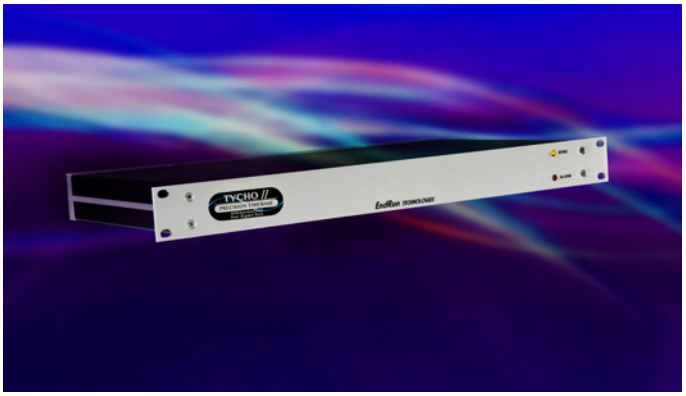
EndRun TECHNOLOGIES
"Smarter Timing Solutions"

Tycho II *Precision TimeBase*

GPS-Synchronized, Modular Time and Frequency Standard

The Tycho II Precision TimeBase is a cost-effective GPS-synchronized, modular, network-centric, time and frequency standard that generates signals with high accuracy, stability and spectral purity. The second-generation Tycho II provides exceptional price/performance value by combining our state-of-the-art time and frequency technology with a powerful network timing packet engine to synchronize virtually any stand-alone or network-connected system.

The modular architecture allows you to configure Tycho II to meet your requirements of today, and add option modules in the field to meet future needs. Tycho II's high-reliability design and trouble-free operation, combined with our efficient sales and support, provides the lowest total cost of ownership in the industry. Tycho II supports mission-critical operations in a wide range of government and commercial applications including telecommunications, satellite communications, digital video broadcast, simulcast radio, test range, test and measurement, calibration labs, power utilities and many more.



GPS Timing and Frequency Control

At the core of Tycho II is an EndRun GPS Receiver optimized to provide exceptional Coordinated Universal Time (UTC) accuracy (<25 nanoseconds RMS) and stability (<6 parts in 10^{-14} averaged 100k seconds). For ultimate performance, the innovative Real-Time Ionospheric Corrections (RTIC) option measures and removes ionospheric delay that meets or exceeds the performance of L1/L2 solutions.

User Configurable, Modular Design

The system's modularity supports a suite of field installable, plug-and-play option modules. Up to five modules can be accommodated, providing up to 23 time and frequency outputs in an efficient 1U chassis. Available output signals include IRIG-B time code, 1/5/10 MHz, ultra-low phase noise, telecom T1/E1, Direct Digital Synthesizer (DDS) from 1-10 MPPS, pulse rates, ASCII time messages, and more.

Security Hardened - Dual Gigabit Network Interface

Dual, security-hardened, gigabit Ethernet ports provide a high capacity Network Time Protocol (NTP) server and optional IEEE-1588 Precision Time Protocol (PTP) Grandmaster to synchronize clients on two networks. The Synchronous Ethernet (SyncE) option provides physical layer frequency synchronization and Synchronization Status Messaging communicates clock status to the respective network elements. The IPv4/IPv6 interface is security-hardened to meet the highest Information Assurance (IA) requirements.

Reference Oscillators

A variety of top-quality quartz oscillators are available to handle the full range of holdover, phase noise and short-term stability requirements. We design and manufacture our own OCXO oscillators to achieve performance and quality not found elsewhere. The proprietary design uses a 3rd-overtone, SC-cut crystal built with the highest-quality components and subjected to rigorous testing to guarantee industry-leading performance. The Ultra-Low Phase Noise option enables spectrally-pure 5 and 10 MHz outputs with phase noise less than -118 dBc and -113 dBc, respectively, at a 1 Hz carrier offset.

