

PTS PRECISION TEST SYSTEMS

GPS10R/RB - 10 MHz, GPS Disciplined, Rubidium Frequency Standards



Key Features

- Completely self-contained units. No extra computer needed. Full information available via LCD.
- Rubidium Oscillator locked to GPS satellite signal. Accuracy to parts in 10^{-13} (Stratum 1 performance)
- Free run mode. Rubidium still gives an accurate output without a GPS satellite signal (Stratum 1, 72 hr)
- Two 1 pps time outputs. Typical error < 20 ns compared to UTC. Jitter < 300 ps
- Ultra Low Phase Noise, e.g. -148 dBc/Hz at 1 kHz offset
- Multiple 10 MHz Frequency Outputs plus other outputs
- RS232 interface. Full control and interrogation of the GPS10R/RB via RS232
- 19" 2U high rack mountable case (GPS10RB) or bench mount unit (GPS10R)
- Very Low Microphonics
- Optional DDS Outputs. Generate any frequency from 0 to 1640 MHz in 1 or 10 μ Hz steps
- Optional DDS with Sine and Cosine outputs
- Optional single frequency output. Single frequency is fixed and can be anywhere from 0 to 10 GHz
- Optional alarm relay outputs. Dual changeover relay is operated in an alarm condition
- Optional antenna amplifier. Place GPS antenna up to 350 m (1150 feet) away from GPS10R/RB
- Optional time code outputs (BCD, IRIG-B, IRIG-E and ESE-TC90)
- Optional redundancy. Operate two units in a redundancy set-up for added security with automatic switchover. Five 10 MHz outputs as standard. More outputs can be added if required.

- Optional Slave Clock Display. Display provides 25 mm high digits of time or date
- Optional Windows Software. Allows GPS10R/RB to be monitored from a remote location
- Optional GSM Interface. GPS10R/RB can send a SMS to ten GSM phones in the event of an alarm
- Optional additional outputs. Up to 100 extra sinewave outputs can be added (requires separate box)
- Optional 5 MHz outputs instead of 10 MHz. A 10 MHz output is still available
- Optional high quality distribution amplifier giving increased isolation and phase stability
- Optional Ethernet interface. Enables the GPS10R/RB to communicate over the internet
- Custom built options available upon request
- High quality design

General Description

The GPS10R/RB are 10 MHz, GPS disciplined, rubidium frequency standards. They combine the short-term stability of an atomic rubidium oscillator with the long-term stability and traceability of the Global Positioning Service (GPS) set of satellites. The GPS10R/RB achieves short and long-term frequency accuracy of parts in 10^{-13} . Thus the GPS10R/RB exceeds the requirements of a Stratum 1 level frequency standard.

Options for the GPS10R/RB include an antenna amplifier enabling the antenna to be placed up to 350 meters from the GPS10R/RB, various fixed high frequency outputs, alarm relay outputs, redundancy, battery backup supply, time code outputs and a variable frequency output.

Rubidium for the price of an OXCO Oscillator

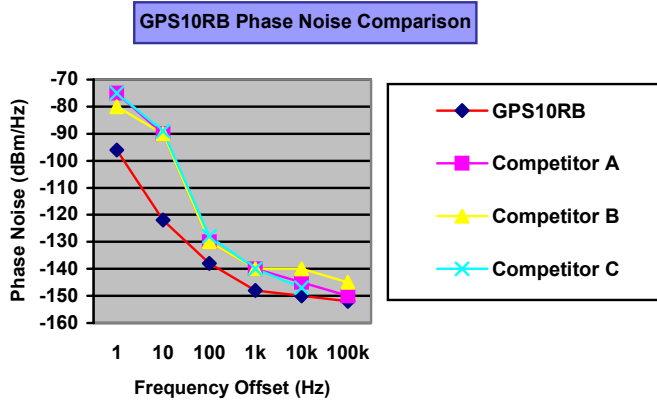
The GPS10R/RB incorporate an atomic rubidium oscillator as the main frequency reference, but costs the same as some competitive units that use less accurate crystal oscillators. The rubidium used in the GPS10R/RB is 30 times more stable than any OXCO available. This means the GPS10R/RB achieves a frequency stability of typically 7×10^{-13} in 1000 sec. Frequency Standards that use a crystal oscillator as the main reference can only achieve this stability when measurements are averaged over one week or one month. This means the GPS10R/RB can be used as a frequency reference for frequency counters etc and measurements can be made in seconds, not days or weeks as is the case for crystal oscillator based units.

