

A Sequence of Events Recording (SER) system provides a system-wide, computerized event log with a list of all events, ordered and categorized by various attributes, such as timestamp, equipment/circuit name, event type, state change, and time-quality indicator. The SER system enables “root-cause analysis” to identify potential problems before they lead to an outage—or to answer the question “what happened and when?” to minimize downtime if an event does occur. In addition, SER data enables other diagnostics tools, such as measurement of circuit breaker operating count and operating times to compare with benchmarks for preventative maintenance and to support arc flash safety.



SYSTEM DESCRIPTION

SER units shall be equipped with “high-speed” (1 msec resolution, +/- 0.5 msec accuracy) digital inputs for monitoring and recording all state changes (OFF-to-ON and ON-to-OFF), including the following:

- Breaker status: OPEN (via “a” aux. contact, normally-open)
- Breaker status: CLOSED (via “b” aux. contact, normally-closed, redundant to ensure positive indication)
- Breaker trip: TRIPPED (via relay “trip” or breaker “bell alarm” contact)
- Drawout breaker position: Racked OUT/IN (via cell switch, or TOC)
- Electrically-operated breaker OPEN/CLOSE command indication (via switch contacts, allows measurement of operating time)
- Differential relay, ground fault, undervoltage, overvoltage, reverse power, sync check (normal, alarm/tripped), TVSS status
- Auto-transfer status (source1, source2, test)
- UPS switching status (normal, static bypass, maintenance bypass)
- Other alarm conditions (refer to customer drawings for monitored points)

Provide one SER at locations that include an advanced Power Quality Meter (PQM) and connect the SER’s trigger output to the PQM to trigger waveform capture with any event. Provide additional SERs as required to monitor status points, as specified on customer drawings.

PRECISION TIME SYNCHRONIZATION

Precision Time Synchronization shall be provided as shown on the drawings to synchronize all devices in the EPMS accurate to within 100 microseconds of each other sufficient to provide time-stamping of events with 1-msec resolution. The EPMS supplier shall provide the design of the precision time synchronization system as part of the EPMS.

- A. Precision Time Protocol (PTP):** Precision time synchronization shall be accomplished using PTP (defined by IEEE 1588) over the Ethernet network enabled by Sequence of Events Recorders from Trystar, LLC. or approved equal.
- B. PTP Profile:** The PTP precision time synchronization over Ethernet shall be capable of providing the specified accuracy without the need for IEEE 1588-compliant network equipment required for higher accuracy systems. Devices shall support the PTP Profile (based on End-to-End Default Profile defined in IEEE 1588-2008, Annex J and IEEE 1588-2019, Annex I) to achieve the specified performance and scalability.
- C. Precision Time Reference:** The first SER shall accept its time source via IRIG-B or DCF77 (from a GPS receiver/clock) or via NTP or Modbus TCP over Ethernet. This SER shall in turn serve as PTP grandmaster for all other SERs and other PTP-compatible devices, with automatic synchronization of PTP slaves to within 100 microseconds. A minimum of 200 PTP slaves shall be supported by any device serving as PTP grandmaster.
- D. Legacy Time Protocol Support:** Devices not capable of supporting PTP directly shall be synchronized to the same time reference using the appropriate PTP Legacy Interface to the SER, using the legacy time protocol supported by the device (Unmodulated IRIG-B007, C37.118, IEEE 1344, DCF77, 1per10 or ASCII/RS-485 via 5 Vdc, 24 Vdc or RS485 outputs.). Sequence of Events Recorders (SER)

SEQUENCE OF EVENTS RECORDERS (SER)

Sequence of Events Recorders shall be model SER-32e with 32 digital inputs in base configuration; and accommodate up to two expansion modules supporting 8 digital inputs or 8 relay outputs within each module from Trystar, LLC., or approved equal. The EPMS supplier shall program each SER with actual equipment and channel names and state descriptions for display on the embedded web pages. Submit names, descriptions, and other information for approval before configuring the SERs.

- A. Event Recording:** The Event Recorder shall be equipped with “high-speed” (1-msec resolution, +/- 0.5 msec accuracy) digital inputs for up to 48 channels to monitor and record all state changes (OFF-to-ON and ON-to-OFF). To ensure reliable operation and avoid over-sensitive, “nuisance” event recording, each input channel shall be individually configurable as follows:
 - 1. Filter (minimum time delay to avoid false events caused by noise)
 - 2. Debounce (temporarily disable event recording following an event, to prevent generation of multiple event records for a single state change)
 - 3. Chatter (max. number of events for a given input channel, to avoid filling memory with erroneous events associated with a faulty input signal)
 - 4. Scan Status (0 = disabled, 1 = enabled)
 - 5. Channel Description (32 characters)
 - 6. OFF-state Description (16 characters)
 - 7. ON-state Description (16 characters)
 - 8. Inverted (0 = normal, 1 = inverted—reports status opposite the sensed state)
 - 9. Trigger Output (0 = disabled, 1 = enabled)