High Reliability and Two-Year Warranty

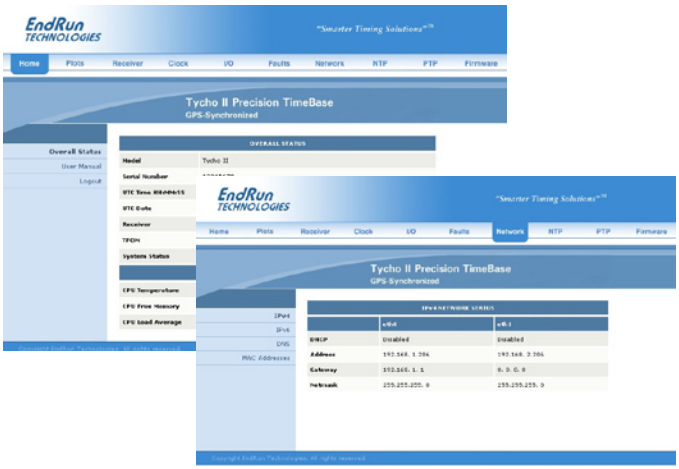
Tycho II uses EndRun's power-efficient, fanless design and thermal packaging with an estimated MTBF of over 25 years. The system is made in America, backed by a two-year warranty, a 60-day money-back guarantee, and supported by EndRun's top notch technical support team free of charge!

FEATURES

- Timing accuracy: <25 nanoseconds RMS to UTC(USNO). <10 nanoseconds (optional).
- Real-Time Ionospheric Corrections for L1/L2 performance (optional).
- Frequency accuracy: <6 x 10^{-14}.
- No frequency steps - guaranteed.
- Ultra-low phase noise 5 & 10 MHz output options.
- Short-term stability <4 x 10^{-13} at 1 second (optional).
- Dual-gigabit Ethernet ports.
- NTP Stratum 1 Server.
- IEEE-1588 PTP Grandmaster (optional).
- SyncE with SSM (optional).
- IRIG-B time code and 1 PPS outputs.
- Modular, plug-and-play design with up to 23 output signals.
- Telecom T1/E1 output option.
- GPS almanac/ephemeris data, YUMA/RINEX formats.
- Free technical support and software upgrades.
- 60-day money-back guarantee.

BENEFITS

- Time standard traceable to UTC(USNO).
- Frequency standard with atomic clock stability.
- Ultra low phase noise frequency reference for communication systems.
- Master Clock with time code generator.

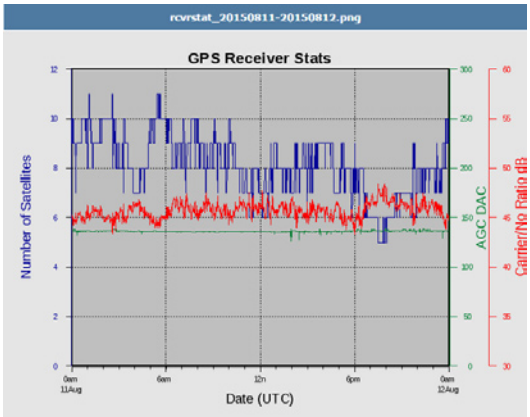


Secure Web Interface (HTTPS)
for System Monitoring & Firmware Upgrades

Web Interface

The Tycho II web interface is designed with security in mind, so its use is restricted to monitoring status, alarms, configuration settings, and installing firmware upgrades. Configuration and control is conducted via the network or serial command line interface. Firmware upgrades are enabled only after an authentication process. In addition, the web interface can be completely disabled for those who need the highest level of security.

The web page tabbed panels offer quick access to information about the GPS Receiver, Clock, I/O, Faults, NTP, PTP and the Firmware. Firmware upgrades are easy with the point & click upgrade process. Also, a link to the resident User Manual is available on the Home page.



Charts available for GPS, Oscillator, NTP and CPU statistics

Measurement Statistics and Charting

Real-time charting of GPS, Oscillator, NTP and CPU statistics are available via the Web Interface. Measurements are continuously computed and displayed in real-time with daily and weekly charts. The charts are automatically archived into month and year directories that remain resident for up to ten years.

The GPS chart provides a valuable, quick reference to assess the current and historical status of the GPS link to insure the Tycho II is and was performing to specification. The number of satellites in view, carrier-to-noise ratio, and the automatic-gain-control (AGC) are key metrics that reflect the quality and operation of the GPS receiver. The Oscillator chart shows the internal chassis temperature, oscillator electronic frequency control value and the offset of the receiver subsystem to the GPS reference. It is useful for verifying that the unit was locked to the GPS system at a certain time. The NTP statistics chart shows the NTP packets sent, packet rate and the accuracy of the NTP/System Time relative to UTC. The CPU statistics chart shows the free memory, processor load and CPU temperature.

