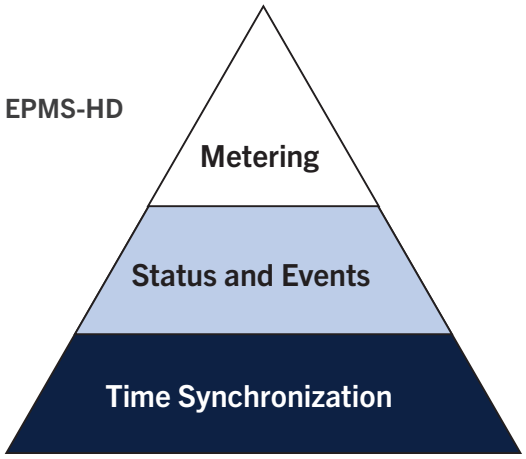
EPMS-HD—Reliable Power Starts with Precision Timing



Essential elements of High-Def Power Management

Power Management in High Definition

Electrical Power Management Systems (EPMS) provide visibility into complex and dynamic networks from the electric utility service points and alternate energy sources all the way to critical loads. In the past, energy costs were the primary focus of the EPMS. Today, that's just the beginning.

Energy Metering—Necessary but not Sufficient

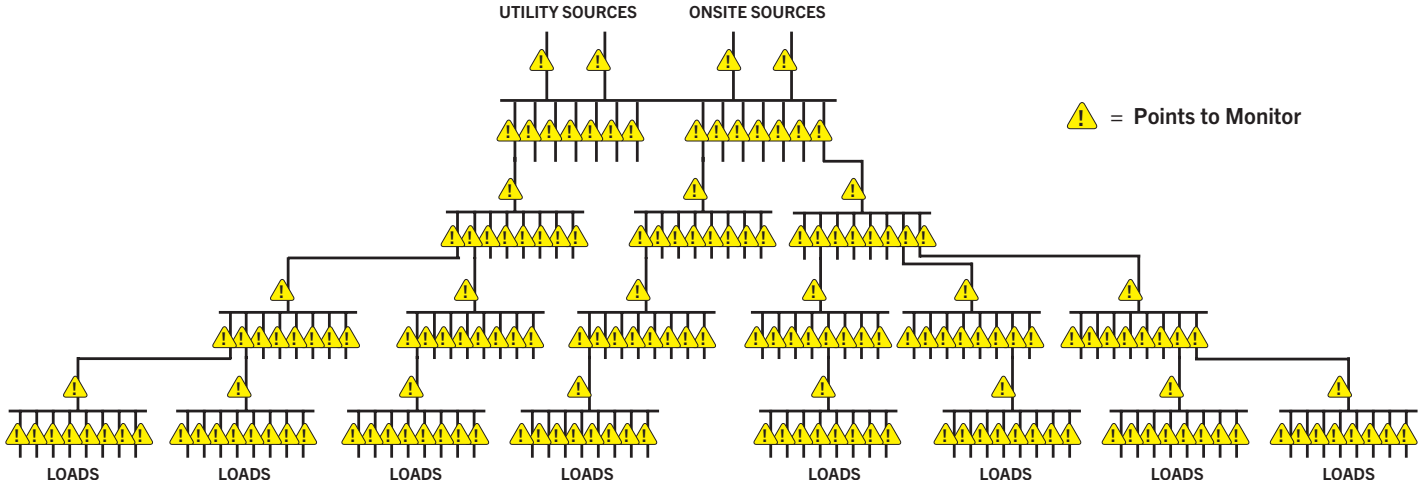
Energy savings have always been the "tip of the iceberg," easy to understand, easy to justify investment in EPMS infrastructure. Large systems may include a hundred power meters deployed in key locations. But this leaves thousands of unmonitored points—potential blind spots waiting to cost you time and money.

Monitor Everything—More Data = Better Decisions

Today, the "Internet of Things" has created the expectation that every device should be networked. Sequence of Events Recorders (SER), with up to 32 high-speed digital inputs, off er an affordable means to monitor everything, especially points nearest the loads. For the facilities engineer on-site, this saves the time to traverse the building or campus just to find out which breaker(s) tripped, when and why. For those managing the site remotely, this data is simply a necessity.

Synchronize All Clocks—the Foundation for Meaningful Analysis

EPMS devices must share a common time reference for data to make sense, yet time synchronization is sometimes overlooked. How fast is fast enough? In today's complex electrical networks, state changes can occur in a quarter-cycle or less, and so 1-msec resolution is the commonly accepted benchmark for meaningful analysis. Time synchronization must be on an order of magnitude better, or 0.1 msec (100 microseconds). Today, Precision Time Protocol (PTP per IEEE 1588)makes such hi-res time synchronization over Ethernet simple, aff ordable and scalable.



