SEL Advanced Digital Fault Recorder (DFR) Solutions



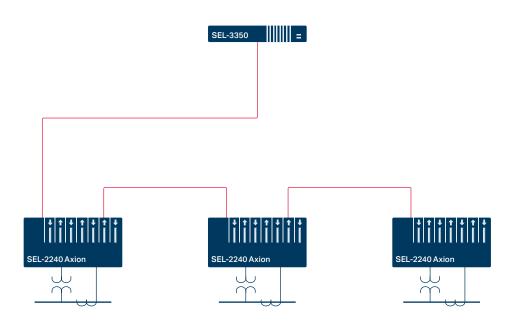
Comprehensive substation data collection, monitoring, and visualization

- Capture system events at 24 kHz, record dynamic disturbance data, log Sequence of Events (SOE) data, and locate faults.
- Leverage IED data to investigate disturbances, monitor assets, and exceed NERC PRC-002 standards.
- Stream and record continuous oscillography data at 3 kHz.
- Calculate and stream energy packets.
- Use the powerful Real-Time Automation Controller (RTAC) logic engine to monitor critical substation assets and networks.
- Analyze event reports, visualize streaming data, and centralize data collection with advanced software.



Direct Measurement Solutions

Direct measurement DFR solutions combine the SEL RTAC with the SEL-2240 Axion[®] modular I/O platform to sample currents and voltages, generate event reports, continuously record dynamic disturbance data, and log SOE data.



Scalable

Apply up to 16 protection-class CT/PT modules supporting 96 analog inputs in one Axion system for recording fault data at up to 24 kHz. Merge digital status tags from Axion I/O modules with multiple CT/PT module fault records using the Recording Group configuration to create system-level event reports.

High-Speed Fault Recording With Axion I/O

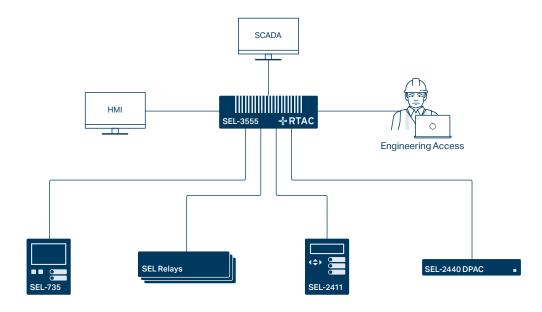
Customize fault recording by choosing from 1 to 24 kHz reports varying from 1 to 576 seconds. With up to 2 TB available for fault record storage, you can locally store up to 10,000 reports and continuously record at 3 kHz.

Use the advanced SELoGIC® engine in the Axion to trigger events. Cross-trigger other fault recorder systems or relays using IEC 61850 GOOSE messages or MIRRORED BITS® communications. The Recording Triggers extension in ACSELERATOR RTAC® SEL-5033 Software lets you configure triggers without writing a single line of code.

With $synchrow WAVe^{\circ}$ Event Viewer, you can perform detailed analysis, like fast Fourier transform (FFT) and spectral analysis, to find harmonic content in the power system.

Integrated Solutions

Integrated DFR solutions use the RTAC to collect event reports and SOE data from IEDs and continuously record dynamic disturbance data streamed by IEDs. Leverage existing systems with SEL relays and other IEDs to perform dynamic disturbance and fault recording that exceeds standards such as NERC PRC-002.





Applications

Record Disturbances and Exceed NERC PRC-002 Requirements

Capture power system data to support event analysis and locate faults. Easily exceed requirements for standards such as NERC PRC-002. Our advanced DFR solutions generate and collect event reports, capture synchrophasors for dynamic disturbance data, record SOE data, and calculate fault locations using an impedance-based algorithm.

Stream and Record Continuous Oscillography

Advanced DFR solutions support continuous oscillography streaming and recording at 3 kHz—providing significantly more visibility into power system behavior than intermittent event reports.

Our solutions use the Axion Wave Server for oscillography streaming and the powerful RTAC logic engine for oscillography recording. With 2 TB of local storage, the RTAC supports continuous oscillography recording at 3 kHz for 10 consecutive days or more.

