Precise Time-Scale System

Fully Integrated, World-Class Turnkey Timing System

Features

- One 5071A high performance cesium clock
- 8 Channel measurement system
- Real-time clock with user outputs
- GNSS common view time comparison
- BIPM reporting
- Frequency accuracy $\pm 1 \times 10^{-14}$ (long term)
- Time accuracy to 10ns RMS to UTC(USNO)
- Battery back-up
- Local Graphical User Interface

Optional Features

- Ability to add up to five additional cesium or Hydrogen Maser clocks

Benefits:

- Faster deployment
- Ease of use
- Lower total cost of ownership
- Superior quality
- High reliability
- Proven support services

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(lab). Local UTC timescale 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 measured and reported to the BIPM in accordance with its published method and format.

The Symmetricom® Precise Time-Scale System meets these requirements using Symmetricom manufactured precise timing products. Compared to other solutions, the Symmetricom system offers faster deployment, ease of use, lower cost of ownership, higher product quality, reliable operation, and a single point of responsibility for all system support.

Symmetricom's 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 Precise Time-Scale System can combine up to five high-performance cesium frequency standards or active Hydrogen Masers in a time-scale that drives the local real-time clock (RTC) signal. A high performance timing quality GNSS receiver provides the information used to steer the system output to UTC and generate GPS CV 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 timescale availability in a unit as small as one instrument rack,a first in the industry.

In short, it is now possible to purchase a fully integrated, world-class time-scale system comparable to the best national laboratories with standard hardware and software along with superior support and services. A unique set of design features enables the state-of-the-art functionality,

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performance, and reliability needed to establish a national timing reference or a global or regional navigation satellite system timing reference anywhere in the world.

FIG 1 Precise Time-Scale System

Baseline System Configuration

The Precise Time-Scale system comes completely operational in a single rack with one cesium clock, measurement HW & SW, Real-Time Clock, Graphical User Interface, computer server, database and battery back-up. One advantage the system offers is the ability to easily add clocks. The user may add up to two additional cesium clocks to the rack and three more cesium clocks or Hydrogen Masers outside the rack at a later time to further improve system performance. In addition, the modular configuration provides the ability to plug-and-play the additional clocks without the need to significantly reconfigure hardware or the need for expensive reengineering.

The base system consists of:

- Equipment rack
- One 5071A high performance cesium standard
- 8 channel measurement hardware with database server
- Real-time clock with chassis mainframe and modules
- UTC recovery, steering, common view, monitor and control software
- LCD monitor
- Keyboard
- Battery backup unit
- System integration and packaging
- On-site installation and training

This single-rack system provides a time scale referenced to UTC, real-time frequency and time references, and GPS common view data that may be used to contribute clock data to the BIPM for the UTC calculation. Table 1 shows the standard configuration and services along with upgrade options.

If further customization is required for your specific needs, please contact the Symmetricom factory.

The choice of input clocks and frequency standards depends on the applications for the system's frequency and time outputs. All Symmetricom atomic clocks interface to the time scale system and provide status and fault monitoring information. Other atomic clocks can be used without status and fault monitoring.

Services

Symmetricom provides a wide range of services based on customers needs. With over 40 years of designing timing systems for mission critical applications, Symmetricom has a complete setup and supporting resources to ensure customers are able to use all of the features of a Precise Time-Scale System.

Available services for Precise Time-Scale Systems include:

- Site survey and verification
- Customer-witnessed factory acceptance testing
- On-site installation
- Training
- Extended warranty and in-country support
- System spares program
- Software and systems support 24x7
- BIPM contribution and timekeeping consulting

Additional essential spare hardware is recommended to be purchased in order to achieve the required system availability taking into account the time required to repair and return failed equipment including shipping and possible customs clearance. Alternatively, in-country comprehensive extended hardware warranty may be considered to ensure optimum system availability. Ultimate availability is assured by considering a dual-string seamless fail-over and self-correcting time-scale system; please contact the Symmetricom factory for information regarding availability and redundancy.

