

GPSR Users Reference Manual

VERSION 1.0

Part Number: 36882-00

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1.0 Overview

This user guide describes the installation, operation, and features of the GPSR. The GPSR was built in accordance with Nortel Specification GSPX26AB. The issue of this specification in effect at the time this manual was written is:

stream: 01 issue: 02.
Dated June10, 1998

The GPSR can be described in a summary fashion as a GPS disciplined oscillator, which provides outputs of 1 PPS, 10 MHz, and serial data using the SCPI protocol. The quality and characteristics of these outputs will be described in detail in subsequent sections of this user guide. As a minimum the following items should be available to utilize the GPSR.

User Reference Manual (36882-00)
Trimble GPS_Monitor Program
Serial Interface Cable
Power Cable
Power Supply
Antenna
Antenna Feed Cable
PC Running Windows 95® or Windows NT®

Each of these user elements will be described in added detail in the following sections of this overview.

1.1 Trimble GPS_Monitor Program

The Trimble GPS_Monitor Program, referred to hereafter as the monitor is written in Borland Builder® and will run under both the Windows 95® and Windows NT® Operating Systems. The monitor exchanges information with the GPSR using the SCPI protocol and an RS-422 compatible physical layer. Table 1.1 below shows the serial interface parameters.

Table 1.1 Serial Interface Parameters

Parameter	Value
Baud rate	19.2 kbps
Data format	1 start 1 stop 7 data odd parity
Communication Standard	RS-422

The monitor is provided on 3.5" media, and is supplied with each GPSR. The program file name is gps_monitor.exe. The program may be installed by using Windows Explorer® to copy the monitor from the appropriate drive (usually a:) to a hard drive on the PC. At this point the program can be used like any other Windows executable.

1.2 Serial Interface Cable

The serial interface cable is used to connect the GPSR to the PC running the monitor. The output connector of the GPSR used for this purpose is a female DB-25 located on the rear panel of the GPSR and labeled J3. The pinouts associated with this connector are provided in Table 1.2 below.

Table 1.2 Connector Pinouts J3 (rear panel)

Signal Name	Connector Pins	Description
10 MHz (1)	15 12	Differential pseudo-ECL 10 MHz (1) – 10 MHz (1) +
PPS (1)	17 9	Differential pseudo-ECL PPS (1) – PPS (1) +
10 MHz (2)	11 24	Differential pseudo-ECL 10 MHz (2) – 10 MHz (2) +
PPS (2)	8 21	Differential pseudo-ECL PPS (2) – PPS (2)+
Transmitted data	2 14	EIA RS-422 TXDA TXDB

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Received data	3 16	EIA RS-422 RXDA RXDB
Ground	7	

CAUTION! When using J3 care must be taken to avoid grounding or applying voltage to the pseudo-ECL outputs. The drivers associated with these signals are destroyed by prolonged exposure to such conditions.

In order to use the serial signals with the PC running the monitor, the RS-422 differential signals must be converted to RS-232 single ended signals. A number of converters are commercially available which serve this purpose. Trimble P/N 16637-00 REV. B is a suitable converter. In most cases the converter must be used with an adapter wired to avoid damage to the pseudo-ECL signals also present on J3. This is the case with the Trimble converter. The pinouts on the PC are listed in Table 1.3 below.

Table 1.3 Connector Pinouts PC COM Ports

SIGNAL NAME	DB-9 PIN NUMBER	DB-25 PIN NUMBER
Receive (into PC)	2	3
Transmit (out of PC)	3	2
Ground	5	7

1.3 Power Cable and Power Supply

The power cable attaches to rear panel connector J4. The connector on the GPSR is an AMP Mate-N-Lok II, part number 770025-1. The mating connector can be obtained from AMP.

NOTE: The GPSR connector has female contacts, contact number 770250-2.

The orientation of the power connector on the GPSR is shown in GSPX26AB Section 5.1.5. The figure is reproduced below for convenience. The GPSR uses about 15 watts of power at turn on (cold), and the power consumption declines to about 8 watts after warm-up. A nominal input voltage of 27 VDC is recommended, and voltages of 24VDC to 56VDC may be used as shown in GSPX26AB Section 5.2. These figures are also reproduced below for convenience.

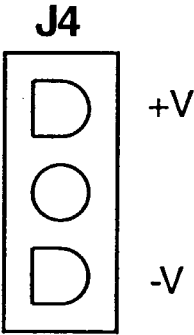
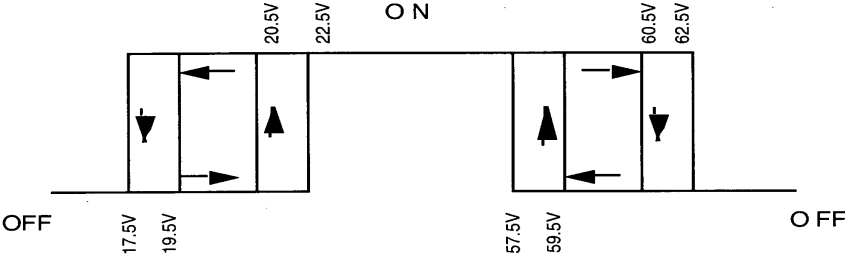
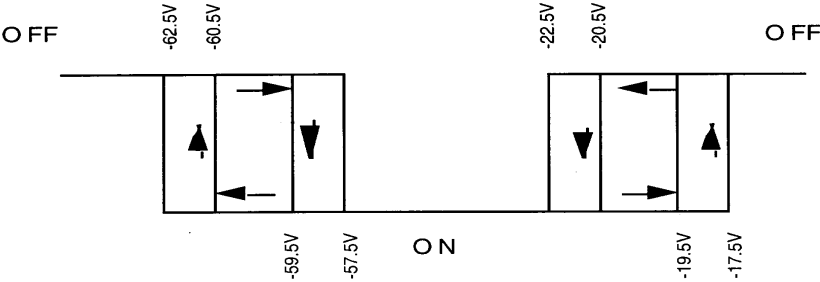


Figure 9: Power Connector Orientation



Input Voltage and Power Hysteresis, GPSR (+27V Input)



Input Voltage and Power Hysteresis, GPSR (-54V Input)

Above figures reproduced from GSPX26AB

It is recommended that stranded 18 gauge (or thicker) wire be used to supply power to the GPSR.

1.4 Antenna and Antenna Feed Cable

The GPSR is designed to utilize an active antenna and a low loss feed cable. The antenna and feed cable are not supplied with the GPSR. The antenna-input connector is a female type-N connector, and it is located on the rear panel of the GPSR, J1.

The GPSR supplies current to the active antenna via the feed cable center conductor. The GPSR can source up to 50 milliamperes at 5VDC for this purpose.

The GPSR is designed to anticipate a net gain of +10 dB at the input type-N connector. For example, if the antenna gain is 30 dB, then the allowable cable loss is 20 dB. Table 1.4 below summarizes the cable loss and time delay characteristics of cable types commonly used with the GPSR.

Table 1.4 Cable Loss (1575 MHz) and Delay Characteristics

CABLE TYPE	CABLE LOSS (APPROX.)	TIME DELAY
LMR-400	0.05 dB / foot	1.33 nanoseconds / foot
LMR-400	0.167 dB / meter	4 nanoseconds / meter
RG-213	0.1 dB / foot	1.67 nanoseconds / foot
RG-213	0.33 dB / meter	5 nanoseconds / meter

NOTES: Cable losses greater than 20 dB require the use of inline amplification.
Cable time delay is compensated using the GPS_Monitor. (see Section 4.0)

2.0 Functional Description

A functional block diagram of the GPSR is presented in Figure 2.0. The remainder of this section references this figure.