Since this method does not rely on triggers, it guarantees that power system events will never be missed. It also streamlines deployment, allowing you to exceed compliance with standards such as NERC PRC-002—even without configuring triggers. You can easily export data to CSV and COMTRADE data formats to support compliance activities.

Our advanced DFR solutions also support many months of recording for other analog data, such as synchrophasors from any phasor measurement unit (PMU) clients.

Proactively Monitor Substation Assets

In addition to performing core DFR functions, the RTAC logic engine supports advanced monitoring for substation assets, such as CTs/PTs and networks. You can also configure custom logic to support applications such as monitoring breaker wear.

Measure Energy With Greater Precision

Traditional phasor-based measurements rely on steady-state conditions. Industry-exclusive energy packet technology from SEL precisely reports the energy flow under all system conditions, regardless of the frequency, angle, or distortion. Process Axion Wave Server samples in the RTAC logic engine to calculate, stream, and record energy packets.

Supporting Software

Simple Configuration

ACSELERATOR RTAC is a graphical, easy-to-use software tool for configuring the SEL RTAC. Its DFR library extension allows you to build an advanced DFR system in minutes using a simple settings form.

| 1 | | | | | Axion DFR - SEL AcSELerator RTAC | | | 2022 |
|--|----------------------|--|---|---|---|--|------------------|-------------------------|
| Effic Home Insert | View | | | | | | | 9- |
| Devices | v Thems 304L | t Import Access Pont Folder IEC Thems Southers Folders Use | 61131-3 Tag Lists er Logic Tag Lists | Recording Groups Recording Groups Recording Groups Continuous Recording Group | Extensions CDC Type 2 Client | | | 2 |
| Project Image: Control of the second se | Digital_Fault_Record | der | | | CDC Type 2 Server | | | |
| | | Project Properties Digital_Fault_Recorder | | | CtPt Monitor | | | |
| | Digital Fault Record | ult Recorder (Version: 1.35.0.0) | | | Digital Fault Recorder | | | |
| | General Settings | Setting | Value | Range | Dynamic Disturbance Recorder | | Comment | |
| - 🤁 Tag Processor | Node Configuratio | n 🕨 🖾 General | | | Email Plus | | | |
| Tags | Substation Assets | Build DFR | | False, True | Falling Conductor Protection | the DFR settings. | | |
| System | Controller | System Nominal Prequency System Phase Rotation | 60 ABC | 50,60 ABC_ACB | FTP Sync | order. | | |
| - () Main Controller - () System_Time_Co | A CONTRACTOR OF C | System Phase Rotation Station Name | | ABC,ACB String (1-64 chars) | Indirect Tagging | e DFR is monitoring. Station Name is used in the COMTRADE event records configuration file. | | |
| - () SystemTags | | Company Name | | String (1-64 chars) | Recording Triggers | y Name is used in the COMTRADE event records configuration file. | | |
| Contact I/O | | Minimum Live Voltage | 5.00 | REAL, 0.00 - 100.00 | Report Generator | assets nominal voltage, required to enable recording trigger conditions based on voltage measurements. | | |
| - D Access Points | | Store DFR events in SOE Log | | False, True | Simple Tag Mapper | and Trigger conditions in the RTACs SOE log. | | |
| - 📁 Access Point Router - 📁 User Logic | 1 | Enable Local DFR Monitoring | | False, True | | ing of the status of the DER with output to RTAC auxiliary LEDs and Digital Output contacts. | | |
| - Virtual Tag Lists | | Enable Synchrophasor Server | | False, True | Set this value to True to enable PMU output | for all configured assets via a IEEE C37.118 Synchrophasor Server. | | |
| Digital_Fault_Record | er 1 | Recording Settings - Continuous Include High-Resolution Channel | | False, True | Indiada hish caralatian 3 kiri analan shannal | is in the Continuous Recording records. Disable to save disk space and allow for longer retention durations on smaller drives. | | |
| | | Data Retention Duration | | 1-365 (days) | The data retention period for Continuous Re | | | |
| | | Recording Settings - Fault Record | | a man freeday | | | | |
| | | Recording Rate | 24 | 24,8,4,2,1 | Fault recording rate in kHz. | | | |
| | | Recording Length Min. | | REAL, 0.1 increments from 0.5 to 24 | The minimum length of the fault oscillography | | | |
| | | Recording Length Max. | | REAL, 0.1 increments from <min> to 24</min> | The maximum length of the fault oscillograph | | | |
| | | Pre-Trigger Length | 2 | REAL, 0.01 increments from 0.05 to <min-0.05></min-0.05> | The pre-trigger length of the fault oscillograp | shy capture, in seconds | | |
| | | | | | | | | |
| | | 1 of 15 | | | | | | 2 |
| | - | | | | | | | |
| | 1EC 61131: But | ld | | | | | | 3 |
| | | Application: SEL_RTAC.Application | | | | | | - |
| | Typify code | 0 errors, 0 warnings | | | | | | |
| AcSELerator RTAC Ready | Coubse contress | o oraș o naringi | | | | (A Logic For | nne 🙆 Offine 🔳 (| antabase 🔰 Password Off |

