# 59551A GPS Measurements Synchronization

## Low Cost, High Accuracy Timing for Electric Power Transmission System Analysis

**59551A**
GPS Measurement Synchronization Module

**59552A**
Fiber Optic Distribution Amplifier

**59553A**
Fiber Optic Receiver

Symmetricom
*Heartbeat of the Net*

# High Accuracy GPS Synchronization for Power Transmission Systems

*Symmetricom's 59551A GPS Measurements Synchronization Module is a precision timing product to meet the needs of wide-area electric power transmission systems. Based on advanced Global Positioning System (GPS) technology, the module has superior long-term timing accuracy — less than 1 microsecond. Even when the satellite signal is lost, the 59551A ensures system synchronization for up to 24 hours in holdover mode. The low cost and superior performance of the 59551A permit exhaustive measurement and analysis of power system performance.*

The functional versatility of Symmetricom's 59551A allows you to:

- Provide a synchronization foundation for monitoring existing wide-area transmission systems, or for emerging real-time monitoring and control applications.
- Time Tag key events to facilitate efficient fault location, network disturbance analysis, and detailed sequence-of-events analysis.
- Configure input/output to simplify integration with event and fault recorders or with EMS/DSM solutions.

The accuracy and full feature set of the 59551A are unmatched by other products in the marketplace.

Fault Location and wide-area synchronization of the transmission system are significantly enhanced with the 59551A.

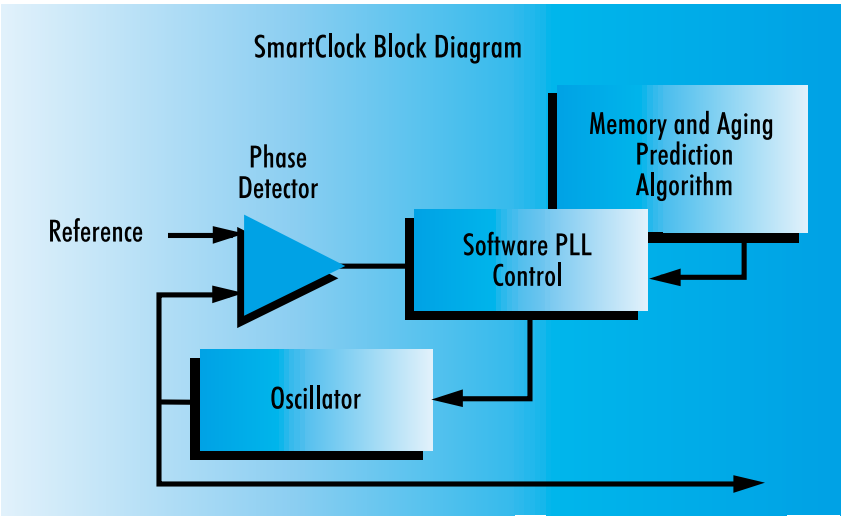
For significantly less cost compared with alternative solutions, the 59551A now enables you to introduce synchronization techniques to many areas of power system analysis and optimization. With Symmetricom's proven records for high reliability and product longevity, the 59551A maximizes the availability of detailed performance data for the systems of today and the future.

## Accurate, Affordable Synchronization — Even with Loss of GPS Signal

The time base for the 59551A starts with the 10811D Quartz Oscillator, a highly reliable crystal component characterized by low sensitivity to temperature changes, low phase noise and well-understood aging characteristics. Integrated with the quartz oscillator, the SmartClock algorithm greatly enhances the performance of the 59551A, making it equivalent to a rubidium-based product — for a much lower cost. The algorithm compares the oscillator frequency with the GPS reference signal. By "learning" the aging and environmental effects on the oscillator over time, SmartClock adjusts the oscillator output frequency accordingly and significantly improves the achieved accuracy of the solution.

# Deliver Timing Signals While Capturing Critical System Events

SmartClock provides a unique holdover mode to ensure accurate synchronization even if the satellite signal is interrupted or lost. SmartClock will continue to maintain time and frequency with less than 8.6 microseconds loss in accuracy for up to 24 hours of GPS signal loss.



SmartClock provides equivalent performance to rubidium-based clocks at a lower cost.