Security-Hardened Network Interface

Extra care has been taken with Tycho II to "harden" it against network attacks and achieve the highest level of information assurance. It was developed with the latest version of the Linux operating system and security protocols. The Linux distribution is based on Slackware, a distribution that is famed for its security.

In a purpose-built appliance like Tycho II, there are only a few settings that need to be made that are typically set only once in the lifetime of the product. Since this is a set-it-and-forget-it box, we have eliminated all extraneous protocols/services in order to minimize exposure to security holes. Configuration is primarily performed via the secure SSH interface although Telnet (if enabled) and the serial port are also available. Monitoring of system status and alarm information is easily accomplished via the secure HTTPS webpage interface, command line interface (SSH, Telnet, serial port), or SNMP. Security-conscious users can further strengthen the network interface by disabling protocols (e.g HTTPS, Telnet) and restrict network access to specific hosts.

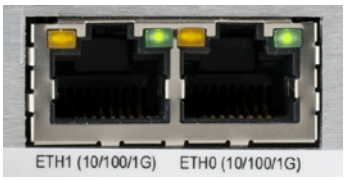
We designed Tycho II in such a way that it is not necessary for you to know Linux to use the product. For those users who are familiar with Linux, we make it easy for you to customize various aspects of the operation to your requirements.

Full User Control

Configuration and control is accomplished through either the network or serial ports. A handful of simple commands and interactive configuration wizards are provided for you to setup and control the product. Online help for all of the Tycho II-specific commands is available, as well as the standard help (manual) files for all of the available Linux commands.

Dual Gigabit Ports

Two independent 10/100/1000 Base-T Ethernet ports are provided. The ports are capable of generating 7,500 NTP packets per second with a timestamp accuracy of better than 10 microseconds. For PTP/IEEE-1588 applications, you can purchase the option to run on one or both ports with a timestamp accuracy of less than 8 nanoseconds. See the PTP/IEEE-1588 option datasheet for details on using Tycho II as a PTP Grandmaster.



Dual Gigabit Ports

Tycho II Rear Panel with Five Option Modules Installed

Tycho II Inputs, Outputs and Options

Tycho II provides a complete suite of time and frequency capabilities with an exceptionally high number and variety of outputs in a standard 1U chassis. The modular, plug-and-play design of Tycho II and wide range of option cards make it easy to tailor the unit to support your applications. The basic Tycho II supports several outputs via the standard CPU module that can also be expanded with options.

CPU Module

The CPU module is standard on all Tycho II units and includes the GPS receiver antenna input, RS-232 console port, and three timing ports for 1 PPS, AM Code and Spare (for options). The 1 PPS reference is a positive pulse with the leading edge exactly on-time. The AM code output provides user-selectable IRIG-B formats as well as NASA-36 and 2137 time codes. The dual-gigabit Ethernet ports support two networks. The following section describes the options available on the CPU Module:

Programmable Pulse Output (PPO) Option

The PPO Option provides user-selectable, on-time pulses at decade rates from 1 PPS to 10 MPPS (1, 10, 100, 1k, 10k, 100k, 1M, 10 MPPS). Other selections are 1PPM (pulse per 60 seconds, on the minute), 1PP2S (pulse per 2 seconds, on the even second), and Inverted 1 PPS (falling edge on-time). The PPO output is provided on the Spare BNC.

1 PPS Output Option

Additional 1 PPS outputs can be provided on the Spare BNC. A 1 PPS at RS-422 levels is available via a DB9M connector in lieu of the Spare BNC.

Direct Digital Synthesizer (DDS) Option

The DDS Option provides user-selectable pulse rates from 1 PPS to 10 MPPS, in 1 PPS steps. The DDS output is provided on the Spare BNC.

10 MPPS Output Option

The 10 MPPS Rate Output Option provides a fixed on-time pulse rate on the Spare BNC.

Alarm Output Option

The Alarm option provides an open-collector output to indicate a major alarm condition such as loss of GPS system lock. The Alarm output is commonly connected to a switch and distribution chassis and is installed on the Spare BNC or a terminal block.

Serial Time Output Option

The Serial Time Output consists of a once-per-second, ASCII time message to sync computer systems or equipment. Format selections are Sysplex, Truetime, EndRun, NENA and NMEA. The output is at RS-232 or RS-422 levels on a DB9M connector.