Automated Data Collection

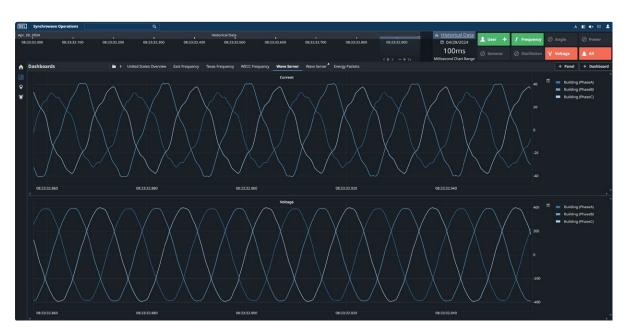
Use the Data Management and Automation (DMA) application suite on the SEL Blueframe® application platform to automate and centralize the collection of event reports and SOE data from multiple DFR deployments.

| DISTURBANCE MO | DNITORING REPORT: 4/8/2022, 2:0 | 8:45 PM | | | L+ 1 | Export Report 🕒 New Repo | rt 🕜 Edit Report | |
|------------------|---------------------------------|------------------|------------|---------------|----------------|----------------------------|-------------------------|--|
| Search: | | | | | Refresh Report | Details | Download Event | |
| lesource | ▼ Timestamp | ▼ Event | ▼ Message | ▼ Туре | | Resource: Z2_SEL-451-2 (| 4) | |
| Z2_SEL-451-2 (4) | 11/19/2021, 12:44:17.651 AM | Relay | Enabled | SOE | | Timestamp: 4/8/2022, 2:08 | :24.374 PM | |
| Z2_SEL-451-2 (4) | 11/19/2021, 12:44:17.651 AM | Power-up | Group 1 | SOE | | Event: TRIG | | |
| 22_SEL-451-2 (4) | 7/23/2021, 3:56:20.231 PM | Settings changed | Class R CC | SOE | | Type: Oscillography | | |
| Z2_SEL-451-2 (4) | 7/23/2021, 3:56:17.823 PM | Reclose Shot 0 | Asserted | SOE | | | | |
| Z2_SEL-451-2 (4) | 7/23/2021, 3:56:17.821 PM | Settings changed | Class L CC | SOE | | Recordings: 4 | | |
| Z2_SEL-451-2 (4) | 7/23/2021, 3:56:17.821 PM | Relay | Enabled | SOE | | View Event: Compre | mpressed - FILTERED 🛛 🔻 | |
| 22_SEL-451-2 (4) | 7/23/2021, 3:56:17.764 PM | Relay | Disabled | SOE | | Her creat. | | |
| 22_SEL-451-2 (4) | 7/23/2021, 3:55:40.650 PM | Relay | Enabled | SOE | | Resource ID: 00000000-0004 | 1-4000-8000-00000000104 | |
| Z2_SEL-451-2 (4) | 7/23/2021, 3:55:40.650 PM | Power-up | Group 1 | SOE | | | | |
| Z2_SEL-451-2 (4) | 7/7/2021, 5:09:18.397 PM | Settings changed | Class R CC | SOE | | | | |
| Z2_SEL-451-2 (4) | 7/7/2021, 5:09:15.851 PM | Reclose Shot 0 | Asserted | SOE | | | | |
| 22_SEL-451-2 (4) | 7/7/2021, 5:09:15.849 PM | Settings changed | Class L CC | SOE | | | | |
| Z2_SEL-451-2 (4) | 7/7/2021, 5:09:15.849 PM | Relay | Enabled | SOE | | | | |
| Z2_SEL-451-2 (4) | 7/7/2021, 5:09:15.793 PM | Relay | Disabled | SOE | | | | |
| Z2_SEL-451-2 (4) | 7/7/2021, 5:08:46.650 PM | Relay | Enabled | SOE | | | | |
| Z2_SEL-451-2 (4) | 7/7/2021, 5:08:46.650 PM | Power-up | Group 1 | SOE | | | | |
| 22_SEL-451-2 (4) | 4/8/2022, 2:08:24.374 PM | TRIG | | Oscillography | | | | |
| 22_SEL-451-2 (4) | 4/8/2022, 2:07:21.624 PM | TRIG | | Oscillography | | | | |
| Z2_SEL-451-2 (4) | 4/8/2022, 2:06:29.503 PM | TRIG | | Oscillography | | | | |
| 2_SEL-451-2 (4) | 4/8/2022, 2:05:26.439 PM | TRIG | | Oscillography | | | | |
| 2_SEL-451-2 (4) | 4/8/2022, 2:04:21.191 PM | TRIG | | Oscillography | | | | |
| 2_SEL-451-2 (4) | 4/8/2022, 2:04:16.082 PM | TRIG | | Oscillography | | | | |
| 2_SEL-451-2 (4) | 4/8/2022, 2:04:15.018 PM | TRIG | | Oscillography | | | | |
| Z2_SEL-451-2 (4) | 4/8/2022, 2:03:14.147 PM | TRIG | | Oscillography | | | | |
| Z2_SEL-451-2 (4) | 4/8/2022, 2:01:13.030 PM | TRIG | | Oscillography | | | | |