A commercial/industrial power network branches radially from sources to loads; high defi nition means visibility at every point, all devices synchronized.

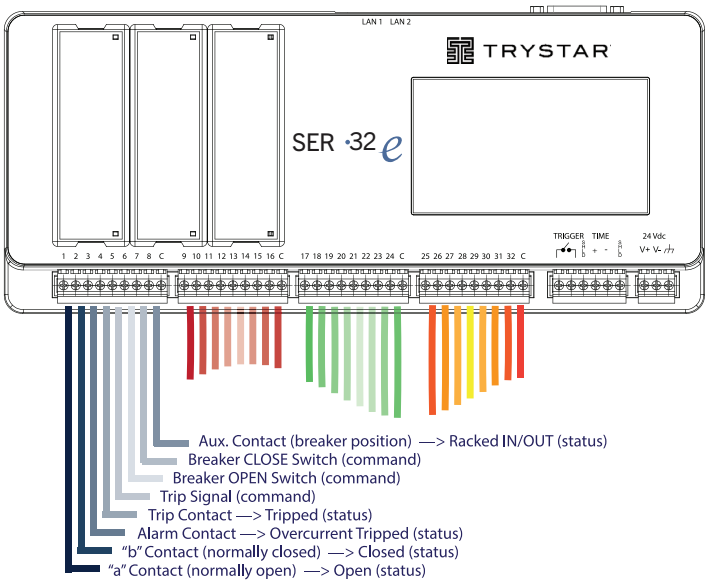
STATUS MONITORING

Know the Status of Every Point in Your System

Sequence of Events Recorders (SER) provide high-speed digital inputs to monitor status of up to 32 points. They complement relays and meters that don't support event recording or whose I/O count is not sufficient. Their primary purpose is typically for breaker monitoring, but they can monitor the status of any discrete contact (off or on), and so they are used in a variety of applications, as shown at left.

SER typical monitored points:

- Breaker status: open/closed/tripped
- Relay trip signal: normal/trip
- Control switches: open/close commands
- Control scheme status: auto/manual/test
- Auto-transfer switch (ATS) status: normal/emergency/test
- UPS status: normal/transfer/bypass
- Generator status: stopped/running
- Battery status: normal/alarm
- TVSS, transformer temperature, fan status and other auxiliary contacts and alarms



The Trystar SER Event Recorder has 32 high-speed digital inputs; typical connections are shown (low voltage drawout circuit breaker).

Typical Breaker Monitoring Options

The most economical option is to use one SER to monitor up to 32 circuit breakers, each through its auxiliary contact (“a” contact). For breakers with a separate “trip” (or “alarm”) contact, use 2 inputs per breaker to report open/closed/tripped status. For status monitoring requiring positive indication of open/close (vs. wiring defects, control power loss, etc.), use 3 inputs per breaker: “a” contact (open), “b” contact (normally closed), and “trip” contacts. Other inputs can be used to provide additional valuable data, such as external trip signal, switch status or other control scheme data. More data enables better decisions.

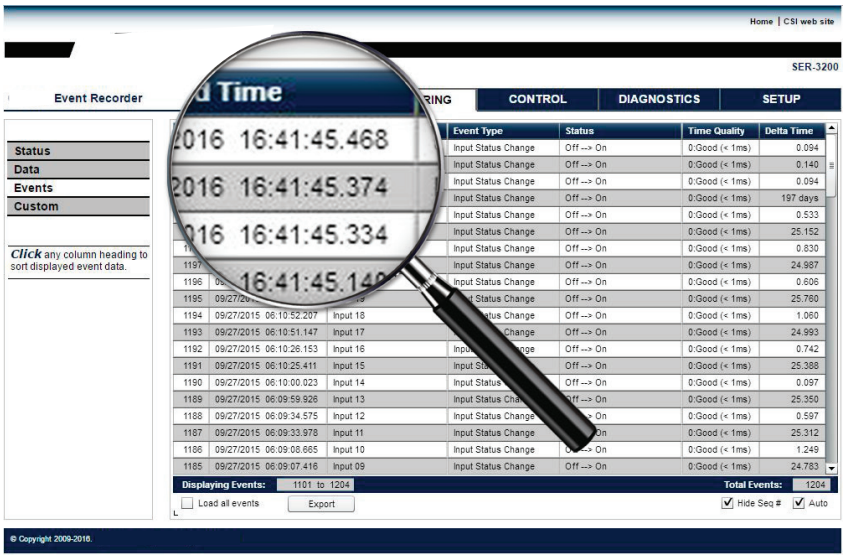
Operations Counters

Operations counters are maintained for all 32 channels, with date/time of last reset. These can be useful for monitoring the number of breaker operations, the number of battery charge cycles, or any other on/off transition. Each channel can be reset individually, reflecting the number of operations since last reset.

