Modulated Precision Clock (MPC)

USER MANUAL

Modulated Precision Clock (MPC) User Manual

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MPC Receiver	One (1) Year
GPSAntenna™ Series	One (1) Year
Cables and Accessories	Ninety (90) Days
Software Support	One (1) Year

Date of sale shall mean the date of the invoice to the original customer for the product. NovAtel's responsibility respecting this warranty is solely to product replacement or product repair at an authorized NovAtel location only.

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There are no user serviceable parts in the GPS receiver and no maintenance is required. When the status code indicates that a unit is faulty, replace with another unit and return the faulty unit to NovAtel Inc.

Before shipping any material to NovAtel or Dealer, please obtain a Return Material Authorization (RMA) number from the point of purchase.

Once you have obtained an RMA number, you will be advised of proper shipping procedures to return any defective product. When returning any product to NovAtel, please return the defective product in the original packaging to avoid ESD and shipping damage.

Customer Service

EURO4 FIRMWARE UPDATES AND UPGRADES

Firmware *updates* are firmware revisions to an existing model, which improves basic functionality of the GPS receiver. During the one-year warranty coverage following initial purchase, firmware updates are supplied free of charge. After the warranty has expired, firmware updates and updated manuals may be subject to a nominal charge.

Firmware *upgrades* are firmware releases, which increase basic functionality of the receiver from one model to a higher level model type. When available, *upgrades* may be purchased at a price, which is the difference between the two model types on the current NovAtel GPS Price List plus a nominal service charge.

Please see *Section 6.2, MPC Firmware Upgrades & Updates on page 75* for a description on how your MPC is upgraded/updated via the web.

CONTACT INFORMATION

Firmware updates and upgrades are accomplished through NovAtel authorized dealers.

Contact your local NovAtel dealer first for more information. To locate a dealer in your area or if the problem is not resolved, contact NovAtel Inc. directly using one of the following methods:

Call the NovAtel GPS Hotline at 1-800-NOVATEL (North America), or 403-295-4900 (international).

Fax: 403-295-4901

E-mail: support@novatel.ca

Website: http://www.novatel.com

Write: NovAtel Inc., Customer Service Dept., 1120 - 68 Avenue NE, Calgary, AB., Canada, T2E 8S5

✉ Before contacting NovAtel Customer Service regarding software concerns, please do the following:

Install the MPC on the internet with a fixed IP address or phone number so that NovAtel Customer Service can access it directly. Also, supply your IP address, or phone number, to NovAtel Customer Service.

You may be requested to send Customer Service any *. log files that appear in your MPC's ftp site or your root directory.

Notices

The following notices apply to MPC.

CSA NOTICE

Each MPC unit has been tested by a Canadian Standards Association (CSA) inspector and found to comply with the special Inspection Requirements of Electrical Equipment. More specifically, this equipment has been tested for Dielectric strength up to 1000 VAC. The supplied AC electric cord is also approved and must be used with this equipment at all times. The primary fuse rating must be strictly adhered to as labelled on the rear of the unit near the fuse holder. Each MPC unit must have the CSA approved label attached on the rear of the unit.

CAUTION!

1. This device incorporates circuitry to absorb most static discharges. However, severe static shock may cause inaccurate operation of the unit. Use anti-static precautions where possible.
2. This device is a precision instrument. Although it is designed for rugged operating conditions, it performs best when handled with care.
3. The MPC can accept an input supply voltage in the range 100 to 240 VAC. This may not be the same range as other NovAtel products with which you are familiar. Operating the MPC below 100 VAC causes the unit to suspend operation. An input voltage above 240 VAC may physically damage the unit.
4. Drawing more than the specified maximum current (1.5 amp) may cause the internal fuse to interrupt the current. Restoring normal operation will require replacing the fuse.

Foreword

Congratulations!

Congratulations on your purchase of the Modulated Precision Clock (MPC).

NovAtel is an industry leader in state-of-the-art GPS receiver design. We believe that our MPC will meet your high expectations, and are working hard to ensure that future products and enhancements will maintain that level of satisfaction.

This is your primary hardware and software reference.

Scope

This manual contains sufficient information on the installation and operation of the MPC and its software to allow you to effectively integrate and fully operate it. It is beyond the scope of this manual to provide details on service or repair. Contact your local NovAtel dealer for any customer-service related inquiries, see *Customer Service on Page 10*.

After the addition of accessories, an antenna and a power source, the MPC will be ready to go.

The MPC incorporates a Vacuum Fluorescent Display (VFD) on its front panel and this manual will take you through its menus and features, see *VFD Menus on Page 40*. A *VFD Menus Quick Look* weatherproof guide is also provided to help you find the VFD windows you need in a hurry, using the navigation buttons on the MPC.

The Euro4 in the MPC utilizes a comprehensive user-interface command structure, which requires communications through its communications (COM) ports. A supplementary manual is included to aid you in using the commands and logs available in the OEM4 family of receivers.

It is recommended that these documents be kept together for easy reference.

A graphical user interface is provided for your MPC via the internet, see *Section 6.1, Modulated Precision Clock Website on Page 49.*

Prerequisites

A standard internet browser, e.g. Netscape or Microsoft Internet Explorer, is required on a PC work station to access the *Modulated Precision Clock* website.

Chapter 1 Introduction

The MPC is a high performance, high accuracy, GPS receiver with fast data update rates and integrated memory in its hard disk for data logging. The MPC's front panel also features a Vacuum Fluorescent Display (VFD) panel and keypad for on the fly configurations.

Depending on which model you purchase, the MPC is capable of receiving and tracking the L1 C/A code, L1 and L2 carrier phase and L2 P-Code (or encrypted Y-Code) of up to 12 satellites. Patented Pulsed Aperture Correlator (PAC) technology combined with a powerful microprocessor make possible multipath-resistant processing and excellent acquisition and re-acquisition times.

Once you connect the MPC to an antenna and power source, it begins operating as a fully functional GPS system (see *Chapter 2, Quick Start on Page 16* and *Chapter 3, MPC Setup Considerations on Page 18*, for more information on this topic). *Figure 1* shows the MPC without an antenna or connecting cables.

Figure 1: MPC

1.1 Models and Features

The MPC is available in several different firmware models whose configurations may include other additional features. Some possible configurations can be seen in *Table 1*.

Table 1: MPC Controller Models

Model Name	Firmware Feature
MPC-L1	L1-only
MPC-L1L2	L1/L2
MPC-L1L2W	L1/L2 with WAAS [a]

a. Please see *Appendix C, WAAS Overview on Page 95*.

All the above models are capable of multiple positioning modes of operation:

- Single point
- Pseudorange differential corrections
- Post-processed RTK-type accuracy

The MPC has a carrying handle that can be adjusted through 360 degrees. To move the handles, press in the buttons and turn in the direction you want the handles to go. Let go of the buttons and move the handle slightly so as to lock it in place.

Each model has the following standard features:

- NovAtel's advanced OEM4 L1/L2 GPS technology in its Euro4 card
- Capability to log up to 19 GB of data on its hard disk
- Capability to execute scheduled logging on its hard disk
- Vacuum Fluorescent Display (VFD) panel and keypad for on the fly data information and configurations
- 4 internet/intranet connect options (ethernet, direct-PPP, modem client or modem host)
- 1 DGPS/RTK communications port for L1/L2 differential broadcasts
- Field-upgradeable firmware (program software). What makes one model different from another is software, not hardware. This unique feature means that the firmware can be updated anytime, anywhere, without any mechanical procedures whatsoever. For example, a model with L1/L2-only capabilities can be upgraded to a model with L1/L2 WAAS in only a few minutes at your installed location (instead of the days or weeks that would be required if the receiver had to be sent to a service depot). All that is required to unlock the additional features is a special authorization code and internet, or intranet, accessibility. Please see *Section 6.2, MPC Firmware Upgrades & Updates on page 75* for a description on how your MPC is upgraded/updated via the web.

1.2 ACCESSORIES AND OPTIONS

The MPC can be used with the following accessories:

- Power cable to connect the MPC to a 110 or 220 VAC power source
- An optional choke ring is available for the 501 antenna (model A031)
- Optional NovAtel GPSAntenna Model 600 series - dual or single frequency, active antennas designed for high-accuracy applications without the need for a choke ring
- Optional NovAtel Model C005, C015, or C030 coaxial antenna cable in 5 m (16.4'), 15 m (49.2'), or 30 m (98.4') lengths
- Optional serial cables for compatibility with certain data communications devices to the DGPS or PPP ports
- User-supplied RJ11 cable for the Modem port connector
- User-supplied RJ45 cable for the Ethernet port connector

Should you need to order an accessory or a replacement part, NovAtel part numbers are shown in *Appendix D on Page 97*. Not all of the above accessories are available from NovAtel.

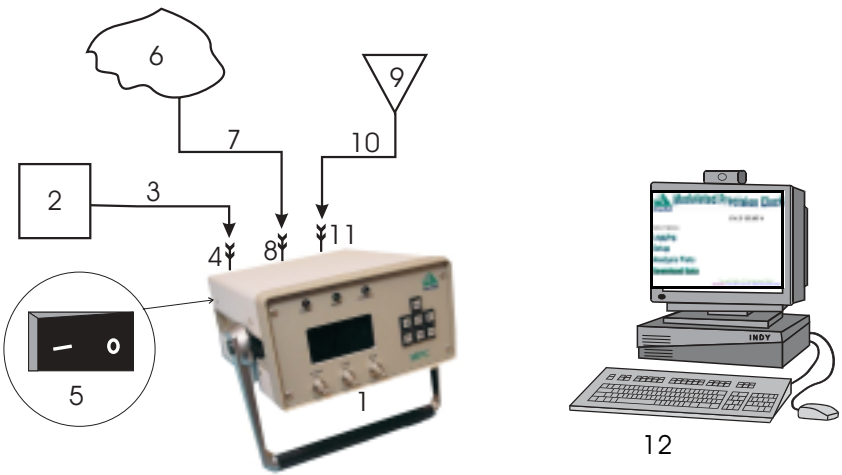
Chapter 2 Quick Start

Setting up the MPC is a straightforward process, whether you are in the field (collecting data) or back at the office (configuring the MPC, or transferring collected data to your PC for post-processing).

CAUTION!: See the cautions on *Page 11* of the *Notices* for a list of items you should be aware of as you set up and use the MPC.

Figure 2 displays how you might typically set up the MPC at the office (for example, as a base to set up other receivers in the grid, or to transfer collected data from other receivers to the base MPC, or as a stand alone receiver). In these situations, the MPC is connected to the internet and energy is supplied by means of a power source in the range 100 to 240 VAC. No matter what country the power source comes from, the MPC will automatically recognise and accept the voltage.

Figure 2: Typical MPC Setup



Reference	Description	Reference	Description
1	MPC	8	Modem (RJ11), Ethernet (RJ45) or PPP (RS232) connector
2	Power source		
3	MPC power cable	9	GPS antenna
4	Input Power connector	10	GPS antenna cable
5	Close-up of on/off (-/o) switch	11	GPS Antenna In connector
6	Internet provider	12	User-supplied PC to view the *Modulated Precision Clock* website on the internet
7	User-supplied RJ45 cable to Ethernet, or RJ11cable to Modem, or RS232 cable to PPP connector		

A typical configuration would result from the following steps (see also *Figure 2 on Page 16*):

1. Place the MPC on a desk or other suitable work surface.
2. Connect the output of a power source to the Power Input port on the back of the MPC.
3. Connect a GPS antenna to the GPS Antenna In connector on the back of the MPC.
4. Connect an appropriate cable from the back of the MPC (PPP, Ethernet or Modem port) to your intended internet or intranet connection source.
5. Press the power button.
6. Configure your intended internet connection using the VFD menus. The MPC supports many options for internet connectivity, please see *Section 4.2, Configuring the Network* starting on *Page 25* for details.
7. Monitor the MPC status using the VFD menus.
8. Obtain the MPC IP address given by your internet provider, as displayed by the VFD or provided by your MPC Administrator, to use as a URL to go to the *Modulated Precision Clock* website for your MPC receiver using a PC. The following is a fictional example:

   http://123.123.123.123/

✉ Your Network Administrator may wish to provide you with a “STATIC” IP location on your internal network (intranet) and associate this IP address with a name, for example “MPC1”, in your Domain Name Server (DNS). In this case, you would access your MPC’s web page via the URL:

http://mpc1/

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9. Browse to the *Modulated Precision Clock* website.
10. The *Modulated Precision Clock* website for your MPC now becomes your user interface where you can set up logging, modify configurations, view logging summaries and plots, and download data.

The sections of *Chapter 3, MPC Setup Considerations starting on Page 18* give further details on Steps #2 to #5, while *Chapter 5, VFD Menus starting on Page 40* gives details on the menus in Steps #6 & #7, *Section 4.2, Configuring the Network* starting on *Page 25* helps with Step #6, and *Modulated Precision Clock Website on Page 49* is devoted to Steps #8 and #9.

✉ The MPC is designed for continuous operation. However, if you need to power down the unit, it is recommended that you always use the *MPC Shutdown Type* menu, see *Page 45*. Then give the internal operating system a few minutes to flush its cache buffers to the hard drive, and turn off the power at the power switch.

Chapter 3 MPC Setup Considerations

3.1 Choose the Right Antenna

The recommended antenna is from the **GPS-600** antenna series, which are ideal for all applications. A Model 600 GPSAntenna provides comparable performance to a choke ring ground plane antenna while being much lighter and smaller.

When installing the antenna system,

- choose an antenna location that has a clear view of the sky so that each satellite above the horizon can be tracked without obstruction.
- mount the antenna on a secure, stable structure capable of safe operation in the specific environment.

The purpose of the GPS antenna is to convert the electromagnetic waves transmitted by the GPS satellites into RF signals. An active GPS antenna is required for the MPC to function properly; there is a provision to enable or disable the DC power to the active GPS antenna in case you wish to use an antenna that has an alternate power source. Please refer to the ANTENNAPOWER command in *Volume 2* of the *OEM4 Users' Guide* for details on the command to do this. See *List Current Configuration on Page 63* for information on how to issue commands via the *Modulated Precision Clock* website.

An active antenna is required because its low-noise amplifier (LNA) boosts the power of the incoming signal to compensate for the line loss between the antenna and the Euro4 GPSCard. If the limit of 14 dB of allowable cable loss is exceeded, excessive signal degradation will occur and the GPSCard may not be able to meet its performance specifications.

NovAtel offers a variety of single and dual-frequency GPSAntenna models. All include band-pass filtering and an LNA. The GPSAntenna you choose (models 501, 511, 521 and 531 are L1-only; models 600, 502, 503 and 512 are dual-frequency GPSAntennas) will depend on your particular application. Each of these models offer exceptional phase-center stability as well as a significant measure of immunity against multipath interference. Each one has an environmentally-sealed radome.

NovAtel also offers high-quality coaxial cable in standard 5 (Model C005), 15 (Model C015) and 30 m (Model C030) lengths. These come with a TNC male connector at each end. Should your application require the use of cable longer than 30 m you will find the application note *Extended Length Antenna Cable Runs* at our website, http://www.novatel.com, or you may obtain it from NovAtel Customer Service directly; see the *Customer Service Section* at the beginning of this manual.

High-quality coaxial cables should be used because a mismatch in impedance, possible with lower quality cable, produces reflections in the cable that increase signal loss.

While there may be other coaxial cables and antennas on the market which may also serve the purpose, please note that the performance specifications of the MPC are warranted only when it is used with NovAtel-supplied accessories

The Euro4 GPSCard is factory-configured for operation with any of the dual-frequency factory configured GPSAntenna models, in which case no special wiring is required. The internal antenna power source of the Euro4 can produce +4.25 to +5.25 V DC at up to 90 mA.

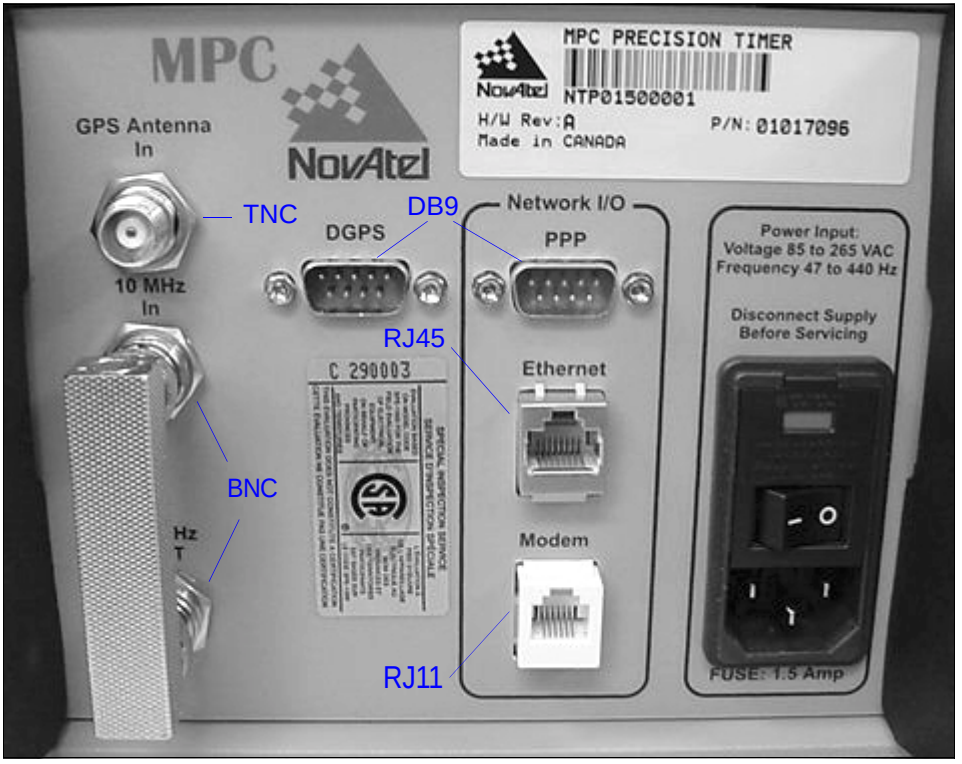
CAUTION

No warranty is made that the MPC will meet its performance specifications if a non-NovAtel antenna is used.

3.2 Rear Panel Functionality

The connections on the rear panel and their connector types are shown on *Figure 3*.

Figure 3: Close-up of Connectors on Rear Panel



Each connector is keyed to ensure that the cable can be inserted in only one way, to prevent damage to both the MPC and the cables. Furthermore, the connectors that are used to mate the cables to the MPC require careful insertion and removal. Observe the following when handling the cables.

- To insert a cable, make certain you are using the appropriate cable for the port - the serial cable has a different connector (DB9) than the GPS Antenna In (TNC), or the Modem (RJ11), or the Ethernet (RJ45) connectors.

WARNING: DO NOT PULL DIRECTLY ON THE CABLES.

3.2.1 10 MHz In and 10 MHz Out

There are two BNC connectors on the back of the MPC for 10 MHz In and 10 MHz Out. These two connectors are looped using an RF Loop-Back connector. Therefore by default, the 10 MHz Oven Controlled Crystal Oscillator (OCXO) in the MPC is looped back to the GPS receiver. The GPSCard phase locks to the 5 or 10 MHz reference signal supplied to the rear panel 10 MHz port.

The RF Loop-Back connector can be removed if you prefer to provide your own external oscillator through the 10 MHz In connector. In this case, the EXTERNALCLOCK command, refer to *Volume 2* of the *OEM4 Users' Guide* and *List Current Configuration on Page 63*, allows you to set up an external oscillator and its frequencies.

Figure 4 shows how the clock card and Euro4 card work together using the loop connector or using a user-supplied external clock.

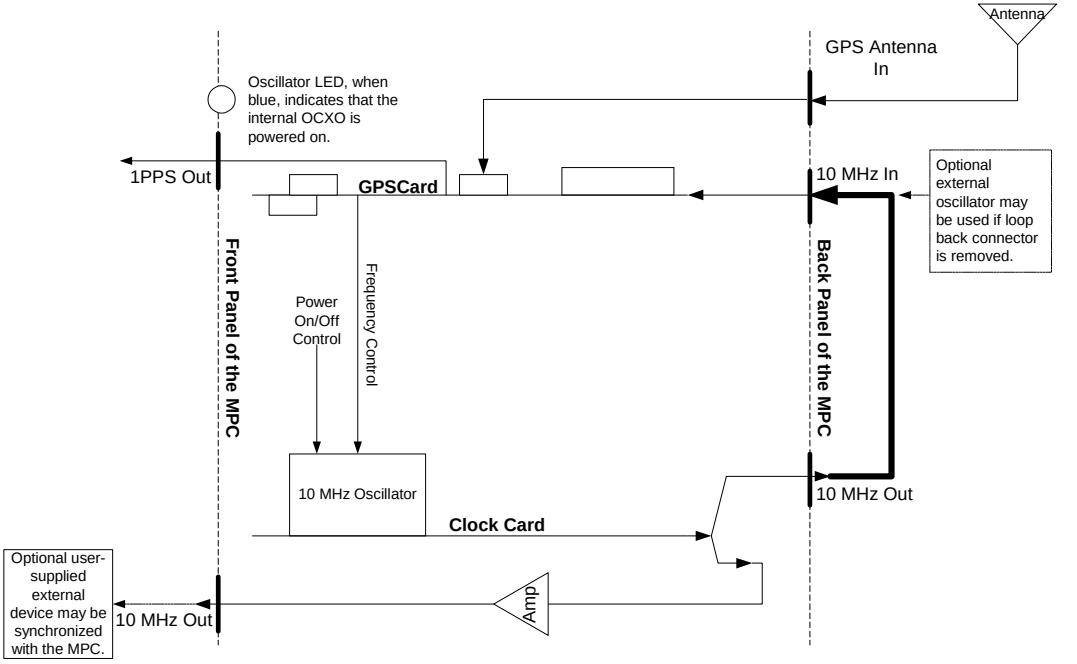


Figure 4: 10 MHz In/Out Data Flow

For further information on the signals or connector type for the 10 MHz In and 10 MHz Out ports, please see *Appendix A, Input/Output Connectors on Page 78.*

3.2.2 DGPS

A data serial cable is needed to connect the MPC from the DGPS connector to an external device.

