Symmetricom®

XLi IEEE 1588 Grandmaster

GPS Referenced IEEE 1588 Grandmaster Clock and IEEE 1588 Accuracy Measurement System

KEY FEATURES

- Better Than 50 Nanosecond Time Stamp Accuracy to UTC
- Operates as IEEE 1588 Grandmaster or Slave Clock
- Optional Master & Slave in Same Chassis for Network Measurements
- Time Interval Measurements of Slave Clock Accuracy
- Synchronized with a 12 Channel GPS Receiver
- Better Than $1x10^{-12}$ Frequency Accuracy
- Supports Primary and Secondary Reference Inputs
- Standard 10/100Base-T Ethernet
- Telnet, SNMP & Enterprise MIB
- Standard Vacuum Fluorescent Display and Keypad
- Flash Memory for Remote Software Upgrades
- IRIG Generator or Synchronized Generator
- Standard 1PPS, Selectable Pulse Rate Outputs, Alarm, Auxiliary Reference, and Various Time Code In/Out

KEY BENEFITS

- Nanosecond caliber synchronization accuracy possible between clocks over standard Ethernet network infrastructure.
- Use the Time Interval measurements to characterize network element induced time transfer errors.
- Uses GPS for precise UTC time accuracy.
- Operate as IEEE 1588 protocol Grandmaster clock for IEEE 1588 slaves, boundary clocks, and ordinary clocks.
- Plug and play compliant with IEEE 1588-2002.

IEEE 1588 Precise Time Protocol (PTP), with nanosecond caliber time transfer accuracy, provides a significant improvement in synchronization over Ethernet networks. This technology offers major cost savings in time distribution since it can be deployed using hardware clocks and standard Ethernet LAN hubs, switches and Cat 5 cables. The low overhead, multicast protocol can use the same LAN as normal network traffic.

The XLi IEEE-1588 Grandmaster contains a dedicated 1588 time stamp processor. Operating at 100Base-Tx line speed with deep time stamp packet buffers, the XLi Grandmaster can support thousands of 1588 slaves. This is made possible in part by sending periodic 1588 *Sync & Follow_Up* messages using multicast addressing, and in part by being able to quickly and accurately process 1588 slave initiated *Delay_Req* and *Delay_Resp* messages.

Ideal for measurement purposes, the XLi Grandmaster can also operate as a 1588 slave. Network elements such as hubs and switches degrade time transfer accuracy when using 1588 over Ethernet. Switches in particular add nondeterministic latency and jitter to packet transit times from a 1588 master to 1588 slaves. As a result, the 1588 slave synchronization accuracy is degraded from that of the master.

Having the XLi Grandmaster operate as a slave is extremely useful for network time transfer accuracy measurements involving a 1588 slave separated from the XLi Grandmaster by network elements or topology. The remote slave 1PPS is compared to the remote GPS receiver 1PPS in the XLi Grandmaster using the standard Time Interval function. This enables accurate measurements to be made of the network between the GPS referenced 1588 Grandmaster and the remote slave. Operating as a 1588 slave also means accurate time can be transferred over Ethernet to the XLi Grandmaster and, for example, output as IRIG B time code.

The XLi Grandmaster can also be configured with two 1588 ports. These ports can operate as two independently configured Grandmasters or as a Grandmaster and a slave. The master and slave configuration is an excellent 1588 network element or topology measurement solution. Synchronize the slave to the master with network elements or topology in-between, then measure the slave 1PPS to the master using the standard Time Interval function in the Grandmaster. This is very useful in characterizing the time degradation effects of delay and jitter introduced by any network element or topology before deployment.

Optional TimeMonitor software collects and analyzes Time Interval data from the XLi Grandmaster. Statistics, histograms, mean time interval error charts, and much more are quickly and easily computed on small to extremely large datasets.