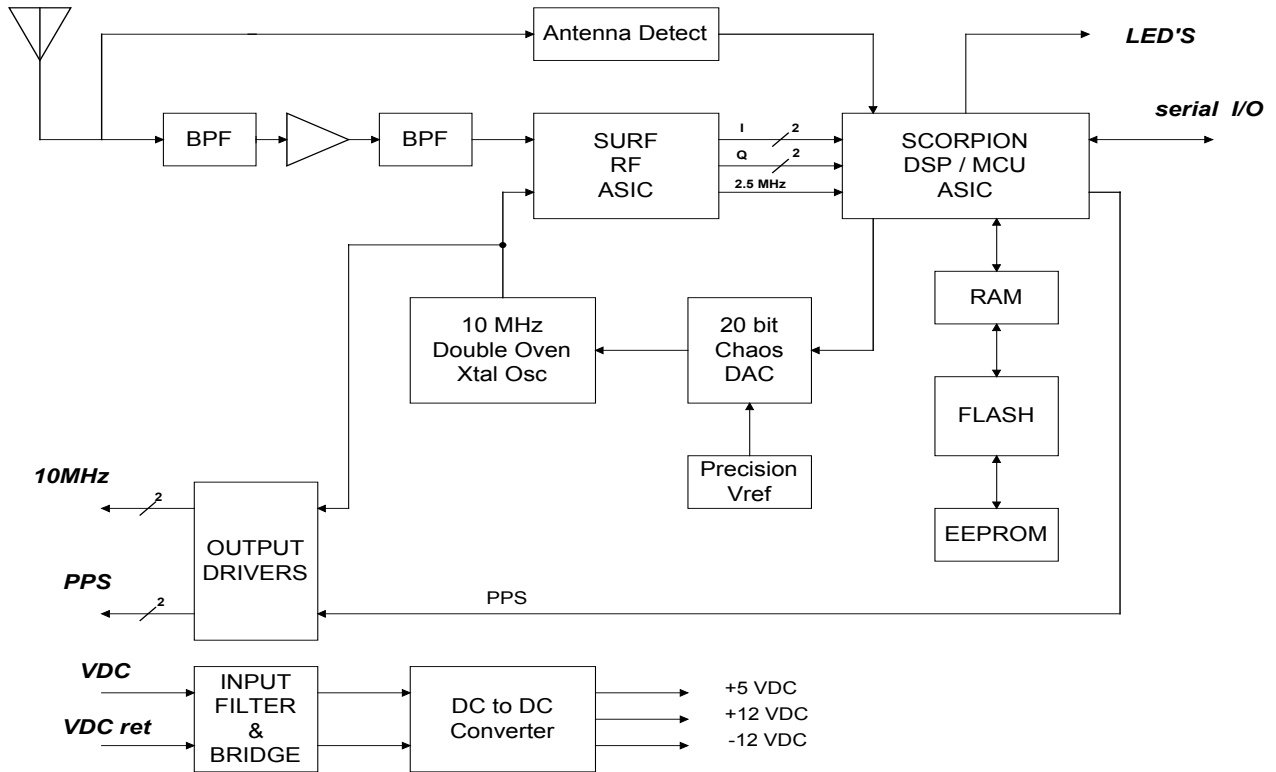


Figure 2.0 GPSR FUNCTIONAL BLOCK DIAGRAM

2.1 RF Input Path

The RF path consists of bandpass filtering and amplification. An extra LNA has been added to the GPSR RF path to accommodate the net 10 dB input level required. The RF circuitry also includes a current sensor for the detection of short or open conditions.

2.2 RF ASIC

The RF ASIC used in the GPSR is a custom TNL IC called the SURF. The Surf has two attributes which make it ideal for the application, compatibility with a 10 MHz frequency plan and 2 bit quantization of the baseband I and Q data. The 10 MHz frequency plan allows the direct use of the GPSR primary reference oscillator. The 2 bit quantization provides high jam resistance.

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2.3 DSP ASIC

The DSP ASIC is a custom TNL IC called the Scorpion. Scorpion contains 8 independent GPS channels as well as a 68330 microprocessor. Other resources found on this chip include dual UARTS, a real time clock, and a temperature sensor. The 68330 is a four MIPS processor. GPS functions present a peak loading of less than two MIPS, leaving more than two MIPS for the other GPSR tasks. RAM, FLASH, and EEPROM are external to the Scorpion.

2.4 20-bit DAC

The oscillator is controlled by a 20-bit DAC driven by the Scorpion. This DAC is a custom TNL design, and is implemented in programmable logic. In addition to high resolution, this DAC has excellent linearity and a very low temperature coefficient. The DAC source voltage is derived from a precision voltage reference.

2.5 10 MHz Oscillator

The oscillator used in the GPSR is a double oven SC-cut crystal oscillator selected for both excellent frequency stability over temperature as well as low phase noise.

2.6 Power Supply

The GPSR accommodates a wide range of input voltages, 22 volts to 60 volts. The GPSR is not damaged by input voltage polarity reversal. Nominal input voltage is specified to be +27VDC or -54 VDC.

2.7 LED Indicators

Table 2.7 below lists the GPSR front panel LED's and their function.

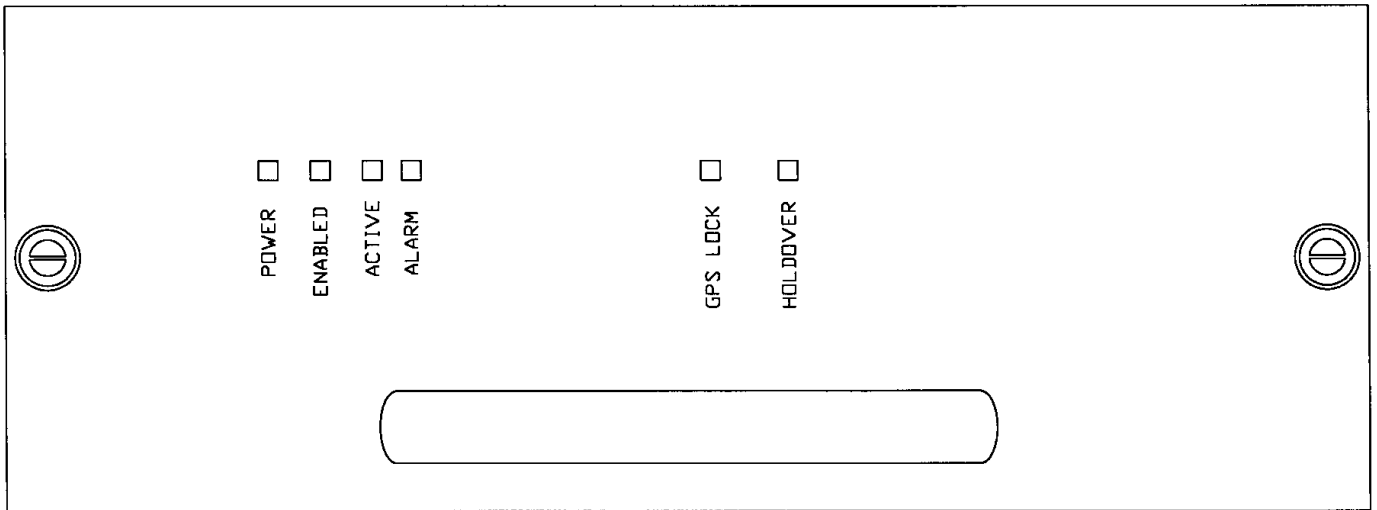
Table 2.7 GPSR Front Panel LED's

Name	Color	Control	Function
Power	Green	GPSR	On indicates power is applied to GPSR
Enabled	Green	User	On indicates user has enabled GPSR
Active	Green	none	None assigned
Alarm	Red	GPSR/User	Logical -OR- of GPSR and user inputs
Lock	Green	GPSR	On when GPSR tracking/using satellites
Holdover	Yellow	GPSR	On when GPSR is in the holdover state.