EVENT RECORDING

SER: The Black-Box Recorder for Power Systems

Like an airliner’s black box recorder, Sequence of Events Recorders (SERs) record exactly what happened and when, to 1 msec. Unlike the airliner example, this data is used again and again. SER systems record the exact time of the initiating event, as well as the resulting series of events, all in chronological order. Some events are bad because they cannot be anticipated, and even worse if they cannot be explained. Other events are designed responses (breaker trips, control system actions, etc.). It is equally important to verify that these events happened on time—or know if they didn’t and why.



Trystar SER Event Recorders have a built-in web server for monitoring, setup and diagnostics. (The Events web page is shown above.)

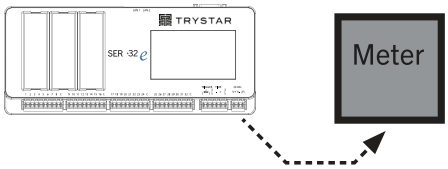
Elapsed Time Measurement (Stopwatch Function)

By recording the exact time of both the starting event (command) and ending event (status), the SER measures elapsed times, such as circuit breaker opening times—to 1 ms. Breaker opening times vary as a result of many factors, and so it's helpful to compare under similar load conditions. By monitoring several start/end pairs—open, close or trip command (from a relay, PLC or switch)—and the resulting status change (breaker trip, a or b contacts), the SER reports opening times under different loading:

- No load (initiated by manual control switch).
- Normal load (initiated by control scheme).
- Overcurrent trip (initiated by relay trip signal).

Trigger Output for Waveform Capture by a Power Meter

In addition to precise time synchronization via PTP, a second form of synchronization provides critical data for power system analysis. The SER can be configured to output a trigger pulse for any detected status change. Typically, this is used with a compatible power meter to capture voltage and current waveforms associated with the event, both pre- and post-event.



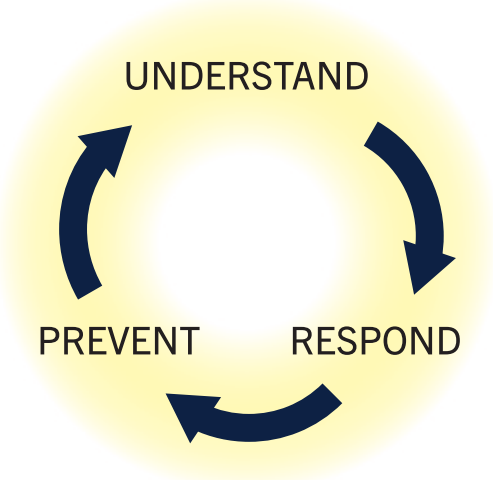
Trystar SER, with Trigger Output for Waveform Capture

Whether the power meters themselves have the benefit of high-res time sync or not, it is easy to correlate the waveforms with the precise time-stamp by the SER device, making the SER's I/O a logical extension of the power meter's own capabilities.

TIME SYNCHRONIZATION BENEFITS

Time-sync is Essential for High-Def Power Management

Precision timing is essential for modern industrial/commercial power systems. In complex electrical networks, state changes can occur in a quarter-cycle or less. System-wide clock synchronization is essential for meaningful analysis. A common time base is foundational to ensure a "single version of the truth."



▶ **Understand—Use as a forensics tool to gain knowledge**

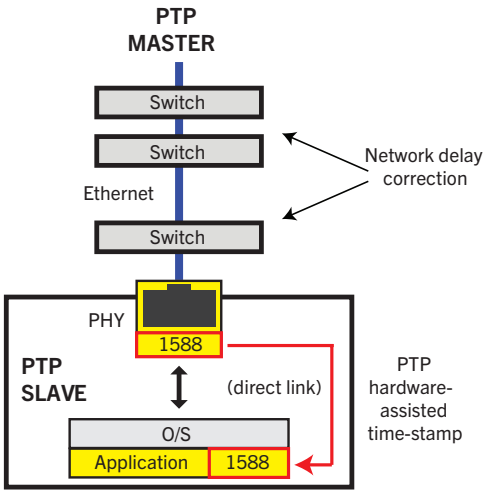
- Perform root-cause analysis based on reliable data.
- View current and voltage waveforms captured with each event.
- Determine if the initial source was internal or external.