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MEASURE TIME TRANSFER ACCURACY ACROSS NETWORKS

Hubs & Switches Add Non-Deterministic Packet Delays

When measuring time transfer accuracy across networks at the sub-microsecond level, network elements such as hubs and switches begin to introduce time degrading, asymmetric delays. Switches in particular employ queues that depending on data traffic levels can randomly delay timing packets reducing the IEEE 1588 slave accuracy from that of the grandmaster. Typically the mean time offset error at the slave will increase, as will the standard deviation of that error, when timing and data traffic coexist on the same network paths.

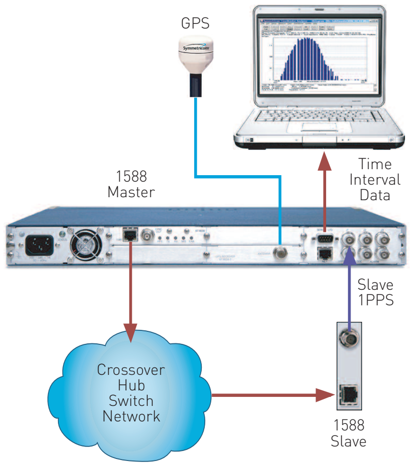
IEEE 1588 slave accuracy is best measured by comparing the 1PPS output of the slave to the 1PPS output of the Grandmaster. This can be done using an oscilloscope, counter, or the Time Interval function standard in the XLi Grandmaster. GPS is also a very useful reference if the Grandmaster and slave are widely separated.

Time Interval Analysis

The standard Time Interval function in the XLi Grandmaster precisely measures the interval between the Grandmaster 1PPS and the rising edge of an external IEEE 1588 slave 1PPS. This measurement is output via the serial port or Telnet every second as an ASCII string of the minor time (fractional second), accurate to 5 nanoseconds of the Grandmaster. This difference is an indicator of how well a slave clock can be synchronized to the Grandmaster. Statistical analyses of the time intervals reveal the slave's mean clock offset from the Grandmaster and distribution around the mean.

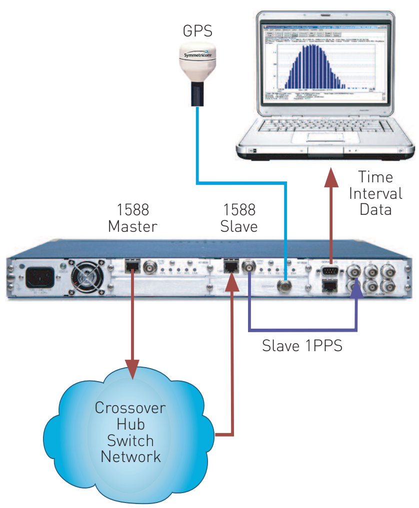
Time Interval analysis is a useful and convenient tool to assess time transfer accuracy using IEEE 1588 though network elements or switches. Note that if resolution beyond 5 nanoseconds is desired in a lab environment, then using a frequency counter or oscilloscope are useful to compare the Grandmaster and slave 1PPS signals.

Characterize IEEE 1588 Slaves and Network Elements



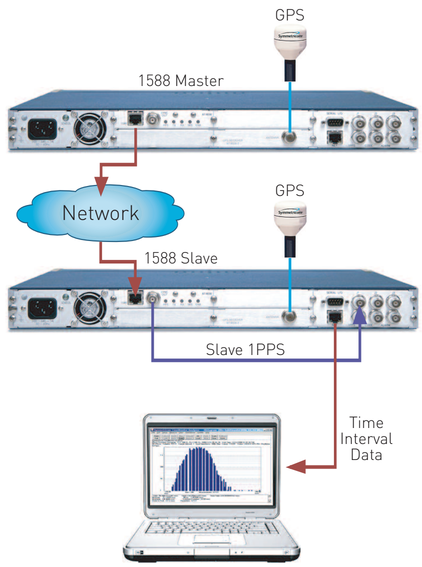
The XLi Grandmaster measurement capability lends itself well to third party IEEE 1588 slave characterization and network element delay measurements. A baseline can be measured with the slave connected to the Grandmaster via a crossover cable, and the 1PPS of the slave connected to the Time Interval input port. Then network elements or topologies can be added in place of the crossover cable and time transfer accuracy changes at the slave studied and characterized.