## Event Time Tagging

Time tagging, a standard feature of the 59551A, lets you time-stamp and store events for failure or sequence-of-events analysis. Resolution of 100 nanoseconds guarantees that critical events are marked accurately. Up to 256 tagged events are stored in each buffer memory and can be retrieved on a first-in, first-out (FIFO) basis. Memory can also be downloaded to a computer for automated or remote evaluation.

## Input/Output Choices

The input/output capabilities of the 59551A allow the generation of appropriate synchronization signals for a variety of transmission system requirements. Separate front and rear RS-232C ports make it easy to connect the 59551A with external computers and let you analyze data or enter commands without interrupting the output signals. The module can also be used with a variety of existing event and fault recorders.

Other standard input/output features include:

- IRIG-B output
- An Alarm BITE (Built In Test Equipment) output indicating a system fault or loss of satellite lock
- Timer output, programmable to produce a pulse at a specific time of day or a repetitive signal with a period from one second to one year.

## Delivering Signals for a Range of Applications

Synchronization of measurements is critical for reliably increasing power capacity, quality, and services. The 59551A GPS Measurements Synchronization Module is the first product to cost-effectively provide wide-area synchronization of measurements. It overcomes the limitations of traditional measurement tools and greatly extends applications directed at monitoring and controlling power transmission systems.

With its low cost, the 59551A can be placed at all critical points in a power system. With units synchronizing multiple points in the transmission network, you can gather enough reliable and meaningful field data and extract crucial system performance and operating characteristics.

The resolution and time tagging features of the 59551A make it ideally suited to applications such as traveling wave fault location, phasor measurement, stability protection and adaptive relaying. The 59551A can also provide key data for newly evolving monitoring applications, such as digital fault and disturbance recording. It can contribute to the verification of computer modeling of transmission and generation systems.

# A Reliable, Easy-to-use Solution

## Physical and Operating Characteristics

The 59551A module, a single rack mountable unit, requires a 58532A GPS antenna. All programming and monitoring of the receiver is done through a serial interface. Four front panel LEDs indicate status and are set by the internal GPS receiver. These LEDs indicate different states during operation:

- GPS Lock (satellites acquired and tracking)
- Alarm (GPS signal loss)
- Holdover (with GPS signal loss, the SmartClock takes over and maintains time and frequency)

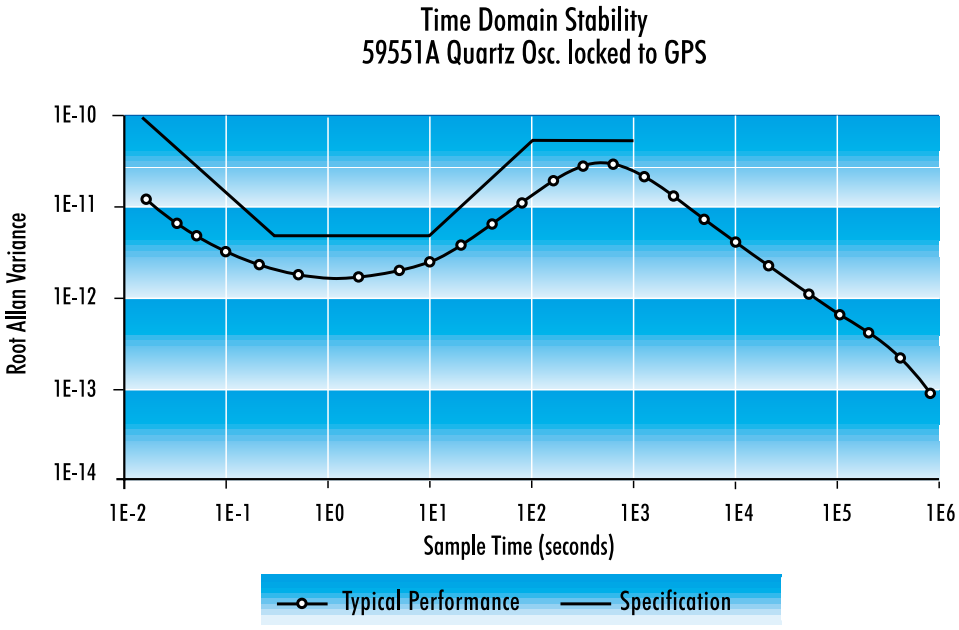
During a cold start (the first time the GPS receiver has been powered up at a new location), the receiver will achieve full lock to GPS in under 30 minutes, and valid Time Of Day signal will be present on the serial port. A lock is accomplished in under three minutes for a warm start, and under one minute for a hot start/reacquisition.

