



INSTRUMENTS, INC.

The **GPS TIME MACHINE/TM-3™** Time & Frequency System

Spectrum Instruments introduces an improved version of the GPS Time-Machine/TM-3™ Time & Frequency System. The TM-3 represents a complete GPS-based precise time and frequency solution designed for use in a wide variety of applications, including wireless telecommunications.



The GPS Time-Machine/TM-3™ Time & Frequency System offers the following features and performance:

- GPS-disciplined oscillator with 10 MHz sine wave and TTL outputs.
- Meets MTIE requirement for a Stratum-1 primary clock source.
- Optional auxiliary frequency output such as 1.544 MHz or 2.048 MHz slaved to primary frequency reference.
- Frequency accuracy of 1×10^{-11} (long-term).
- One pulse-per-second (1 PPS) output with separate ASCII serial time message.
- Timing accuracy of ± 50 ns.
- Programmed output pulse with 100 ns resolution.
- External event time-tag with 100 ns resolution.
- Optional IRIG B serial time code output (TTL & Modulated).
- RS-232 control interface for control by a host computer.
- Windows®-based control and display software.
- Static and dynamic timing modes.
- Timing information derived from all satellites tracked with only one satellite required in static timing mode.
- State-of-the-art GPS technology.
- Front panel indicators for power status, time valid, and alarm status.
- 18 to 32 VDC operation with lithium battery back-up for GPS data and unit configuration.

The GPS Time-Machine/TM-3™ Time & Frequency System consists of a state-of-the-art GPS timing receiver integrated with proprietary microprocessor-controlled timing and interface logic, and includes a separate GPS antenna.

The GPS receiver simultaneously tracks all available satellites. The microprocessor-controlled timing and interface logic derives precise timing information from these satellites and provides additional features including the standard 1 pulse-per-second (1 PPS) output and associated ASCII serial time message, external event time-tag, programmed output pulse, and optional IRIG B serial time code generator. The timing and interface logic also controls an ovenized 10 MHz crystal oscillator and additional clock features.

The antenna is an all-weather, high-performance quadrifilar design with an integrated low-noise preamplifier. It is flush mounted and comes complete with 50 feet of RG-58 cable. An optional mast-mount is available. Pre-amplifier power is supplied to the antenna via the coaxial cable.

Control, operation, and status of the GPS Time-Machine/TM-3™ Time & Frequency System is accomplished via the control interface, which consists of a standard RS-232 serial port and a user-friendly, Windows®-based control program. This accommodates a wide variety of host computers and equipment including any personal computer with an available serial communications port. All communications to and from the unit utilize a series of compact, ASCII messages which allow the host to make changes to the operating parameters and read GPS tracking, status, and timing information.

The GPS Time-Machine/TM-3™ Time & Frequency System is capable of autonomous operation without connection to a host computer. Once power is applied, the unit requires no intervention to acquire satellites and provide the basic time and frequency functions based on factory default settings. A host computer may be connected for initialization purposes and left connected to monitor the system operation. The host may be disconnected at any time, and the unit will continue to operate normally with the configuration selected. Subsequent power-on starts use the last configuration in effect when power was turned off.

The GPS Time-Machine/TM-3™ Time & Frequency System features two timing modes—static and dynamic. Static timing mode may be used when the user is stationary and his position and altitude are known. Only one satellite needs to be tracked to operate in this mode. Dynamic timing mode is used when the user is not stationary or when his position or altitude is not known. In this mode, the unit continuously computes the position and derives timing information from all available satellites.

A GPS-disciplined ovenized crystal oscillator (OCXO) is incorporated in the GPS Time-Machine/TM-3™ Time & Frequency System to provide a very precise and stable frequency standard. After a few hours of tracking GPS signals, the accuracy of this source approaches that of the Cesium clocks on the GPS satellites. The output frequency is 10 MHz, and both sine wave and TTL outputs are provided. The sine wave output is extremely high quality in terms of phase noise and spectral purity and is suitable for use as the primary source for driving local oscillator synthesizers in wireless communications systems.

An auxiliary frequency output may be provided by a phase locked loop (PLL) synthesizer in the GPS Time-Machine/TM-3™ Time & Frequency System. This output is available as a factory option and several commonly used frequencies are available, such as 1 MHz, 5 MHz, 1.544 MHz, and 2.048 MHz. This output retains the accuracy and stability of the primary 10 MHz output, and its stability meets the MTIE requirement for a Stratum-1 primary clock source. The performance of this system in the absence of GPS signals (coasting) is excellent due to the high quality OCXO incorporated in the product.