IEEE-1588 Loopback Tests Using a Two-Port Grandmaster



The XLi Grandmaster can host a second IEEE 1588 module that acts as a slave (or a second Grandmaster port if needed). In this configuration network elements and topologies can be characterized and studied using a single XLi Grandmaster in the absence of a second XLi Grandmaster or third party IEEE 1588 slave. A baseline can be measured with the slave port connected to the Grandmaster port via a crossover cable, and the 1PPS of the slave connected to the Time Interval input port. Then network elements or topologies can be added in place of the crossover cable and time transfer accuracy changes at the slave studied and characterized.

One-Way Path Latency Tests Using Two GPS Referenced Grandmasters



In some cases the network topology under test physically separates the Grandmaster from the slave by an inconvenient distance. In this scenario two GPS referenced XLi Grandmasters work well to make the measurements.

One XLi Grandmaster operates as a master, with time stamps referenced to UTC by way of the GPS receiver. The other Grandmaster is configured with the IEEE 1588 module operating as a slave (not as a reference for the XLi Grandmaster). The 1PPS from the slave module is measured using the Time Interval function of the GPS referenced XLi clock. The precise UTC time available via GPS is the common time reference used to make the measurements of the slave clock accuracy.

XLi IEEE 1588 Grandmaster Specifications

IEEE 1588 SUBSYSTEM (per port)

- Compliance: IEEE 1588-2002
- Number of IEEE 1588 ports: 1 Standard 10/100 Base-T
- Max line speed: 10Base-T/100Base-Tx
- Grandmaster operation
  - Time stamp accuracy: <50 nS to XLi clock with standard deviation <30 nS and RMS <80 nS
  - Sync Intervals: 1, 2, 8, 16, and 64 seconds
  - Packet throughput: >100 Delay_Req/second
  - Delay_Req buffer: 256 time stamps
- Slave operation
  - Sync interval: 2 seconds
  - Grandmaster accuracy: <18 nS to XLi master clock with standard deviation <150 nS and RMS <150 nS via crossover cable
  - 1588 module 1PPS accuracy: <50 nS to XLi master clock with standard deviation <135 nS and RMS <145 nS via crossover cable

GPS RECEIVER

- Receiver input: 1575.42 MHz L1 C/A code
- Tracking: 12 parallel channels with TRAIM
- Acquisition time: Cold start <20 min. (typical)
- 1PPS output accuracy: UTC(USNO): ±30 nS RMS 100 ns peak 99%
- Frequency output accuracy: 1×10^{-12} @ 1 day
- Stability when not tracking satellites: 5×10^{-7} (0°C to 50°C) typical