After two days of operation (power applied with GPS lock), the receiver will be able to maintain a holdover performance level of less than 8.6 microseconds for the 1 pulse-per-second (PPS) signal.

The 59551A rack-mountable module can be accessed through separate front and rear RS-232C ports. A front-panel connector for an external computer lets you analyze data or enter commands without interrupting the output signals. Other ports allow connections to a variety of existing event and fault recorders.

## System Availability

The crystal ovenized oscillator at the heart of the 59551A has been in production for over 15 years, has an MTBF (Mean Time Between Failures) of greater than 500,000 hours, and requires no routine maintenance. Comparable rubidium-based products require more frequent replacement at significantly higher cost. The reliable operation and lack of required adjustments make the 59551A well suited for unattended operation. Combined with programmability, the 59551A's reliability also meets the requirements for remote site applications.




The 59551A features <110ns performance even in the presence of selective availability.

# Specifications and Characteristics of the 59551A

## GPS Receiver Features

Six-channel, parallel tracking GPS engine
C/A Code, L1 Carrier
SmartClock technology
Enhanced GPS technology

## 1 PPS Output

| | |
|---|---|
| Specifications: | |
| Locked Pulse-to-pulse jitter of leading edge | <750 ps with at least one satellite in view. |
| Time Accuracy | < 110 nanoseconds with respect to UTC (USNO MC)—95% probability when unit is properly installed, calibrated, and locked to GPS. |
| Unlocked Accumulated time error | <8.6 $\mu$s accumulated in 24 hours of unlocked operation. (See Note 1.) |
| Supplemental Information: | |
| Pulse Width | 26 $\mu$sec |
| Amplitude | >2.4 volts into 50 Ω load. (TTL compatible) |
| Connector | BNC |
| Rise Time | <5 ns |

## Additional Features

| | |
|---|---|
| Alarm BITE Output: | |
| Basic unit output | Solid state relay (normally open); closed contact indicates system fault or loss of satellite lock. Contact rating 200 Vdc @ 0.5 amps. |
| Connector | Twin BNC |
| IRIG-B123 Output Port | BNC connector. |
| Three Time-tag Inputs: | |
| Received signal | TTL, 50 Ω. |
| Time-tag accuracy | Same as the accuracy of the 59551A. |
| Quantization | 100 ns |
| Connector | BNC |
| Minimum Pos/Neg pulse width | 200 ns |
| Three time-tag buffers | 256 events each, retrievable via RS-232C. |
| Minimum time between events | 1 ms |
| Maximum stamp rate | 1 measurement per ms |
| Timer/Clock Output: | |
| Programmable Pulse Output | Single pulse at the time programmed via RS-232C port, or repetitive output pulse at a programmable repetition period from 1 second to 1 year. |
| Quantization | 100 ns |
| Accuracy | Same as the time accuracy of the 59551A. |
| Front Panel Indicators (LEDs) | Power, GPS Lock, Holdover, and Alarm |
| Remote Interface: | |
| (Two RS-232C Ports) | |
| RS-232C DTE configuration | Complete remote control and interrogation of all instrument functions and parameters. |
| Factory defaults | Baud rate 9600, 8 data bits, 1 start bit, 1 stop bit, no parity. Other settings are programmable. |
| Connectors | 9-pin female rectangular D subminiature (DB-9) on front panel; 25-pin female rectangular D subminiature (DB-25) on rear panel. |

Time code output is available to a computer immediately preceding the 1 PPS signal for the current second.