Power Supply Options

The Tycho II is equipped with an AC power supply and supports an optional DC supply. For high reliability, dual-redundant power supplies are supported in AC/AC, AC/DC or DC/DC configurations. A dual power supply configuration occupies two option slots.

- AC power supply: 90-132/180-264 VAC.
- DC power supply: 12, 24, 48, or 125 VDC.
- Connector type: IEC 320 (AC), 3 position terminal block (DC).

Modular Plug-and-Play Architecture

Tycho II's versatile, modular design allows you to custom configure the unit to meet your application requirements. The plug-and-play architecture supports up to 5 option modules and 23 time and frequency outputs. Option modules are normally installed at the factory, but most are available as field upgrades. An important benefit of a modular system is that you can add modules in the field as needed to accommodate future requirements. At power-on/boot time, the Tycho II software performs a system scan, detects the installed modules, and configures them per your configuration settings.

Following is a summary of the standard Tycho II option modules. For a detailed description, please see the Tycho II Options datasheet.

Digital Output Module

This module adds four buffered, digital signal outputs to your Tycho II. The module is popular to distribute digital pulse rates and time code.

- Signal types: 1PPS, Programmable Pulse Output (PPO), Time Code, Direct Digital Synthesizer (DDS) at integer rates between 1 PPS and 10 MPPS.
- Signal level and connector: TTL (BNC), RS-232 (DB9M), or RS-422 (DB9M).

Analog Time Code Output Module

This module adds four buffered analog time code outputs to your Tycho II that match the user-selected format of the CPU AM Code output.

- Signal types: IRIG-B120 (IEEE-1344), IRIG-B122, IRIG-B123, NASA-36, or 2137.
- Signal level and connector: 1 Vrms (BNC).

Low Phase Noise Output Module

This module outputs four spectrally pure frequency signals with high port-to-port isolation. When distributing low phase noise, best practice is to establish direct point-to-point connections to receiving equipment with high quality cable. The low phase noise level and stability is dependent on the Tycho II's reference oscillator.

- Signal types: 5, 10 MHz.
- Signal level and connector: +13dBm (BNC).

Sine Wave Output Module

This module adds four frequency outputs to your Tycho II for customers that do not need high-performance low phase noise. The stability is dependent on the Tycho II's reference oscillator.

- Signal types: 1, 5, or 10 MHz.
- Signal level and connector: +13dBm (BNC).

Telecom Clock Module

This module adds two telecom outputs to enable Tycho II as a Primary Reference Clock. A full suite of telecom signal types and formats are available to provide high-stability Building Integrated Timing Supply (BITS) clock signals directly to digital equipment. An optional alarm port is also available. An oscillator upgrade to an OCXO is required to meet G.811, G.823 and G.824 standards.

- Signal types: T1, J1, E1, Composite Clock, 1.544/2.048 Mbps. Optional Alarm.
- Connector type: RJ48C or DB9M.

Tycho II Precision TimeBase Specifications

GPS RECEIVER
- L1 Band - 1575.42 MHz.
- 12 Channels, C/A Code.
- 15 dB minimum gain at receiver input.
- Static and dynamic (shipboard) operating modes.
- Timing Receiver Autonomous Integrity Monitoring (TRAIM).
- TNC connector (female) on rear panel, Zin = 50Ω. 5 VDC to antenna.

1 PPS TIMING CHARACTERISTICS
The following accuracy and stability specifications assume a stationary platform, 4 satellite lock, and antenna installation with a full view-of-the-sky.
- Accuracy: <25 nanoseconds RMS to UTC(USNO) when locked*.
  <10 nanoseconds RMS to UTC(USNO) with 10-Nanosecond Calibration Option
- Stability: TDEV <10 ns @ τ <10^5 secs, $\sigma y(\tau)$ <$6x10^{-14}$ @ τ=10^5 secs.
- Positive TTL pulse into 50Ω (Zout = 50Ω) or RS-422 levels (option).
- User-Selectable Width: 20 us, 1 ms, 100 ms, 500 ms.
- User Calibration: +/- 500 us, 1 ns resolution.

* See GPS-UTC Timing Specifications for details.