3.0 Operation

3.1 GPSR Front Panel

The GPSR front panel is depicted in the drawing below. Shown are the six (6) front panel LED indicators, the rack mount fasteners, and the handle.



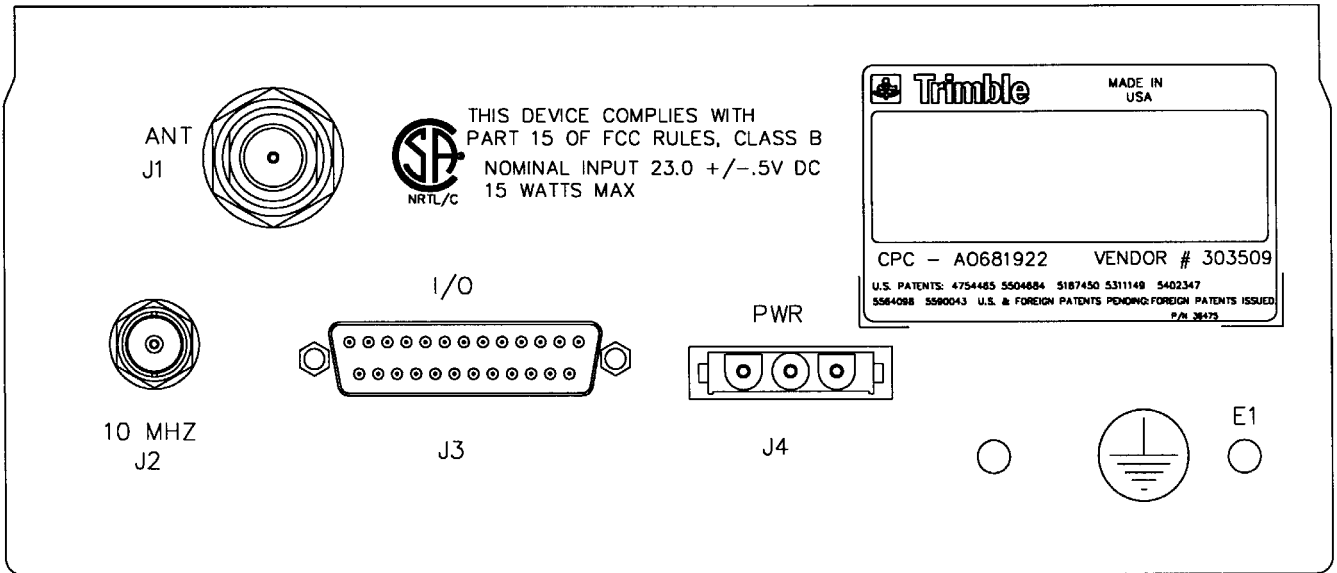
The function of the LED's is as follows:

- Power (green) on indicates prime power applied to GPSR
- Enabled (green) controlled by base-station software
- Active (green) not used
- Alarm (red) on indicates an alarm condition
- GPS Lock (green) on indicates GPSR is locked to GPS
- Holdover (yellow) on indicates GPSR is in holdover

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3.2 GPSR Rear Panel

The GPSR rear panel is depicted in the drawing below.



Connector functions and characteristics:

J1	type-N	female	antenna input (+10 dB to +60 dB) at GPS L1 carrier
J2	BNC	female	10 MHz sinusoidal output, 50 ohm, 2 Vpp nominal
J3	DB-25	female	system I/O (see Table 1.2)
J4	Mate-N-Lok	male	see Section 1.3
E1	M5 x 20mm		ground stud
	M5		threaded hole

3.3 Powering Up the GPSR

The following steps are necessary to power-up and use the GPSR.

Step 1

Connect the antenna to the GPSR using rear panel type-N connector labeled J1.

Step 2

Apply prime power using rear panel connector J4. Refer to Section 1.3 of this Guide. The application of prime power results in the following actions internal to the GPSR.

1. Front panel lights flash; internal diagnostics are performed (less than 15 seconds). “Power” LED remains illuminated while power is applied.
2. Satellite acquisition process is initiated. Acquisition times up to 60 minutes may be anticipated depending on satellite availability and antenna location.
3. If GPSR has no stored position, a self-survey is performed (2000 averages default). The GPSR performs one position fix per second in the survey mode.
4. 10 MHz and 1 PPS outputs are locked to GPS. The “lock” LED will illuminate when this occurs.
5. GPSR reverts to time only mode when survey is complete. If the GPSR has an accurate position stored it will use this position immediately. The time only mode is the most accurate timing state of the GPSR. In this mode the GPSR uses all available satellites to derive the best time solution using the assumption that the current location is static and accurate.

Step 3

Connect the GPSR to a host PC running the Trimble GPS_Monitor Program. Refer to Section 1.2 of this Guide for interface details.

Step 4

Start the monitor program. This program allows the user to control and monitor the status of the GPSR. Section 4 of this Guide details the installation and use of the monitor program.

Step 5

Program the correct antenna delay corresponding to the length and cable type used in the antenna system. The cable delay can be entered at any time, and is retained by the GPSR in non-volatile memory. **The accuracy of the timing signals requires this step**, although the frequency stability of the GPSR is not affected by cable delay.

Step 6

Connect the GPSR to the host system using J3. This step should be performed after the user is satisfied that the GPSR is performing properly using the monitor program.

3.4 Operational Tips

There are many user selectable parameters that affect the operation of the GPSR. The most important of these parameters are:

1. Antenna Delay (refer to Sections 3.3 step 5 and Section 1.4)

2. Antenna location

The satellite orbits are inclined at approximately 60 degrees relative to the equator. When one examines the geometry resulting from this orbital plane it is very clear that site locations in the Northern Hemisphere should give preference to antenna locations which have a clear view to the South. Likewise site locations in the Southern Hemisphere should give preference to a northern view of the sky. This affect becomes more pronounced as the latitude increases in absolute value.

3. Input Position

GPSR performance is a strong function of the accuracy of the input position relative to the actual location of the antenna. Several position integrity functions are included in the GPSR firmware.

If, during power-up, the GPSR senses that no position is stored, a self-survey is performed; 2000 position averages are used for the survey.

If, during power-up, the stored position produces pseudo-range residuals that are beyond a preset threshold, the GPSR will assume that the stored position is no longer accurate, and a self-survey will be performed.

If the GPSR has a stored position at power-on, but is not able to track satellites for thirty minutes, a self-survey is performed.

4.0 Using the Trimble Monitor Program

4.1 Preliminaries

The monitor program will run under Windows 95® or Windows NT®. The monitor program will not run under DOS or Windows 3.X®.

The above sentence was typed in bold print for good reason. Experience has shown that we receive more support calls related to this issue than any other. The monitor supports either COM1 or COM2 of the host PC. COM port selection is another seemingly simply step that is easy to get wrong. Lastly, pay very close attention to the interconnect cable that connects the host PC to the GPSR. The key details related to this cable are enumerated below.

1. GPSR physical layer

The GPSR serial outputs are RS-422 compatible. These are differential output signals. PC's use an RS-232 physical layer, which is single-ended. These physical layers are not compatible, and a converter should be used for both the transmit and receive signals. If a converter is not available, and one is absolutely desperate, it is usually possible to connect the PC pins to the negative sense of the RS-422 GPSR pins and get reliable operation. This is not recommended, and is not supported by Trimble.