## Environmental Specifications

| | |
|---|---|
| Measurements Synchronization Module (59551A): | |
| Operating | 0°C to 50°C |
| Storage | –40°C to +80°C |
| Antenna (58532A): | |
| Operating | –30°C to +80°C |
| Storage | –40°C to +85°C |

## Additional Information

| | |
|---|---|
| Power Requirements: | |
| DC Power | 129 Vdc nominal (115 to 140 Vdc operating range) |
| Input Power | < 35 Watts (nominal) |
| Dimensions | 88.5 mm (3.5 in) H × 212.6 mm (8.53 in) W × 348.3 mm (13.7 in) D |
| Weight | 3.6 kg (8 lbs) |
| Surge withstand | Meets IEEE/ANSI C37.90, C37.90.1 |

Note 1. This specification has a 95% probability, and is based on the availability of four or more GPS satellites during three days of locked operation with a fixed antenna location. The temperature must remain within a 10°C range between 10°C and 40°C.

# A Simple, Modular Approach to Signal Routing

## Antenna, Cabling and Installation Information

Symmetricom's 58532A Active Antenna Assembly is recommended to ensure specified performance. For optimum performance, the antenna should be installed in a location which gives it a clear view of the entire sky.

Power Requirements (supplied by 59551A): 5 volts nominal. 50 ma max.

Antenna Cable: 58520A. Cables are RG-213 with a type N connector on one end and a type TNC connector on the other.

Up to 175 ft. (53 m) of cable may be used between the antenna and the receiver. For applications which require longer cable runs, please consult your Symmetricom representative. Lower loss cable and antenna line amplifiers are available to meet most needs.

The standard 59551A GPS Measurements Synchronization Module does not include a display. While a display is not necessary, it may be convenient to track the receiver's progress during installation and startup by monitoring the satellites being tracked, location, time, various figures of merit available from the instrument, and other parameters.

## 59552A Fiber Optic Distribution Amplifier and 59553A Fiber Optic Receiver

High-integrity distribution of a common clock is the backbone for power utility substation synchronization. Symmetricom's 59552A Fiber Optic Distribution Amplifier and 59553A Fiber Optic Receiver provide a simple, modular approach to signal routing. Immunity to electrical noise makes fiber optic cable a superior choice for the challenging environment of the power substation.

The 59552A Fiber Optic Distribution Amplifier receives a digital (TTL) signal and an analog signal via two BNC connectors. The 59552A combines the signals, and transmits the result on each of eight fiber optic outputs. Signal integrity is even maintained over customer-supplied, fiber optic cable lengths of up to a kilometer.

A 59553A Fiber Optic Receiver resides near each remote equipment installation. The 59553A receives the signal on fiber optic cable, separates analog and digital waveforms, and outputs each signal on a BNC connector.

Symmetricom fiber optic products are designed to provide clean timing-quality transmission signals to monitoring, analysis and control equipment. In a typical application calling for distribution of 1 pulse per second (1PPS) and IRIG-B time code, each substation instrument receives an identical, synchronous, high-quality clock signal and precise time of day.

Symmetricom's 59552A Fiber Optic Distribution Amplifier and 59553A Fiber Optic Receiver.

## System Specifications

| | |
|---|---|
| COMBINED MODE | |
| Transmission distance | up to 1 km |
| Digital edge rate maximum | 1 kHz |
| Digital edge delay | 2 $\mu$s $\pm$5% (input of 59552A to output of 59553A — excluding delay through fiber-optic cable; cable adds approximately 5 ns/meter) |
| Digital output pulse width | 70 $\mu$s (nominal) |
| Digital input pulse polarity | positive or negative (selectable with internal jumper) |
| Digital output pulse polarity | positive or negative (selectable with internal jumper) |
| Digital output pulse, risetime/falltime | less than 5 ns into a 50 Ω load |
| Digital output short-term jitter | 5 ns rms (nominal) when signal transmitted 1 km |
| Analog input frequency range | 10 Hz to 10 kHz |
| Analog voltage gain | unity (input of 59552A to output of 59553A driving 600 Ω load) |
| DIGITAL MODE | |
| Transmission distance | up to 1 km |
| Digital edge rate maximum | 5 Mbd |
| Digital edge delay: | |
| rising edge | 120 ns (nominal) plus delay through fiber-optic cable; cable adds approximately 5 ns/meter |
| falling edge | 85 ns (nominal) plus delay through fiber-optic cable; cable adds approximately 5 ns/meter |
| Digital output pulse width: | output replicates input subject to delay constraints noted above |
| Digital output short-term jitter: | |
| rising edge | 3 ns rms (nominal) when signal transmitted 1 km |
| falling edge | 2 ns rms (nominal) when signal transmitted 1 km |
| Digital pulse, risetime/falltime | less than 5 ns |

High-quality timing signals (both 1PPS and IRIG-B) are available as standard back-panel outputs of the HP 59551A GPS Measurements Synchronization Module.