▶ **Respond—Verify that systems operated as designed**

- Evaluate control sequences, timing, and operator actions.
- Confirm protective device time-current coordination.
- Restore service quickly if an outage does occur.

▶ **Prevent—Implement corrective actions to prevent problems**

- Resolve or mitigate persistent problems.
- Provide documentation for management, the electric utility, legal, insurance, etc.
- Identify slow breakers before they can cause an arc flash hazard.



PTP uses 1588 hardware-assisted timestamping in the Ethernet physical layer (PHY) for high precision

The Breakthrough Technology: Precision Time Protocol (PTP)

Today, Precision Time Protocol (PTP) defi ned in IEEE Std. 1588™ makes precision time synchronization over Ethernet simple, aff ordable and scalable. The key difference is the ability of the special 1588 Ethernet interface itself to timestamp messages (to very high precision) eliminating the uncertainty normally associated with Ethernet communications (non-deterministic) and device operating systems.

PRECISION TIME PROTOCOL (PTP)

PTP (IEEE 1588) Changes Everything

Precision Time Protocol (PTP) takes advantage of special Ethernet hardware-assisted timestamping to eliminate device operating system delays and adjust for network latency. The resulting time synchronization accuracy is expressed in microseconds, even over an Ethernet network. The IEEE 1588 standard is intended to be flexible enough to support a range of applications. For interoperability, specific choices of attributes and setting ranges must be defined for each application, called a profile.

The Power Profile—Not for Everyone

A second IEEE standard (IEEE C37.238) proposes a unique subset of attributes and settings (“Power Profile”) optimized for certain power system applications. However, the name is unfortunate, because it is mainly intended for applications that require 1-µsec accuracy, such as synchrophasors for electric utility substation automation. By contrast, in commercial/industrial power applications, where 100-µsec accuracy is sufficient to achieve meaningful 1-msec timestamp resolution, the Power Profile’s strict rules add unnecessary cost, making it unsuitable.

The Simple PTP Profile—Just Right

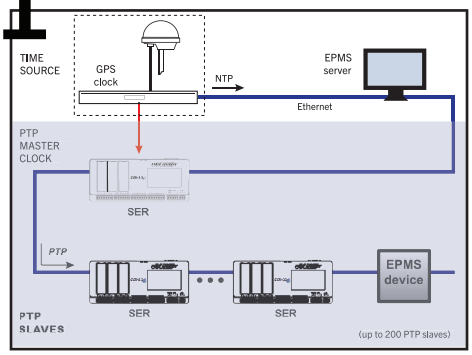
The Power Profile requires all Ethernet switches to be 1588-compliant to serve as “transparent clocks” and adjust PTP packets “on the fly.” This is required to achieve 1-µsec accuracy but unnecessary for less-demanding applications such as Sequence of Events Recording (SER). For these, Trystar proposes the “Simple” PTP Profile, based on the IEEE 1588 Default Profile. This “Goldilocks solution” is just right for commercial/industrial EPMS, ensuring the required accuracy without imposing unnecessary restrictions or changes to the Ethernet data network.

TIME SYNCHRONIZATION DESIGN

Time Synchronization as Easy as 1-2-3

Time synchronization requires a time source and a means to distribute this time reference to all devices. For precision time sync, devices don't just "snap" to the new time value at each update; they learn to "beat in rhythm" with the master clock, maintaining precise synchronization at all times. Trystar SER Event Recorders accept a variety of time-source options, and sync with each other automatically over Ethernet, using PTP. In addition, an SER can serve as a "time sync hub" for devices that do not yet support PTP. Simple, building-block options are shown below. Technical details are provided in Tech Note TN-101, SER System Design Guide.

