Symmetricom

Commercial Time-Scale System

Fully Integrated, World-Class Turn-Key Timing System

STANDARD FEATURES

- Include Up To 7 High Performance Cs Clocks
- GPS Common View Time Comparison
- BIPM Reporting
- Frequency Accuracy +/- 1E-14 (Long Term)
- Time Accuracy to 5ns RMS to UTC (USNO)
- NTP
- Battery Back-Up
- Local GUI

OPTIONAL FEATURES

- Active H-Maser
- Multi-Channel Measurement System
- Hot Swap Distribution Chassis
- Multiple Outputs
- TWTT
- Data Storage

As the international standard time scale, Universal Coordinated Time (UTC) is the composite of clocks throughout the world. The time of each clock is reported to the International Bureau of Weights and Measures (BIPM) using either GPS common view (CV) or Two-Way Satellite Time and Frequency Transfer. National laboratories also compute a local time scale steered to agree with UTC designated as UTC(local). Local UTC time-scale systems have state-of-the-art frequency stability, phase noise performance, and system availability. To be incorporated in UTC, their internal clocks cannot themselves be steered by UTC and the CV data must be calculated and reported to the BIPM in accordance with its published method and format.

The Symmetricom Time-Scale System meets these requirements using Symmetricom manufactured commercial timing products. Compared to other solutions, Symmetricom offers faster deployment, lower ownership costs, higher product quality, spare parts that are easier and less expensive to get, and a single point of responsibility for all system support.

The Symmetricom solution unites these advantages with the world's most widely adopted frequency standards for UTC generation. (The Symmetricom 5071A, alone accounts for 76% of all UTC clocks and contributes 87% of UTC time.) The Symmetricom –Time-Scale System can combine up to seven high-performance frequency standards in a time scale that drives the local real-time clock (RTC) signal. A timing quality GPS receiver provides the information used to steer the system output to UTC and generates GPS common-view data. This allows the frequency standards to be reported to the BIPM for inclusion in the international time scale. As a fully integrated solution, the system provides industry-leading frequency stability, phase-noise performance, and time-scale availability in a unit as small as one instrument rack.
In short, it's now possible to purchase a fully integrated, world-class timing solution comparable to the best national laboratories with commercial hardware and software support included. A unique set of design features enables the state-of-the-art functionality, performance, and reliability needed to establish a national timing reference or a global or regional navigation satellite system.

FIG 1 Turn Key Timing System

CONFIGURATION OPTIONS

One advantage of a modular solution is the ability to cost-effectively plug and play components to tailor the solution to a specific need. Symmetricom offers a variety of frequency standards and other configuration options. A minimum system consists of:

- Equipment rack
- 5071A cesium standard
- Monitor
- Keyboard
- Battery backup unit (BBU)
- Modular chassis with controller, synthesizer, RF distribution amplifier, and GPS receiver,

This minimum system provides a time scale steered to UTC, real time frequency and time references, NTP, and GPS common view data that may be used to contribute clock data to the BIPM for the UTC calculation. Additional clocks, the clock measurement system, supplemental power backup, the database, additional signal generation, and additional signal distribution may be added later. Table 1 shows the equipment provided in the standard configuration and available equipment upgrades.

Some of the options available within the framework of the standard Timescale System are:

- Adding a two-way time transfer modem
- Adding or deleting output signal types and distribution
- Adding or deleting cesium standards
- Adding one or more active hydrogen masers

The choice of frequency standards depends on the applications for the system's frequency and time outputs. All Symmetricom atomic clocks interface to the Timescale System and provide status and fault monitoring information.