Coupled with the 59551A, the 59552A and 59553A form a complete master clock and distribution system for power substations. This system could be used for applications such as fault location, adaptive relaying, and disturbance analysis.

### *Configuration Information*

There are two ways the 59552A and 59553A fiber optic products can be configured to distribute signals:

- The "Combined Mode" configuration distributes two signals, one analog and one digital (such as IRIG-B and 1PPS respectively).
- The "Digital Mode" configuration distributes one digital signal (such as a 1PPS signal).

If your application requires transmission of only one digital signal, you may choose to use the Digital Mode. Digital Mode passes signals with minimal delay compared to that associated with combining digital and analog information.

The factory configures the instruments for Combined Mode operation. Selection of Digital Mode operation requires reconfiguration of both the 59552A and 59553A by repositioning of internal jumpers.

Both warranted specifications and operating characteristics are covered in the table above and on page 8. The word "nominal" appears next to a characteristic to distinguish it from the warranted specifications.

## Specifications and Characteristics

### *59552A Fiber Optic Distribution Amplifier*

| | |
|---|---|
| INPUTS | |
| One digital input typically used as 1PPS input | |
| One analog input typically used as IRIG-B123 input | |
| Digital input: | |
| Input signal requirements | TTL |
| Input impedance | 50 Ω to GND (default) or 1 kΩ to +5 volts configurable with internal jumper |
| Analog input: | |
| Input signal requirements | 5 volts peak-to-peak (nominal) |
| Input impedance: | 600 Ω (default) or 10 kΩ configurable with internal jumper |
| Outputs | |
| Number of optical outputs | 8 |
| Optical connector | metal ST |
| Front-panel LEDs indicating: | Power<br>Digital input active<br>Analog input active<br>Note that annunciator is activated at a minimum voltage 1.6 volts pk-pk (nominal) |
| Power Requirements: | |
| dc Power, (standard) | 129 Vdc, 115 to 140 Vdc operating range |
| ac Power, (Option 170) | 90 to 132 Vac or 198 to 264 Vac, automatically selected; 50 to 60 Hz |
| Dimensions: | |
| Height | 88.5 mm (3.5 in) |
| Width | 212.6 mm (8.53 in) |
| Depth | 348.3 mm (13.7 in) |
| Weight | 3 kg (6.6 lbs) |
| | Half-Rack module |

### *59553A Fiber Optic Receiver*

| | |
|---|---|
| INPUTS | |
| Number of optical inputs | 1 |
| Optical connector | metal ST |
| Outputs | |
| One digital output typically used as 1PPS output | |
| One analog output typically used as IRIG-B123 output | |
| Digital Output: | |
| Output signal | TTL |
| Output impedance | drives 50 Ω to GND |
| Analog Output: | |
| Output signal | 5 volts peak-to-peak (nominal) |
| Output impedance | drives 600 Ω to GND |
| Front-panel LEDs indicating: | Power<br>Digital input active<br>Analog input active<br>Note that annunciator is activated at a minimum voltage of 1.6 volts pk-pk (nominal) |
| Power Requirements: | |
| dc Power (standard) | 129 Vdc, 115 to 140 Vdc operating range |
| ac Power (Option 170) | 90 to 132 Vac or 198 to 264 Vac, automatically selected; 50 to 60 Hz |
| Dimensions: | |
| Height | 87.1 mm (3.4 in) |
| Width | 133.2 mm (5.2 in) |
| Depth | 185.3 mm (7.3 in) |
| Weight | 0.91 kg (2.0 lbs) |
| Fiber Optic Cable Core Size Recommendations | 62.5/125 μm |

## Ordering Information

| | |
|---|---|
| 59552A | Option 170 (90-264 Vac) |
| 59553A | Option 170 (90-264 Vac) |

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