Accurate Timing Outputs

There are two 1 pps (pulse per second) outputs that are derived from the GPS receiver or the rubidium oscillator. The 1 pps signal from the GPS receiver is aligned to UTC with less than 20 ns error. The 1 pps from the rubidium is also aligned to UTC but has the advantage of less than 300 ps jitter (typically < 150 ps). Most other frequency standards quote 50-100 ns jitter.

Very Low Phase Noise

The GPS10R/RB are one of the lowest phase noise frequency standards available, at any price! Phase noise is often overlooked, but is one of the most important specifications of a frequency standard. Many of today's high performance signal generators, for example, have very low phase noise outputs. These signal generators have their own internal, low phase noise, crystal oscillator. However, if this type of instrument is used with an external frequency source, it is essential that the external frequency source has an equally low phase noise output as the internal oscillator. Otherwise the signal generators phase noise will be impaired. Of course it's not only signal generators that could suffer, but also any other type of instrument that relies on a low phase noise frequency source, to operate correctly.



The graph to the left shows the GPS10R/RB phase noise (red trace) compared with three competitors (Pink, Yellow, Blue traces). As can be seen the GPS10R/RB has lower phase noise than its competitors.

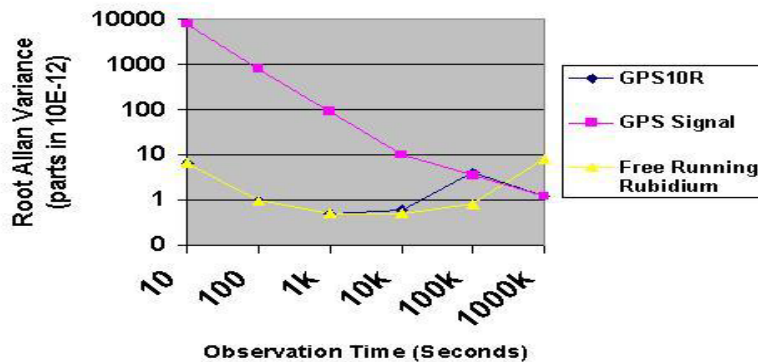
Competitor's specifications drawn from internet publications. GPS10R/RB phase noise independently measured (smoothed display).

Keyboard Control and LCD Display

A 16-way keyboard is used to interface to three microprocessors that control the GPS10R/RB. The LCD display's over 50 different menus. These menus show all the relevant information including time, position (longitude, latitude, height), number of satellite tracked, health of each satellite and the status of the rubidium oscillator.

Allan Variance Plot of the GPS10R/RB and the GPS signal

The diagram below shows the Allan variance of a typical GPS signal (pink), the Allan variance of the GPS10R/RB's rubidium oscillator when free running (not locked to the GPS signal) (yellow) and the actual output of the GPS10R/RB when locked to the GPS signal (blue). As can be seen, the GPS10R/RB combines the short-term stability of the rubidium oscillator with the long-term stability of the GPS signal to achieve short and long term stability of its frequency output signal.



Multiple Frequency Outputs

The GPS10R/RB has many different output options. These outputs are:

- Buffered 10 MHz sinewave outputs. Each output is fully isolated from each other. The amplitude of each output can be individually adjusted from 0 dBm to +13 dBm. Harmonic distortion of these outputs is better than -65 dBc. Five outputs as standard. Option 12 adds a further five, making ten in total.
- Square wave output that can drive TTL levels into a 50 Ω load impedance. The frequency of the square wave can be set to 10, 5, 2, 1, 0.1 MHz and 1 pps via the front panel keyboard. One output as standard and two available with option 12.
- Dual one pulse per second outputs. These 1 pps outputs are either derived from the GPS receiver, or from the rubidium receiver. The leading edge of the GPS 1 pps signal is aligned to UTC time ± 20 ns. The Rb 1 pps output signal has very low jitter of < 300 ps. These outputs can drive TTL levels into a 50 Ω load impedance.
- A slave 10 MHz output is available to connect more distribution amplifiers, such as the PTS50 or DA101010, to the GPS10R/RB. Thus it is possible to get multiple 10 MHz outputs that can be used to provide 10 MHz reference signals to an entire building or workshop, for example.