STANDARD INPUT/OUTPUT SIGNALS

- Eight standard I/Os: Two for control and monitoring: Serial and Ethernet port. Six for signals: 1PPS out, code in, code out, rate out, aux reference, and Open Collector Alarm output. (all with BNC female connector).
- RS-232/422: User selectable up to 19200 bps
  Connector: Male 9-pin D subminiature
- Network interface: Standard 10/100 base-T RJ-45 8-pin connector. Protocols: Telnet and SNMP for the user interface, FTP (for firmware upgrades).
- 1PPS: Pulse width: 20 µs (±1µs) on the rising edge on time, TTL levels into 50Ω, BNC female connector.
- Code input: AM or DC code IRIG-A, B, and NASA-36
  AM Code: 0.5 Vp-p to 10 Vp-p, 100 kΩ ground, ratio (AM): 3:1 ±10%
  DC Code: Logic low <1.25 V and Min 300 mV, Logic Hi >1.25 V and Max 10 V.
  Impedance: 100 K or 50Ω
  Polarity: positive or negative
  Connector: BNC female
- Code out: Default is IRIG-B AM
  Format: AM or DC code IRIG-A, B, and NASA-36.
  AM Code: 3 Vp-p, into 50Ω ±10%, ratio (AM): 3:1.
  DC Code: TTL into 50Ω
  Connector: BNC female
- Rate out: Default: 10 MPPS. Rate: 1PPS, 10 PPS, 100 PPS, 1 KPPS, 10 KPPS, 100 KPPS, 1 MPPS, 5 MPPS, and 10 MPPS. Duty cycle: 50% and 60/40%.
  Amplitude: TTL levels into 50Ω
  Connector: BNC female
- Aux ref input: Input frequency: 1, 5, and 10 MHz sine-wave.
  Amplitude: 1 Vp-p to 10 Vp-p at 1 kΩ to ground. 1 Vp-p to 3 Vp-p at 50Ω to ground.
  Impedance: Configurable 1 kΩ or 50Ω to ground
  Connector: BNC female
- Alarm: Open collector. Max 25V/50 mA.
  Connector: BNC female

OSCILLATOR

- Standard oscillator: VCTCXO

MECHANICAL/ENVIRONMENTAL

- Time and frequency system
  - Power: Voltage: 90–260 Vac. Frequency: 47–440 Hz
  - Connector: IEC 320
  - Size: 1U: 1.75˝ x 17.1˝ x 15.35˝ (4.44 cm x 43.4 cm x 38.9 cm) Standard 19" (48.26 cm) EIA rack system,
  - Operating temperature: 0°C to +50°C (+32°F to +122°F)
  - Storage temperature: –55°C to +85°C (–67°F to +185°F)
  - Humidity: 95%, non-condensing
  - Display: Graphics (160 X 16) vacuum fluorescent display. One line for time and day of year (TOD). Two-line alpha-numeric display for status messages and user input.
  - Keypad: Numeric 0–9, left, right, up, down, CLR, Enter, time key, status key and menu key.
- Antenna
  - Size: 3˝ Dia. x 3˝ H (7.62 cm x 7.62 cm)
  - Input: BNC female to GPS receiver. TNC on antenna
  - Power: +12 Vdc
  - Operating temperature: –55°C to +85°C (–67°F to +185°F)
  - Storage temperature: –55°C to +85°C (–67°F to +185°F)
  - Humidity: 95%, non-condensing
- Certification: UL, FCC, CE, and C-UL

TIME INTERVAL MEASUREMENT

- Measurement
  - Rate: 1 per second
  - Resolution: 5 nS
  - Accuracy: ±5 nS (+ clock accuracy)
  - Range: 0.0 to 1 year
- Input frequencies
  - Rate: 1PPS
  - High level: Logic Hi >1.25V <10V
  - Low level: Logic Low <1.25V >0V
  - Active edge: Rising (Positive)
  - Pulse width: 100 nS minimum
  - Input impedance: >1k, jumper selectable to 50

EVENT TIMING MEASUREMENT

- Measurement
  - Rate: 10/second or 100/second burst
  - Resolution: 5 nS
  - Accuracy: ±5 nS (+ clock accuracy)
  - Range: 0.0 to 1 year

PRODUCT INCLUDES

XLi IEEE 1588 Clock, Cat 5 crossover cable and network cable, AC power cord, null modem cable, user guide on CD, rack mount brackets, L1 GPS antenna assembly with 50 ft. RG-59 cable, mounting hardware.

Rear view: Single 1588 port, Model 1510-702

Rear view: Dual 1588 port, Model 1510-703

OPTIONAL ACCESSORIES

TimeMonitor software to collect the Time Interval measurement data directly from the XLi and provide the analysis and graphs to better understand time and frequency transfer using 1588 technology.

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