A unique feature of the GPS Time-Machine/TM-3™ Time & Frequency System is the availability of a filtered timing pulse output. This output is available as a factory option and may be set to a variety of frequencies. It is coherent with the 10 MHz clock and has the same accuracy and stability as the primary 10 MHz output. The leading edges of this signal are synchronized to the average value of the 1 PPS signal from the GPS receiver, and the nature of the filtering provides for an output signal with exceptionally low jitter.

The programmed output pulse feature allows the user to specify a date, time, repetition rate, and polarity for generating an output pulse with 100 ns resolution.

The external event time-tag feature marks the date and time of occurrence of an external event with 100 ns resolution. The polarity of the input pulse is selectable. Multiple events are buffered and event times are supplied to the host computer via the control interface.

An IRIG B serial time code generator option is available in the GPS Time-Machine/TM-3™ Time & Frequency System and provides precise time outputs in industry standard IRIG B format. Two outputs are provided— IRIG B002, a pulse-width modulated logic signal, and IRIG B122, a 1 kHz amplitude modulated carrier.

The GPS Time-Machine/TM-3™ Time & Frequency System Control/Display Software supplied with the unit will run on most Windows®-based personal computers equipped with at least one free serial communications port. The software allows the user to change the operating configuration of the unit and view status and control information. A DOS-based control program is also optionally available.

The front panel of the GPS Time-Machine/TM-3™ Time & Frequency System includes a power switch and LED indicators to indicate the power status, valid GPS-corrected time (time valid), and alarm status. All connections to the unit are made with standard connectors located on the rear panel.

The GPS Time-Machine/TM-3™ Time & Frequency System comes complete with an external antenna, a 50 foot RG-58 antenna cable assembly, control/display software, a PC interface cable, an AC power adapter, and a comprehensive user manual.

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GPS TIME-MACHINE/TM-3™ SPECIFICATIONS

PHYSICAL (GPS TIME-MACHINE)

HEIGHT: 1.52 in. (38.6 mm)
WIDTH: 7.29 in. (185.2 mm)
DEPTH: 9.00 in. (228.6 mm)
WEIGHT: 2.6 lbs. (1.2 kg)

PHYSICAL (ANTENNA)

HEIGHT (top to flange): 3.9 in. (98.4 mm)
HEIGHT (overall): 5.0 in. (126.6 mm)
DIAMETER: 3.54 in. (90.0 mm)
WEIGHT: 0.66 lbs. (0.30 kg)
MOUNTING: Flush mount. Optional 1.25" mast mount.
CABLE: RG-58 (50 ft.) with TNC connectors standard. Longer cables optional.

ENVIRONMENTAL (GPS TIME-MACHINE)

OPERATING TEMPERATURE: -10 to +60 °C (0 to +50 °C for Stratum-1 specifications).
TEMPERATURE RATE: 8.3 °C per hour maximum for Stratum-1 specifications.
HUMIDITY: Up to 95% RH, non-condensing.

ENVIRONMENTAL (ANTENNA)

OPERATING TEMPERATURE: -40 to +85 °C
HUMIDITY: Water-proof/All-weather

PERFORMANCE (GPS)

RECEIVER TYPE: Eight-channel, parallel-tracking, CA code, L1 carrier
TIME TO FIRST FIX:
Hot Start: <15 seconds typical (valid almanac, time, date, position and ephemeris)
Warm Start: <45 seconds typical (valid almanac, time, date, and position)
Cold Start: <10 minutes typical (no information)
ALTITUDE: -1000 to +40,000 ft.
POSITION UPDATE RATE: Once per second, nominal.
MAXIMUM VELOCITY: 1000 knots (515 m/s)
MAXIMUM ACCELERATION: 4 g
POSITION ACCURACY: Less than 15m SEP

PERFORMANCE (TIME)

1 PPS OUTPUT (Referenced to UTC):
Conditions: Static Mode - Position known.
2D Dynamic Mode - HDOP<2.
3D Dynamic Mode - PDOP<2.
Accuracy: ±50 ns
Stability (1 sigma): 50 ns
Resolution: 100 ns
Drift Rate (Coasting): 4x10⁻⁹ typical

1 PPS TIME MESSAGE: Serial, ASCII date and time of next 1 PPS epoch

PERFORMANCE (FREQUENCY)

GPS-CORRECTED 10 MHz SINE WAVE FREQUENCY OUTPUT:

Conditions: Time Valid.