- Optional high frequency outputs can be specified at the time of ordering. These fixed high frequency outputs can be as high as 10 GHz (higher frequencies available upon special request) and are phase locked to the main frequency reference. Note: this option only generates one fixed frequency.
- Optional DDS Output enables the GPS10R/RB to produce a sinewave or squarewave output that is locked to the GPS10R/RB. The frequency range of this output is 1 μ Hz to 80 MHz (1 μ Hz steps) or 10 μ Hz to 1640 MHz (10 μ Hz steps). This option can be used to generate the popular 2048 kHz and 13 MHz frequencies as well as any frequency in the range 1 μ Hz to 80 MHz or 10 μ Hz to 1640 MHz.
- Optional Time Code Output. This option generates the industry standard IRIG-B, IRIG-E and ESE-TC90) time code formats. Also a 48 bit BCD time code can be generated with option 16.

Free Run Mode. Ideal for portable applications

The GPS10R/RB is normally operated with the Rubidium oscillator's 10 MHz output, locked to the GPS satellite system. In the event of a failure of the GPS signal for any reason, the GPS10R/RB will automatically switch over to free run mode. In this mode, the GPS10R/RB's Rubidium Oscillator still achieves Stratum 1 performance over a 72 hour period.

Also the GPS10R/RB can be used for portable applications where a satellite signal is not available, or the time required to lock the GPS10R/RB is not available. When the GPS10R/RB is powered up it can be set to the free run mode. The Rubidium Oscillator "remembers" the last known good frequency setting and adjusts itself to this frequency. Thus an accurate 10 MHz is available within a few minutes of switch on. This mode is ideal for setting up GSM base stations that require an accurate time base for frequency measurement.

RS232 and USB Interface

The RS232 interface allows complete control and interrogation of the GPS10R/RB. An optional USB adapter allows the GPS10R/RB to be controlled via the USB port of the PC.

Options

The GPS10R/RB have many options enabling them to work in varied applications. Not all options can be installed at the same time. Some options require a separate case. The options are listed below:

Option 01: Second Frequency Output, 0 to 500 MHz spot frequency.

This option gives a second frequency output. The frequency is fixed and cannot be changed. The spot frequency must be advised by the customer prior to manufacture. The frequency can be in the range 0 to 500 MHz. For example, option 01A gives a 100 MHz output.

Option 02: Second Frequency Output, 500 to 1000 MHz spot frequency.

This option gives a second frequency output. The frequency is fixed and cannot be changed. The spot frequency must be advised by the customer prior to manufacture. The frequency can be in the range 500 to 1000 MHz.

Option 02A: Second Variable Frequency Output, 780 to 820 MHz.

This option gives a second frequency output. The frequency is variable and can be changed from 780 MHz to 820 MHz in 100 kHz steps. The frequency output has good phase noise and low spurious.

Option 03: Second Frequency Output, 1 GHz to 3.2 GHz spot frequency.

This option gives a second frequency output. The frequency is fixed and cannot be changed. The spot frequency must be advised by the customer prior to manufacture. The frequency can be in the range 1 GHz to 3.2 GHz.

Option 03A: Second Variable Frequency Output, 2.25 GHz to 2.65 GHz.

This option gives a second frequency output. The frequency is variable and can be changed from 2.25 GHz to 2.65 GHz in 100 kHz steps. The frequency output has good phase noise and low spurious.

Option 04: Antenna Amplifier

The GPS35 is a GPS Antenna Amplifier. When used with low loss cable, antenna lengths of over 300 m (1000 feet) can be achieved, making installation in large buildings or basements possible.

Option 05, 05 and 05B: DDS Signal Generator

Option 05 adds a DDS (direct digital synthesis) signal output to the GPS10R/RB. The DDS output has a squarewave and sinewave output. The frequency of this output is adjustable from 1 μ Hz to 80 MHz in steps of 1 μ Hz. Thus this option can be used to generate the popular 2048 kHz and 13 MHz outputs often needed in Telecommunication systems. The DDS output is locked to the main 10 MHz rubidium frequency oscillator. Option 05A gives a higher output. Option 05B adds a Sine and Cosine outputs (in place of squarewave output).