2. Signal Connection

The converted RS-422 signals from the GPSR transmit data pins must be routed to pin 2 of a PC using a DB-9 connector, or to pin 3 of a PC using a DB-25 connector. See Tables 1.2 and 1.3.

The converted RS-422 signals from the GPSR receive data pins must be routed to pin 3 of a PC using a DB-9 connector, or to pin 2 of a PC using a DB-25 connector. See Tables 1.2 and 1.3.

The ground pin of the GPSR must be connected to pin 5 of a PC DB-9 connector or to pin 7 of a PC DB-25 connector.

Caution

It is EXTREMELY important to leave all other pins of the GPSR unconnected. The GPSR can be physically damaged if this caution is ignored.

End Caution

4.2 Using the Program

The monitor main program screen is reproduced below. The initial part of this discussion will center on the main screen. This screen (with different or missing data fields) will be the screen the user sees when the monitor program is invoked (after the COM port select screen, which allows the user to pick COM1 or COM2 on the host PC).

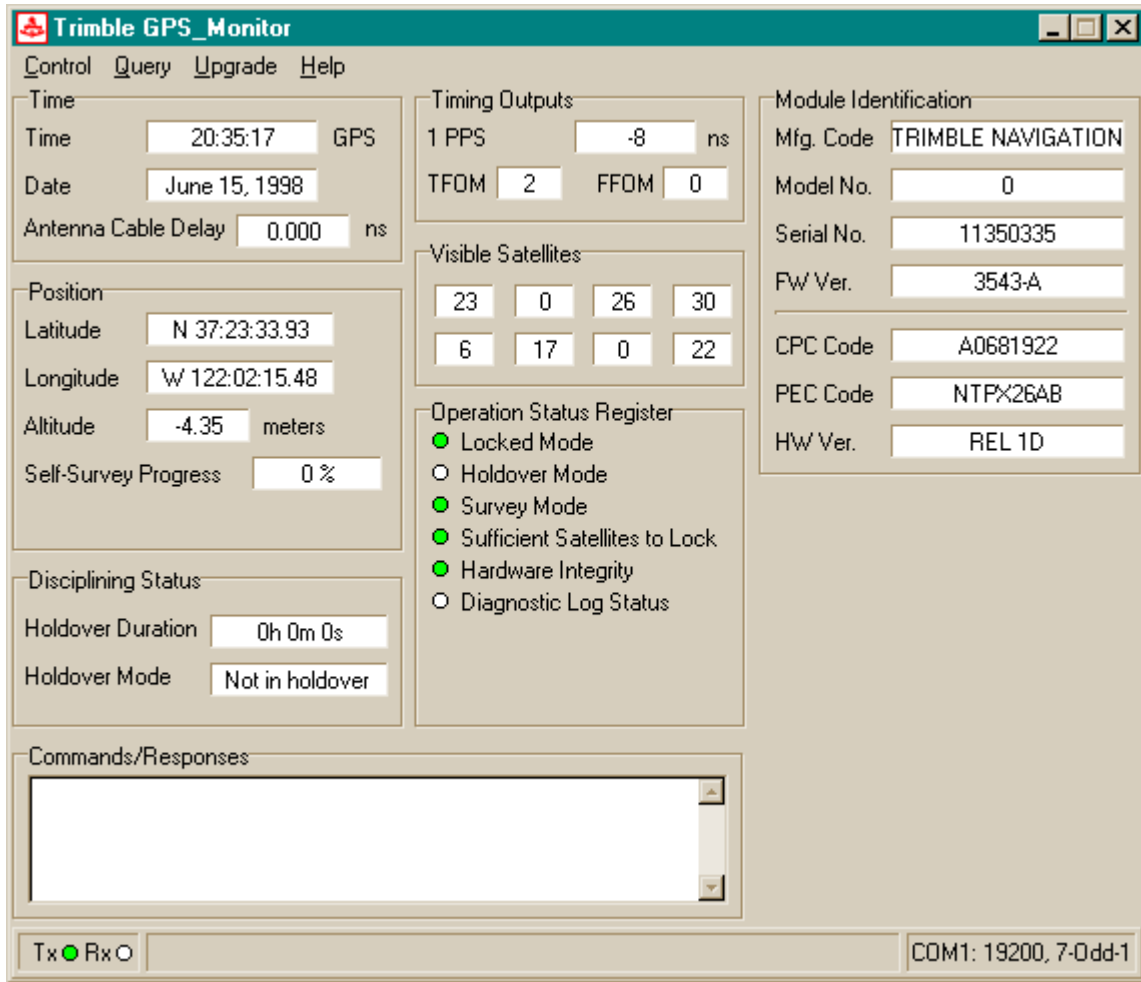


Figure 4.0 Monitor Main Menu Screen

The main screen shown in Figure 4.0 has a number of data fields. The field labels generally give sufficient clarity, and additional details are provided in Section 4.2.4. Subsequent subsections will detail pull-down menu fields for controlling the GPSR. These fields are accessed by using the cursor to select the item of interest on the “menu bar” (located immediately below the program title bar). The common alternative selection method of holding down the ‘alt’ key while depressing underlined letter of the desired action keyword is also supported throughout this program.

The Commands/Responses window shows the commands sent to the GPSR and the GPSR response. This window can be used as a diagnostic tool.

4.2.1 “Control”

The monitor display changes as shown in Figure 4.1 below when the “control” pull-down menu is selected. The cursor is not shown in any of the screens.