The Differential GPS (DGPS) communication port is bi-directional and factory configured for RS232. It is typically used to communicate DGPS broadcast data to transmitting radio equipment.

For communication to occur, the MPC serial port configuration must match that of the external

device's. The MPC's default port settings are [RS232, 9600 BPS, no parity, 8 data bits, 1 stop bit, no handshaking, and echo off]. Changing the default settings can be easily accomplished by means of the COM command (which is described in *Volume 2* of the *OEM4 Users' Guide*).

For information on issuing commands to the MPC via the *Modulated Precision Clock* website, see *List Current Configuration on Page 63.*

For further information on the signals, or connector pin-outs, for this serial port, please see *Section A.3, Port Pin-Outs on Page 79.*

See *Appendix D, Replacement Parts on Page 97*, if you need to consult a list of NovAtel part numbers.

3.2.3 Network I/O

In the Network I/O group of connectors there is an RJ11 Modem jack, an RJ45 Ethernet jack and an RS232 PPP port.

Data and receiver information can be viewed, configured and downloaded via the internet using these connections and the *Modulated Precision Clock* website. See also *Section 4.2, Configuring the Network on Page 25* and *Chapter 5, VFD Menus on Page 40*.

3.2.3.1 PPP

The Point to Point Protocol (PPP) connector is an RS232 communications port to support TCP/IP communication using a "Direct Connection" to a user supplied computer. See also *Section 4.2.2, Modem or Direct Connect (PPP) Client on Page 26.*

The PPP connector provides a direct TCP/IP data link from the MPC to a computer that supports this protocol.

For further information on the signals, or connector pin-outs, for this serial port, please see *Section A.3, Port Pin-Outs on Page 79.*

3.2.3.2 Ethernet

Connect to the internet from this port using a Patch RJ45 cable. See also *Section 4.2.1, Ethernet Connect on Page 25*.

3.2.3.3 Modem

The MPC contains an internal modem. You can connect to the MPC by phoning in from your computer/modem, or you can configure the MPC to phone out to an Internet Service Provider or internal network (intranet). See also *Section 4.2.2, Modem or Direct Connect (PPP) Client on Page 26.*

Use a Patch RJ11 cable to connect the MPC from the Modem port to the telephone system.

3.2.4 Power

After initial connection of the power source to the receiver and pressing the power switch on the back of the unit (see *Figure 3 on Page 19*), the Power LED on the front of the MPC glows red.

The PWR button on the keypad is used to access the MPC Shutdown Type screen in the VFD menus, see *Pages 45*. Choosing REBOOT will cause the embedded PC to reboot. Choosing POWERDOWN will terminate the programs running on the embedded PC and cause the PC buffers to be flushed to the hard drive. The keypad will be unusable again until the power switch is turned off, then on, and the VFD is visible again.

The VFD display will screen-save and appear black after 5 minutes of inactivity. Hit any key on the VFD keypad for it to be restored.

The MPC requires an input supply voltage that comes from a normal power source of 110/220 volts at 50/60 Hz AC through its 3-pin power connector. The MPC has an internal power module that does the following:

- filters and regulates the supply voltage
- protects against over-voltage, over-current, and high-temperature conditions
- provides automatic reset circuit protection

WARNING:

1. Supplying the MPC with an input voltage that is below 100 VAC will cause the unit to suspend operation. An input voltage above 240 VAC may physically damage the unit.
2. Disconnect the power source before servicing the power connector's 1.5 Amp fuse.

The Power Input connector on the MPC contains a 1.5 Amp fuse that can be serviced as long as the MPC is disconnected from power.

As is also described on *Page 42*, the GPS row in the MPC System Status screen of the VFD menus provides information and error messages including any to do with voltage. Also, the RXHWLEVELS log, refer to *Volume 2* of the *OEM4 Users' Guide*, contains environmental and voltage parameters.

The data logging mechanism is designed to be robust and to endure power interruptions (and similar disruptive events) with minimum loss of data. In this situation, allow for your data to be possibly reduced by several seconds up to a maximum of a minute. To the extent possible, error messages attempt to describe the problem. If you require further information on this topic, please refer to the description of the RXSTATUS log in *Volume 2 of the OEM4 Users' Guide*.

✉ The MPC is designed for continuous operation. However, if you need to power down the unit, it is recommended that you always use the *MPC Shutdown Type* menu, see *Page 45*. Then give the internal operating system a few minutes to flush its cache buffers to the hard drive, and turn off the power at the power switch.

For a listing of the required input supply voltages, see *Appendix A, MPC Specifications on Page 77*. For more information on the supplied 3-pin power cable, see *A.4, Power Cable on Page 80*.

3.2.5 RF Port & Cables

The GPS Antenna In connector is bi-directional in that it accepts RF signals from the antenna, and it supplies DC power to the low-noise amplifier (LNA) of an active antenna. It has a TNC female connector. Power to this port can be disabled via the ANTENNAPOWER command, refer to *Volume 2* of the *OEM4 Users' Guide*.

The receiver obtains a partially filtered and amplified GPS signal from the antenna via the coaxial cable. The RF section performs the translation from the incoming RF signal to an IF signal usable by the Euro4's digital section. It also supplies power to the active antenna's LNA through the coaxial cable while maintaining isolation between the DC and RF paths.

The RF section can reject a high level of potential interference (e.g., MSAT, Inmarsat, cellular phone, and TV sub-harmonic signals). For further information on the signals or connector type for the GPS Antenna In connector, please see *Appendix A, Input/Output Connectors on Page 77*.

While there may be other coaxial cables on the market that might also serve the purpose, please note that the performance specifications of the MPC are guaranteed only when it is used with NovAtel-supplied RF cables.

3.3 Front Panel Functionality

As shown in *Figure 5*, the MPC's front panel has a VFD display with a keypad including an ENTER and ESC button, see *Chapter 5, VFD Menus on Page 40*, and a power (PWR) button, see *Section 3.2.4, Power on Page 22*.

Figure 5: MPC Front Panel

There are three color indicators above the VFD screen:

Power This LED glows red while power is applied

Status This diagnostic LED glows green to indicate satellite tracking and computed solution. If the indicator is not illuminated, the receiver is not tracking satellites properly. The GPS row in the MPC System Status screen of the VFD menus provides status information, see *Page 42*

Oscillator This LED glows blue when the internal OCXO is powered on

3.3.1 I/O Connectors and Cables

Below the VFD screen on the front of the MPC are three BNC female connectors: 10 MHz Out, 1PPS Out and Mark In.

3.3.1.1 10 MHz Output

The 10 MHz output provides a high-stability reference 10 MHz frequency that is by default phase locked to GPS time. It permits the synchronization of other equipment requiring an extremely stable reference signal of 10 MHz. See also *Figure 4 on Page 20*.

The steering of the internal OCXO is controlled by the CLOCKADJUST, EXTERNALCLOCK and CLOCKCALIBRATE commands. The status of the clock steering process is provided by the CLOCKSTEERING log and the time history plots on the *Modulated Precision Clock* website.

Refer to *Volume 2* of the *OEM4 Users' Guide* for more information on these commands and logs. For details on time plots, please see *Section 6.1.3.1, Time Plots on Page 67*.

3.3.1.2 1PPS Output

Upon determination of position-time, the receiver will align the one pulse per second (1PPS) signal to the GPS epoch. Its specifications and electrical characteristics are described in *Front Panel 1PPS Out on Page 78*. From this time onwards the 1PPS triggers every second. By default, the OCXO frequency is adjusted to maintain the 1PPS signal within 10 ns of GPS time. The bandwidth of the OCXO clock steering loop is adjustable with a default value of 1/100 Hz or approximately a 15 minute time constant.

The CLOCKADJUST command is used to enable or disable the clock steering. The CLOCKCALIBRATE command is used to set the parameters of the clock steering loop. It also provides an auto-calibration procedure to find or reset the centre point and gain of the control loop. Please refer to *Volume 2* of the *OEM4 Users' Guide* for details on these commands.

Immediately on start-up of the receiver, the 1PPS is active (at 1Hz) but it is not aligned to the GPS epoch. The timing of the 1PPS will be adjusted when position-time is known.

1 Hz GPS measurements are taken on the 1PPS. These measurements include pseudorange, carrier phase and Doppler.

3.3.1.3 Mark Input

The Mark In connector provides a connection for an input mark with an input pulse greater than 55 ns. Time tags output log data to the time of the falling edge of the mark input pulse. Logs with the ONMARK trigger will output when a trigger event passes the Mark In connector.

If you supply the reference frequency and 1PPS signal, your 1PPS signal will be connected to the Mark In connector. The receiver can be configured to adjust its internal 1PPS to match your 1PPS to within 50 ns. Refer to the ADJUST1PPS command in *Volume 2* of the *OEM4 Users' Guide*.

Chapter 4 Using the MPC

Before using MPC for the first time, ensure that you have followed the installation instructions of *Chapter 2, Quick Start* and *Chapter 3, MPC Setup Considerations, starting on Page 16.*

CAUTION!: See the cautions on *Page 11* of the *Notice* for a list of items you should be aware of as you set up and use the MPC.

4.1 Self-Test

When power is applied, it takes several minutes for the computer within the MPC to boot up. It takes up to 15 minutes for the internal OCXO to warm up to a point where the frequency is stable enough to track satellites.

Once powered and stable, the MPC performs the first phase of self-test functions. If no problems are detected, the STATUS LED on the front of the MPC will glow green. You can monitor the MPC using the VFD panel Status menu and/or RXSTATUS log. Self-test status of the internal GPSCard can be examined via the self-status word in the RANGE and RXSTATUS data logs, refer to *Volume 2* of the *OEM4 Users' Guide*.

System and logging status reports may also be seen via the internet on the *Modulated Precision Clock* website, see *Section 6.2, MPC Firmware Upgrades & Updates* starting on *Page 75*.

If the MPC fails its self-test, please refer the problem to your dealer or NovAtel Customer Service.

4.2 Configuring the Network

There are three connectors on the back panel of the MPC that allow connectivity to the internet:

- Ethernet
- Modem
- Direct (PPP)

These MPC internet ports, user security, and internet method can be configured using the menus on the front panel of the MPC. A limited amount of the system status may also be viewed in these menus. See *Chapter 5, VFD Menus on Page 40* for more details.

How to set up the different ports for connection to the internet and then how to connect to the internet from each port is described in the following sections.

4.2.1 Ethernet Connect

The Network Administrator must use the Configure Ethernet menus as described in *Section 5.2.4, Configure Ethernet on Page 46* to decide whether or not the IP address is assigned automatically via a Dynamic Host Configuration Protocol (DHCP) server on the local network (intranet). If AUTO IP in

the menu is changed to ‘YES’, then the IP, SUBNET and GATEWAY rows will be assigned automatically upon activation.

Connect an RJ45 cable from your local internet or intranet wall jack to the Ethernet port on the MPC.

You may receive an IP address or a “static” IP location on your internal network (intranet) given by your Network Administrator to use as a URL. An IP location associates an IP address with a name, for example “MPC1”, in your Domain Name Server (DNS).

Open your internet browser and connect to the internet on a PC. In the Address field of your internet browser, type in the IP address or static IP location to go to the *Modulated Precision Clock* website for your MPC. The following URLs are fictional examples:

http://123.123.123.123/

http://mpc1/

You can monitor your connection status in the Connect menu described in *Section 5.2.2, Connect on Page 44*.

Details on the *Modulated Precision Clock* website login and features can be found in *Section 6.1* starting on *Page 49*.

4.2.2 Modem or Direct Connect (PPP) Client

Use the Configure Modem menus as described in *Section 5.2.5, Configure Modem on Page 47* or the Configure Direct menu as described in *Section 5.2.6, Configure Direct (PPP) on Page 48* to set up the modem direct connection. Then decide whether or not the IP address is assigned automatically for the MPC. If AUTO IP in the CONFIG MODEM or CONFIG DIRECT menu is changed to ‘YES’, then the IP row will be assigned automatically upon activation.

Connect an RJ11 cable from a phone jack to the Modem port on the MPC, or an RS232 cable from the PPP port on the MPC to a COM port on your PC.

In order to install a modem or PPP connection for your PC follow the rest of this section.

On your PC select Start | Settings | Control Panel from the taskbar and click on the Modems icon as seen in *Figure 6.*

Figure 6: Modems Icon

The Modems Properties dialog will appear as seen in *Figure 7*.

Figure 7: Modems Properties

Click on the Add button to install the modem or PPP connection and the Install New Modem dialog will appear as seen in *Figure 8*.

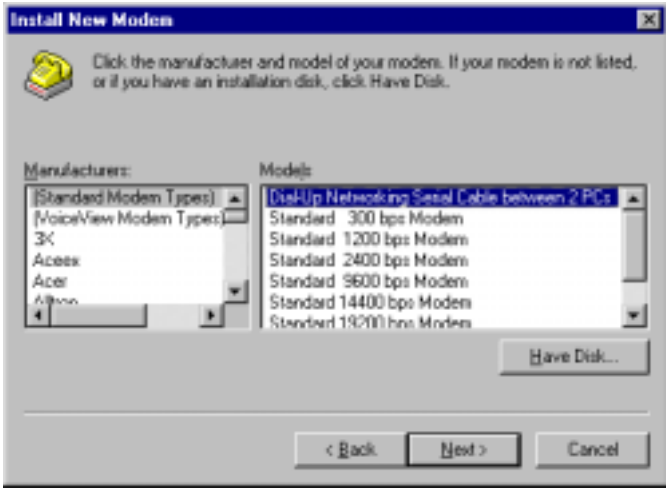


Figure 8: Install New Modem

In the Install New Modem dialog, select a modem or direct connection from the list. Insert your operating system install disk into your CD drive (e.g. Windows NT) and click on the Have Disk

button. The modem installation will continue as seen in *Figure 9*.

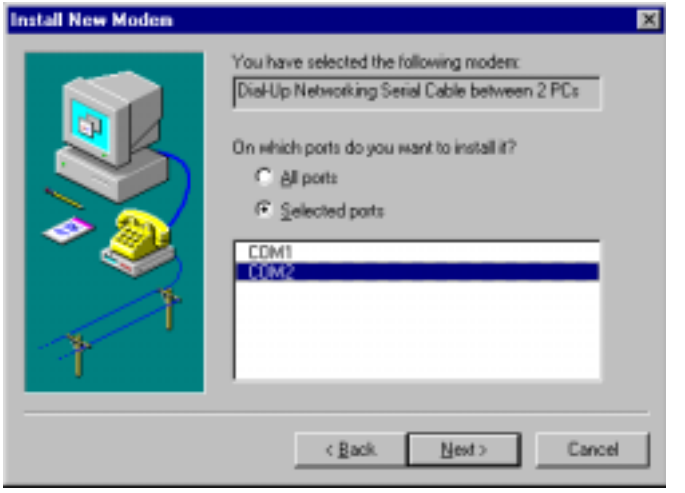


Figure 9: Modem Installation Continued

Click in the Selected Ports field and select the PC port that your MPC will be connected to from the list. Click on the Next button.

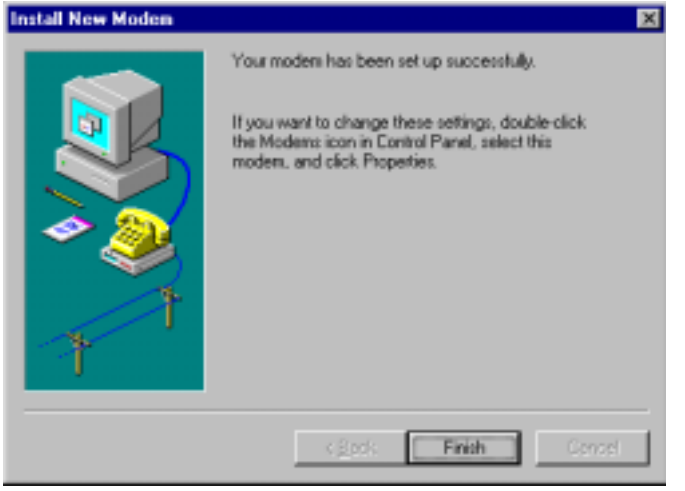


Figure 10: Modem Installation Finish

Click on the Finish button, see *Figure 10*, and you will be returned to the Modems Properties dialog, see *Figure 11 on Page 29*, but you will now see the modem you installed.

Figure 11: Installed Modem Properties

Select your connection in the Modem column and click on the Properties button. Its properties dialog will appear as seen in *Figure 12*.

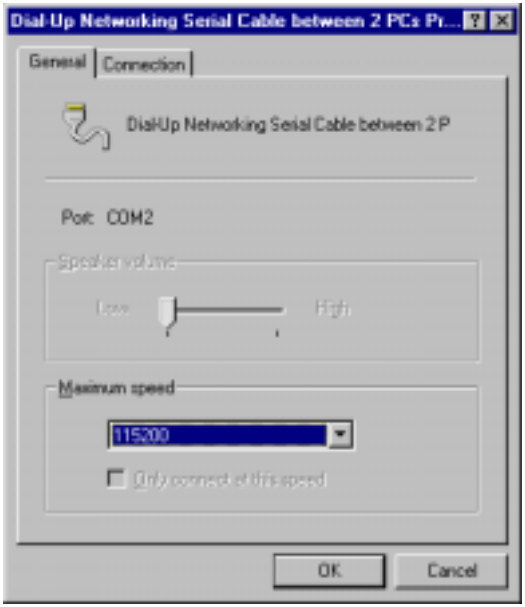


Figure 12: Connection Properties

In the General tab, ensure that the Maximum Speed is set to 115200 to match the MPC. Click on the

OK button.

Return to the Control Panel and select the Network icon as seen in *Figure 13*.

Figure 13: Network Icon

The Network dialog appears as seen in *Figure 14*.

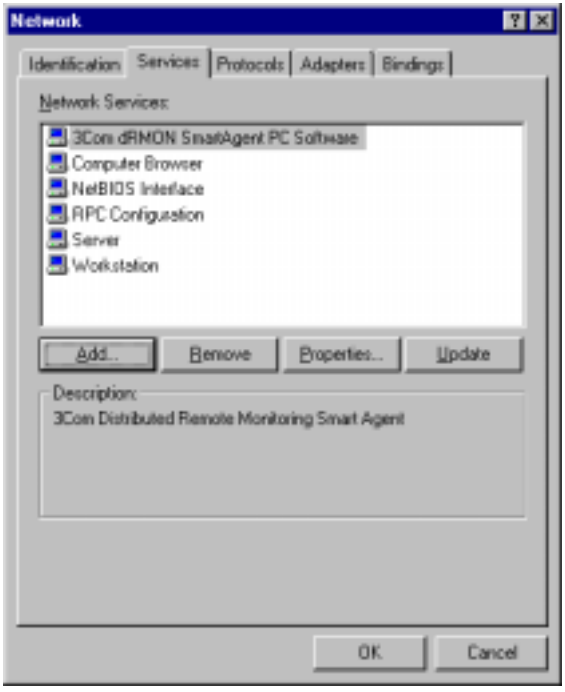


Figure 14: Network Services

Select the Services tab in the Network dialog. Click on the Add button to add a Remote Access Service (RAS) and the Select Network Service dialog will appear as seen in *Figure 15 on Page 31*.

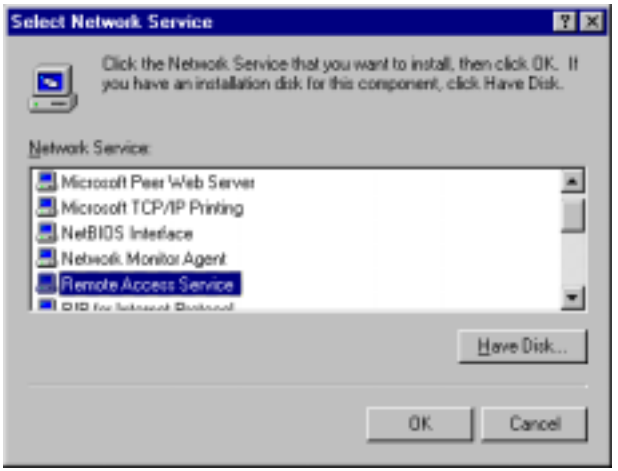


Figure 15: Select Network Service

Select Remote Access Service and ensure your operating system install disk is in the PC disk drive. Click on the Have Disk button and the Add RAS Device dialog will appear as seen in *Figure 16*.