Option 06: RS232 Cable

The RS232 cable connects the GPS10R/RB to a PC enabling control and interrogation of the GPS10R/RB by the PC.

Option 07 and 07A: Alarm Relay Output

This option adds a dual changeover relay that is activated in the event of an alarm. Each relay contact is rated at 30 VDC and 1 Amp. Option 07A increase relay current to 30 V at 5 amps.

Option 08: Redundancy

Option 08 adds redundancy. With this option, two GPS10R/RB's can be configured into a redundancy set-up with five main 10 MHz outputs (ten outputs with option 12). Normally one unit will supply the 10 MHz outputs (locked to the GPS satellite). In the event of failure of this unit, the 10 MHz outputs will be automatically switched to the second GPS10R/RB unit. The second GPS10R/RB unit will then supply the 10 MHz outputs, locked to the GPS system. Even if both GPS antennas are disconnected, and one unit completely fails, there will still be a 10 MHz from the second unit running from the rubidium oscillator. Both units are identical; there is no master or slave. Simply, whatever unit is healthy will supply the 10 MHz output. System status is available via the RS232 interface. This option is ideal for applications that require extra security. Extra 10 MHz outputs can be added if required.

Option 09: IRIG-B Output

This option gives the industry standard IRIG-B or IRIG-E time code output. The output can be internally set to give an AM modulated signal or TTL output.

Option 11: Clock / Date Display Unit

Option 11 provides a remote Clock / Date display. The display consists of a 6 digit 25 mm high digital LED display that can be read from a distance of 10 metres. The display can be located remotely from the GPS10R/RB. The display requires a cable connection from the GPS10R/RB although a wireless unit is available on special order.

Option 12: Additional 5 sinewave outputs

The GPS10R/RB has five isolated 10 MHz sinewave outputs. Option 12 adds a further five making ten in total.

Option 12A: 10.23 MHz Outputs

This option changes the five sinewave outputs to 10.23 MHz. A rear panel input connector allows the DDS option (option 05) to generate 10.230 MHz and be available on these five isolated outputs.

Option 13: Mute Sinewave Outputs in the event of an alarm

This option disables all the sinewave outputs in the event of an alarm or error.

Option 14: Service manual

The service manual has service information and realignment procedures.

Option 15: Windows Software

This windows software operates on Windows XP. It allows all the main parameters of the GPS10R/RB to be monitored and recorded by the PC.

Option 16: BCD Time Code Output.

This option gives a 48 bit BCD time code output. The time output is in the format HH:MM:SS.ssssss. The fractional seconds have a resolution of 100 ns. The output is updated every 100 ns and is accurate to UTC to within 200 ns.

Option 17: DDS Generator 0 to 400 MHz

This option adds a DDS generator that can operate from 0 to 400 MHz in 0.1 Hz steps.

Option 18: Ethernet Port with NTP Server

This option allows the GPS10R/RB to be connected remotely, via the internet.

Option 19: +24VDC Input

This option allows the GPS10R/RB to be externally powered by a +24 VDC supply at 5 amps. In the event of AC power being lost, the GPS10R/RB will instantly switch over to the external +24 VDC supply (supply not included).

Option 20: 2.048 MHz G703:10 output

This option gives the popular 2.048 MHz output. The output is a squarewave with amplitude of ± 1.2 V in 75 Ω

Option 21: Lightning Protection

This option adds lightning protection to the antenna input. The protection is placed close to the GPS antenna.

Option 22: 0 to 1640 MHz DDS Output.

This option adds a DDS output. The output can be set anywhere from 0 to 1640 MHz in 10 μ Hz steps.

Option 23: GSM Interface

This option enables the GPS10R/RB to send a SMS (short message service) or Text to ten GSM mobile phones in the event of an error.

Option 24: Frequency Change to 5 MHz (also requires option 12 additional 5 outputs to be installed)

This option changes all sinewave outputs to 5 MHz instead of 10 MHz. A 10 MHz output is still available.

Option 25: USB Adapter

Allows GPS10R/RB to be controlled from a USB port of a PC.

