understand anomalous behavior in the power system and help utilities isolate failing equipment, locate faults, predict maintenance needs, and much more.

DFR systems provide supplemental recording for substations with longer recording lengths than traditional relays in order to capture more data during events. Traditional protective relays have limited event recording capabilities, including lower sampling rates, shorter recording lengths, and less data storage. Longer event recording durations, combined with scalable digital storage and faster sampling rates, allow DFRs to record large amounts of valuable data that other sources cannot capture. In some applications, DFR systems operate independently to provide monitoring-only access to the substation. In other applications, DFRs integrate with other electronic devices to provide substation automation functions (e.g., engineering access, event collection, communications processing, SCADA, etc.). In either case, these supplemental DFR data provide important context for analyzing power system events and maintaining power system integrity.

SEL DELIVERS A ROBUST DFR SOLUTION

The powerful processing capabilities of the SEL-3555 Real-Time Automation Controller (RTAC) can be combined with the flexible and modular SEL-2240 Axion® I/O platform to solve the digital fault recording needs in the substation. Whether it functions as a standalone DFR device that operates independently of the system or a combined DFR system with substation automation functionality, the Axion is a robust solution. The Axion can support over 96 current and voltage channels and hundreds of digital inputs. With a 2 TB solid-state drive, the SEL-3555 RTAC (or the lower-cost SEL-3350 Automation and Computing Platform) has plenty of storage for over 10,000 fault recordings, more than 10 days of continuous oscillography recording at 3,000 samples per second, and more than 30 days of Dynamic Disturbance Recording (DDR) for synchrophasors, fundamental quantities, rms measurements, total harmonic distortion, and more.
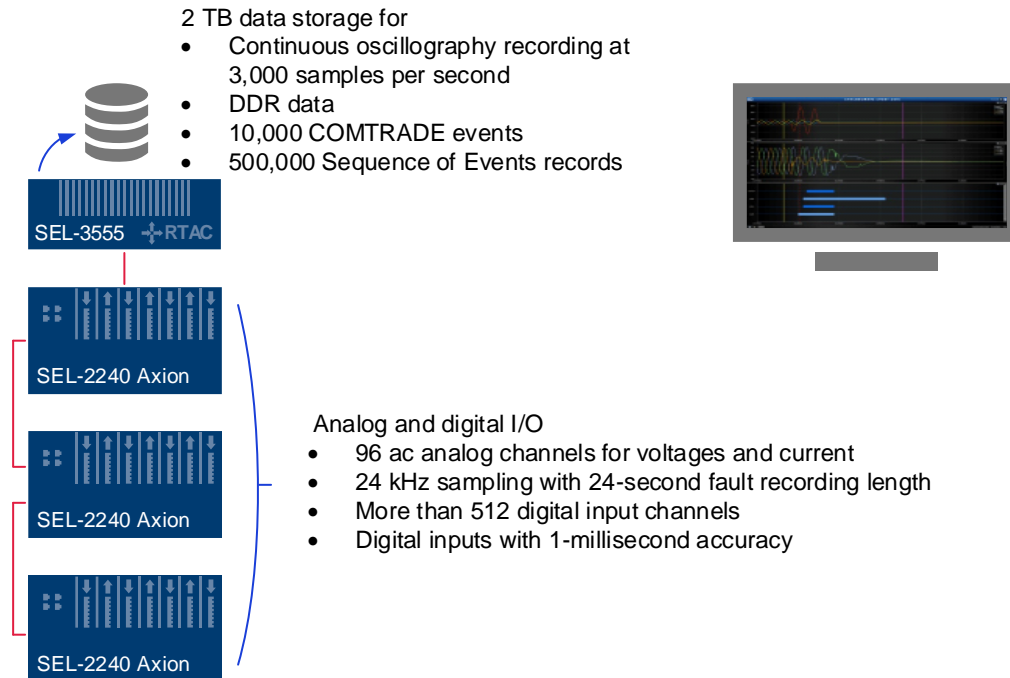
2 TB data storage for
- Continuous oscillography recording at 3,000 samples per second
- DDR data
- 10,000 COMTRADE events
- 500,000 Sequence of Events records

Analog and digital I/O
- 96 ac analog channels for voltages and current
- 24 kHz sampling with 24-second fault recording length
- More than 512 digital input channels
- Digital inputs with 1-millisecond accuracy

Figure 1   Expandable DFR Solution

PROTECTION-RATED SAMPLING AND RECORDING

The SEL-2245-42 AC Protection Module samples analog voltages and currents at 24 kHz and records for as long as 24 seconds. For longer disturbance conditions, the ac protection module can also support multiple back-to-back event recordings, allowing the system to capture extended data recordings. The protection module includes three protection class current transformers (CTs) and three potential transformers (PTs) that meet protection application requirements for transient waveforms. The CTs support 1 A_{rms} or 5 A_{rms} nominal input ratings, measure inputs up to 15 A continuous, and can operate at up to 300 A_{rm} during transient events. The PTs are optoisolated and support a nominal voltage input range of 67 to 240 V_{rms}.

CONTINUOUS 3 kHz SAMPLE RECORDING AND STREAMING

Continuously record and stream up to 96 channels of voltage and current point-on-wave samples at 3,000 messages per second using the Axion Wave Server. The SEL-3350 and the SEL-3555 RTAC each store more than 10 days of analog samples from the SEL-2245-42 AC Protection Modules. Additionally, the SEL-5702 Synchrowave® Operations Software receives, records, and analyzes this time-domain sample stream on an offsite server. The Axion Wave Server provides real-time access to substation voltages and currents in the power system. This technology simplifies NERC PRC-002 compliance by providing a simple, triggerless solution.

IMPEDANCE-BASED FAULT LOCATION

Calculate the distance to the fault using the RTAC fault location library. This library automatically parses event recording from the ac protection modules and processes them through an impedance-based fault location algorithm to provide fault distances of transmission lines. This library validates fault locations against existing protection schemes. Users can program multiple instances of the fault location function block to process fault recordings for all channels in the system.

DIGITAL FAULT RECORDING TRIGGERS

The Recording Triggers library implements simple triggers for over and under thresholds or rate-of-change excursions. IEC 61131 logic is implemented to create custom, advanced triggers and never miss an important power system anomaly. Communication protocols (IEC 61850 GOOSE, Modbus, DNP, etc.) are added to communicate cross triggers between multiple Axion systems, or SEL-2244 Digital I/O Modules are used to trigger multiple devices at one time.

EVENT RECORDING FILE TRANSFER

Extract fault and DDR data manually using the RTAC web application. Events are automatically collected and stored offsite using a variety of options, including Secure File Transfer Protocol or the SEL Blueframe® platform with Data Management and Automation software. Storing data offsite provides fast and convenient access to vital substation data, supplying immediate data for engineering analysis and long-term trending.

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