Figure 16: Add RAS Device

Select your connection in the RAS Capable devices field and click on the OK button. The Configure Port Usage dialog will appear as seen in *Figure 17*

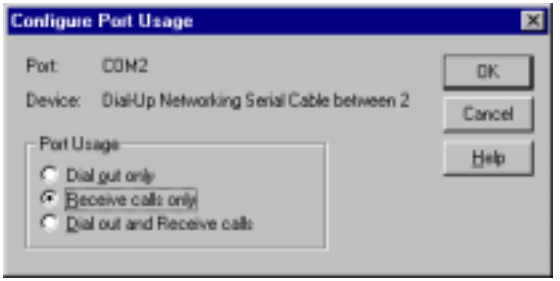


Figure 17: Configure Port Usage

Click in the Receive Calls Only field and then click on the OK button. The Network Configuration dialog will appear as seen in *Figure 18 on Page 32.*

Figure 18: Network Configuration

Check the TCP/IP check box and click in the Allow Any Authentication Including Clear Text field. Click on the Configure button next to the TCP/IP check box and the RAS Server TCP/IP Configuration dialog will appear as seen in *Figure 19*.

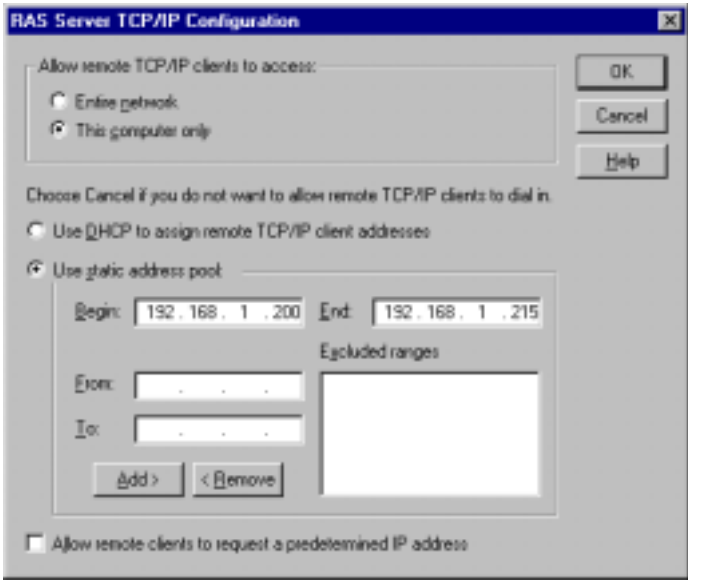


Figure 19: RAS Server TCP/IP Configuration

Click in the Use This Computer Only field and then the Use Static Address Pool field. Enter the Begin

and End addresses as shown in *Figure 19 on Page 32*. Click on the OK button and the Remote Access Setup dialog will appear with your connection port, device and type showing as in *Figure 20*.

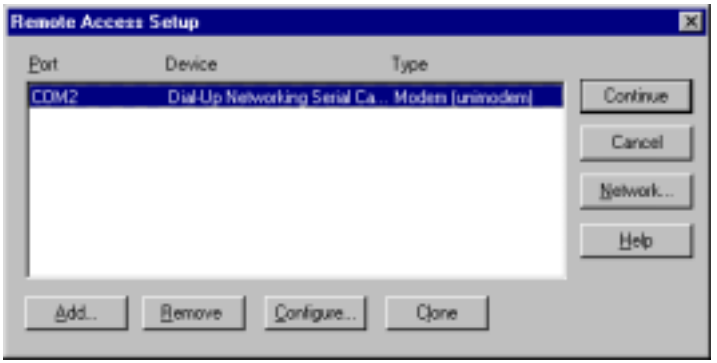


Figure 20: Remote Access Setup

From the taskbar, select Start | Programs | Administrative Tools (Common) | Remote Access Admin, see *Figure 21*.

Figure 21: Remote Access Admin Route

The Remote Access Admin dialog will appear as seen in *Figure 22*.

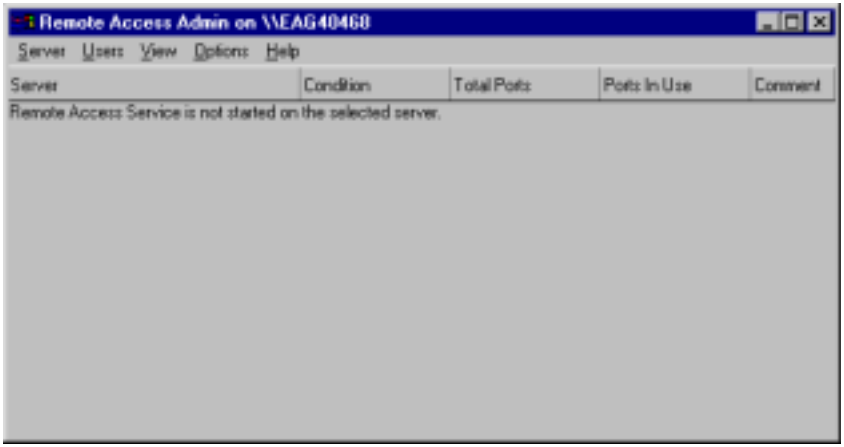


Figure 22: Remote Access Admin on PC

From the main menu, select Server | Start Remote Access Service and the Start Remote Access Service dialog will appear as seen in *Figure 23*

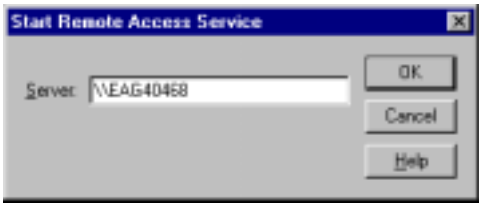


Figure 23: Start Remote Access Service

You may see some service control messages before the Remote Access Admin dialog reappears with your connection status visible, see *Figure 24*.

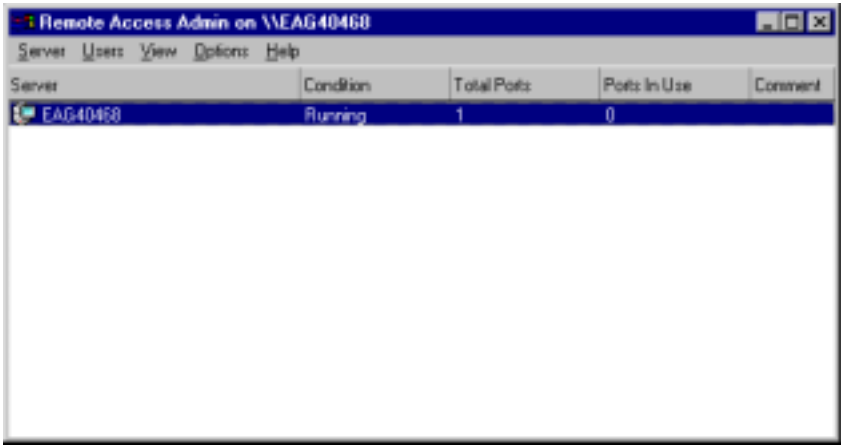


Figure 24: Remote Access Admin

On the taskbar, select Start |Administrative Tools (Common) || User Manager for the User Manager dialog to appear as seen in *Figure 25*

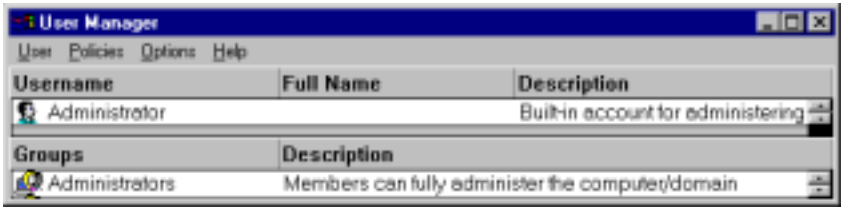


Figure 25: User Manager

From its main menu, select User | New User and the New User dialog will appear as shown in *Figure 26.*

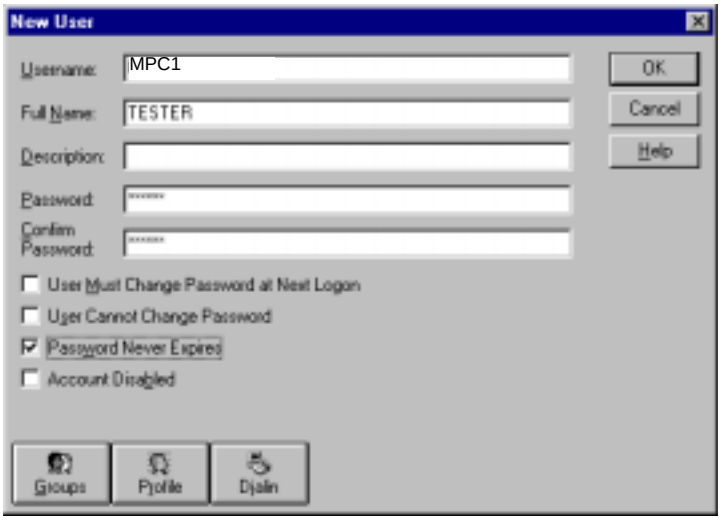


Figure 26: New User

Enter a User Name and Password that the MPC will use to ‘sign on’ to your computer, in bold uppercase letters only because only uppercase letters can be entered in the VFD screens, in the Username and Password fields. Re-enter your password in the Confirm Password field. You may also enter text in the Full Name field, such as MPC1, for easy identification.

Check in the Password Never Expires check box and then click on the Dialin button. The Dialin information dialog will appear as seen in *Figure 27 on Page 36.*

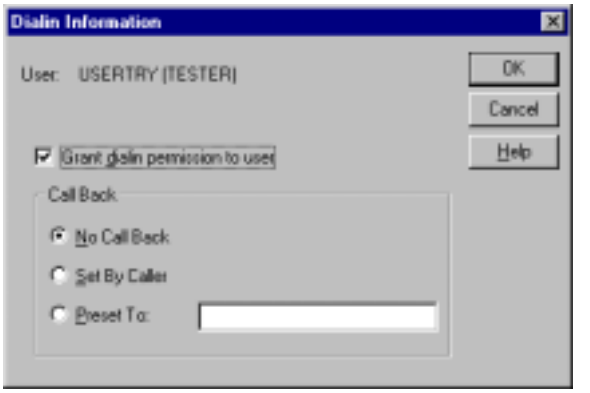


Figure 27: Dialin Information

Check the Grant Dialin Permission to User check box and click in the No Call Back field. Click on the OK button.

Restart your PC for the new settings to take effect.

Ensure your MPC is powered on. At the MPC VFD screen, use the navigation button to go to the CONFIG DIRECT, or CONFIG MODEM, menu. Set up a client as described in *Section 5.2.3, Configure Client on Page 45*. If you have a PPP connection, use the MPC navigation buttons to go to the CONFIG DIRECT menu, see also *Section 5.2.6, Configure Direct (PPP) on Page 48*. Or, if you have a modem connection, use the MPC navigation buttons to go to the CONFIG MODEM menu, see also *Section 5.2.5, Configure Modem on Page 47*. Examples of both menus are shown in *Figure 28*.

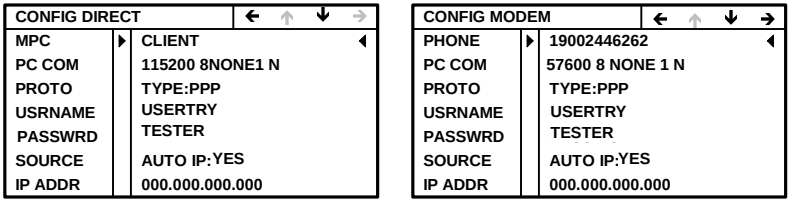


Figure 28: Config Direct and Modem Menus

Select your protocol (PROTO: TYPE) as PPP. Enter the same User Name and Password that you set up for the MPC to 'dial in' to your computer. In the SOURCE row, select AUTO IP:YES.

Use the MPC navigation buttons to go to the MPC CONNECT menu, see also *Section 5.2.2, Connect on Page 44*. An example of the MPC CONNECT menu is shown in *Figure 29*.

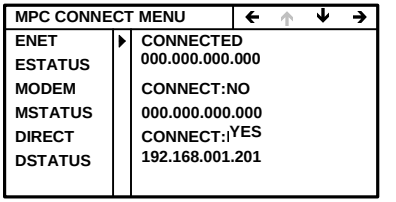


Figure 29: MPC Connect Menu

Change the DIRECT row status to CONNECT:YES. Once you have pressed the ENTER key, the MPC will attempt to 'dial in' to the host computer. If successful, the IP address will appear in the DSTATUS row if there are no errors, and an error message will appear if there is an error.

Open your internet browser and type in the IP address shown in the DSTATUS row as the URL.

If successful, you should see the loading screen as shown in *Figure 30*.

Figure 30: Loading Screen

This is followed by the Log In dialog as shown in *Figure 31*.

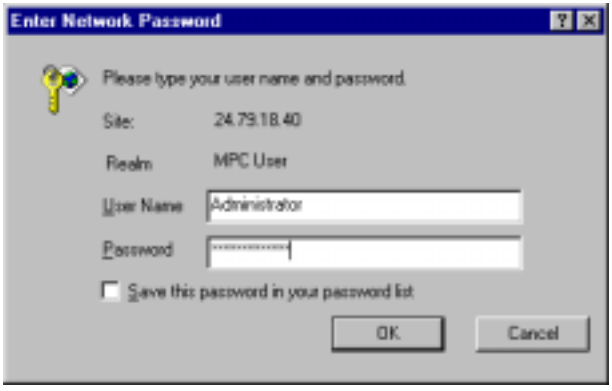


Figure 31: Website Password

At this point, you can use the preconfigured Administrator User Name and Password to 'log on' to the *Modulated Precision Clock* website:

User Name: Administrator
Password: Administrator

If you are successfully logged on to the *Modulated Precision Clock* website, you should see its home page, see *Figure 43, Modulated Precision Clock Home Page on Page 49.*

We recommend that you change the Administrator Password to protect your MPC from unwanted access. If you forget your Administrator Password, you can set up a new Client User Name and Password through the VFD CONFIG CLIENT menu, see *Section 5.2.3, Configure Client on Page 45* and *Figure 32 on Page 38*, and toggle the ADMIN row to YES.

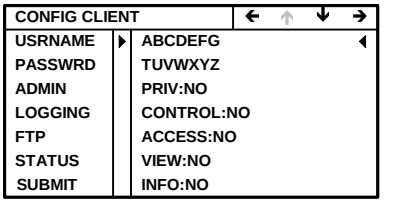


Figure 32: CONFIG CLIENT Menu

You can add\edit users and their privileges by choosing Setup in the Modulated Precision Clock home page followed by the Set Up Users button. See also *Section 6.1.2.7, Set Up Users on Page 65*.

Details on the *Modulated Precision Clock* website login and features can be found in *Section 6.1* starting on *Page 49*.

You can also monitor your connection status in the VFD CONNECT menu described in *Section 5.2.2, Connect on Page 44*.

4.3 Communication

After a network connection has been established, the *Modulated Precision Clock* website is used for all other aspects of the system such as configurations, monitoring and data collection. See *Section 6.1, starting on Page 49* for details on the *Modulated Precision Clock* website.

Some examples of the types of information that can be monitored via the website are:

- Temperature
- Number of satellites
- Clock feedback
- Receiver messages
- Multipath
- Signal strength
- Sky coverage

4.3.1 Logging Data

The most basic activity is logging raw data. Each logging session (one uninterrupted period of time) is stored on the internal hard disk and may also be downloaded via the *Modulated Precision Clock* FTP site.

MPC records raw data in the form of logs, which are written to the hard disk as configured in the *Modulated Precision Clock* website. If you wanted to analyze the data in these logs yourself, the details of the logs are documented in *Volume 2 of the OEM4 Users' Guide*.

4.3.2 Differential GPS

If you are using your MPC as a reference or remote station to receive and transmit differential corrections, you will need to provide a data link between the reference station and rover(s). Generally

a data link capable of data throughput at a rate of 2400 bits per second or higher is sufficient for the examples shown below. The external device is connected to the MPC's DGPS port with a user-supplied RS232 cable.

Pre-configure the MPC as a base station via the *Modulated Precision Clock* website, see *Set Up Base Station on Page 63* for details.

Pre-configure a rover/remote station, for example a NovAtel ProPak or DL-4 receiver, as follows:

interfacemode port rx_type tx_type

For example:

RTCA `interfacemode com3 rtca none`
RTCM `interfacemode com3 rtcm none`
CMR `interfacemode com3 cmr none`

✉ The DGPS port on the back of the MPC is connected internally to COM3 of the Euro4 GPSCard.

MPC commands can be issued via the *Modulated Precision Clock* website, see *List Current Configuration on Page 63* for details.

4.3.3 Errors

In the case of a power interruption or similar disruptive event, during a data-recording session, allow for your data to be possibly reduced by several kilobytes. To the extent possible, error messages, refer to the RXSTATUS log in *Volume 2 of the OEM4 Users' Guide and the GPS*, attempt to describe the problem. As is described on *Page 31*, the GPS row in the MPC System Status screen of the VFD menus also provides status information.

✉ The MPC is designed for continuous operation. However, if you need to power down the unit, it is recommended that you always use the *MPC Shutdown Type* menu, see *Page 45*. Then give the internal operating system a few minutes to flush its cache buffers to the hard drive, and turn off the power at the power switch.

Chapter 5 VFD Menus

The front panel of MPC has a Vacuum Fluorescent Display (VFD) with 7 interaction keys. The panel consist of four navigational, a combination edit/enter, a power, and an escape key.

The main functions of the VFD menu are:

- MPC Status
- MPC Connect
- Configure Client
- Configure Ethernet
- Configure Modem
- Configure Direct (PPP)

Accompanying this manual is a water/tear proof VFD Menus Quick Look Guide for on the fly referencing of menu locations.

The current menu page being displayed is shown in the top left corner of the VFD screen. *Figure 33* shows the layout of the VFD area.

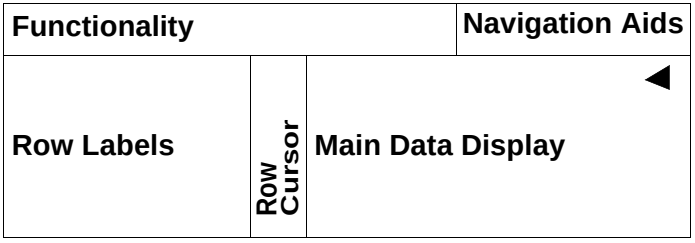


Figure 33: VFD Areas

The VFD areas are defined as:

- *Functionality:* The title of the current menu page.
- *Main Data Display*: Current data and depends on the active Functionality.
- *Row Labels*: Row labels for the data being displayed in the Main Data Display
- *Row Cursor*: This cursor indicates the current row. It is especially useful for choosing a row to edit.
- *Navigation Aids*: Four directional arrows show you how you can proceed through the menu items for the current Functionality.
- ◀ : This edit cursor appears when the digits, or a group, in a row become editable. See also *Edit Digit Display* and *Edit Group Display* on *Page 41*.

When the MPC is first powered up, and after an initialization period, the NovAtel logo appears followed by the MPC SYSTEM STATUS menu, see *Figure 34 on Page 41* and also *Page 42*, from

where you can access any of the main functionality menus and their columns.

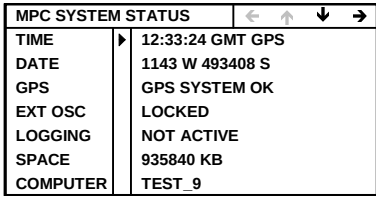


Figure 34: Opening Menu

5.1 Menu Access

The menu structure is arranged as columns of functionality. Each column may have several pages of related data where a page can have up to seven rows.

Simple menu access is achieved by following the directional arrows in the top right of the VFD when they appear (← ↑ ↓ →). An arrow that does not appear signifies that there is no menu in that direction. Pressing the <ESC> key continually will take you back through menu items until you return to the top of the menu where you started.

There are two mechanisms for editing data, Edit by Digit and Edit by Group.

5.1.1 Edit Digit Display

Press the <ENTER> key to cause the ◀ indicator to appear on the row you wish to edit, and a cursor to appear under the first digit of that row. Cursor horizontally to the digit to be changed, then cursor up to increase its value or down to decrease its value. A numeric values ranges from 0 to 9 and an alpha character can be A to Z. Press the <ENTER> key again to save the new value.

Alpha-numeric fields can be shortened by toggling the characters to spaces. When the screen is refreshed the spaces will disappear and leave you with a shortened entry. Address fields, such as IP addresses, may have truncated values in the memory, for example ‘195.45.61.1’, but will appear padded with zeroes, for example ‘195.045.061.001’, in the VFD menu.

✉ The VFD menus only provide upper case letters.

An example of a screen in edit digit display mode is shown in *Figure 35.*

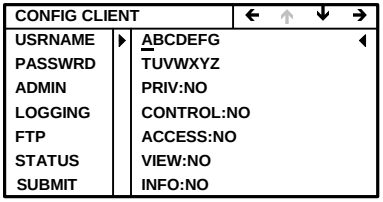


Figure 35: Edit Digit Mode

5.1.2 Edit Group Display

Press the <ENTER> key to cause the ◀ indicator to appear on the row you wish to edit, and the first

group in an editable row to be underlined. The left and right arrows move the cursor to the groups in the row. The up and down arrows cycle through a list of choices for that group value. An example of a group value that the cursor has been moved to, is the PPP value shown in *Figure 36*.

Press the <ENTER> key to return you to the top of the menu and save the new group value.