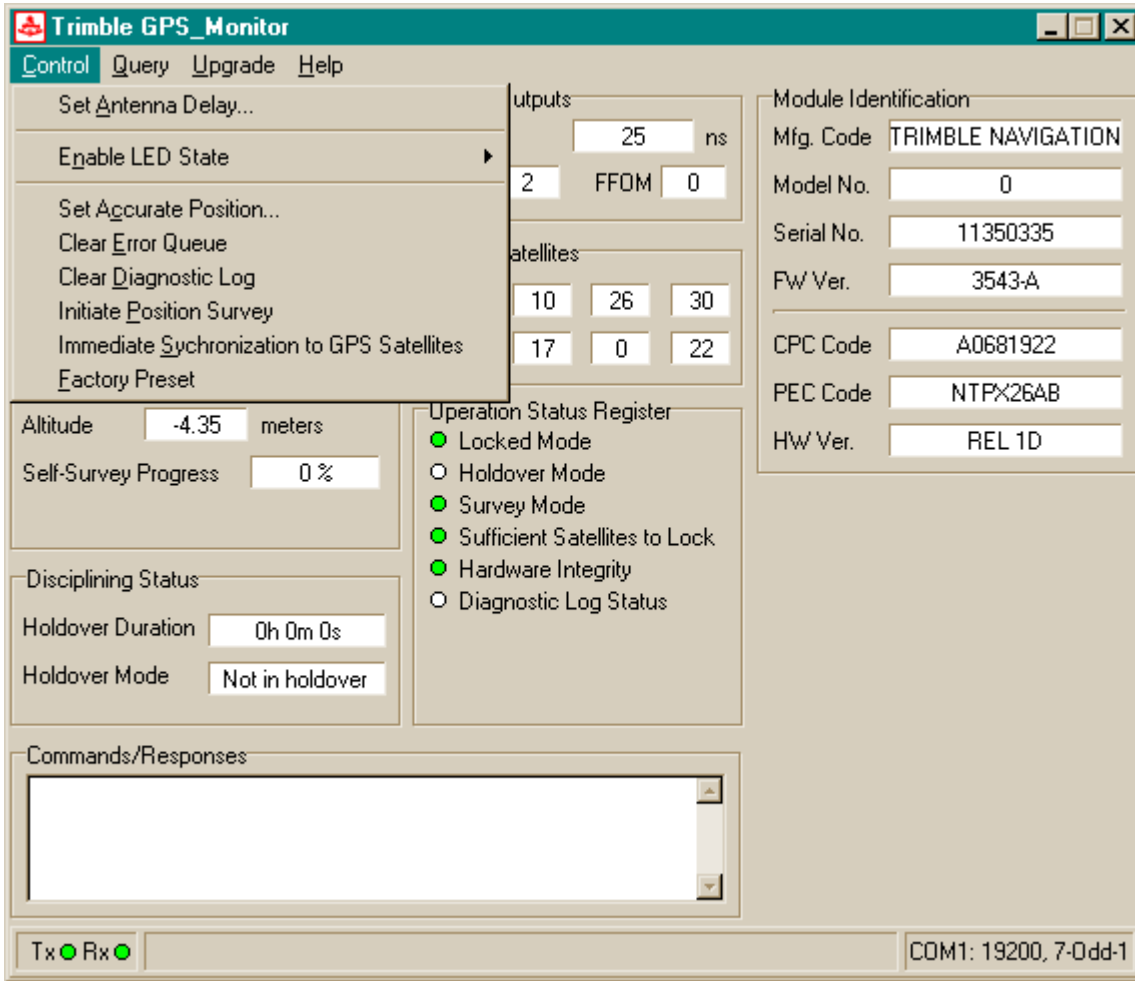
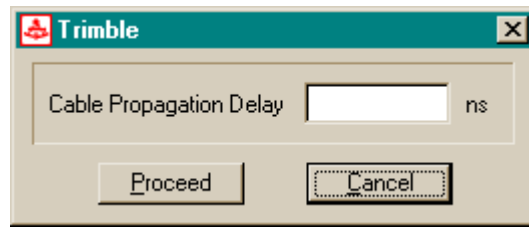
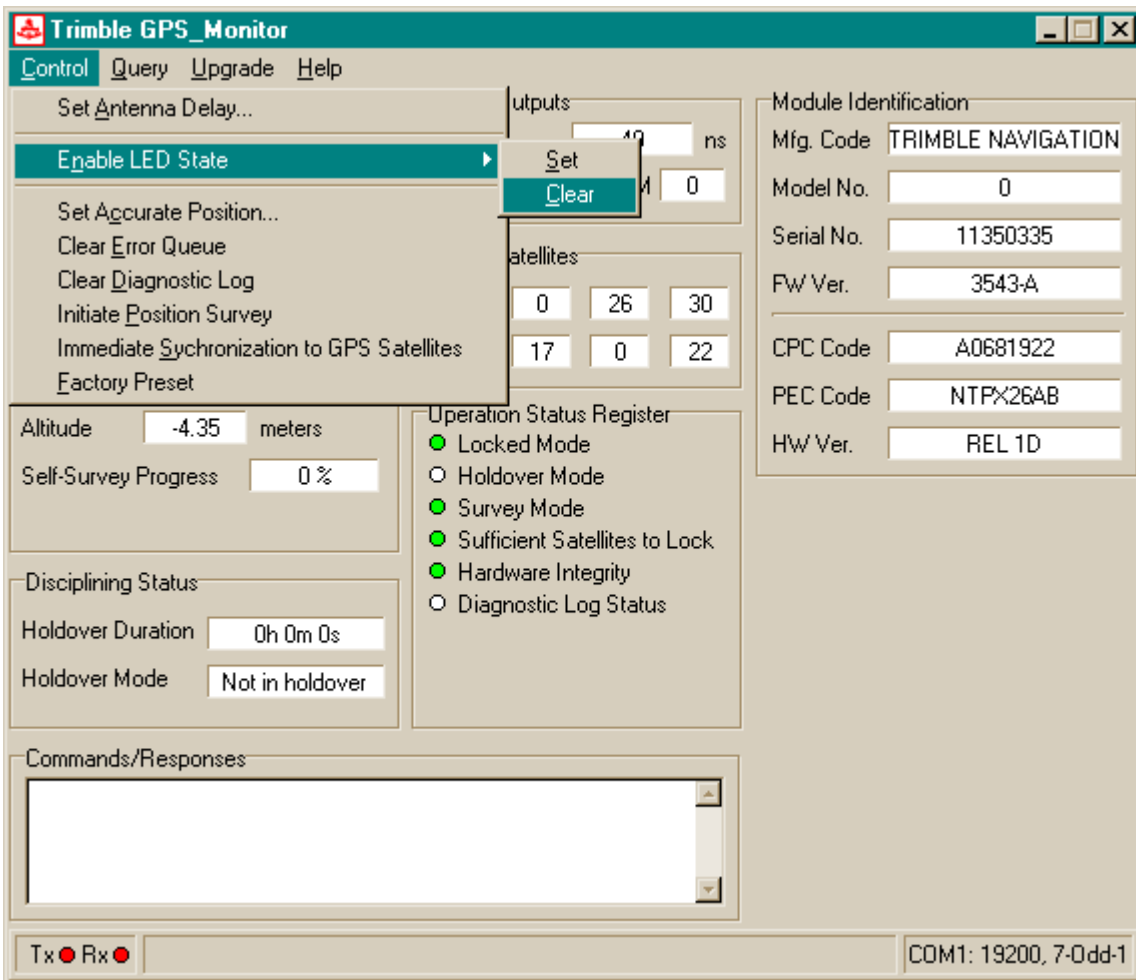


Figure 4.1 “Control” Pull-down Menu

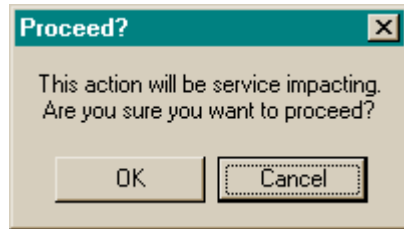
Each item in the “control” pull-down is clearly labeled. For example, to change the antenna delay, select the “Set Antenna Delay” field. Doing so results in the following screen display located approximately in the middle of the main display screen.



The user simply enters the appropriate value of cable delay in integer nanoseconds and selects the “proceed” field. Use the data in Table 1.4 to determine an appropriate value for cable delay. An “Enable LED state” selection results in the following screen .The user can set or clear the LED.



Some data field selections result in a query to the user. One such field is the “Initiate Position Survey” field. The following screen is displayed when this selection is made. The user is given a warning and a choice to either proceed or cancel the selection.



4.2.2 “Query”

Selecting the “query” pull-down menu produces the screen display in Figure 4.2 below.