Precise Time-Scale System

Precise Time-Scale Systems - Single rack configuration (with one cesium clock) Produces a real-time clock referenced to UTC via GNSS. The RTC has a single 5 MHz output, single IRIG-B output and a single 1 PPS output.
SINGLE-STRING TURNKEY TIMING SYSTEM consisting of: One 5071A-C001 cesium clock, System 2000 real-time clock/modules 8 Channel Measurement (MMS) unit with database server Battery back-up equipment 41 U Instrument rack and components to integrate the system UTC Recovery, Steering, Common view, Monitor & Control SW System design, integration and test included System packaging and documentation included On-site installation and training included Rack, monitor, keyboard and cables
Multiple Clock Upgrade Options
Add up to two additional 5071A high performance cesium clocks in the rack Add three additional cesium clocks or MHM2010 Active Hydrogen maser clocks outside the rack
Optional Services (consult Symmetricom factory for individual pricing)
Customer-witnessed factory acceptance test, 2 days on-site, Boulder CO Engineering – customer site facility infrastructure verification visit, 2 days (site consulting) 1 year extended HW warranty (Precise Time-Scale System HW excluding cesium) Essential system hardware spares Annual post installation SW and system support Annual comprehensive in-country extended HW warranty BIPM contribution and time keeping consulting

Table 1 Symmetricom Precise Time-Scale System Configurations

Precise Time-Scale System

Specifications

NUMBER OF CLOCKS:
- Up to three high-performance 5071A cesium clocks in the rack
- Up to three MHM2010 Active Hydrogen Maser clocks or external cesium clocks

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

Switching: automatic seamless switching between real-time clock references with no long-term time or frequency discontinuities or errors

OUTPUTS:

5 MHz (steered system output)
Level: 13 ± 1 dBm, 50 Ω
Spurious: < -80 dBc
Harmonics: < -40 dBc

10 MHz (steered system doubled output)
Level: 13± 1 dBm, 50 Ω
Spurious: < -80 dBc Harmonics: < -40 dBc

Phase Noise:

Offset frequency (Hz)	5 MHz (dBc/Hz)	10 MHz (dBc/Hz)
1	-106	-100
10	-136	-130
100	-151	-145
1 k	-156	-151
10 k	-160	-154
100 k	-160	-154

DATA STORAGE: Sufficent to store clock measurements for 10 years

SHORT-TERM STABILITY:

τ (s)	$\sigma_y(\tau)$
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	$1x10^{-14}$

BATTERY BACKUP: 24 VDC Nominal, >6 hrs

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

IRIG output from the Precise Time-Scale System supports the following:
IRIG- B (Amplitude modulated)
Format: 123
Amplitude: 6V Peak-to-peak nominal
Modulation ratio: 3 to 1

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

TIME COMPARISON:
Passive comparison with UTC via GNSS (<1 ns resolution)
- L1+L2 codeless reception, GLONASS, and GALILEO future upgrade optional

Time comparisons of 6 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 is 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

FREQUENCY ACCURACY:
$\pm 1x10^{-14}$ for 10 day averages after 60 days of continuous operation

FREQUENCY HOLDOVER:
$\pm 1x10^{-13}$ for 30 days over the full temperature range

1PPS Output Performance	One 5071A Cesium Reference Clock	Two 5071A Cesium Reference Clocks (Option)	Three 5071A Cesium Reference Clocks (Option)	Three 5071A Cesium and One H-MASER Reference Clocks (Option)
Time Accuracy Relative to UTC(USNO) at time of Shipment	10 ns	10 ns	10 ns	10 ns
10,000 sec stability (ADEV)	$8.5x10^{-14}$	$6x10^{-14}$	$4.9x10^{-14}$	$3x10^{-15}$
100,000 sec stability (ADEV)*	$2.7x10^{-14}$	$1.9x10^{-14}$	$1.6x10^{-14}$	$3x10^{-15}$
Time Holdover**	10 ns	10 ns	10 ns	10 ns
Jitter	<100 ps	<100 ps	<100 ps	<100 ps
Low Level into 50Ω load	Logic 0 <0.8 V	Logic 0 <0.8 V	Logic 0 <0.8 V	Logic 0 <0.8 V
High Level into 50Ω load	Logic 1 >4.5 V (with dist amp)	Logic 1 >4.5 V (with dist amp)	Logic 1 >4.5 V (with dist amp)	Logic 1 >4.5 V (with dist amp)

* Typically achieved after extended period of unperturbed continuous operation. Temperature variation: +/-0.25 °C, Relative humidity: +/-10%

** Assumes the system has been in continuous operation for 60 days. Performance is GNSS-limited, assuming a 10 day steering time constant

Precise Time-Scale System generates the following reports:
BIPM clock report
BIPM GNSS common view report
ITU two-way time transfer report (With the customer provided SATRE modem)

ENVIRONMENTAL

Power: 100, 120, 220, or 240 VAC nominal, 47-63 Hz, 1 kW maximum; 24 VDC nominal

Ambient temperature: 0 – 50 °C

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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