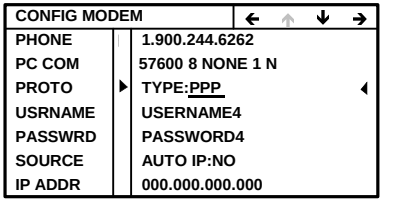


Figure 36: Edit Group Mode

5.2 Menus

This section describes, and graphically gives examples of, the main menus and their sub-menus.

5.2.1 Status

The STATUS functionality group provides diagnostic information about the MPC. Its home screen gives you MPC's overall operational status and the current GMT time. None of the rows in the column are editable. *Figure 37* shows the STATUS menus.

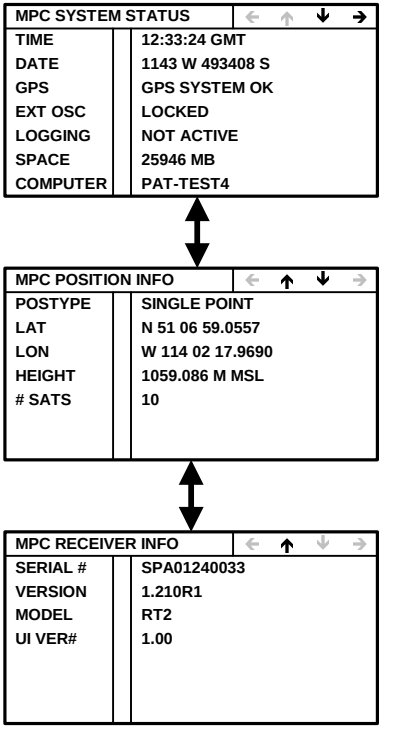


Figure 37: STATUS Menus

The information in this column is refreshed every second unless another column in the menus is being edited. The 1 second refresh will continue once the editing has stopped. As seen from *Figure 37 on Page 42*, there are several STATUS functionality categories:

- MPC SYSTEM STATUS
  - TIME: The current GMT time in hours, minutes and seconds. The time is the PC time, which is steered by GPS.
  - DATE: The current GPS week and seconds into the week once the GPSCard has a valid solution and is connected.
  - GPS: On start-up, 'NOT CONNECTED' will be displayed until the GPSCard is connected. Then information on any GPS receiver system errors detected are displayed. When there are no errors, there is a 'GPS SYSTEM OK' message.
  - EXT OSC: Displays either 'LOCKED' or 'NOT LOCKED' depending on if the oscillator in use has achieved lock or not respectively.
  - LOGGING: Shows if the logging of GPS data is currently 'ACTIVE' or 'NOT ACTIVE'.
  - SPACE: Provides the available recording space left on the MPC hard drive in megabytes (mB).
  - COMPUTER: Shows the name given to the MPC. See *Configure Ethernet on Page 46* where the computer name can be edited.
- MPC POSITION INFO
  - POS TYPE: Current position mode:
    - NO POSITION: There is no current position mode.
    - FIXED POSITION: The position has been fixed.
    - SINGLE POINT: The position is from single-point averaging.
    - PSR DIFF POS: The position measurement is from pseudorandom code on the GPS signals.
    - L1_FLOAT: The position is from floating ambiguity estimates that converge over time.
    - ION FREE FLOAT:
    - NARROW FLOAT:
    - L1 INTEGER: The position is from carrier phase ambiguity estimates that are only allowed to take on integer values.
    - WIDE INTEGER:
    - NARROW INTEGER:
  - LAT: The current latitude in degrees, minutes, seconds and decimal seconds to 4 decimal places.

- LON: The current longitude in degrees, minutes, seconds and decimal seconds to 4 decimal places.
- HEIGHT: The current mean sea level (MSL) height in meters to 3 decimal places.
- # SATS: The number of GPS satellites currently being tracked.

- MPC RECEIVER INFO
  - SERIAL #: The GPSCard serial number.
  - VERSION: The GPSCard firmware version.
  - MODEL: The GPSCard model.
  - UI VER: Shows the current version of the VFD user interface software.

5.2.2 Connect

The CONNECT function menu allows you to view the GPSCard's current connection status with three other devices. *Figure 38* shows the MPC CONNECT MENU screen.

.

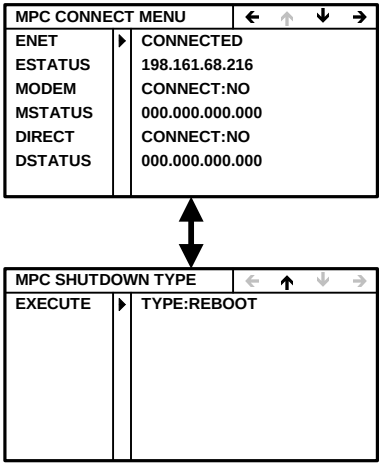


Figure 38: MPC Connect Menu

As seen in *Figure 38*, there are two Connect functionality menus:

- MPC CONNECT MENU
  - ENET: 'NO' or a connection status message depending on whether there is or is not respectively a connection to the internet. If there is a status message the IP address will also appear on the next row.
  - ESTATUS: The IP address of the ethernet connection.

The ENET and ESTATUS rows are updated every 60 seconds unless a row is being edited. The 60 second refresh will continue once the editing has stopped.

- MODEM: CONNECT: YES or NO depending on whether there is or is not respectively a connection via the modem card.
- MSTATUS: The IP address of the modem connection or a status message.
- DIRECT: CONNECT: YES or NO depending on whether there is or is not respectively a connection via the serial port.
- DSTATUS: The IP address of the direct connection or a status message.

The MSTATUS and DSTATUS rows are refreshed when the Remote Access Service (RAS) calls back.

- MPC SHUTDOWN TYPE
  - EXECUTE: Choose either 'REBOOT' or 'POWERDOWN' in the TYPE data display. Press the <ESC> key to do neither and return to the last menu. Choosing REBOOT will cause the MPC to reboot. Choosing POWERDOWN will power down the internal embedded PC. The keypad will be unusable again until the power switch is turned off, then on, and the VFD is visible again.

✉ The MPC is designed for continuous operation. However, if you need to power down the unit, it is recommended that you always use the *MPC Shutdown Type* menu, see *above*. Then give the internal operating system a few minutes to flush its cache buffers to the hard drive, and turn off the power at the power switch.

5.2.3 Configure Client

The CONFIG CLIENT menu allows you to enter information about the security rights for individuals using the system. An example may be seen in *Figure 39.*

CONFIG CLIENT		
USRNAME	▸	ABCDEFG ◂
PASSWRD		TUVWXYZ
ADMIN		PRIV:NO
LOGGING		CONTROL:NO
FTP		ACCESS:NO
STATUS		VIEW:NO
SUBMIT		INFO:NO

Figure 39: Config Client Menus

It is only necessary to use the VFD menu the first time the MPC is used, usually by any Administrator with full privileges. User information can be added/edited using the Modulated Precision Clock website. See also *Section 6.1.2.7, Set Up Users on Page 65*.

The CONFIG CLIENT menu contains the following information:

- CONFIG CLIENT
  - USRNAME: A user ID in the form of a user name (8 characters

maximum). The MPC allows multiple users. Example of clients may be the administrator who has all privileges, the users who have some but not all privileges, and guests who have little or no privileges.

- PASSWRD: A password for the above user (8 characters maximum).
- ADMIN: 'YES' or 'NO' depending on whether this user has or has not respectively system privileges.
- LOGGING: 'YES' or 'NO' depending on whether this user has or has not respectively the right to control logging.
- FTP: 'YES' or 'NO' depending on whether this user has or has not respectively access to the MPC's File Transfer-Protocol (FTP) service.
- STATUS: 'YES' or 'NO' depending on whether this user has or has not respectively the right to view the MPC SYSTEM STATUS pages via the *Modulated Precision Clock* website, see *Chapter 6 starting on Page 49*. See also *Status on Page 42*.
- SUBMIT: Toggling to YES, and then pushing the <Enter> key, submits the username, password and privileges to the appropriated configuration files on the web server.

5.2.4 Configure Ethernet

The CONFIG ETHERNET menu allows you to configure the ethernet or internet connection with the MPC. *Figure 39* shows the CONFIG ETHERNET menu.

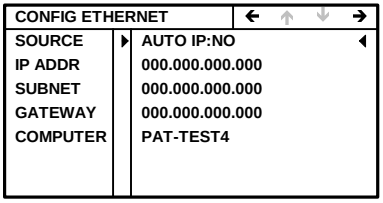


Figure 40: Config Ethernet Menu

- CONFIG ETHERNET
  - SOURCE: 'YES' or 'NO' depending on whether or not respectively the IP address is assigned automatically via a Dynamic Host Configuration Protocol (DHCP) server on the local network (intranet). If AUTO IP is changed to 'YES', then the IP, SUBNET and GATEWAY rows will be assigned automatically upon activation and anything in the IP ADDR row will be deleted.
  - IP ADDR: The internet protocol (IP) address.
  - SUBNET: The address of the system of interconnections within the communications system that allows the components to communicate

directly with each other.

- GATEWAY: The address of the device that will transfer messages out of the local network to the internet.
- COMPUTER: Give your MPC a network name (8 characters maximum).

5.2.5 Configure Modem

The CONFIG MODEM functionality group allows you to configure the internal modem connection with the MPC. *Figure 41 on Page 47* shows the CONFIG MODEM menus.

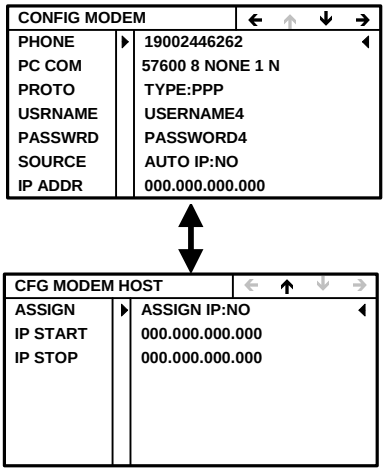


Figure 41: Config Modem Menus

As seen from *Figure 41*, there are two CONFIG MODEM menus. One is for a client connection, see also *Section 4.2.2, Modem or Direct Connect (PPP) Client on Page 26*, and the other is for a host connection:

- CONFIG MODEM (Client)
  - PHONE: The phone number of the service that the MPC is to call.
  - PC COM: The communication parameters for the MODEM port.
  - PROTO: The network protocol. The two choices are Point-to-Point (PPP) or Serial Line Internet (SLIP) Protocol.
  - USRNAME: The MPC's client user name on the remote network.
  - PASSWRD: The password for the above client.
  - SOURCE: 'YES' or 'NO' depending on whether or not respectively the IP address is assigned automatically by the host computer. If AUTO IP is changed to 'YES', then the IP row will not be editable and anything in the IP ADDR row will be deleted.
  - IP ADDR: The internet protocol (IP) address.

• CFG MODEM HOST

The MPC modem is preconfigured for auto-answering as a host. It will issue an IP address in the range 192.160.200 to 192.160.215, and establish a PPP connection to the client. The client must use an Administrator username and password or set up a user, see also *Section 5.2.3, Configure Client on Page 45.*

- ASSIGN: 'YES' or 'NO' depending on whether or not respectively the IP start and stop addresses are assigned automatically. If ASSIGN is changed to 'YES', then the IP START and IP STOP rows will not be editable.
- IP START: Start of address space that the MPC will use to issue addresses.
- IP STOP: End of address space.

5.2.6 Configure Direct (PPP)

The CONFIG DIRECT menu allows you to configure the connection with a host computer that is connected directly to the MPC via an RS232 cable. *Figure 42* shows the CONFIG DIRECT menu.

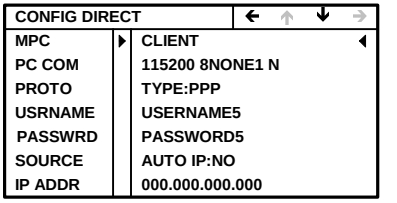


Figure 42: Config Direct

• CONFIG DIRECT

- MPC: Shows if the MPC is functioning as a client.
- PC COM: The communication parameters for the PPP port.
- PROTO: The network protocol. The two choices are Point-to-Point (PPP) or Serial Line Internet (SLIP) Protocol.
- USRNAME: The user name that the MPC will use to 'sign on' to the host computer.
- PASSWRD: The password for the above user.
- SOURCE: 'YES' or 'NO' depending on whether or not respectively the IP address is updated automatically. If AUTO IP is changed to 'YES', then the IP row will not be editable and anything in the IP ADDR row will be deleted.
- IP ADDR: The internet protocol (IP) address.

Chapter 6 Software Programs

The MPC software for the Euro4 GPSCard and the VFD are already installed.

The *Modulated Precision Clock* website is accessible on a PC via an internet connection. It is your source for MPC setup, logging, system summaries and analysis plots. Details are given in *Section 6.1, Modulated Precision Clock Website* starting below.

Please see *Section 6.2, MPC Firmware Upgrades & Updates starting on Page 75* for a description on how your MPC is upgraded/updated via the web. See also *Customer Service on Page 10*.

6.1 Modulated Precision Clock Website

To access the *Modulated Precision Clock* home page, use the IP address given by your internet provider, as displayed by the VFD or provided by your Network Administrator, to use as a URL for your MPC receiver using a PC. The following is a fictional example:

```
http://123.123.123.123/
```

Your Network Administrator may wish to provide you with a “STATIC” IP location on your internal network (intranet) and associate this IP address with a name, for example “MPC1”, in your Domain Name Server (DNS). In this case, you would access your MPC’s web page via the URL:

```
http://mpc1/
```

See also the *Connect* and *Config* menu sections of *Chapter 5, VFD Menus starting on Page 44*, and *Section 4.2, Configuring the Network on Page 25*, for information on configuring your MPC and connecting to the internet using the VFD menus.

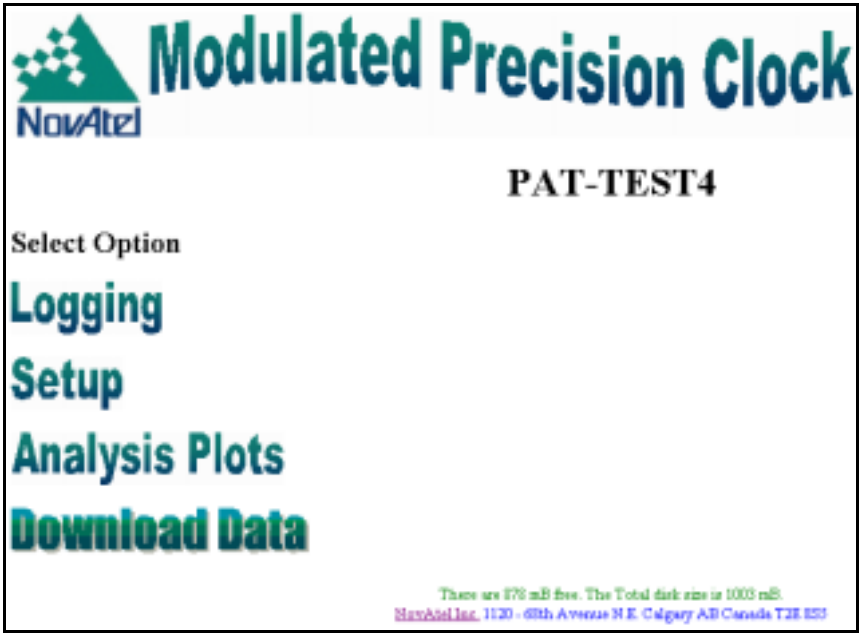


Figure 43: Modulated Precision Clock Home Page

As seen from *Figure 43 on Page 49*, there are four options in the *Modulated Precision Clock* home page:

Logging, see *Section 6.1.1, Logging* below

Setup, see *Section 6.1.2, Setup Configuration on Page 55*

Analysis Plots, see *Section 6.1.3, Analysis Plots on Page 67*

Download Data, see *Section 6.1.4, Download Data on Page 72*

Once you are on the Modulated Precision Clock web page, you can type in your user ID and password, and click on the OK button to log in. Your MPC administrator is responsible for updating users and passwords, please see *Section 5.2.3, Configure Client on Page 45*. An example of the Modulated Precision Clock website login is shown in *Figure 44* below.

Figure 44: MPC Website Login

You will then be able to view the Home page, as seen in *Figure 43 on Page 49*, and be able to click on the links that you have access to.

6.1.1 Logging

Logs and commands can be set up and logging statistics can be viewed from the Logging Control page. Select one of above options by clicking on the appropriate button, or return to the Home page by clicking on the Home button, see *Figure 45*.

Figure 45: Logging Control

6.1.1.1 Logging Setup

You can set up logs for up to 5 channels on your MPC. Select a channel and click on its button, see *Figure 46*.

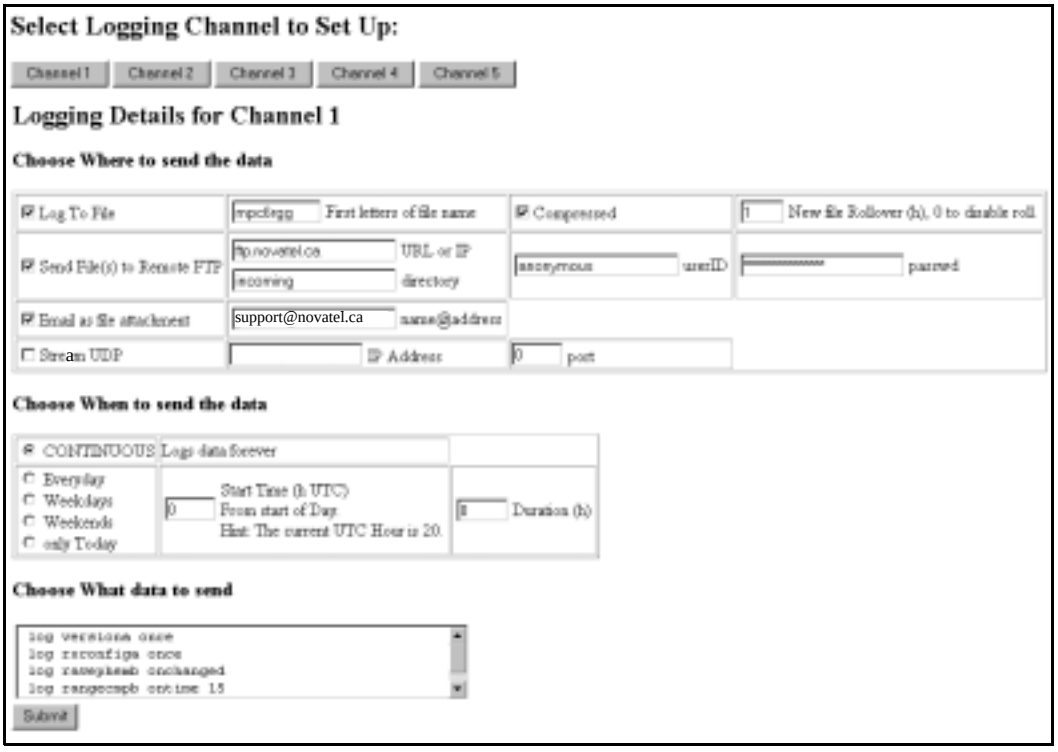


Figure 46: Set Up Logging

First, choose where to send your data.

If you select Log to File, give your schedule for that channel a name in the First Characters of File Name field. If this field is left blank, the schedule for that channel will be ignored. The name you give this schedule will form part of the filename written to the hard disk in the MPC. The file name will take the form:

FIRSTCHARSyymmddhh

where FIRSTCHARS is the name you gave to the schedule in the First Characters field, yy, mm and dd are the year, month and date respectively and are generated from the MPC's internal Time at the nearest hour (hh on a 24 hour clock) on every hour that is divisible by the Rollover amount.

Click in the Compressed check box if you wish your file to be compressed.

Enter the amount of rollover time (in hours) in the Rollover field. If you enter 0, roll over is disabled.

You may also send your data to a Remote FTP site, as an e-mail file attachment, and a Stream User Datagram Protocol (UDP) by clicking in their respective check boxes and entering appropriate information in their required fields. The UDP message format is shown in *Table 2 on Page 52*.

Table 2: UDP Message Format

Description	Offset	Size	Type	Value
Sync1	0	1	uchar	0xAA
Sync2	1	1	uchar	0x44
Sync3	2	1	uchar	0x16
MPCID	3	4	ulong	0....MAX_ULONG (unique MPC station ID, see *Section 6.1.2.1, Set MPC Name on Page 56*)
Hop Count	7	1	uchar	0...255 (the number of times the UDP was forwarded between NovAtel relay stations)
Message Length	8	2	ushort	0...65535 (size of the imbedded message but not including the header)
Message	10	<65535	binary	NovAtel OEM4 ASCII or binary message

Next, choose when to send the data or set up a schedule. Choosing CONTINUOUS logs your data continuously. It will start a new file every hour that is divisible by the Rollover amount in the Choose Where section. The other choices are Everyday, Weekdays, Weekends, and Only Today. If you select any of these choices, you can then enter a UTC start time in hours in the Start Time field and the amount of hours to continue logging in the Duration field. The start time refers to the start of the day.

Finally, type in the logs you want in this schedule in the Choose What section's edit box. Ensure each log request is on a new line. For more information on the available logs for the OEM4 family of receivers, please refer to *Volume 2 of the OEM4 Users' Guide*.

Click on the Submit button when you have completed your schedule list. The Command/Response Summary for your schedule will appear. An example is shown in *Figure 47 on Page 53*. If you misspell any of the logs, the Command/Response window will contain syntax errors for you to check.

Click on the Cancel button to return you to the main Logging Control window (*Figure 45 on Page 50*).