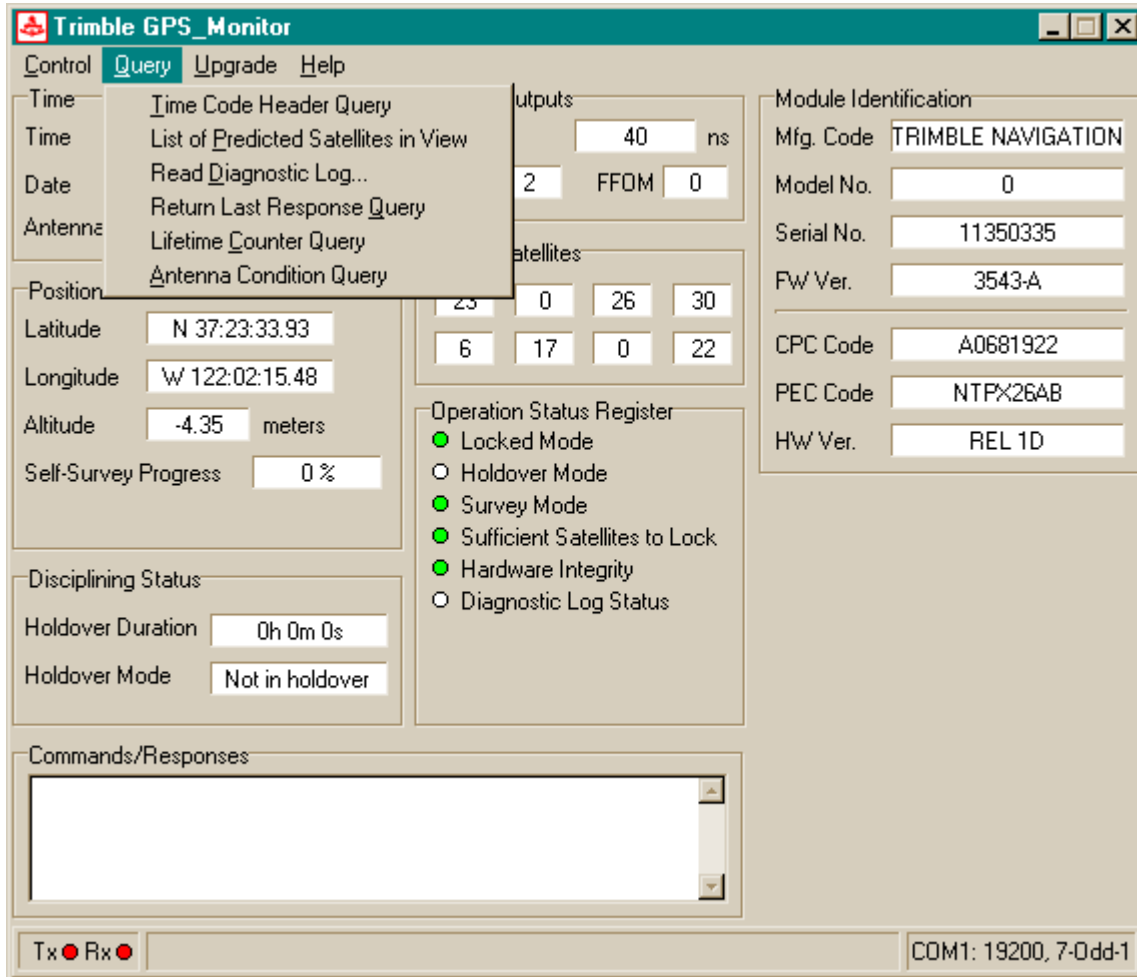


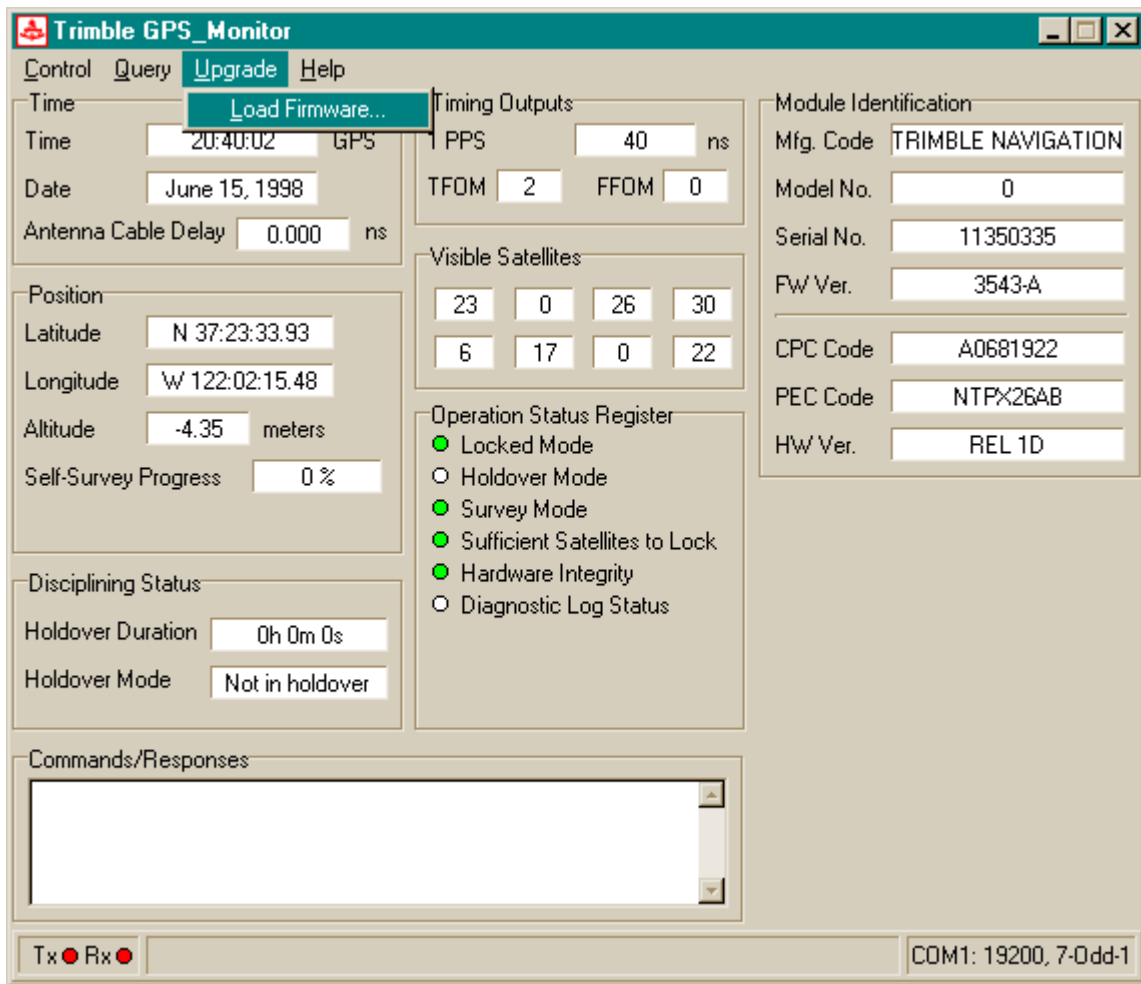
Figure 4.2 “Query” Pull-down Menu

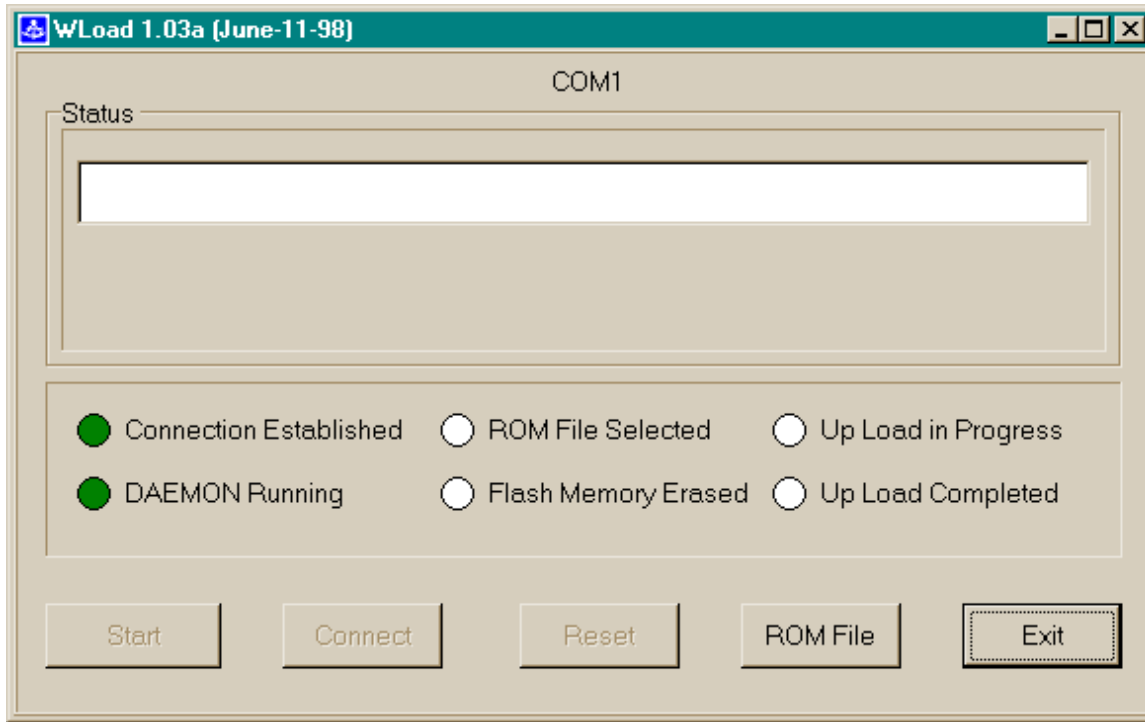
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The options in this pull-down are easy to understand, and each refers to a Nortel defined SCPI command/response. Selecting an option from the query menu will lead to additional self-explanatory response screens.

