## SEL Advanced Digital Fault Recorder (DFR) Solutions



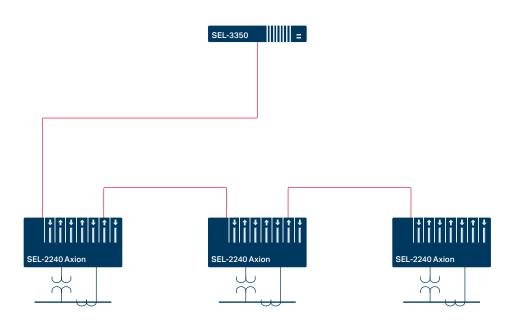
# Comprehensive substation data collection, monitoring, and visualization

- 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<sup>®</sup> 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

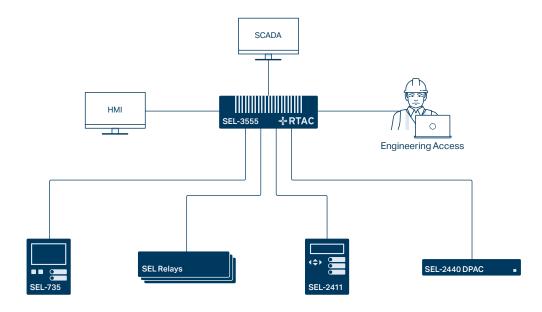
Customize fault recording by choosing from 1 to 24 kHz reports varying from 1 to 576 seconds. With up to 2 TB available for fault record storage, you can locally store up to 10,000 reports and continuously record at 3 kHz.

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

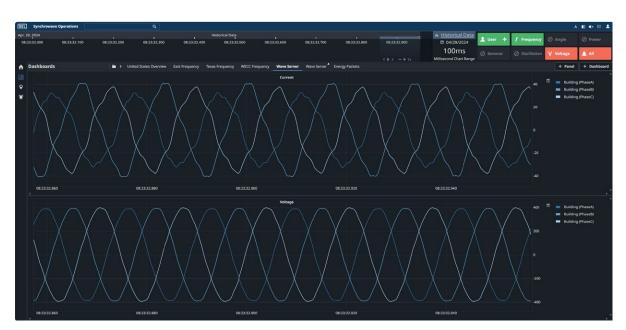
Use the Data Management and Automation (DMA) application suite on the SEL Blueframe® application platform to automate and centralize the collection of event reports and SOE data from multiple DFR deployments.

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				

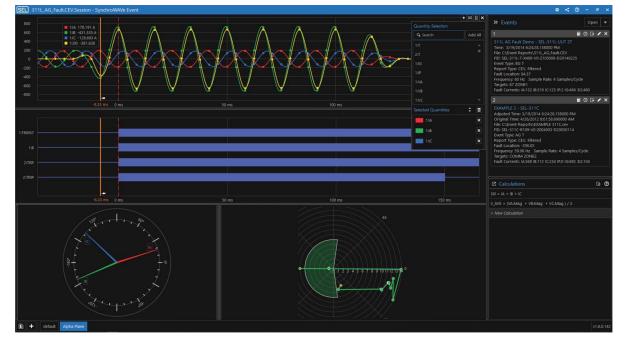
DMA Disturbance Monitoring applications on SEL Blueframe

#### 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.

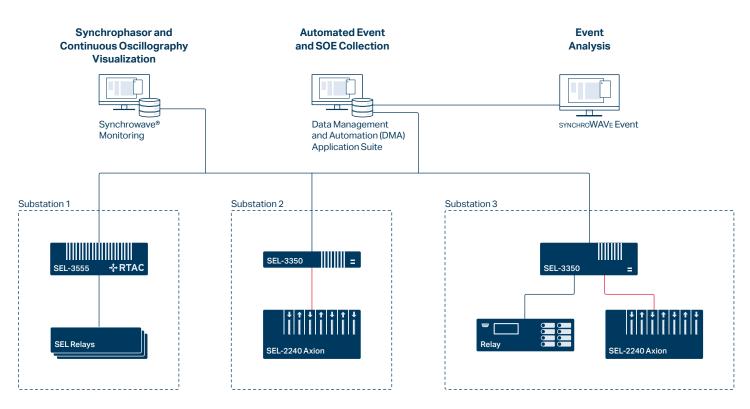


#### Synchrowave Operations software



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		
	<b>Transient Fault Record Length</b> 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: $-40^{\circ}$ 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.



Making Electric Power Safer, More Reliable, and More Economical +1.509.332.1890 | info@selinc.com | selinc.com



(-40° to +185°F)