Filename Examples:

If it is 3 p.m. and you request CONTINUOUS in the Choose When section, and 6 in the Choose Where section's Rollover field, hh will be 12 and will roll over at 6 p.m. (only 3 hours later) when hh will be 18. The next rollover will be at midnight (6 hours later) when hh will be 00.

Here are some filename examples starting at 5:45 p.m., the First Letters of File Name were entered as 'range', with a rollover of 6 hours:

```
range02011712.bin     range02011718.bin     range02011700.bin
range02011806.bin     range02011812.bin
```

✉ 1. The MPC internal time is Coordinated Universal Time (UTC) and may vary by several hours from your local time.

2. If you have any difficulty with sending files, for instance e-mail or external ftp, NovAtel Customer Service may request any GPSServer.log or LoggerServer.log files from your MPC's ftp site or root directory.

6.1.1.2 Parsing Responses

Click on the Parsing Responses button to go to the Command/Response System Summary window as seen in *Figure 47*.

Figure 47: Command/Response System Summary

There are three types of output in the summary:

Cmd — A log summary in the form:

Cmd: *YYYY-MM-DD hh:mm:ss.ss*>LOG THISPORT_*c log*

where

YYYY is the calendar year (e.g. 2002)

MM is the calendar month (01-12)

DD is the calendar date (01-31)

hh.mm.ss.ss is the time in hours (00-23), minutes (00-59) and decimal seconds (00.00-59.99) in GMT

LOG or UNLOG

c is the channel number

log is the LOG command if applicable (Please refer to *Volume 2* of the *OEM4 Users' Guide* for possible formats of the LOG command and for a listing of the available logs.)

Res — An OEM4 response summary in the form:

Res: *YYYY-MM-DD hh:mm:ss.ss> response*

where

YYYY-MM-DD hh:mm:ss.ss are as they are in Cmd above

response is a message, or a response to a log command

Notice in *Figure 47 on Page 53* that an RXHWLEVELS log was misspelled in the Logging Control window and is highlighted here. The response, in the form of an error message, is also highlighted in *Figure 47*.

Prs — Is a parsing response such as an MPC system response in the form:

Prs: *start >stop* (*c*) *action*

where

start time is the time, in GMT, that the parse response started in the form *YYYY-MM-DD hh:mm:ss.ss* as described in Cmd above

stop time is the time, in GMT, that the parse response ended in the form *YYYY-MM-DD hh:mm:ss.ss* as described in Cmd above

c is the channel number

action is an MPC file or system action

The Home button will return you to the *Modulated Precision Clock* home page (*Figure 43 on Page 49*).

6.1.1.3 Logging Stats

In the Logging Control window, click on the Logging Stats button to bring you to the Logging Statistics page. An example is shown in *Figure 48*.

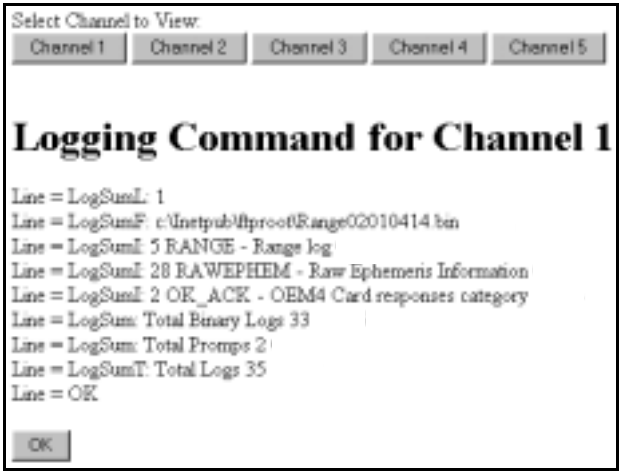


Figure 48: Logging Statistics

Choose a Channel by clicking on its button. Log summaries are shown line by line. The following definitions apply:

LogSumL:	Specifies the channel number
Log SumF:	Specifies the file name and location on the MPC
LogSumI:	A log, command or message that has occurred as a result of the current channel's schedule. The log name is preceded by the number of times it has been received and recorded in the file. It is then followed by a short definition.
LogSum:	On its own, LogSum gives a count of the Total Binary Logs, the Total ASCII logs or the Total Prompts (or messages) that have occurred as a result of the current channel's schedule.
LogSumT:	Specifies the total number of logs, command and prompts based on the LogSum lines above.

Click on the OK button to return you to the main Logging Control window (*Figure 45 on Page 50*).

6.1.2 Setup Configuration

The Setup Configuration window allows you to configure your internet connection, modify the name you give to your MPC, check the receiver configuration and reconfigure your MPC using commands, adjust services, upload data, and upgrade/update the MPC firmware. The Setup Configuration window can be seen in *Figure 49.*

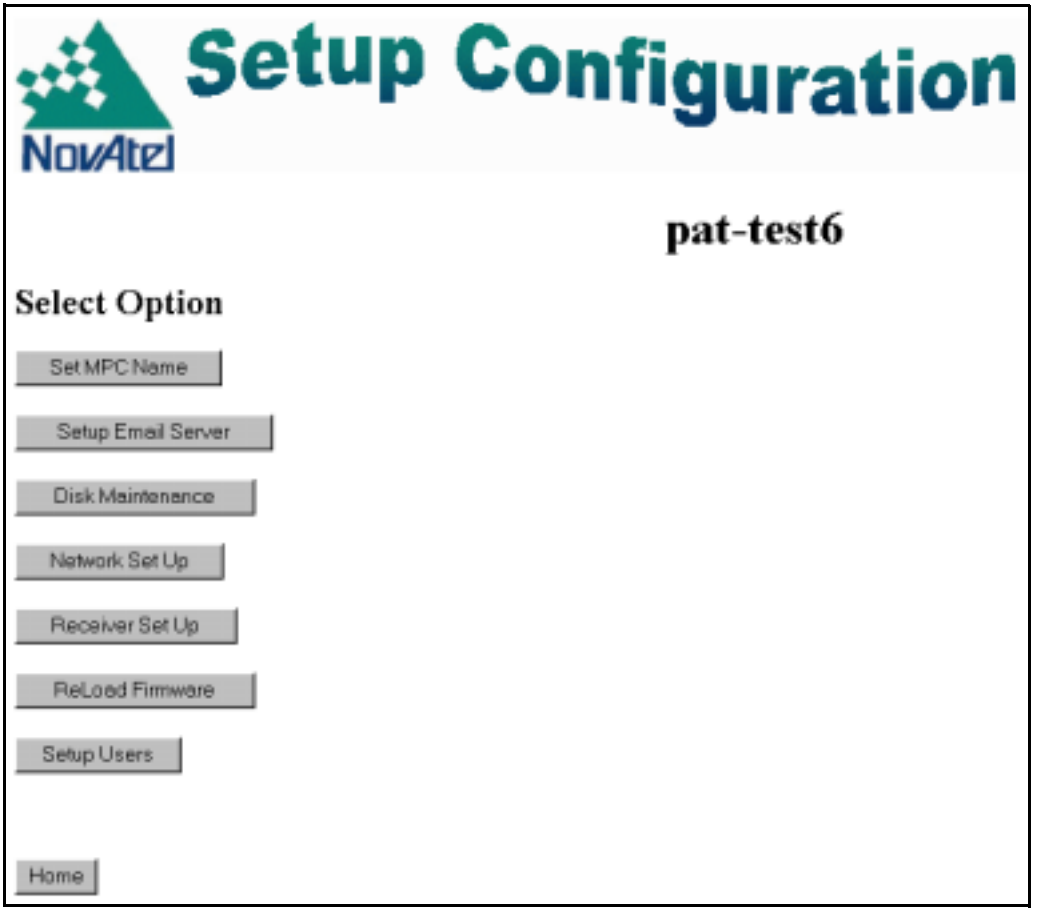


Figure 49: Set Up Configuration

6.1.2.1 Set MPC Name

Click on the General Setup button for the Modify Receiver Parameters window to appear as seen in *Figure 50 on Page 56*.

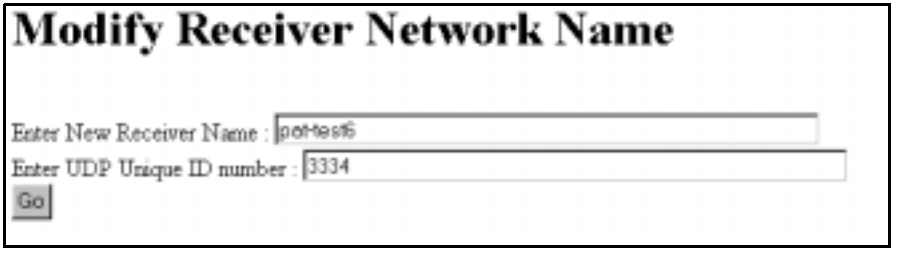


Figure 50: General Receiver Setup

The Receiver Name is a name you give your MPC that is meaningful to you. This name will also appear in the main *Modulated Precision Clock* windows (Logging, System Summary Response, Setup and Analysis Plots). The Enter UDP Unique ID number field allows you to give your MPC a unique

ID number which is imbedded in the UDP data stream (if used), see *Section 6.1.1.1, Logging Setup on Page 51*. It uniquely identifies the messages as originating from your MPC. Click on the Go button to save your changes.

6.1.2.2 Set Up E-Mail Server

If you intend to transfer collected data files via an e-mail attachment, you must set up e-mail server information through The Set Up E-Mail Server page as seen in *Figure 51*.

Figure 51: Set Up E-Mail Server

Type in the URL of the e-mail server in the Enter URL of Email Server field. The Enter UserID For Email Server field allows you to type in your e-mail server user identification. Click on the Go button to save your changes, or on Cancel to disregard your changes, and return you to the main Setup Configuration page.

6.1.2.3 Disk Maintenance

In the Setup Auto Disk Cleanup section of the Disk Maintenance window, see *Figure 52 on Page 58*, select the type of cleanup to allow. The choices are:

• Disable auto disk cleanup	Data logging will stop when the disk space reaches the minimum set in the Minimum Free Disk Space (Full Level) MB edit field.
• Delete Old Files	Enter the maximum age of files to keep in days. Files older than this will be deleted.
• Delete the Oldest Files when Full	Enter the minimum disk space to be left. This is done by replacing old files with new files that go over the minimum.

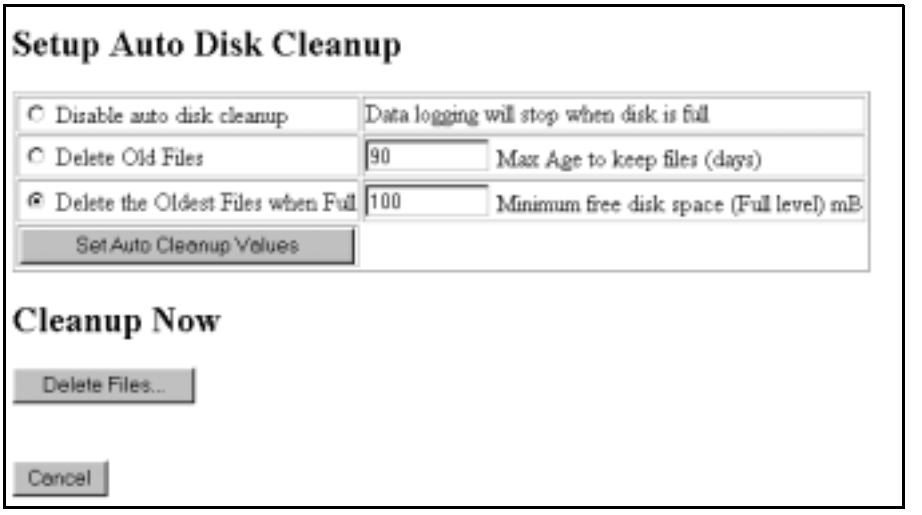


Figure 52: Disk Maintenance

Click on the Set Auto Cleanup Values button to save your selection, or click on the Cancel button to disregard your changes and return you to the main Configuration Setup window. Click on the Delete Files button and the Delete Files window will appear as seen in *Figure 53*.

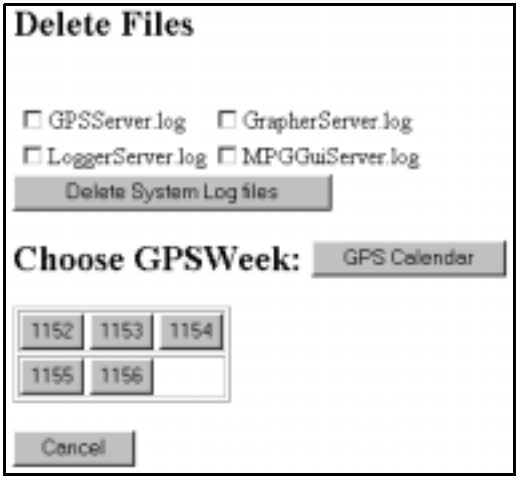


Figure 53: Delete Files

The *.log checkboxes in the top half of the dialog allow you to select log files for deletion. These log files contain messages and information on different parts of your MPC as seen below:

GPSServer	GPSCard
GrapherServer	MPC Plots
LoggerServer	Logging Setup and Logged Files
MPCGuiServer	VFD Panel

These types of files are on the MPC's ftp site or root directory and may be requested by Customer

Service if you have any MPC questions or problems.

Files that become too large can be selected here and then deleted by clicking on the Delete System Log Files button.

The bottom half of the Delete Files dialog allows you to choose a week number by clicking on one of the available GPS weeks button. If you need to refer to a calendar of GPS weeks, click on the GPS Calendar button first. A description of the GPS Calendar is given in *Section 6.1.4, Download Data on Page 72*.

When you have clicked on a GPS week's button, a dialog will appear showing the files available for deletion, see *Figure 54*.

Figure 54: Choose Files to Delete

Select a file for deletion and click in its check box. Choose more than one file if applicable and click on the GO button to delete them or click on the Home button to return to the main Setup Configuration page and abandon deletion.

6.1.2.4 Network Setup

In the Setup Configuration window, click on the Network Setup button. The Select Port to Configure window appears as seen in *Figure 55 on Page 59*.

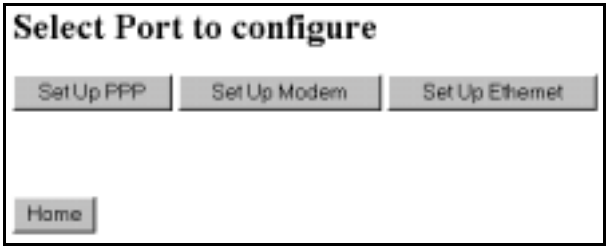


Figure 55: Network Setup

From this page you can choose the Set Up button for your internet connection. The choices are PPP, Modem and Ethernet.

CONFIGURE PPP PORT

An example of the Configure PPP Port window is shown in *Figure 56*.

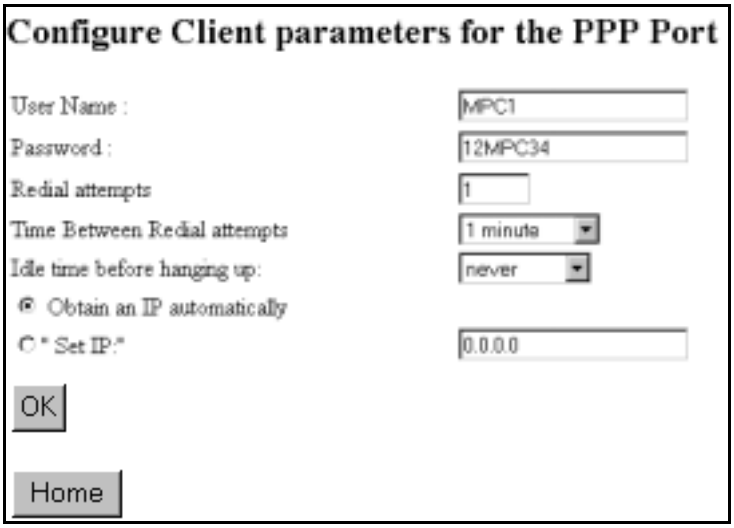


Figure 56: Configure PPP Port

First enter the user name and password the MPC will use to 'connect' to the PPP host in the User Name and Password fields. Then enter the number of redial attempts you would like the MPC to make and choose a length of time between these attempts.

Choose how long, or never, to wait while the connection is idle before the MPC should hang up.

Select to enter the IP address for the direct connection in the Set IP field, or select Obtain an IP Automatically for the IP address to be assigned automatically.

Click on the OK button to save your changes or click on the Home button to cancel the settings return you to the *Modulated Precision Clock* home page.

✉ Some of these parameters can also be adjusted via the VFD panel on the MPC.

CONFIGURE MODEM PORT

An example of the Configure Modem Port window is shown in *Figure 57*.

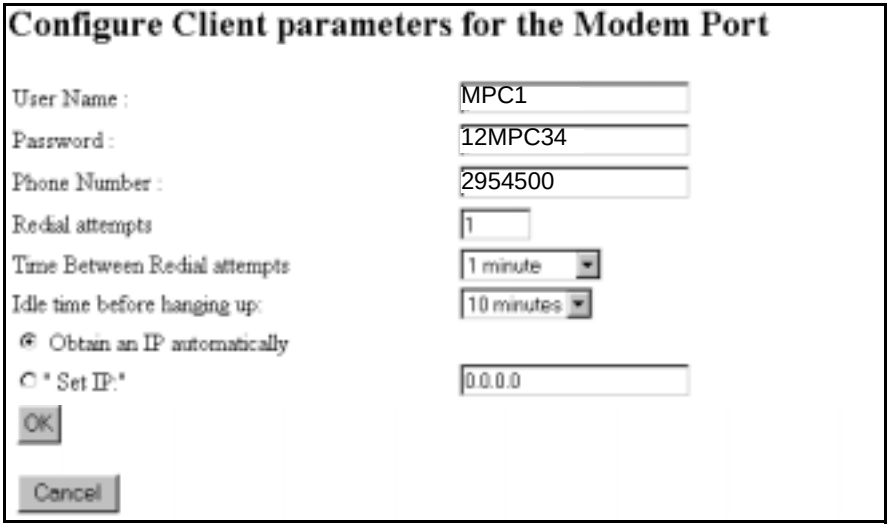


Figure 57: Configure Modem Port

First enter the user name and password the MPC will use to 'connect' to the PPP host in the User Name and Password fields. Then enter the phone number that the modem is to call out on to make a connection with the host or internet service provider. Enter the number of redial attempts you would like the modem to make and choose a length of time between these attempts.

Choose how long, or never, to wait while the connection is idle before the modem should hang up.

Select to enter the IP address for the modem connection in the Set IP field, or select Obtain an IP Automatically for the IP address to be assigned automatically.

Click on the OK button to save your changes or click on the Home button to cancel the settings return you to the *Modulated Precision Clock* home page.

✉ Some of these parameters can also be adjusted via the VFD panel on the MPC.

CONFIGURE ETHERNET PORT

An example of the Configure Ethernet Port window is shown in *Figure 58*.

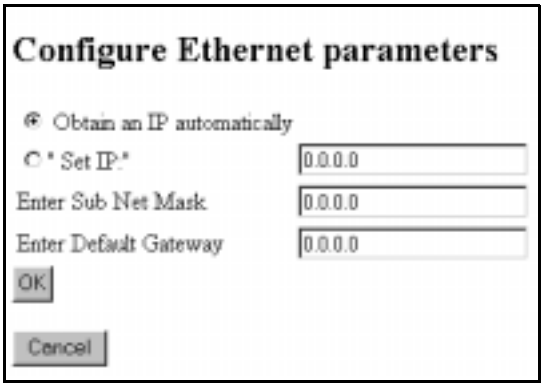


Figure 58: Configure Ethernet Port

Select whether to enter the IP address for the modem connection in the Set IP field, or select Obtain an IP Automatically for the IP address to be assigned automatically.

If you selected the Set IP field, enter the address of the system of interconnections within the communications system that allows the components to communicate directly with each other in the Enter Sub Net Mask field. Enter the default gateway address in the Enter Default Gateway field.

Click on the OK button to save your changes, or click on the Cancel button to cancel the settings and return you to the main Network Setup page.

✉ Some of these parameters can also be adjusted via the VFD panel on the MPC.

6.1.2.5 Receiver Setup

Click on the Receiver Setup button in the main Configuration Setup window to bring you to the Receiver Setup window as seen in *Figure 59*. There are three options in this screen that are described further in this section:

- Set Up Base Station
- List Current Configuration
- Parsing Responses

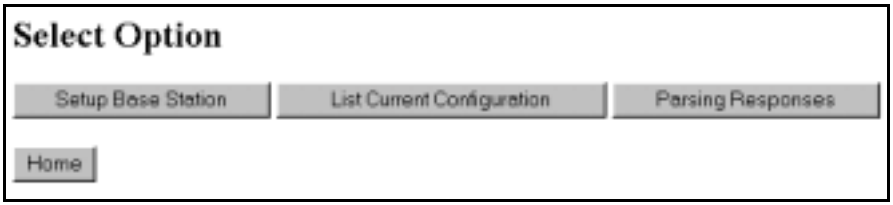


Figure 59: Receiver Setup

SET UP BASE STATION

To set up your MPC as a base station, click on the Set Up Base Station button in the Receiver Setup dialog, see *Figure 59*, to bring you to the List Current Configuration window where you can enter GPS commands. See also *List Current Configuration starting on Page 63*.