Standard Configuration (Single Cesium Clock Steered to UTC) **Produces a real time clock steered to UTC via GPS. The RTC has 5 outputs at 5 MHz and a single 1 PPS output.**
5071A High Performance Cesium Standard
Real Time Clock Subsystem
Switch & Distribution Subsystem
Battery Backup Subsystem
UTC Recovery, Clock Steering and Common View Monitor & Control Software
Rack, monitor, keyboard and cables
Upgrade to include 8-Clock Measurement System:
8 Channel Multi Clock Measurement System
Database
Multiple Clock Upgrade
5071A High Performance Cesium Standard (S)
MHM2010 Active Hydrogen Maser (S)
1MHz, 10 MHz, and IRIG-B Upgrade
Additional RF and timecode outputs

Table 1 Symmetricom Timescale System Configurations

SYSTEM SPECIFICATIONS FOR STANDARD SYMMETRICOM TIME-SCALE SYSTEM

NUMBER OF CLOCKS: 3 or more high-performance 5071A cesium clocks

SYSTEM TIME AND FREQUENCY:
Time scale computed as the average of the clocks

Switching: automatic switching between clocks with no time or frequency discontinuities and long-term time or frequency errors

OUTPUTS

5 MHz (Steered system output)
Level: 13 ± 1 dBm, 50 W
Spurious: < -80 dBc
Harmonics: < -40 dBc
Phase noise:

Offset frequency (Hz)	dBc/Hz
1	-106
10	-136
100	-151
1 k	-156
10 k	-160
100 k	-160

SHORT-TERM STABILITY:

τ (s)	σy(t)
1	$5x10^{-12}$
10	$3.5x10^{-12}$
100	$8.5x10^{-13}$
1 k	$2.7x10^{-13}$
10 k	$8.5x10^{-14}$
100 k	$2.7x10^{-14}$
500 k	$1x10^{-14}$

FREQUENCY ACCURACY: $\pm 1x10^{-14}$ for 10 day averages after 10 days of continuous operation

FREQUENCY HOLDOVER: ±1x10-13 for 30 days over the full temperature range

1 PPS

Time accuracy:	5 ns RMS relative to UTC(USNO) at time of shipment
Time stability (wander):	3 ns RMS relative to UTC(USNO) via passive GPS
Time holdover:	± 300 ns relative to UTC over the full temperature range after 10 days of operation
Time transfer accuracy:	2 ns RMS relative to UTC via GNSS common view
Jitter:	< 100 ps
Level:	Logic 0 < 0.8 V, Logic 1 > 4.5 V into a 50 W load

NTP Transactions: > 200/s (without S250i)

DATA STORAGE: Sufficient to store all clock comparison measurements for 10 years

BATTERY BACKUP: 24 VDC Nominal
> 2 hrs

USER INTERFACE: All control through a local GUI using keyboard, mouse, and LCD display

STATUS MONITORING:
Outputs
System specifications
Clock parameters
Power supply voltages
Backup battery status
Faults stored in a database for analysis

TIME COMPARISON:
Passive GPS comparison with UTC via GPS (< 1 ns resolution)
-L2 codeless reception, GLONASS, and GALILEO upgrade optional

Two-way GPS comparison with UTC via BIPM Common-View and Clock Reports (< 2 ns RMS)

Time comparisons of 3 clocks and real-time steered clock < 1 ps

TIME SCALE
No discontinuity in time scale on clock additions or deletions

Clock models
- Cs clocks have white fm and random walk fm
- H masers have white pm, white fm, random walk fm, random walk frequency aging

Clock weighting to optimize short and long-term stability
- 3 weights per clock

Kalman filter time and frequency estimation
-Minimum squared error estimates
- Optimum transient response

Filter remains optimum even when measurement data are missing
- Bad data filtering
- Fast rejection based on matched filter response to known outlier types such as phase steps
- Robust outlier detection based on inconsistencies with the physical model

ENVIRONMENTAL

Power:	100, 120, 220, or 240 VAC nominal, 47-63 Hz, 1 kW maximum 24 VDC nominal
Ambient Temperature:	0 – 50 ºC
GNSS Antenna Location:	Roof Mounted with clear view of sky above 10 degrees Surveyed antenna position with accuracy < 0.5 m required (survey service optional)