- B. Event Log:** The Event Recorder shall monitor the status of all input/output channels and record up to 8192 events in non-volatile memory, accessible from multiple masters. Each event record shall contain descriptive information as follows:
1. Date/time stamp (1-msec resolution)
 2. Channel name
 3. Event type
 4. Input/output status
 5. Time quality
 6. Unique sequence number
 7. Delta time between events
- C. Relay Outputs:** The Event Recorder [model SER-32e] shall have two expansion modules capable of supporting eight (8) relay outputs per module, controllable remotely (open/close) over an Ethernet network using Modbus TCP.
- D. Discrete Trigger Output:** The Event Recorder shall have a discrete output, configurable to trigger an action coincident with an event, such as waveform capture (WFC) by a compatible power meter.
- E. Data Logs for EPSS Test-Compliance Reports:** The Event Recorder shall have sixteen (16) configurable data logs with group assignments to facilitate reporting of Emergency Power Supply System (EPSS) testing. When any group member (input or output) changes state, all members' states are recorded.
- F. Operations Counters:** The Event Recorder shall maintain counters for each channel to count all transitions (OFFto-ON and ON-to-OFF), as well as date/time of last reset, individually per channel.
- G. Ethernet Network Communications:** The Event Recorder shall support Ethernet network communications using Modbus TCP, secure Modbus TCP, RESTful API and embedded web server. The device shall automatically sense network operating parameters, such as network speed (10/100 Mbps) and wiring polarity. The number of simultaneous Modbus TCP or Secure Modbus TCP connections (sockets) shall be 44. Additionally, the Event Recorder shall support SNMP (Simple Network Management Protocol) according to versions 2 and 3, and support user configurable Traps and Informs.
- H. Web Interface:** The Event Recorder shall feature an embedded secure web server to allow monitoring and setup over an Ethernet network using a standard web browser. The following functionality shall be provided via the web interface, over a network:
1. Status Monitoring page shall display ON/OFF status of each input (and output).
 2. Counters page shall display the number of operations for each input (and output) since the last reset and include the date and time of the last reset, per channel. A separate Resets web page shall be provided to allow operations counters for individual channels or all channels to be reset.
 3. Events Monitoring page shall display historical event data (event log), with sortable columns for date/time, channel, event type, status, time quality, delta time (calculated time between events) and unique event sequence number.
 4. System Log page (Audit Log) shall display all events associated with the operation of the Event Recorder separate from the events recorded for inputs and outputs. Each log entry shall include date and time, source of the request, a category, record type, time quality, a unique sequence number, and the requestors user name and IP address.
 5. Test page shall provide a means for performing a simulation test to override status of inputs to test application software. The test page shall support manual and automated simulation of each input.
 6. Diagnostics page shall provide device information and statistics to aid analysis and troubleshooting.

7. Setup pages shall allow the user to change setup parameters and store them in device non-volatile memory.
 - a. Network page shall allow the user to configure communications settings including DHCP, IP address, device identification, device name, enable Modbus communications, select secure communications and set thresholds for network monitoring alarms.
 - b. Time page shall provide the ability to configure the devices time source (PTP, NTP, IRIG-B007, C37.118, IEEE 1344, DCF77, Inter-device over RS485, Modbus TCP), time synchronization output (PTP, IRIG-B007, C37.118, IEEE 1344, DCF77, 1 pulse per 10 seconds, ASCII (ASCII + Quality time code over RS485), local time offsets, and the date format.
 - c. Input page shall allow the user to enable individual channels or all channels, define a name for each input and define text for both ON and OFF status. The Input page shall also provide configuration settings to include filter, debounce and chatter, allow individual channels to be inverted and allow the user to assign any input channel to the Event Recorder's trigger output.
 - d. Output page shall allow the user to enable individual outputs or all outputs, assign a name per channel and define text for both the ON and OFF states.
 - e. SNMP page provides the ability to enable either version 2c or version 3, enable SNMP Informs or Traps, and select triggering event types.
 - f. HTTPS page provides information on current SSL certificate, allows the user to generate a self-signed certificate, download an existing certificate or upload a custom certificate to the Event Recorder.
 - g. Admin page allow the administrator of the Event Recorder to define login credentials for both administrator accounts, both upload and download device configuration files, update the device's firmware, access diagnostic logs, and remotely restart the device.
- H. **Local Display/Keypad:** The Event Recorder shall have a backlit LCD display and keypad or touchscreen to display key data to facilitate commissioning. Displayed items shall include status of inputs/outputs, time sync, current date/time, and device settings. Local setup of Ethernet communications shall also be supported.
- I. **DB15 to Screw-terminal Adapter:** As an option to facilitate wiring of the precision time input and output, an adapter shall be provided to connect to the Event Recorder's DB15 connector and offer a screw-type terminal to facilitate wiring and a diagnostics LED to indicate the presence (or absence) of a valid IRIG-B or DCF77 signal, to assist in commissioning.
- J. **DIN-rail Mounting:** The Event Recorder shall be designed for standard DIN-rail mounting (EN 50022, 35 mm x 15 mm).
- K. **Multiple Masters:** The Event Recorder shall be capable of operating with multiple masters. In G2 (SER32e) devices, there is no fixed limit on the number of concurrent TCP connections. However, the maximum number of HTTPS connections is 1,024 (web server default). The total limit on Modbus TCP (or Secure Modbus TCP) connections (sockets) is 44. At least 32 simultaneous Modbus TCP sockets shall be supported. In addition, multiple, secure web browsing sessions (HTTPS) shall be possible.

L. Regulatory Compliance: The Event Recorder shall be tested to applicable standards as follows:

1. UL-Listed per component requirements for UL-508, NQA-cULus (UL 61010-1, UL 61010-2-201).
2. FCC compliance: FCC Part 15 Subpart B, Class A Digital Device, Radiated Emissions.
3. CE mark (EN 61010-1, EN 61010-2-201)
4. RoHS-compliant, Lead-free, and Halogen-free. Compliant with California Proposition 65 and Conflict Minerals requirements. (Environmental and sustainability.)
5. The Sequence of Events Recorder shall be designed and manufactured in the USA.

M. Technical Specifications: The Event Recorder shall meet or exceed the following:

1. Inputs. Rated for 24Vdc.
2. Outputs. Rated for 24Vdc, 500mA to 1A.
3. Control power. Nominal rating of 24Vdc, 7VA burden.
4. Operating temperature. -25C to +70C