To fix the position for your MPC base, enter the Latitude, Longitude and Height using the FIX command. If you do not fix the base station position, the current position is computed by the MPC.

Use the Set Up Logging window to enter the RTCA, RTCM, or CMR messages that your base station will transmit. See also *Section 6.1.1.1, Logging Setup on Page 51*.

For more information on base station commands and logs, please refer to *Volume 2* of the *OEM4 Users' Guide*.

PARSING RESPONSES SETUP

The Parsing Responses page is also available through the main Logging window. See *Section 6.1.1.2, Parsing Responses on Page 53*.

LIST CURRENT CONFIGURATION

The Set Up Logging screen, see *Figure 46 on Page 51*, is for setting up logs only. Use the List Current Configuration button in the Receiver Setup dialog, see *Figure 59 on Page 62*, to bring you to the Rx Config from GPS screen, shown in *Figure 60 on Page 64*, that will allow you to issue commands to the internal Euro4 GPS receiver or simply check the current receiver configuration.

Once you have reviewed the MPC receiver's current configuration, return to the Receiver Setup page by clicking on the Home button, or add/edit a command by typing it in the Enter GPS Command field.

When you enter a command, ensure to type in its complete syntax if necessary. Only optional fields may be omitted. For details on available commands, please refer to *Volume 2* of the *OEM4 Users' Guide*.

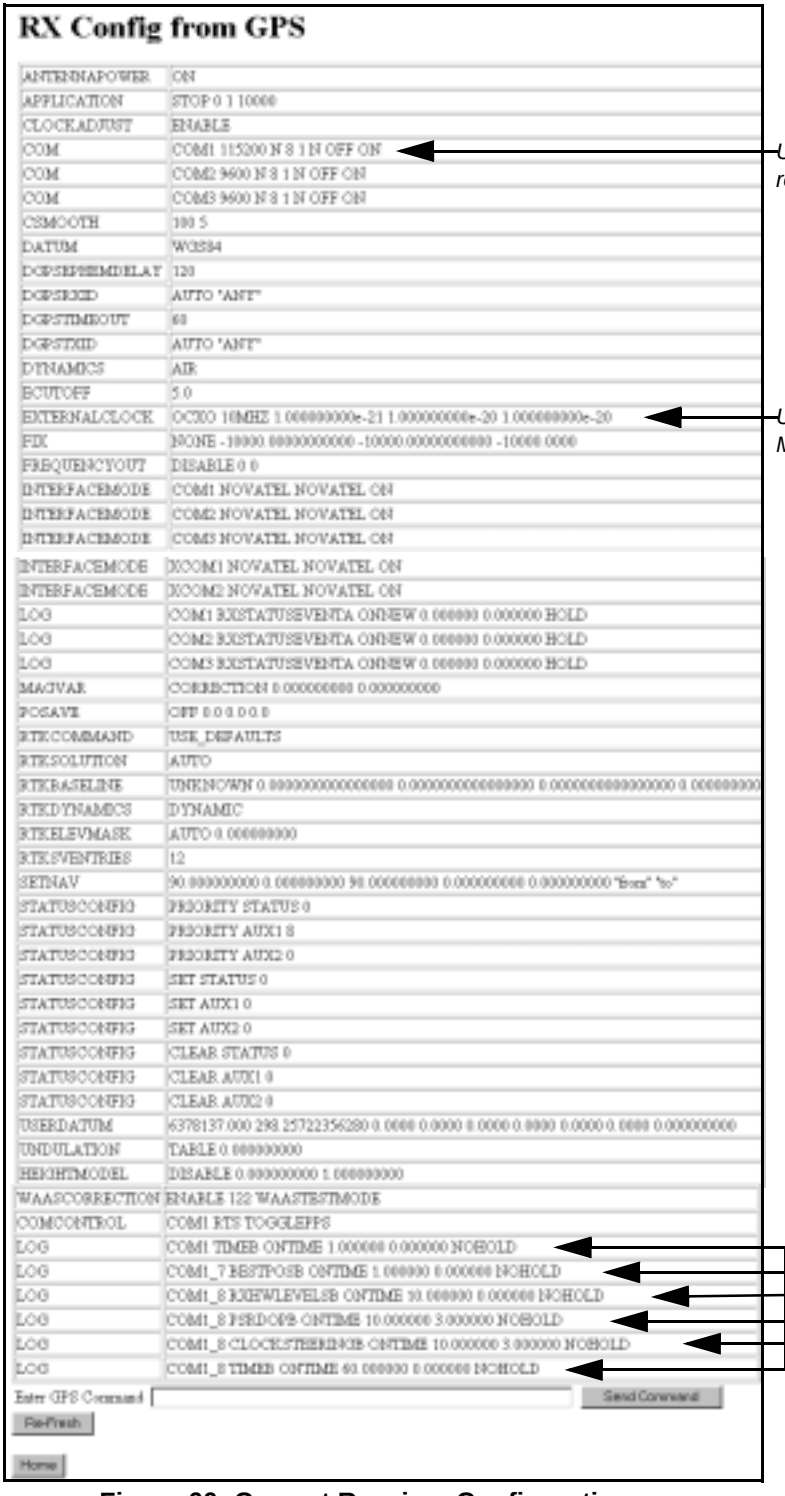
Click on the Send button to send your command to the MPC. The Command\Response System Summary, see *Figure 47 on Page 53* appears with your commanded added at the bottom. Click on the Home button to return to the Receiver Setup page.

Click on the List Current Configuration button to check your new receiver configuration or to add/edit another command.

Click on the Refresh button at the bottom of the Rx Config from GPS screen at any stage to refresh the current configuration list.

WARNING: The Euro4 GPS receiver communicates with the MPC main processor via COM1. Do not disturb the COM1 configuration or unexpected results may occur.

✉ COM3 on the Euro4 GPS receiver is connected to the DGPS port on the back of the MPC for general GPS input/output.



*Used by MPC's internal Euro4 receiver - **do not adjust!***

*Used by MPC's internal 10 MHz OCXO - **do not adjust!***

*MPC status messages to COM1. They are used to update screens and plots - **do not adjust!***

Figure 60: Current Receiver Configuration

6.1.2.6 Reload Firmware

In the Setup Configuration dialog, see *Figure 49 on Page 56*, click on the ReLoad Firmware button to bring you to the screen shown in *Figure 61*.

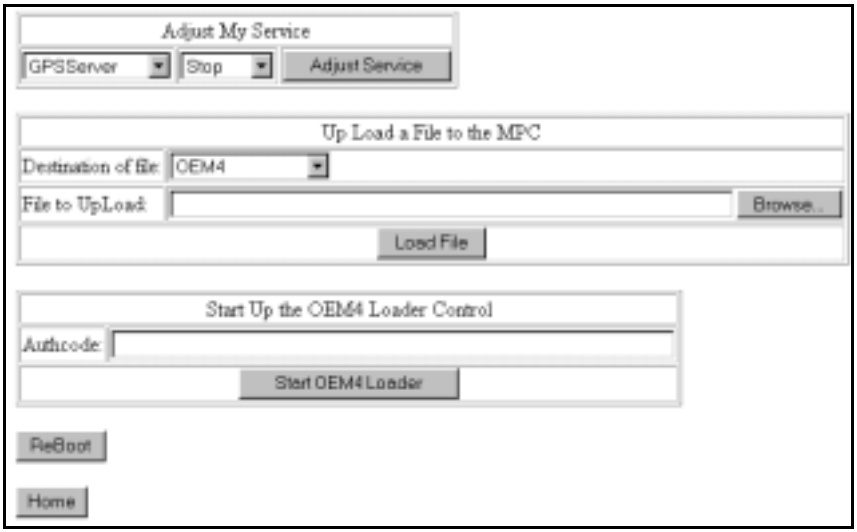


Figure 61: Reload Firmware

WARNING: The Reload Firmware page is intended for use by NovAtel Customer Service personnel only. Incorrect commands on this page may result in the MPC being permanently disabled!

For more information on firmware or PC software upgrades/updates please see *Section 6.2, MPC Firmware Upgrades & Updates on Page 75*.

6.1.2.7 Set Up Users

Click on the Set Up Users button in the main Configuration Setup window and the Set Up Users window will appear as seen in *Figure 62 on Page 65*.

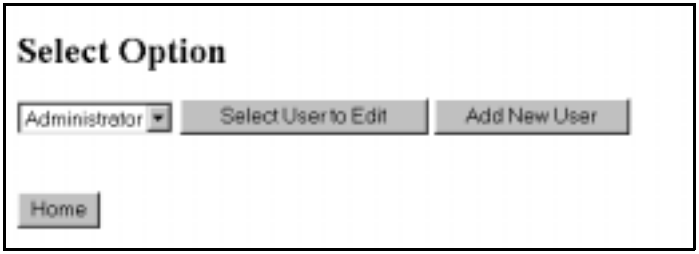


Figure 62: Set Up Users

Once you have selected a user from the list, you can either edit that user, or add a new user. These are described in this section.

SELECT USER TO EDIT

Click on the Edit button in the Set Up Users window and the Edit User window will appear as seen in *Figure 63*.

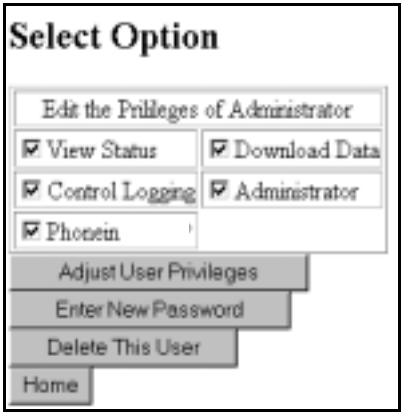


Figure 63: Edit User

Check in the privileges check boxes that apply to the current user. The choices are:

- View Status — The user can view the status pages on the website
- Download Data — The user can download data from the MPC using the website
- Control Logging — The user can use the Logging windows and control logging
- Phonein — The user can phone in to the MPC via the modem connection

Click on the Adjust User Privileges button for the options to take effect.

Click on the Enter New Password button to change the password for the user.

To delete a user, click on the Delete This User button.

When you are done click on the Home button to return you to the main Set Up Users page.

ADD NEW USER

Click on the Add New User button in the Set Up Users window and the New User window will appear as seen in *Figure 64*.

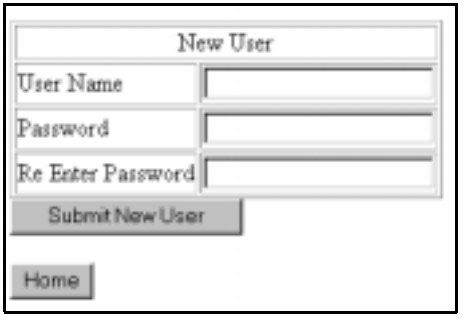


Figure 64: Add New User

Enter a username and password for the new user. Then re-enter the password in the Re Enter Password field to ensure you typed it in correctly.

Click on the Submit New User field to save the new user, or on the Home button to disregard your changes and return to the main Set Up Users page.

6.1.3 Analysis Plots

The Analysis Plots Page gives you a choice of multiple plots in two formats. Icons of the plot formats (Time Plots and Sky Plots) are shown in the Analysis Plots window as seen in *Figure 65*.

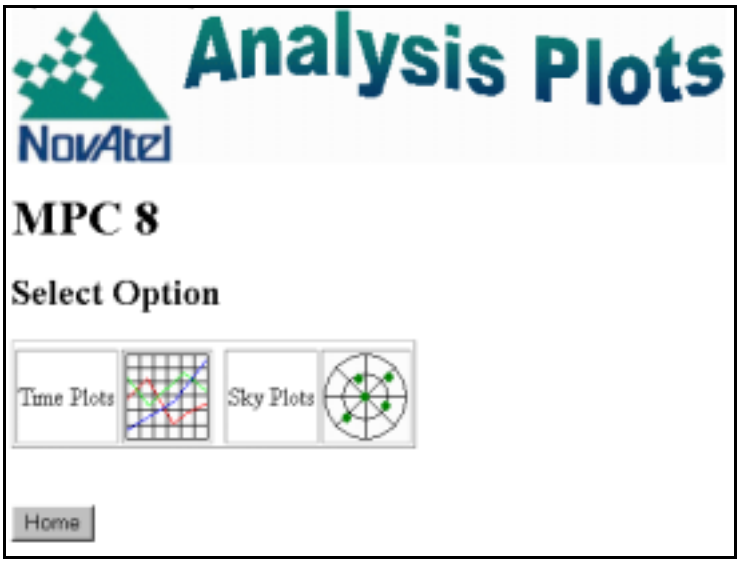


Figure 65: Select Analysis Plot Type

Each of the plots has a Home button. Click on the Home button to return you to the *Modulated Precision Clock* website home page, or use your internet browser's back button to take you back to the plot that you last viewed.

6.1.3.1 Time Plots

When you click on the Time Plots icon in the Analysis Plots page, a dialog appears as shown in *Figure 66* that allows you to select a time plot of your choice and the time period for the plot.

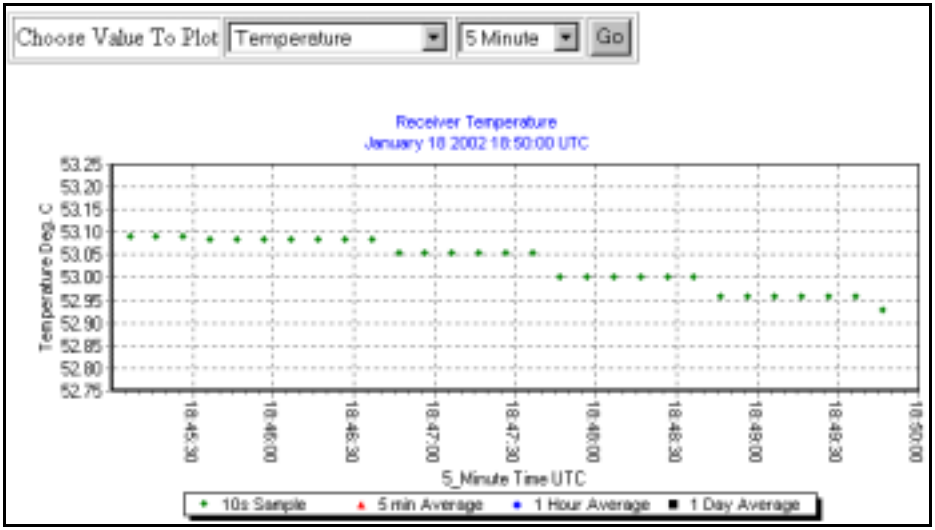


Figure 66: Choose Value to Plot Against Time

The default plot shown is the Temperature Vs. Time plot over 5 minutes. Select a value to plot against time in the Choose Value to Plot field. Your choices are:

- Temperature
- GDOP
- OEM4 Idle Time
- Number of Satellites
- Clock Error
- Clock Steering

Next choose the time period for your plot. The choices range from 5 minutes up to a maximum of 10 years.

Click on the GO button to generate the plot. An example of a Temperature Vs. Time plot over a 6 hour time span is shown in *Figure 67.*

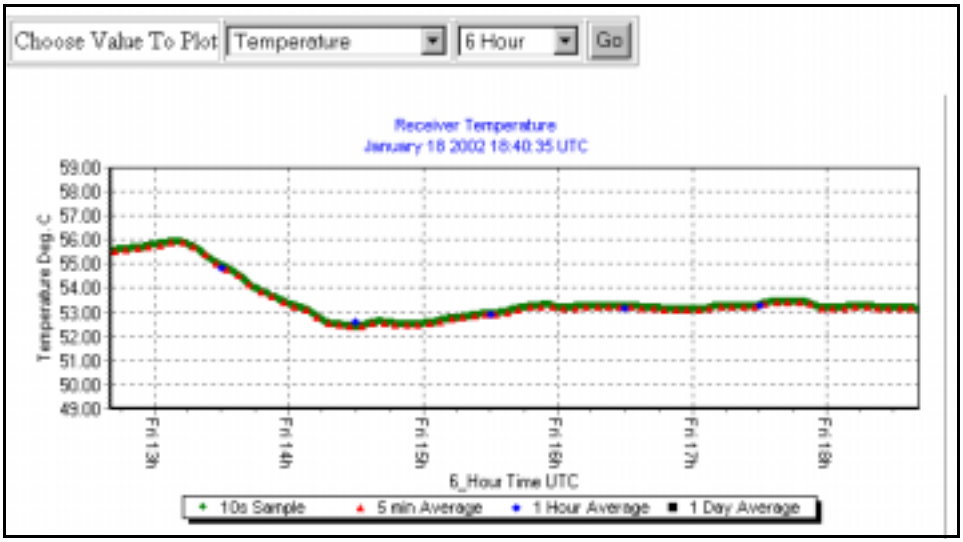


Figure 67: Time Plot Example

Figure 68 shows the key that is displayed with each plot. It is a key of how the points in the plot are portrayed.

Figure 68: Time Plot Key

All plots are displayed in *.PNG format.

6.1.3.2 Sky Plots

When you click on the Sky Plots icon in the Analysis Plots screen, see *Figure 65 on Page 67*, a dialog appears with fields that allows you to select a sky plot of your choice and the time period for the plot. The fields are shown in *Figure 69* below.

Figure 69: Choose Sky Plot

The default plot shown is the Constellation plot over 1 hour. Select a plot type in the Graph Selection field. Your choices are:

- Constellation
- L1 Carrier to Noise Vs. Elevation
- L2 Carrier to Noise Vs. Elevation
- L1 Code Minus Carrier Vs. Elevation
- L2 Code Minus Carrier Vs. Elevation

Next choose the time period for your plot. The choices range from 1 hour up to a maximum of 7 days. Click on the GO button to generate the plot.

In the Constellation plots, each colour represents a satellite PRN. An example is shown in *Figure 70*.

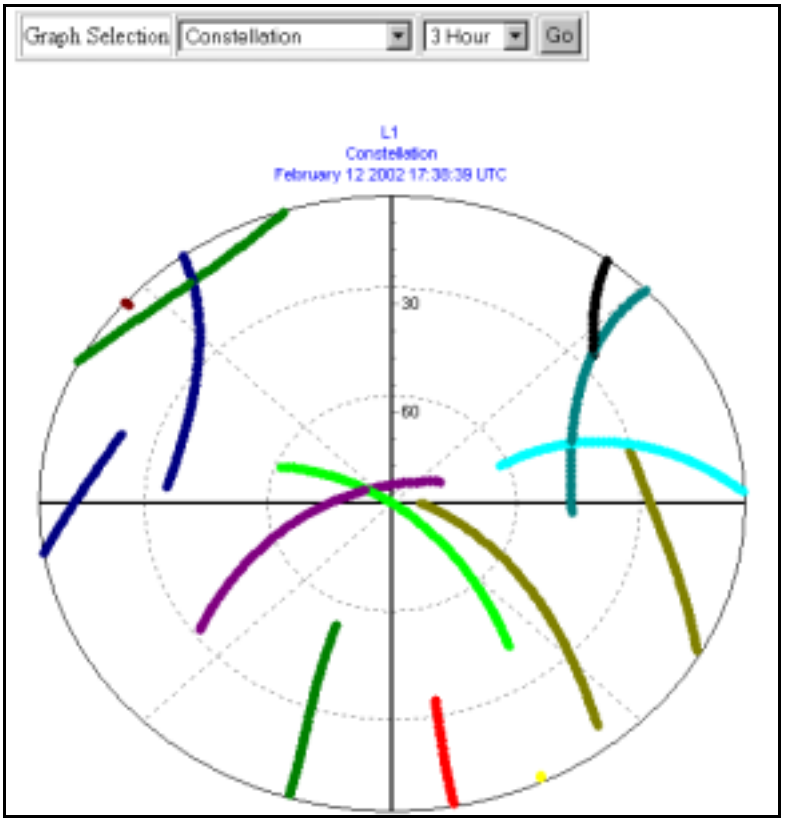


Figure 70: Constellation Sky Plot

In the Carrier to Noise, and Code Minus Carrier, versus Elevation plots, each colour represents the minimum, maximum and mean values of the data. A colour key will be shown on each plot to explain the colours being displayed.

Examples are shown in *Figures 71 and 72 on Page 71*.

All plots are displayed in *.PNG format.