Option 26: High Quality Distribution Amplifier

Option 26 replaced the standard distribution amplifier inside the GPS10RB with a higher quality distribution amplifier. This option replaces the five standard outputs with four sinewave outputs @ $> +10$ dBm. The four

outputs have > 90 dB of channel to channel isolation, > 110 dB of back to front isolation and are phase stable to within 2 degrees. Phase stability is 10ps/°C.

Applications

Applications of the GPS10R/RB include, but are not limited to, the following examples:

- Reference frequency source in a calibration or standards laboratory
- Portable frequency standard
- Calibration of GSM Base Station Clocks
- Reference Frequency and Time source for the electricity generating industry
- Synchronising of telecommunication and computer networks
- Space Measurements.

High Quality of Construction

The GPS10R/RB is made to the highest standards. A purpose built aluminium / steel 19” rack mount case houses all the circuits inside the GPS10R/RB. The GPS10R/RB is CE marked for sale within the EEC.

Active Antenna Supplied as Standard

The GPS10R/RB is supplied with an active antenna. This small unit can be easily fitted to buildings, roofs etc.

GPS10R/RB Specifications

The specifications for the GPS10R/RB are shown on the following pages.

Specifications

Description	Specification	Remarks
Outputs		
Outputs 1, 2, 7, 8, 9		
Connector	Front and rear panel BNC socket	
Frequency	10 MHz	
Accuracy	Refer to Allan Variance section	
Signal Type	Sine wave	
Amplitude	0 dBm to + 13 dBm	Internally adjustable
Harmonic Distortion / Spurious	- 65 dBc / -120 dBm (100 kHz bandwidth)	Typically -70 dBc / -130 dBm
Return Loss	> 20 dB @ 10 MHz	
Output 3 - Square		
Connector	Front and rear panel BNC socket	
Frequency	10, 5, 2, 1, 0.1 MHz and 1 pps	Selectable by keyboard
Accuracy	Refer to Allan Variance section	
Signal Type	Square wave	
Amplitude (open circuit)	0 to 5 V, TTL Compatible	
Amplitude (50 ohm)	0 to > 2.5 V, TTL Compatible	
Output 4 - 1 PPS		
Connector	Front and rear panel BNC socket	
Frequency	1 pulse per second	
Signal Type	Pulse Output	
Amplitude (open circuit)	0 to 5 V, TTL Compatible	
Amplitude (50 ohm)	0 to > 2.5 V, TTL Compatible	
Accuracy to UTC time (GPS 1 pps output)	< 20 ns (6 sigma)	After cable delays taken into account
Jitter of Rubidium Osc. 1 pps output	< 300 ps	
Output 5 - Opt 1		
Connector	Front and rear panel BNC socket	
Other specifications	Refer to separate option document	
Output 6 - Opt 1		
Connector	Front and rear panel BNC socket	
Other specifications	Refer to separate option document	
Output 10 - 10 MHz (Slave)		
Connector	Rear panel BNC socket	
Frequency	10 MHz	
Accuracy	Refer to Allan Variance section	
Signal Type	Sine wave	
Amplitude	> -10 dBm	Fixed level output
Harmonic Distortion	- 20 dBc	Typically -40 dBc
Phase Noise Response (Typical)		
Outputs 1, 2, 7, 8, 9, 10		
At 1 Hz Offset	-96 dBc/Hz	
At 10 Hz Offset	-122 dBc/Hz	
At 100 Hz Offset	-138 dBc/Hz	
At 1 kHz Offset	-148 dBc/Hz	
At 10 kHz Offset	-150 dBc/Hz	
At 100 kHz Offset	-150 dBc/Hz	
At 1 MHz Offset	-154 dBc/Hz	
Allan Variance when locked to GPS Satellites (typical)		
Outputs 1, 2, 3, 4, 7, 8, 9, 10		
Observation Time 1 seconds	< 2 x 10 ⁻¹¹	GPS10R/RB in full lock for > 1 week. > 3 satellites in view. Ambient temperature 0 °C to +50 °C. Temperature change less than 3 °C per hour
Observation Time 10 seconds	< 1 x 10 ⁻¹¹	
Observation Time 100 seconds	< 2 x 10 ⁻¹²	
Observation Time 1000 seconds	< 7 x 10 ⁻¹³	
Observation Time 10000 seconds	< 6 x 10 ⁻¹³	
Observation Time 100000 seconds	< 7 x 10 ⁻¹³	
Observation Time 1 week	< 2 x 10 ⁻¹³	
Rubidium Drift when GPS10R/RB NOT Locked to GPS Satellites		
Outputs 1, 2, 3, 4, 7, 8, 9, 10,11		
Drift due to aging	< 5 x 10 ⁻¹¹ per month	After 30 days operation
Drift due to temperature	< 5 x 10 ⁻¹¹	0 °C to +50 °C