Long-term Accuracy (while tracking): 1×10^{-11} after 24 hours of tracking ($\Delta t=12$ hours).

Short-term Stability:

5×10^{-12} ($\Delta t=1$ second)

8×10^{-12} ($\Delta t=10$ seconds)

2×10^{-11} ($\Delta t=100$ seconds)

1×10^{-10} ($\Delta t=1,000$ seconds)

Accuracy (while coasting):

Conditions: 24 hours of tracking followed by 24 hours of coasting

$< 1 \times 10^{-9}$ at constant temperature

$< 3 \times 10^{-8}$ over 0 to 50 °C range

Phase Noise at Various Offsets, 1 Hz Bandwidth:

1 Hz: < -85 dBc

10 Hz: < -115 dBc

100 Hz: < -135 dBc

1 kHz: < -145 dBc

10 kHz: < -155 dBc

Harmonic Outputs: < -35 dBc

Spurious Outputs: < -70 dBc

Level: +10 dBm nominal into 50Ω

GPS-CORRECTED 10 MHz TTL FREQUENCY OUTPUT:

Accuracy: Same as 10 MHz sine wave frequency output, both tracking and coasting.

Level: TTL into 50Ω

OPTIONAL GPS-CORRECTED AUXILIARY CLOCK OUTPUT:

Frequency: Various frequencies available such as 1 MHz, 5 MHz, 1.544 MHz, and 2.048 MHz.

Accuracy: Same as 10 MHz sine wave frequency output. Meets Stratum-1 MTIE specifications.

Level: TTL into 50Ω

OPTIONAL FILTERED TIMING PULSE OUTPUT:

Frequency: Various frequencies available such as: 1 Hz, 25 Hz, 216.667 Hz and many others.

Accuracy: Same as 10 MHz sine wave frequency output. Meets Stratum-1 MTIE specifications.

Level: TTL into 50 Ω

Characteristics: Coherent with 10 MHz. Leading edge synchronized to average value of PPS from GPS.

INPUTS & OUTPUTS

1 PPS OUTPUT:

Connector: BNC

Drive: TTL levels into 50Ω

Pulse Width: Positive pulse, 1 ms nominal. Rising edge on-time.

Rise Time: 10 ns, maximum

CONTROL PORT:

Connector: DB-9 (Female)

Signal Levels: RS-232C

Signals: Serial data-in, serial data-out, ground

Baud Rate: 9600

INPUTS & OUTPUTS, *Contd.*

AUXILIARY PORT:

Connector: DB-15 (Male)

Alarm Output: Open collector

Serial Time Code Output: TTL levels into 50Ω.

Programmed Output Pulse:

Drive: TTL levels into 50Ω.

Rise & Fall Time: 10 ns, maximum

Pulse Width: 20 μsec, nominal

Polarity: Selectable

Multiplexer Output:

Drive: TTL levels into 50Ω.

Selectable Outputs: 1 kHz, 10 kHz, 100 kHz, 1 MHz, 5 MHz, 10 MHz at 50% duty cycle, programmed output pulse, optional IRIG B serial time code

Rise & Fall Time: 10 ns, maximum

1 PPS Output: Same as BNC output.

Time Message Output: RS-232C, 1200/ 2400/ 4800/ 9600 baud, software-selectable

External Event Input: TTL/CMOS level, edge-triggered. Active edge is software-selectable.

Optional IRIG B Modulated Output (1 kHz):

Output Level: $2.7 V_{PTP}$ into 600Ω.

Modulation Ratio: 3.3 to 1

Optional Auxiliary Clock Output:

Drive: TTL levels into 50Ω.

Frequency: Various frequencies available as factory option.

Output: 50% duty cycle

Rise & Fall Time: 10 ns, maximum

Optional Filtered Timing Pulse Output:

Drive: TTL levels into 50Ω.

Frequency: Various frequencies available as factory option.

Pulse Width: Positive pulse, 500 μsec nominal. Rising edge on-time.

Rise & Fall Time: 10 ns, maximum

ANTENNA INPUT:

Connector: TNC

DC POWER INPUT:

Connector: Coaxial jack

POWER

INPUT SUPPLY VOLTAGE: 18 to 32 VDC

WARM-UP CURRENT: 350 mA @ 24 VDC, typical

OPERATING CURRENT: 200 mA @ 24 VDC, typical