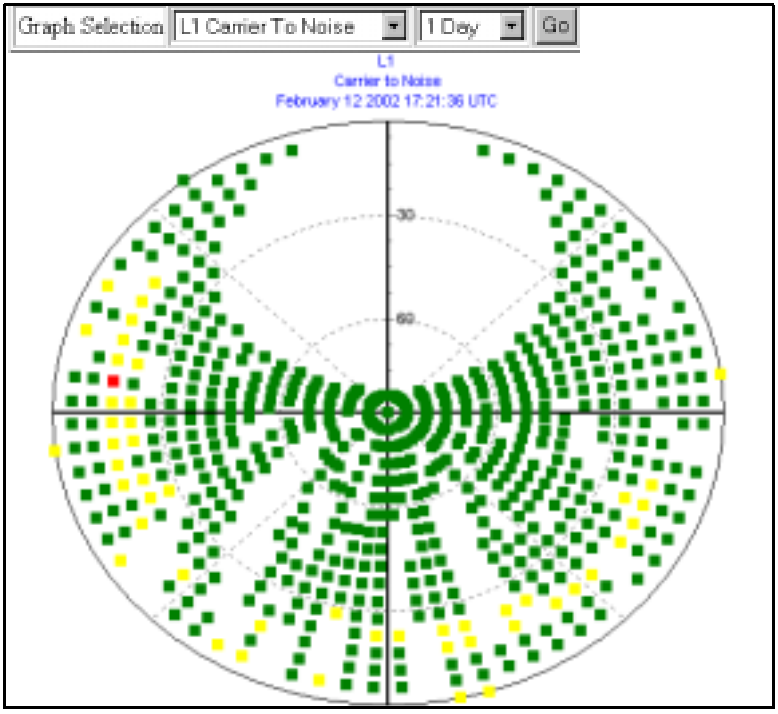


Figure 71: L1 Carrier to Noise Vs. Elevation

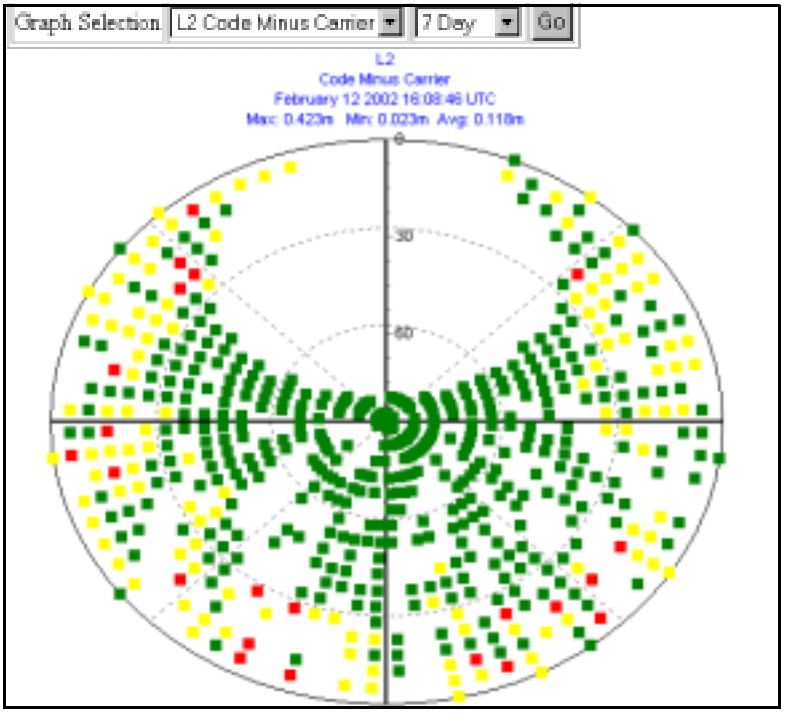


Figure 72: L2 Code Minus Carrier Vs. Elevation

6.1.4 Download Data

In the Logging Control window, click on the Download Data button. The Download Files window appears as seen in *Figure 73*.

Figure 73: Download Data

You are shown a choice of GPS week buttons. You can first use the GPS Calendar button to check which GPS week you are interested in. The GPS Calendar window can be seen in *Figure 74 on Page 72*.

Figure 74: GPS Calendar

Each GPS week is shown in the far left of the screen. There are also three rows for each GPS week that show:

date	The regular calendar dates for the week
ydate	Each corresponding number of days into the year for each day of the week
mjd	The Modified Julian Day (MJF) is defined as the Julian Day minus 2400000.5. For any date in the 20th and 21st centuries, the MJD will be at most five decimal digits long. The Julian Period, an interval of 7980 years, began at 12 noon, January 1, 4713 BC and will end at 12 noon, January 1, 3268 AD.

You can go back or forward through the calendar months by using the Go Back and Go Forward buttons. Alternatively you can select a calendar month and year from their respective drop down boxes and then click on the Go button.

The Home button will return you to the *Modulated Precision Clock* home page (*Figure 43 on Page 49*) so if you have decided on a GPS week number, click on your internet browser's back button to return you to the Download Files window (*Figure 73 on Page 72*). From here you can now click on the GPS week button of your choice. The Choose File to Download window appears as seen in *Figure 75*.

Figure 75: Choose File to Download

Click on the link for the file you wish to download.

Click on the GO FTP link, see *Figure 73 on Page 72*, to go to the FTP address you specified in the Logging Setup window's Send File(s) to Remote FTP field. See also *Section 6.1.1.1, Logging Setup on Page 51*.

Click on the OK button return to the *Modulated Precision Clock* home page. No downloading will take place.

For a description of the format of the filenames, see the *Set Up Logging* section on *Page 51*. Choose a filename and click on its link. A standard Windows download screen appears as seen in *Figure 76 on Page 74*.

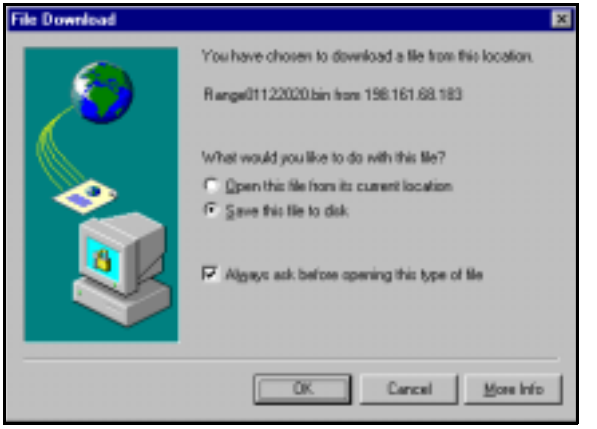


Figure 76: Typical File Download Window

To save the file to disk, choose the Save This File to Disk field. Click on the OK button and a Save As window appears (*Figure 77*) so that you can browse for a location for the file and save the file as a different filename if you choose.

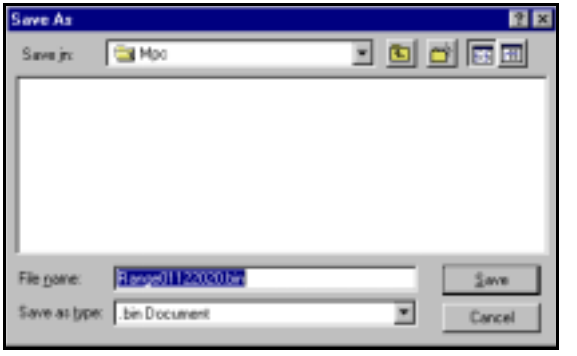


Figure 77: Save As

The Save As window is shown in *Figure 77*. Click on the Save button to save the file in your chosen location.

When you have finished selecting files from the Select File to Download window, click on the OK button to return you to the *Modulated Precision Clock* home page.

6.2 MPC Firmware Upgrades & Updates

The MPC includes two distinct processors in its enclosure:

- a GPS receiver (Euro4 GPSCard)
- an embedded PC running embedded NT

Both of these components has its own microprocessor, and each microprocessor has its own firmware (program software), which is stored in non-volatile memory. What makes one MPC model different from another is software, not hardware. This unique feature means that upgrading the firmware is equivalent to getting an MPC with an entirely different set of features.

The following can be upgraded/updated on the MPC:

- the PC software that controls the VFD display, data storage, communication, web pages and more on your MPC
- OEM4 firmware on the Euro4 GPSCard

For upgrades/updates to the Euro4 firmware and/or PC software, you will need to supply NovAtel Customer Service with the fixed IP address of your installed MPC so that we can program it remotely.

Appendix A Technical Specifications

A.1 MPC Performance

Position Accuracy [a]

Standalone:
- L1 only 1.8 m CEP
- L1/L2 1.5 m CEP

WAAS:
- L1 only 1.2 m CEP
- L1/L2 0.8 m CEP

Code Differential 0.45 m CEP

Post Processed 5 mm + 1 ppm CEP

Time To First Fix

15 minutes (due to OCXO warm-up)

Reacquisition

0.5 s L1 (typical)
6 s L2 (typical)

Data Rates

Raw Measurements: 20 Hz
Computed Position: 20 Hz

Measurement Precision

C/A code phase 6 cm RMS

L1 carrier phase:
Differential 0.75 mm RMS
L2 P code 25 cm RMS

L2 carrier phase:
Differential 2 mm RMS

Internal OCXO

Type	10 MHz SC-Cut, temperature stabilized
Aging	5×10^{-10} per day
Phase Noise L(f)	@10 Hz: -125 dBc/Hz (max.) @100 Hz: -155 dBc/Hz (max.) @1 KHz: -165 dBc/Hz (max.) @10 KHz: -165 dBc/Hz (max.)
Temperature Stability	10 ppb
Mechanical Tuning Range	$\pm 1 \times 10^{-6}$
Electrical Steering Range	$\pm 1 \times 10^{-7}$
PLL to GPS Network (can be disabled)	Loop Type: 2nd Order Bandwidth: 0.003 Hz Time Constant: 5 mins.

Front Panel 10 MHz Out [a c]

$\pm 1 \times 10^{-12}$ per day (steered)

Front Panel 1PPS Out [a b c]

<10 ns RMS (steered)

Onboard Data Storage

< 19 GB

a. Typical values. Performance specifications are subject to GPS system characteristics, U.S. DOD operational degradation, ionospheric and tropospheric conditions, satellite geometry, baseline length and multipath effects. Assumes SA Off.

b. Time accuracy does not include biases due to RF or antenna delay.

c. With respect to GPS system time.

A.2 MPC Specifications

MPC CARDS	
There are 5 cards in the MPC	Euro4 GPS, Computer, Clock, Power, and Modem
INPUT/OUTPUT CONNECTORS	
GPS Antenna Input	TNC female jack, 50 Ω nominal impedance +4.25 to +5.25 V DC, 90 mA max (output from MPC to antenna/LNA) Frequency: L1(1575.42 MHz), L2 (1227.6 MHz)
Power Input	3-pin A/C chord provided (for North American Standard A/C) Voltage: 100 to 240 VAC Frequency: 50 to 60 Hz Warm-up power: 34 W Typical power: 30 W Fuse: 1.5 A
DGPS **PPP** **Ethernet** **Modem**	DE9P connector DE9P connector RJ45 jack [a] RJ11 jack
Individual BNC connectors are described on the next page.	
ENVIRONMENTAL	
Operating Temperature	-40°C to +50°C (receiver)
Storage Temperature	-45°C to +85°C
Humidity	Not to exceed 90% non-condensing
PHYSICAL	
Size (without handle)	148 mm x 258 mm x 365 mm (6” x 10” x 15”)
Weight	6.35 kg (14 lb.)

a. An Ethernet connection can only be made with an RJ45 cable. An RJ11 cable will fit into the Ethernet port but a connection cannot be established.

BACK PANEL 10 MHZ IN	
Connector	BNC female
Capture range	5 or 10 MHz ± 5 Hz
Sensitivity	+9 dBm to +20 dBm into 50 Ω
FRONT PANEL 10 MHZ OUT	
Short Term Stability (Allen Variance)	$\pm 1 \times 10^{-12}$, 1 day
RF Output Power	10 ± 3 dBm into 50 Ω
Output Waveform Harmonics: Spurious:	Sine wave -15 dBc -80 dBc
Phase Noise	@10 Hz: -125 dBc/Hz @100 Hz: -155 dBc/Hz @1 kHz: -165 dBc/Hz
RF Output Connector	BNC Female
FRONT PANEL 1PPS OUT	
Connector	BNC Female
Signal Description	A one-pulse-per-second normally high, active low pulse (1 ms) where the falling edge is the reference.
Output level	Voltage: High > 2.0 VDC Low < 0.55 VDC Min. load impedance: 1 KΩ
FRONT PANEL MARK IN	
Connector	BNC Female
Signal Description	Normally high, active low input pulse must exceed 50 ns in duration. The falling edge is the reference. LVTTL (contact closure compatible).
Output Level	Voltage: High > 2.0 VDC Low < 0.8 VDC Min. load impedance: 1 KΩ

✉ System calibration is required for "Absolute Accuracy" including antenna, cables and MPC.

A.3 Port Pin-Outs

Table 3: MPC COM Port Pin-Outs

Connector Pin No.	PPP RS232	DGPS RS232
1	N/C	N/C
2	RXD	RXD
3	TXD	TXD
4	N/C	N/C
5	GND	GND
6	N/C	N/C
7	RTS	RTS
8	CTS	CTS
9	N/C	N/C

A.4 Power Cable

The power cable supplied with the MPC, connects from the Power Input port on the back of the MPC to an external power source (100 to 240 VAC). An input voltage of less than 100 VAC will cause the unit to suspend operation while an input voltage greater than 240 VAC may physically damage the unit, voiding the warranty. The power cable will automatically adapt its input power to the national power source in the country of use as long as it is within the above range and you have an adapter for your local power receptacle.

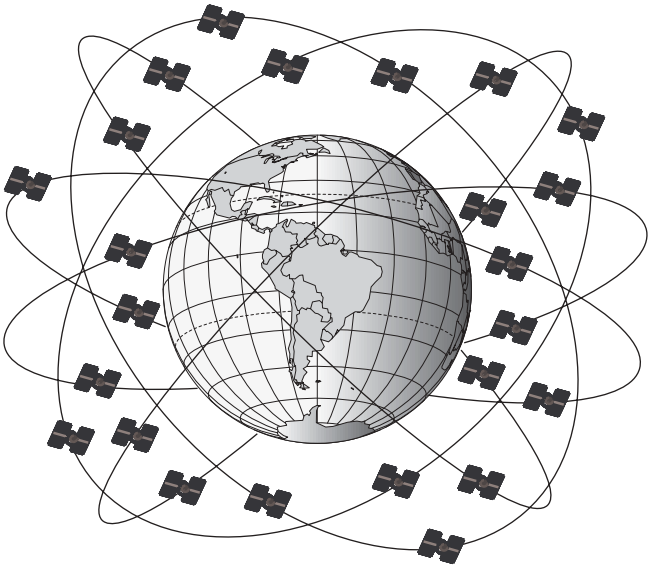
Figure 78: Power Cable

Appendix B GPS Overview

The Global Positioning System (GPS) is a satellite navigation system capable of providing a highly accurate, continuous global navigation service independent of other positioning aids. GPS provides 24-hour, all-weather, worldwide coverage with position, velocity and timing information.

The system uses the NAVSTAR (NAVigation Satellite Timing And Ranging) satellites which consists of 24 operational satellites to provide a GPS receiver with at least six satellites in view at all times. A minimum of four satellites in view are needed to allow the GPSCard to compute its current latitude, longitude, altitude with reference to mean sea level and the GPS system time.

Figure 79: NAVSTAR Satellite Orbit Arrangement



B.1 GPS System Design

The GPS system design consists of three parts:

- The Space segment
- The Control segment
- The User segment

All these parts operate together to provide accurate three dimensional positioning, timing and velocity data to users worldwide.

B.1.1 The Space Segment

The space segment is composed of the NAVSTAR GPS satellites. The constellation of the system consists of 24 satellites in six 55° orbital planes, with four satellites in each plane. The orbit period of each satellite is approximately 12 hours at an altitude of 20 183 kilometers. This provides a GPS

receiver with at least six satellites in view from any point on earth, at any particular time.

The GPS satellite signal identifies the satellite and provides the positioning, timing, ranging data, satellite status and the corrected ephemerides (orbit parameters) of the satellite to the users. The satellites can be identified either by the Space Vehicle Number (SVN) or the Pseudorandom Code Number (PRN). The PRN is used by the NovAtel GPSCard.

The GPS satellites transmit on two L-band frequencies; one centered at 1575.42 MHz (L1) and the other at 1227.60 MHz (L2). The L1 carrier is modulated by the C/A code (Coarse/Acquisition) and the P code (Precision) which is encrypted for military and other authorized users. The L2 carrier is modulated only with the P code.

B.1.2 The Control Segment

The control segment consists of a master control station, five reference stations and three data up-loading stations in locations all around the globe.

The reference stations track and monitor the satellites via their broadcast signals. The broadcast signals contain the ephemeris data of the satellites, the ranging signals, the clock data and the almanac data. These signals are passed to the master control station where the ephemerides are re-computed. The resulting ephemerides corrections and timing corrections are transmitted back to the satellites via the data up-loading stations.

B.1.3 The User Segment

The user segment, such as the NovAtel GPSCard receiver, consists of equipment which tracks and receives the satellite signals. The user equipment must be capable of simultaneously processing the signals from a minimum of four satellites to obtain accurate position, velocity and timing measurements.

B.2 Height Relationships

What is a geoid?

An equipotential surface is any surface where gravity is constant. This surface best represents mean sea-level and not only covers the water but is projected throughout the continents. In North America this surface is most commonly used at its zero value, i.e. all heights are referenced to this surface.

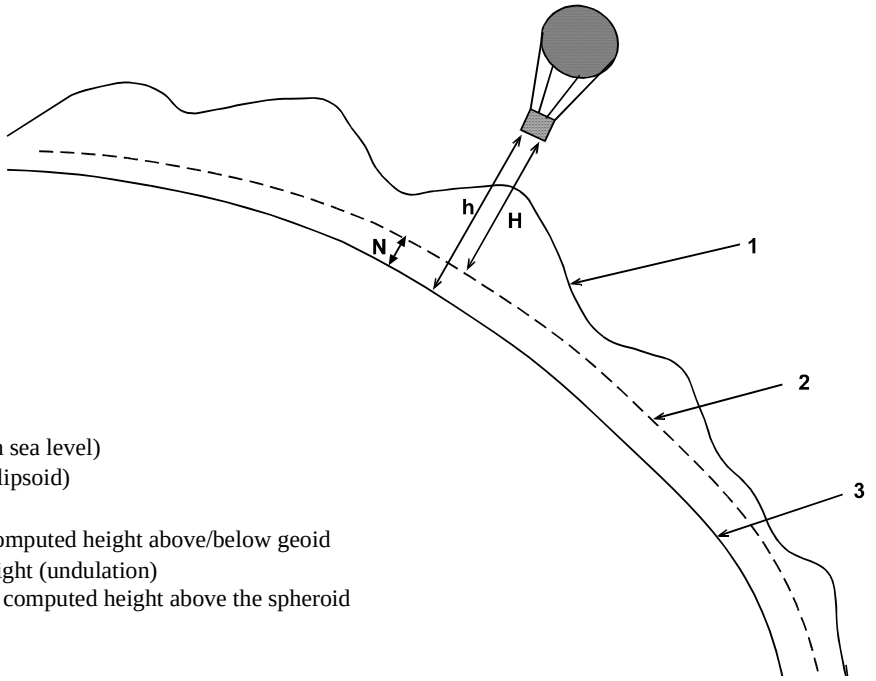
What is an ellipsoid?

An ellipsoid, also known as a spheroid, is a mathematical surface which is sometimes used to represent the earth. Whenever you see latitudes and longitudes describing the location, this coordinate is being referenced to a specific ellipsoid. GPS positions are referred to an ellipsoid known as WGS84 (World Geodetic System of 1984).

What is the relationship between a geoid and an ellipsoid?

The relationship between a geoid and an ellipsoid is shown in *"Illustration of GPSCard Height Measurements" on Page 83*.

Figure 80: Illustration of GPSCard Height Measurements



References:

1 Topography
2 Geoid (mean sea level)
3 Spheroid (ellipsoid)

H = GPSCard computed height above/below geoid
N = Geoidal Height (undulation)
h = GPS system computed height above the spheroid
N = h - H

From the above diagram, and the formula **h = H + N,** to convert heights between the ellipsoid and geoid we require the geoid-ellipsoid separation value. This value is not easy to determine. A world-wide model is generally used to provide these values. NovAtel GPS receivers store this value internally. This model can also be augmented with local height and gravity information. A more precise geoid model is available from government survey agencies e.g. U.S. National Geodetic Survey (http://www.ngs.noaa.gov) or Geodetic Survey of Canada (http://www.geod.emr.ca).

Why is this important for GPS users?

The above formula is critical for GPS users as they typically obtain ellipsoid heights and need to convert these into mean sea-level heights. Once this conversion is complete, users can relate their GPS derived heights to more “usable” mean sea-level heights.

B.3 GPS Positioning

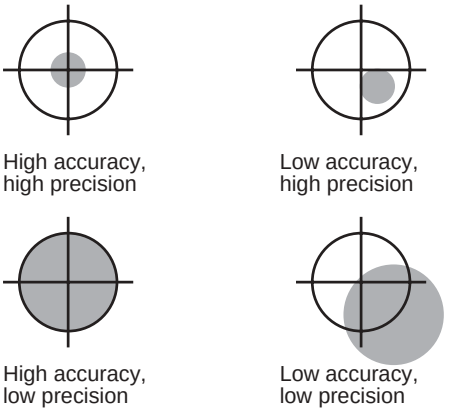
GPS positioning can be categorized as follows:

1. single-point or relative
2. static or kinematic
3. real-time or post-mission data processing

A distinction should be made between *accuracy* and *precision*. *Accuracy* refers to how close an estimate or measurement is to the true but unknown value; *precision* refers to how close an estimate is to the mean (average) estimate. *“Accuracy versus Precision” on Page 84* illustrates various relationships between these two parameters: the true value is "located" at the intersection of the cross-

hairs, the centre of the shaded area is the "location" of the mean estimate, and the radius of the shaded area is a measure of the uncertainty contained in the estimate.

Figure 81: Accuracy versus Precision[1]



B.3.1 Single-Point vs. Relative Positioning

In *single-point* positioning, coordinates of a GPS receiver at an unknown location are sought with respect to the earth's reference frame by using the known positions of GPS satellites being tracked. The position solution generated by the receiver is initially developed in earth-centered coordinates which can subsequently be converted to any other coordinate system. With as few as four GPS satellites in view, the absolute position of the receiver in three-dimensional space can be determined. Only one receiver is needed. With Selective Availability (SA) active, the typical horizontal accuracy obtainable using single-point positioning is of the order of 100 m (95% of the time).