4.2.3 “Upgrade”

The upgrade field selection leads to the following screen display. If the user invokes the “Load Firmware” field, the monitor program will transfer control to a field loading tool. This tool is used to change the firmware resident in the GPSR.





The loader tool takes the user through the following sequence:

- 1> Automatically starts and downloads a Daemon to the GPSR.
- 2> **After Daemon loading is complete the user must then invoke the ROM file button to select the firmware version to be downloaded.**
- 3> The flash memory is then erased, removing the current GPSR firmware.
- 4> The new firmware is then uploaded (a progress bar is shown).
- 5> When the “Up Load Completed” indicator is illuminated, the user must invoke the “exit” button to return to the GPS_Monitor program.
- 6> **After the “exit” is selected the loader tool will prompt the user to cycle power on the GPSR which must be done before the new firmware can be used.**

4.2.4 “Help”

This field is not elaborate, and is simply used to retrieve information about the monitor pedigree, code revision, date, and other fields (perhaps reminder fields on pinouts) as deemed useful for users of this tool.

4.4.5 Main Screen Items

Many of the information fields on the main program screen are self-evident such as position, holdover mode, etc. The purpose of this section is to provide some additional elaboration on some of the fields that may not be obvious. In general the narrative will proceed from top to bottom of the columns starting at the left.

Holdover Duration

This field contains a simple clock that starts when the GPSR enters a holdover mode, either manual or auto, and stops when the GPSR returns to the normal mode. The clock retains the time in holdover until a new a new holdover event occurs.

Command/Response Window

This window is a scrolling display of the commands sent to the GPSR and the responses sent from the GPSR.

Timing Outputs – 1 PPS

This field contains the instantaneous difference between GPS time and the GPSR time. Because GPS is subject to selective availability the GPSR will always be more accurate than a “snapshot” GPS timing fix, and this output will appear to be noisy.

Timing Outputs – TFOM

TFOM is “time figure of merit”, and is a byte field containing an integer between 0 and 9. The TFOM is defined as $\{\log(\text{estimated time error in nanoseconds}) + 1\}$.

Timing Outputs -FFOM

FFOM is “frequency figure of merit”, and is a byte field that describes the relationship of the GPS engine to the precision oscillator. Four values are defined.

- 0 - GPSR is locked to GPS, oscillator is in specification
- 1 - GPSR is locked to GPS, oscillator is not yet stabilized
- 2 - GPSR is in holdover mode
- 3 - GPSR is unlocked, and not in holdover (i.e. just powered up)

Satellite Info

These fields display the PRN numbers (unique identifier) of satellites (SVs) currently being tracked.

Operation Status Register

Locked Mode	on = locked (normal)	off = in holdover
Holdover Mode	on = in holdover	off = not in holdover
Survey Complete	on = survey complete	off = survey not complete
Sufficient Satellites	on = sufficient SVs	off = too few SVs
Hardware Reg. > 0	on = fault detected	off = no fault detected
Diag Log Almost Full	on = log almost full	off = log size OK

Module Identification

Data in these fields contain information relative to the pedigree of the GPSR. Field contents consist of both Trimble and Nortel identification codes.

Tx Rx Indicators

These indicators at the bottom left of the monitor screen flash during serial port transmit (Tx) and serial port receive (Rx) respectively.

19200,7-odd-1

This field at the lower right of the monitor screen indicates the monitor baud rate (19200), number of data bits (7), parity (Odd), and number of stop bits (1). Currently these settings are static, and cannot be altered by the user.

5.0 GPSR Specifications

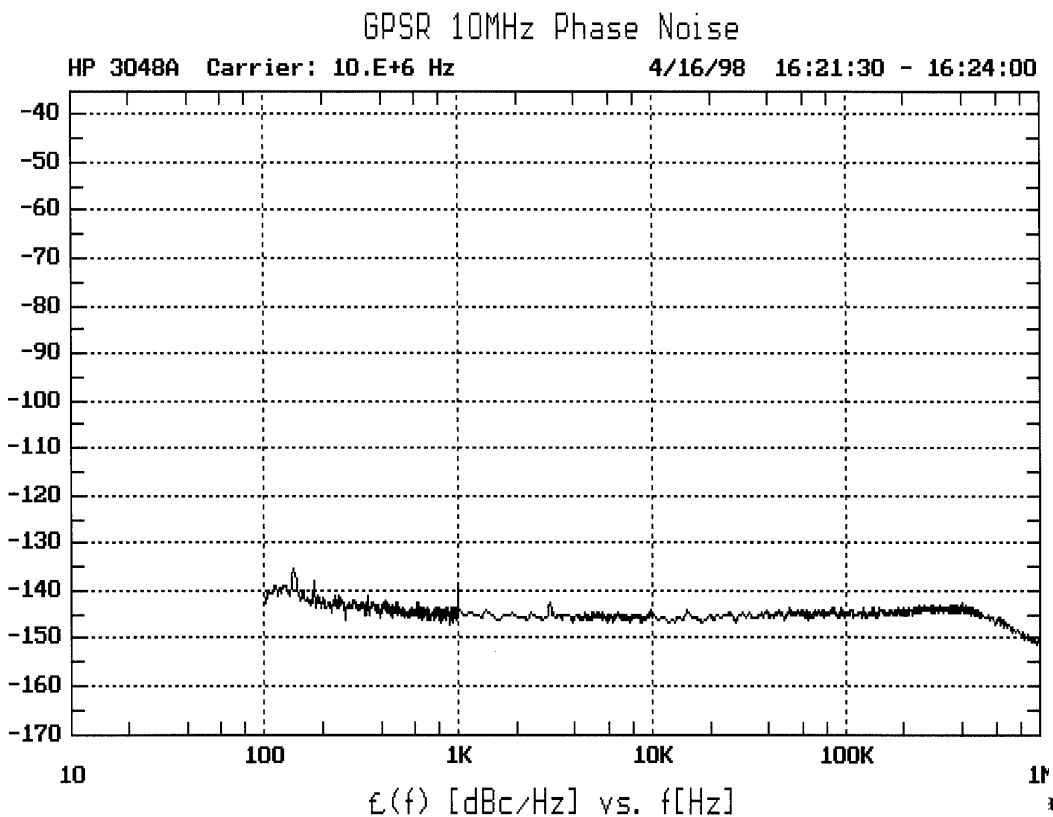
5.1 GPS Engine Characteristics

channels	8 independent tracking channels, L1 C/A code
acquisition threshold	10 dB to 60 dB at input type-N connector
tracking threshold	5 dB to 60 dB at input type-N connector
jam immunity	-110 dBm at L1 (at input type-N connector)
baseband resolution	2 bits (I and Q)
update rate	1 Hz nominal output (5Hz internal)