GPS Receiver		
Number of Channels	12 parallel	Simultaneous operation
Frequency	1575.42 MHz	L1 Frequency
Acquisition Time	< 50 s typical	With current position / time data. No SA
Positioning Accuracy	< 25 m	1 sigma, pos hold mode
Jamming Immunity	-79 dBm @ 1575.42 MHz	Measured at active antenna input
Antenna	Active micro strip patch	Powered by GPS10R/RB
Datum	WGS-84	

Miscellaneous		
Operating Temperature	0 °C to +50 °C	Rear Panel Voltage range selectable on rear panel power inlet assembly Warm up period is < 10 minutes at +20 °C 20 mm type. 250 V rating 20 mm type. 250 V rating
Storage Temperature	-20 °C to +60°C	
Magnetic Field	< 2 x 10E ⁻¹⁰ for 1 Gauss field reverse	
AC Power Inlet with switch	IEC320 power cord	
AC Voltage Range	115 VAC ± 10% 230 VAC ± 10%	
Power consumption	140 watts max (warm up) 70 watts typ (operating)	
Fuse rating	115 VAC - 2 Amp slow blow 230 VAC - 1 amp slow blow	
Dimensions (GPS10RB / GPS10R)		
Width	482.6 mm / 300 mm	
Depth	348 mm / 360 mm	
Height	88 mm / 89 mm	
Weight	7 kg / 8 kg	
Supplied Accessories		
Antenna	Active type, 5V @ 20 mA	
Power cord	IEC320 type	
Instruction manual		

Option 5: DDS Output		
Overall Frequency Range	1 µHz to 80 MHz	Usable to 90 MHz
Frequency Step Size	1 µHz	Subject to jitter specification
Frequency Accuracy	± 300 µHz plus main 10 MHz error	
Sinewave Frequency Range	10 kHz to 80 MHz	
Sinewave Output level	> 0 dBm into 50 Ω	Option > +10 dBm available (opt 05A)
Spurious and Harmonic Output	-40 dBc and -20 dBc respectively	
Squarewave Frequency Range	1 µHz to 50 MHz	Use 50 ohm termination above 1 MHz
Squarewave Output Level	0V to 3V nominal into open circuit	> 0 dBm into 50 Ω
Allan variance (100 second)	2.5 x 10 ⁻¹²	Over 10 MHz to 80 MHz frequency range

Output 9: IRIG Time Code Output		
Output 1 type	IRIG-B or IRIG-E	Internally selectable
Output 2 type	ESE TC-90	
Mark – Space Ratio (output 1)	3.3 to 1	
Output type (output 1)	TTL or AM	Internally selectable
AM Mark Amplitude (output 1)	2.7 V p-p	
Output Impedance (output 1)	600 Ω	

All other options		
Consult Precision Test Systems for further details of other options. Not all options can be fitted at the same time.		

Precision Test Systems			
Head Office - UK	South Africa	USA	Represented locally by:
Precision Test Systems LTD 40 Holkham Avenue, South Woodham Ferrers Essex, CM3 7AU, England Tel: +44 (0) 845 052 0920 Fax: +44 (0) 870 135 4973 Email: uksales@ptsyst.com Web: www.ptsyst.com	Precision Test Systems cc 183 Edison Crescent Hennops Park X7 Pretoria South Africa Tel: +27 (0) 12 653 5848 Email: sasales@ptsyst.com Web: www.ptsyst.com	Precision Test Systems Suite # 981 14781 Memorial Dr. Houston, TX 77079 Tel: 1 888 876 4804 Fax: 1 760 923 6354 Email: usasales@ptsyst.com Web: www.ptsyst.com	

Specifications subject to change without notice. (200706)