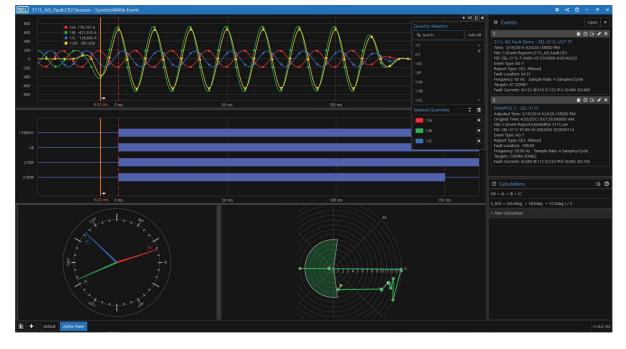
DMA Disturbance Monitoring applications on SEL Blueframe

Data Visualization and Analysis

View and analyze 3 kHz continuous oscillography data and synchrophasor data in real time using SEL-5703 Synchrowave Monitoring software. Access and analyze event reports with SEL-5601-2 SYNCHROWAVE Event software. Synchrowave software provides comprehensive visualization capabilities, such as viewing multiple event files simultaneously and time-aligning synchrophasor data with event reports.

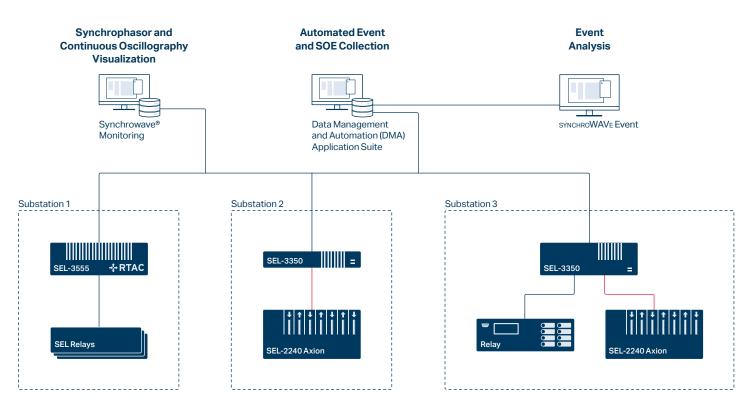


Synchrowave Operations software



SYNCHROWAVE Event software

Complete Solution With Supporting Software



Example 24-Channel DFR Solution Components*

| Product | Part No. |
|--|--|
| SEL-3350 RTAC Processor: Quad-core 1.6 GHz RAM: 8 GB Storage: 2 TB Continuous Recorder license | 3350#4MD8 |
| SEL-2240 Axion Preassembled Axion with 19" rack-mount backplane, Power Coupler with Ethernet, four AC Protection Modules (12 current and 12 voltage channels), and one Digital Input Module (24 digital input channels) | 2240#T4E2 |
| SEL-5601-2 SYNCHROWAVE Event Event analysis software | 5601153WX0 |
| Additional Options | |
| SEL-5703 Synchrowave Monitoring Synchrophasor and continuous oscillography visualization and archiving software | 5703#FB79 |
| SEL DMA Disturbance Monitoring Application Package Automated event and SOE collection software | Available on SEL computing platform hardware or virtual machine deployments. Contact your sales representative for ordering information. |

Specifications

| General | | | | | |
|------------------|---|--------------------------|--|--|--|
| Analog Inputs | 3 Voltages: 6.7–240 V_{LN} | Axion Wave | Stream continuous oscillography | | |
| Per CT/PT Module | 3 Currents: 0.1–20.0 Arms | Server | analog data at 3,000 samples per second to Synchrowave Operations or | | |
| I/O Modules | Digital input: 24 contact inputs | | Synchrowave Monitoring. | | |
| | (24, 48, 110, 125, 220, and 250 Vac/Vdc) | Continuous Recorder | Record currents, voltages, and frequency | | |
| | Standard digital output: 16 standard control outputs | | inputs up to 250 times a second for dynamic disturbance records. | | |