SYSTEM SPECIFICATIONS FOR STANDARD TIME-SCALE SYSTEM WITH AT LEAST 1 ACTIVE HYDROGEN MASER

Adding active hydrogen masers to the Turn-key Timing System provides additional output signals with the best frequency stability commercially available. As with the 5071A units, the masers can be reported to the BIPM for inclusion in the international time scale

NUMBER OF CLOCKS:

2 or more high-performance 5071A cesium clocks

1 or more MHM-2010 active hydrogen masers

SYSTEM TIME AND FREQUENCY:

Time scale computed as the weighted average of the clocks

Switching: automatic switching between clocks with no time or frequency discontinuities and long-term time or frequency errors

OUTPUTS

5 MHz (Steered system output)

Level:	13 ± 1 dBm, 50 W
Spurious:	< -80 dBc
Harmonics:	< -40 dBc

Phase noise:

Offset frequency (Hz)	dBc/Hz
1	-106
10	-136
100	-151
1 k	-156
10 k	-160
100 k	-160

SHORT-TERM STABILITY (1 HZ MEASUREMENT BANDWIDTH):

τ (s)	σy(t)
1	2.5×10^{-13}
10	5×10^{-14}
100	1.3×10^{-14}
1 k	3.2×10^{-15}
10 k	3×10^{-15}
100 k	3×10^{-15}
500 k	4×10^{-15}

FREQUENCY ACCURACY:

±5x10-15 for 10 days after 10 days of continuous operation

FREQUENCY HOLDOVER:

±1x10-13 for 30 days over the full temperature range

1 PPS

Time accuracy:	5 ns RMS relative to UTC(USNO) at time of shipment
Time stability (wander):	3 ns RMS relative to UTC via passive GPS
Time holdover:	± 300 ns relative to UTC over the full temperature range after 10 days of operation
Time transfer accuracy:	2 ns RMS relative to UTC via GNSS common view
Jitter:	< 100 ps
Level:	Logic 0 < 0.8 V, Logic 1 > 4.5 V into a 50 W load

NTP

Transactions: > 200/s (without S250i Enterprise Time Servers)

DATA STORAGE: sufficient to store all clock comparison measurement for 10 years

BATTERY BACKUP: 24 VDC Nominal

> 1 hrs

Hotpack environmental chambers require facility backup power (e.g. generator)

USER INTERFACE: All control through a local GUI using keyboard, mouse, and LCD display

STATUS MONITORING:

Outputs
System specifications
Clock parameters
Power supply voltages
Backup battery status
Faults stored in a database for analysis

TIME COMPARISON:

Passive GPS comparison with UTC via GPS (< 1 ns resolution)
- L2 codeless reception, GLONASS, and GALILEO upgrade optional

Two-way GPS comparison with UTC via BIPM Common-View and Clock Reports (< 2 ns RMS)
Time comparisons of 3 clocks and real-time steered clock < 1 ps

TIME SCALE

No discontinuity in time scale on clock additions or deletions
Clock models
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- Clock weighting to optimize short and long-term stability
- 3 weights per clock

Kalman filter time and frequency estimation
- Minimum squared error estimates
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- Filter remains optimum even when measurement data are missing

Bad data filtering
- Fast rejection based on matched filter response to known outlier types such as phase steps
- Robust outlier detection based on inconsistencies with the physical model

ENVIRONMENTAL

Power: 100, 120, 220, or 240 VAC nominal, 47-63 Hz, 1 kW maximum
24 VDC nominal
Hotpack Environmental Chambers require 208/230 V, 3 kW each

Ambient Temperature: 0 – 50 °C
Hotpack 0 - 30 °C
Without Hotpack, masers located in a room with 23 ± 0.15 °C temperature control
GNSS Antenna Location: Roof mounted with clear view of sky above 10 degrees
Surveyed antenna position with accuracy < 0.5 m required (survey service optional)

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