5.2 10 MHz Sinusoidal Output (J2)

Frequency Accuracy	< 2E-12 one day average < 2E-10 any interval
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Phase Noise

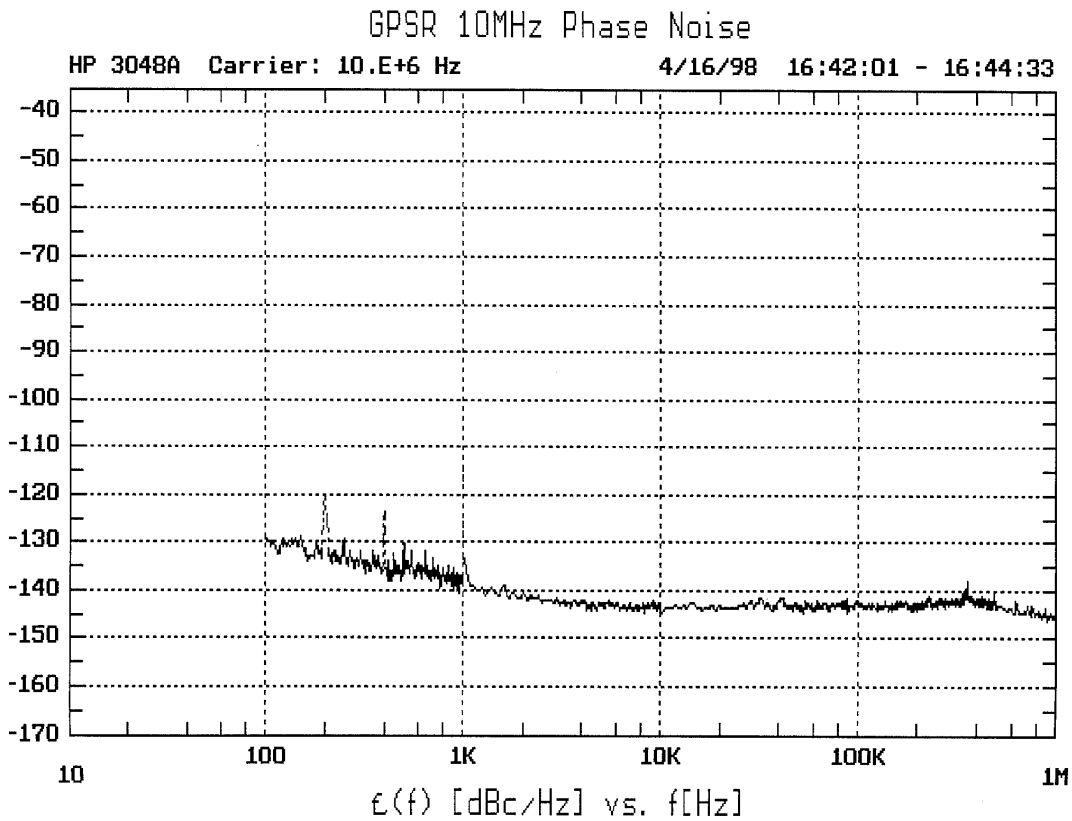


Coupling AC
Waveform Sinusoidal, 2 Vpp nominal, 50 ohm

5.3 10 MHz Pseudo-ECL Output (J3)

Same accuracy performance as 10 MHz sinusoidal output in Section 5.2.

Phase Noise



5.4 1PPS Output (see Table 1.2)

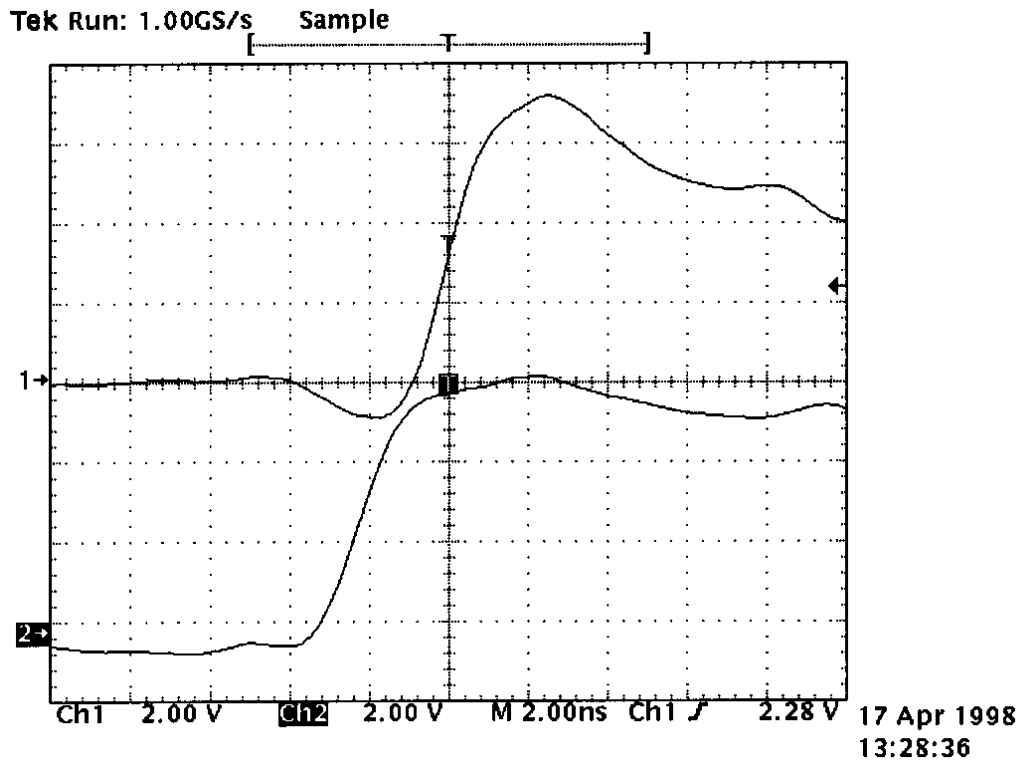
Waveform negative pulse , negative edge 'on time'
Pulse width 12.4 microseconds
Jitter <1 nanosecond pulse to pulse

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Offset relative to 10 MHz (see oscillograph below)

Upper trace : 1PPS Lower trace : 10 MHz Scale : 2ns / div

Output waveforms are pseudo-ECL. Phase sense will be different after conversion to single-ended format using differential ECL receiver.



Time accuracy < 100 nanoseconds relative to GPS (locked)

< ± 7 microseconds per day drift (unlocked) after warm-up
period of 24 hours with GPS lock and position static

5.4 Environmental Specifications

Operating Temperature 0C to +50C

Storage Temperature	-55C to +100C
Humidity	5% to 95%
Altitude	-400 meters to 18000 meters
Vibration	Bellcore GR-63 CORE, Section 5.4.2 (5Hz–200Hz)
Shock	IEC-68-2-27, E2 (3 50g, 11ms, half sine, 3 axes)

5.5 EMC

radiated emissions	FCC part 15 class B (6 dB margin)
conducted emissions	GR-1089-CORE, Section 3.4 10KHz-30KHz
radiated immunity	GR-1089-CORE, Section 3.3.1 (3 dB margin)
conducted immunity	GR-1089-CORE, Section 3.3.3 (3 dB margin)

5.6 Input Power

Warm-up	< 20 watts
Operating	< 10 watts