LOCAL REFERENCE OSCILLATOR
Several oscillator options are available to meet your short-term stability at 1 second (STS), phase noise at 1 Hz offsets in dBc/Hz (LPN) , ageing rate/year (AGE RATE), and temperature stability for 0-70° C (TEMP STAB):

OSCILLATOR	STS (1 sec)	LPN 10/5 MHz	AGE RATE	TEMP STAB
- TCXO (standard)	$2x10^{-10}$	-70/na	$1x10^{-6}$	$2.5x10^{-6}$
- Medium-Stability OCXO	$3x10^{-12}$	-95/-100	$3x10^{-8}$	$4x10^{-9}$
- High-Stability OCXO	$1x10^{-12}$	-105/-110	$3x10^{-8}$	$1x10^{-9}$
- Ultra-Stable OCXO	$4x10^{-13}$	-113/-118	$3x10^{-8}$	$5x10^{-10}$

See Oscillator Options datasheet for more information.

TIME TO LOCK
- < 5 minutes, typical (TCXO). < 10 minutes, typical (OCXO).

NETWORK I/O
- Two rear-panel RJ-45 jacks.
- 10/100/1000Base-T Ethernet.

NETWORK PROTOCOLS
- IPv4/IPv6.
- SNTP, NTP v2, v3, v4, SHA/MD5 authentication, broadcast/multicast mode and autokey.
- SSH client/server with "secure copy" utility, SCP.
- SNMP v1, v2c, v3 with Enterprise MIB.
- HTTPS (Web Interface).
- TIME and DAYTIME server.
- TELNET client/server.
- FTP and DHCP clients.
- SYSLOG.
- Optional PTP/IEEE-1588-2008 (v2) Grandmaster.
- Optional SyncE with Sync Status Messaging (SSM). G.8261, G.8262, G.8264 compliant.

NETWORK SYNCHRONIZATION ACCURACY
- NTP Timestamp Accuracy: < 10 microseconds @ 7,500 requests/second.
- PTP Timestamp Accuracy to Reference Clock: 8 nanoseconds.

TIME CODE CHARACTERISTICS
- Signal: Amplitude-modulated (AM), 3:1 ratio, 1 kHz carrier, 1 Vrms into 50Ω.
- User-Selectable Formats: IRIG-B120 (IEEE-1344), IRIG-B122, IRIG-B123, NASA-36, or 2137.

SERIAL I/O PORT
- RS-232 serial I/O on DB9M jack for secure, local terminal access.
- Parameters fixed at 19200 baud, 8 data bits, no parity, 1 stop bit.

SYSTEM STATUS INDICATORS
- Sync LED: Amber LED pulses to indicate lock status.
- Alarm LED: Red LED indicates a serious fault condition.

POWER
- 90-264 VAC, 47-63 Hz, 1.0A Max. @ 120 VAC, 0.5A Max. @ 240 VAC.
- 3-Pin IEC 320 on rear panel, 2 meter cord included.

SIZE
- Chassis: 1.75"H x 17"W x 10.75"D.
- Weight: <5 pounds.

ENVIRONMENTAL
- Operating Temperature/Humidity: 0° to +50° C / 5% to 90% RH, non-condensing.
- Storage Temperature/Humidity: -40° to +85° C / 5% to 95% RH, non-condensing.

COMPLIANCE
- CE, FCC, RoHS, WEEE.

ANTENNA KIT OPTION
- 40 dB gain LNA with band-pass filter for out-of-band interference rejection.
- Rugged, all-weather housing capable of operation over -40° to +85°C.
- 50' low-loss RG-59 cable. Optional lengths up to 1000' with preamplifiers.
- Mounting kit: 18" long, 3/4" PVC pipe with clamps.
- TNC connector (female), Zout = 50Ω. 5 VDC input.
- Antenna: 3.25"H x 3"diameter.

GPS Antenna Kit

TYCHO II OPTIONS
Refer to the Tycho II Options datasheet for detailed information on all options.

RELATED PRECISION TIMEBASE
The Meridian II is similar to the Tycho II with the addition of a front-panel keypad/display and improved accuracy specification of 10 ns to UTC(USNO).

RELATED DISTRIBUTION PRODUCTS
EndRun provides frequency, pulse and time code distribution products to expand Tycho II outputs:
- FDC3302e High-Performance Frequency Distribution Chassis
- FDC3300e Frequency Distribution Chassis
- PDC3301e Pulse Distribution Chassis
- TDC3303e Time Code Distribution Chassis

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