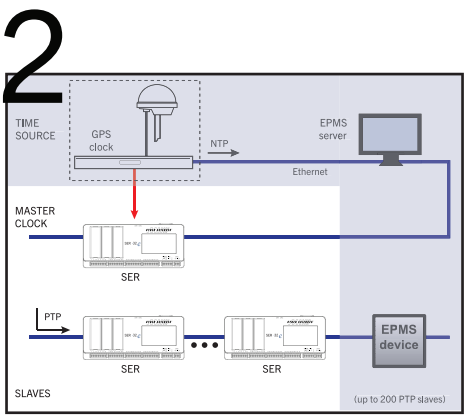
1



Choose a Time Source

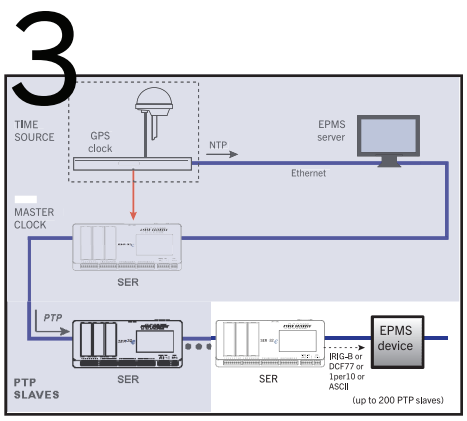
Set the first SER's time from a web browser, EPMS software or NTP server. Optionally, add a GPS antenna/receiver to provide an external time reference traceable to UTC (Coordinated Universal Time), to compare data from other sites or organizations (e.g., electric utilities).

2



Sync all SERs with Each Other (PTP)

Configure the first SER to output PTP (PTP master); all other SERs on the same Ethernet network sync with each other automatically (within 100 µsec). No special Ethernet switches. No additional setup. Set other EPMS devices to use PTP and they'll sync too.



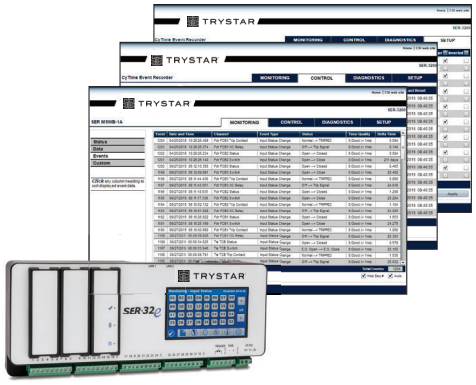
Sync Other EPMS Devices

Sync SERs with other EPMS devices using PTP over Ethernet, all within 100 µsec. No PTP? No problem! For devices that do not yet support PTP, an SER can serve as a "PTP time-sync hub" and output the legacy protocol needed (IRIGB, DCF77, ASCII, etc.).

PTP PROFILE COMPARISON

IEEE 1588 (All Profiles)	**"Simple" PTP" Profile***	**Power Profi le (C37.238)**
GENERAL	**SIMPLE**	**STRICT**
Target accuracy: nanoseconds	**Target accuracy: 100 µs**	Target accuracy: 1 µs
All clock types	Master and Slave-only	All clock types except boundary
Unicast or Multicast	Multicast	Multicast
802.3 (layer 2), UDP/IPv4, UDP/IPv6	UDP/IPv4	802.3 only (layer 2)
PTP-compliant switches	**No special Ethernet switches required**	PTP-compliant switches required
End-to-end or Peer-to-peer	End-to-end (E2E) only	Peer-to-peer (P2P) only
1-step or 2-step	2-step	1-step or 2-step
Variable delay requests	32 seconds	Variable delay requests (typically 1 second)
Does not address max no. of slaves	**Designed to support 200+ PTP slaves**	Does not address max no. of slaves (< 40?)

** Simple PTP is based on the PTP Delay Request-Response Default PTP profile (also called End-to-End), defi ned in IEEE 1588-2019, Annex I.*



SIMPLE.
AFFORDABLE.
SCALABLE.

VISUALIZATION OPTIONS

Embedded Web Server in Every SER

Trystar Sequence of Events Recorders feature an embedded web server, enabling setup and monitoring over an Ethernet network using a standard web browser. Fast and simple access to status, events and diagnostics make commissioning easier and normal operation straight-forward. Configurable text for device name, channel names and even off /on text ensure the flexibility for any application. When part of a complete EPMS system, the web interface complements advanced analysis in EPMS monitoring software.

Easy Integration into EPMS Software or Other Monitoring

For system-wide visualization, native drivers for Trystar SERs are available for most EPMS software. Integration is easy via Modbus TCP and web technologies. A standard (pre-defi ned) register list is documented in the Trystar SER Reference Guide. Monitoring software simply reads real-time data using standard Modbus function codes and loads event log records as needed with new events. Multiple masters are supported, and technical support is available to facilitate development on request.

High-Def Power Management—Design for the *Future!*

You can't manage what you don't know. SERs provide an economical way to gain visibility of multiple points, so you know the status of every point in the system, from the sources to the loads.

EPMS devices must share a common time reference for data to make sense, accurate to 1-msec. Precision Time Protocol (PTP per IEEE 1588) makes this precision time sync over Ethernet simple, affordable and scalable.

Expect more from your investment in EPMS: know what happened and when to one millisecond, and manage your power system—in high definition.

TRYSTAR®

15765 Acorn Trail / Faribault, MN 55021 / 507.333.3990
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