| | All Form A, all Form B, or mixed | | Record continuous oscillography analog data at 3,000 samples per second. | | |
| Configuration | Use the DFR library extension in AcSELERATOR RTAC software to configure hardware, channels, fault recording triggers, SOE logging, dynamic | | Store up to 2 TB of data (more than 10 days of continuous oscillography with 96 channels). | | |
| Fault Recording | disturbance recording, fault locating, and more. Sampling rates: 1, 2, 4, 8, and 24 kHz, | Synchrophasors | Conformance: IEEE C37.118.1-2011 as amended by IEEE C37.118.1a-2014, IEEE C37.118.2-2011 | | |
| radit necoraling | software-selectable | | Accuracy: Level 1 as specified by | | |
| | Transient Fault Record Length Prefault time: 0.05 s — (max. event | | IEEE C37.118 Message rates: 1 to 120 Hz | | |
| | length -0.05 s) | | Measurements: Software-selectable | | |
| | Individual records as long as: 24 seconds for 24 kHz | | (P or M class) | | |
| | 72 seconds for 8 kHz | | Phase voltages | | |
| | 144 seconds for 4 kHz 288 seconds for 2 kHz | | Phase currents | | |
| | 576 seconds for 1 kHz | | Positive-sequence current, frequency, df/dt | | |
| | Data format: IEEE C37.111-2013 COMTRADE | Fault Location | Determine the distance to the fault using | | |
| | File naming: IEEE C37.232 COMNAME | | the SEL RTAC impedance-based fault | | |
| | Store up to 10,000 COMTRADE events. | | location library. | | |
| Cross-Triggering | Cross-trigger multiple SEL Axions using | Time Synchronization | IRIG-B | | |
| | digital I/O with SEL-2244 modules or serial or Ethernet communication links | Synchionization | Precision Time Protocol (PTP) | | |
| | between SEL RTACs. | Operating Temperature | SEL-3350 RTAC: -40° to +85°C (-40° to +185°F) | | |
| SOE Recording | Store up to 500,000 records with 1 ms accuracy. | | SEL-3555 RTAC: -40° to +75°C (-40° to +167°F) | | |
| | | | Axion modules: -40° to $+85^{\circ}$ C | | |

For additional specifications, please refer to the Axion, SEL-3350, and SEL-3555 datasheets. For more information about streaming and recording continuous oscillography and energy packets, please see the Continuous Waveform Recording flyer and application guide AG2023-19.



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(-40° to +185°F)