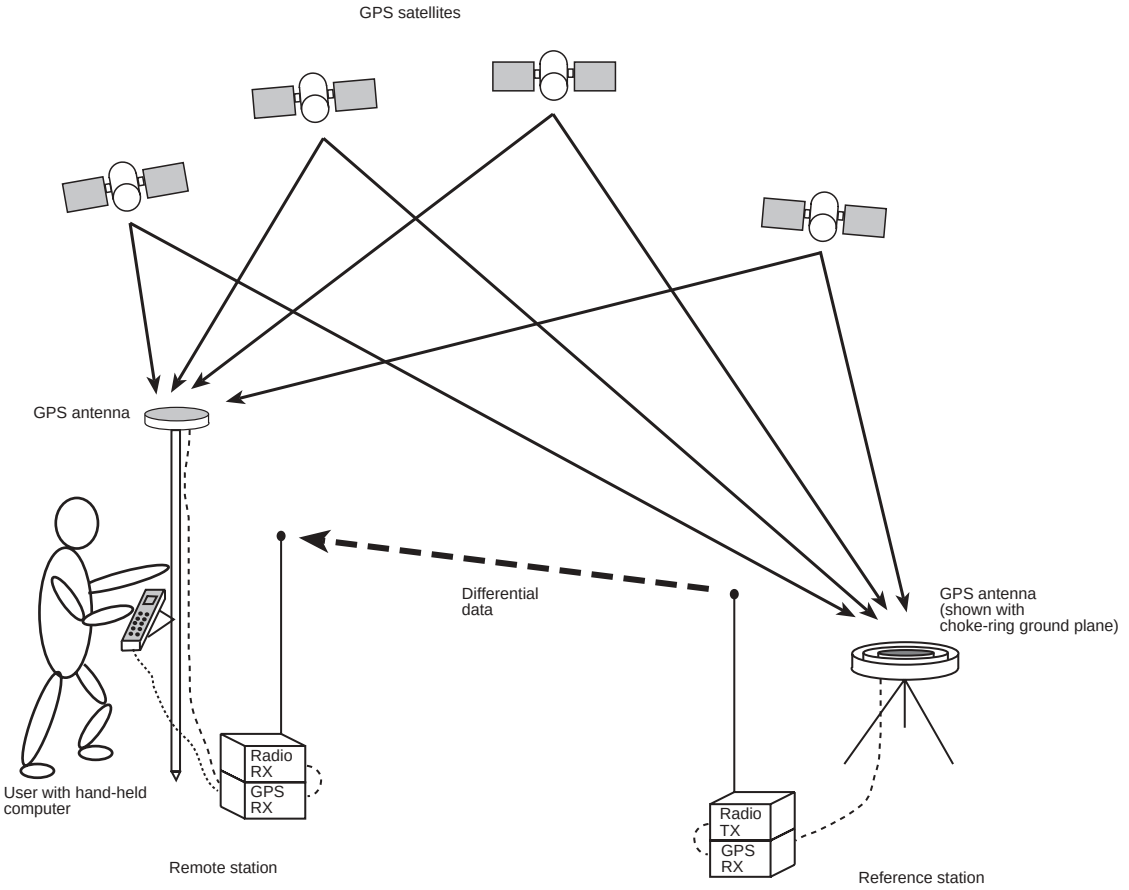
In *relative* positioning, also known as *differential* positioning, the coordinates of a GPS receiver at an unknown point (the "remote" station) are sought with respect to a GPS receiver at a known point (the "reference" station). The concept is illustrated in *Figure 82 on Page 85*. The relative-position accuracy of two receivers locked on the same satellites and not far removed from each other - up to tens of kilometers - is extremely high. The largest error contributors in single-point positioning are those associated with SA and atmospheric-induced effects. These errors, however, are highly correlated for adjacent receivers and hence cancel out in relative measurements. Since the position of the reference station can be determined to a high degree of accuracy using conventional surveying techniques, any differences between its known position and the position computed using GPS techniques can be attributed to various components of error as well as the receiver's clock bias. Once the estimated clock bias is removed, the remaining error on each pseudorange can be determined. The reference station sends information about each satellite to the remote station, which in turn can determine its position much more exactly than would be possible otherwise.

The advantage of relative positioning is that much greater precision (presently as low as 2 mm, depending on the method and environment) can be achieved than by single-point positioning. In order for the observations of the reference station to be integrated with those of the remote station, relative

1.Environment Canada, 1993, Guideline for the Application of GPS Positioning, p. 22.

positioning requires either a data link between the two stations (if the positioning is to be achieved in real-time) or else post-processing of the data collected by the remote station. At least four GPS satellites in view are still required. The absolute accuracy of the remote station's computed position will depend on the accuracy of the reference station's position.

Figure 82: Example of Differential Positioning



B.3.2 Static vs. Kinematic Positioning

Static and *kinematic positioning* refer to whether a GPS receiver is stationary or in motion while collecting GPS data.

B.3.3 Real-time vs. Post-mission Data Processing

Real-time or *post-mission* data processing refer to whether the GPS data collected by the receiver is processed as it is received or after the entire data-collection session is complete.

B.4 Differential Positioning

There are two types of differential positioning algorithms: *pseudorange* and *carrier phase*. In both of these approaches, the "quality" of the positioning solution generally increases with the number of satellites which can be simultaneously viewed by both the reference and remote station receivers. As well, the quality of the positioning solution increases if the distribution of satellites in the sky is favorable; this distribution is quantified by a figure of merit, the Position Dilution of Precision (PDOP), which is defined in such a way that the lower the PDOP, the better the solution.

Due to the many different applications for differential positioning systems, two types of position solutions are possible. NovAtel's carrier-phase algorithms can generate both *matched* and *low-latency* position solutions, while NovAtel's pseudorange algorithms generate only low-latency solutions. These are described below:

1. The *matched* position solution is computed at the remote station when the observation information for a given epoch has arrived from the reference station via the data link. Matched observation set pairs are observations by both the reference and remote stations which are matched by time epoch, and contain the same satellites. The matched position solution is the most accurate one available to the operator of the remote station, but it has an inherent *latency* – the sum of time delays between the moment that the reference station makes an observation and the moment that the differential information is processed at the remote station. This latency depends on the computing speed of the reference station receiver, the rates at which data is transmitted through the various links, and the computing speed of the remote station; the overall delay is on the order of one second. Furthermore, this position cannot be computed any more often than the observations are sent from the reference station. Typically, the update rate is one solution every two seconds.

2. The *low latency* position solution is based on a prediction from the reference station. Instead of waiting for the observations to arrive from the reference station, a model (based on previous reference station observations) is used to estimate what the observations will be at a given time epoch. These estimated reference station observations are combined with actual measurements taken at the remote station to provide the position solution. Because only the reference station observations are predicted, the remote station's dynamics will be accurately reflected. The *latency* in this case (the time delay between the moment that a measurement is made by the remote station and the moment that a position is made available) is determined only by the remote processor's computational capacity; the overall delay is of the order of a hundred milliseconds. Low-latency position solutions can be computed more often than matched position solutions; the update rate can reach 10 solutions per second. The low-latency positions will be provided for data gaps between matched positions of up to 30 seconds (for a carrier-phase solution) or 60 seconds (for a pseudorange solution, unless adjusted using the DGPSTIMEOUT command). A general guideline for the additional error incurred due to the extrapolation process is shown in *Table 4*.

Table 4: Latency-Induced Extrapolation Error

Time since last reference station observation	Typical extrapolation error (CEP) rate
0-2 seconds	1 cm/sec
2-7 seconds	2 cm/sec
7-30 seconds	5 cm/sec

B.5 Pseudorange Algorithms

Pseudorange algorithms correlate the pseudorandom code on the GPS signal received from a particular satellite, with a version generated within the reference station receiver itself. The time delay between the two versions, multiplied by the speed of light, yields the *pseudorange* (so called because it contains several errors) between the reference station and that particular satellite. The availability of four pseudoranges allows the reference station receiver to compute its position (in three dimensions) and the offset required to synchronize its clock with GPS system time. The discrepancy between the reference station receiver's computed position and its known position is due to errors and biases on each pseudorange. The reference station receiver sums these errors and biases for each pseudorange, and then broadcasts these corrections to the remote station. The remote receiver applies the corrections to its own measurements; its corrected pseudoranges are then processed in a least-squares algorithm to obtain a position solution.

The "wide correlator" receiver design that predominates in the GPS industry yields accuracies of 3-5 m (SEP). NovAtel's patented Narrow Correlator tracking technology reduces noise and multipath interference errors, yielding accuracies of 1 m (SEP).

B.5.1 Pseudorange Differential Positioning

B.5.1.1 GPS System Errors

In general, GPS SPS C/A code single-point pseudorange positioning systems are capable of absolute position accuracies of about 40 meters or less. This level of accuracy is really only an estimation, and may vary widely depending on numerous GPS system biases, environmental conditions, as well as the GPS receiver design and engineering quality.

There are numerous factors which influence the single-point position accuracies of any GPS C/A code receiving system. As the following list will show, a receiver's performance can vary widely when under the influences of these combined system and environmental biases.

- **Ionospheric Group Delays –** The earth's ionospheric layers cause varying degrees of GPS signal propagation delay. Ionization levels tend to be highest during daylight hours causing propagation delay errors of up to 30 meters, whereas night time levels are much lower and may be as low as 6 meters.
- **Tropospheric Refraction Delays** – The earth's tropospheric layer causes GPS signal propagation delays. The amount of delay is at the minimum (about three metres) for satellite signals arriving from 90 degrees above the horizon (overhead), and progressively increases as the angle above the horizon is reduced to zero where delay errors may be as much as 50 metres at the horizon.
- **Ephemeris Errors –** Some degree of error always exists between the broadcast ephemeris' predicted satellite position and the actual orbit position of the satellites. These errors will directly affect the accuracy of the range measurement.
- **Satellite Clock Errors** – Some degree of error also exists between the actual satellite clock time and the clock time predicted by the broadcast data. This broadcast time error will cause some bias to the pseudorange measurements.
- **Receiver Clock Errors** – Receiver clock error is the time difference between GPS receiver time and true GPS time. All GPS receivers have differing clock offsets from GPS time that vary from receiver to receiver by an unknown amount depending on the oscillator type and quality (TCXO vs. OCXO, etc.). However, because a receiver makes all of its single-point pseudorange measurements using the same common clock oscillator, all measurements will be equally offset, and this offset can generally be modeled or quite accurately estimated to

effectively cancel the receiver clock offset bias. Thus, in single-point positioning, receiver clock offset is not a significant problem. However, in pseudorange differential operation, between-receiver clock offset is a source of uncorrelated bias.

- **Selective Availability (SA)** – Selective availability is when the GPS Control Segment intentionally corrupts satellite clock timing and broadcast orbit data to cause reduced positioning accuracy for general purpose GPS SPS users (non-military). When SA is active, range measurements may be biased by as much as 30 metres.
  NovAtel's OEM4 GPSCard is a civilian dual frequency GPS receiver that normally tracks:
  - L1 C/A Code
  - L1 Carrier Phase
  - L2 P or Y Code
  - L2 (Codeless) Carrier Phase

  P Code is never tracked on L1 even if AS is disabled.
- **Multipath Signal Reception** – Multipath signal reception can potentially cause large pseudorange and carrier phase measurement biases. Multipath conditions are very much a function of specific antenna site location versus local geography and man-made structural influences. Severe multipath conditions could skew range measurements by as much as 100 meters or more.

The NovAtel GPSCard receivers are capable of absolute single-point positioning accuracies of 15 meters CEP (GDOP < 2; no multipath) when SA is off and 40 meters CEP while SA is on. (As the status of selective availability is generally unknown by the real-time GPS user, the positioning accuracy should be considered to be that of when SA is on).

The general level of accuracy available from single-point operation may be suitable for many types of positioning such as ocean going vessels, general aviation, and recreational vessels that do not require position accuracies of better than 40 meters CEP. However, increasingly more and more applications desire and require a much higher degree of accuracy and position confidence than is possible with single-point pseudorange positioning. This is where differential GPS (DGPS) plays a dominant role in higher accuracy real-time positioning systems.

B.5.1.2 Single-Point Averaging with the GPSCard

By averaging many GPS measurement epochs over several hours, it is possible to achieve a more accurate absolute position. This section attempts to explain how the position averaging function operates and to provide an indication of the level of accuracy that can be expected versus total averaging time.

The POSAVE command implements position averaging for reference stations. Position averaging will continue for a specified number of hours or until the averaged position is within specified accuracy limits. Averaging will stop when the time limit or the horizontal standard deviation limit or the vertical standard deviation limit is achieved. When averaging is complete, the FIX POSITION command will automatically be invoked.

If the maximum time is set to 1 hour or larger, positions will be averaged every 10 minutes and the standard deviations reported in the AVEPOS log should be correct. If the maximum time is set to less than 1 hour, positions will be averaged once per minute and the standard deviations reported in the log will likely not be accurate; also, the optional horizontal and vertical standard deviation limits cannot be used.

If the maximum time that positions are to be measured is set to 24, for example, you can then log AVEPOS with the trigger ‘ontime’ to see the averaging status. i.e.,

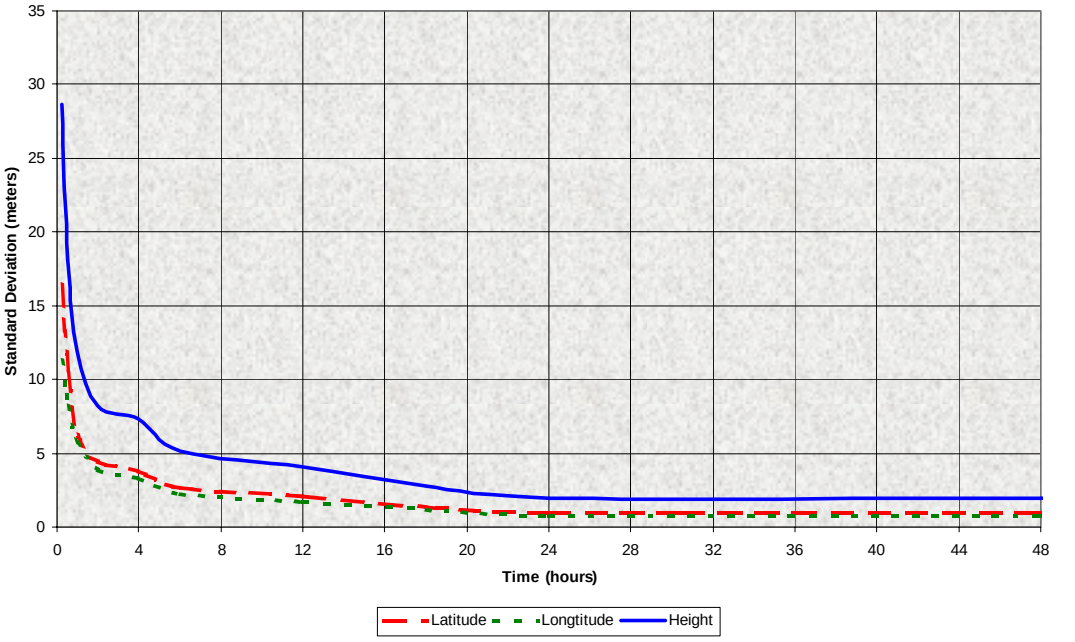
```
posave 24
log com1 avepos onchanged
```

You could initiate differential logging, then issue the POSAVE command followed by the SAVECONFIG command. This will cause the GPSCard to average positions after every power-on or reset, then invoke the FIX POSITION command to enable it to send differential corrections.

The position accuracy that may be achieved by these methods will be dependent on many factors: SA, average satellite geometry, sky visibility at antenna location, satellite health, time of day, etc. The following graph summarizes the results of several examples of position averaging over different time periods. The intent is to provide an idea of the relationship between averaging time and position accuracy. All experiments were performed using a single frequency receiver with an ideal antenna location, see *Figure 83*.

Figure 83: Single-Point Averaging

✉ This graph represents typical results using position averaging.



This function is useful for obtaining the WGS84 position of a point to a reasonable accuracy without having to implement differential GPS. It is interesting to note that even a six hour occupation can improve single-point GPS accuracy from over fifty meters to better than five meters. This improved accuracy is primarily due to the reductions of the multipath and selective availability errors in the GPS signal.

Again, it is necessary to keep in mind that the resulting standard deviations of the position averaging can vary quite a bit, especially over relatively short averaging times. To illustrate, the position averaging function was run for a period of one hour at three different times during the day. The resulting standard deviation in latitude varied from 4.7 to 7.0 meters. Similarly, the variation in longitude and height were 4.9 to 6.7 meters and 10.9 to 12.5 meters respectively. This degree of variation is common for averaging periods of less than 12 hours due to changes in the satellite constellation. The graph, however, should at least provide some indication of the accuracy one may expect from single-point position averaging.

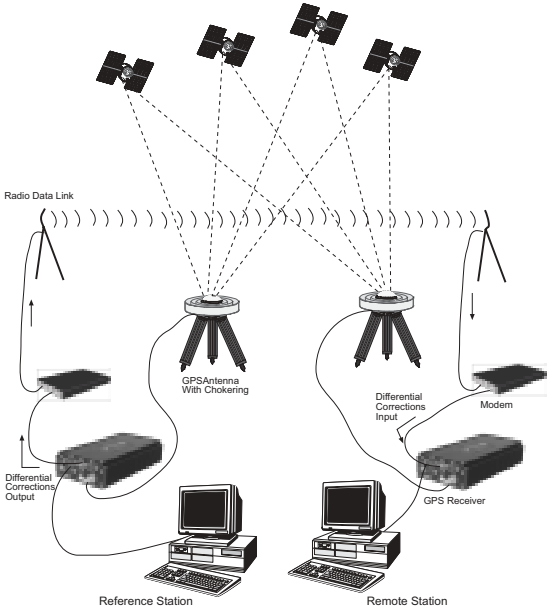
B.5.2 Dual Station Differential Positioning

It is the objective of operating in differential mode to either eliminate or greatly reduce most of the errors introduced by the above types of system biases. Pseudorange differential positioning is quite effective in removing most of the biases caused by satellite clock error, ionospheric and tropospheric delays (for baselines less than 50 km), ephemeris prediction errors, and SA. However, the biases caused by multipath reception and receiver clock offset are uncorrelated between receivers and thus cannot be cancelled by "between receiver single differencing" operation.

Differential operation requires that stations operate in pairs. Each pair consists of a reference station and a remote station. A differential network could also be established when there is more than one remote station linked to a single reference station.

In order for the differential pair to be effective, differential positioning requires that both reference and remote station receivers track and collect satellite data simultaneously from common satellites. When the two stations are in relatively close proximity (< 50 km), the pseudorange bias errors are considered to be nearly the same and can be effectively cancelled by the differential corrections. However, if the baseline becomes excessively long, the bias errors begin to decorrelate, thus reducing the accuracy or effectiveness of the differential corrections.

Figure 84: Typical Differential Configuration



B.5.2.1 The Reference Station

The nucleus of the differential network is the reference station. To function as a reference station, the GPS receiver antenna must be positioned at a control point whose position is precisely known in the GPS reference frame. Typically, the fixed position will be that of a geodetic marker or a pre-surveyed point of known accuracy.

The reference receiver must then be initialized to fix its position to agree with the latitude, longitude, and height of the phase centre of the reference station GPS receiver antenna. Of course, the antenna offset position from the marker must be accurately accounted for.

Because the reference station's position is fixed at a known location, it can now *compute* the range of its known position to the satellite. The reference station now has two range measurements with which to work: *computed pseudoranges* based on its known position relative to the satellite, and *measured pseudoranges* which assumes the receiver position is unknown. Now, the reference station's measured pseudorange (unknown position) is differenced against the computed range (based on known position) to derive the differential correction which represents the difference between known and unknown solutions for the same antenna. This difference between the two ranges represents the combined pseudorange measurement errors resulting from receiver clock errors, atmospheric delays, satellite clock error, orbital errors, and SA.

The reference station will derive pseudorange corrections for each satellite being tracked. These corrections can now be transmitted over a data link to one or more remote stations. It is important to ensure that the reference station's FIX POSITION setting be as accurate as possible, as any errors here will directly bias the pseudorange corrections computed, and can cause unpredictable results depending on the application and the size of the reference station position errors. As well, the reference station's pseudorange measurements may be biased by multipath reception.

B.5.2.2 The Remote Station

A remote station is generally any receiver whose position is of unknown accuracy, but has ties to a reference station through an established data link. If the remote station is not receiving differential corrections from the reference station, it is essentially utilizing single-point positioning measurements for its position solutions, thus is subject to the various GPS system biases. However, when the remote GPS receiver is receiving a pseudorange correction from the reference station, this correction is applied to the local receiver's measured pseudorange, effectively cancelling the effects of orbital and atmospheric errors (assuming baselines < 50 km), as well as eliminating satellite clock error.

The remote station must be tracking the same satellites as the reference station in order for the corrections to take effect. Thus, only common satellite pseudoranges will utilize the differential corrections. When the remote is able to compute its positions based on pseudorange corrections from the reference station, its position accuracies will approach that of the reference station. Remember, the computed position solutions are always that of the GPS receiving antenna phase centre.

B.6 Carrier-Phase Algorithms

Carrier-phase algorithms monitor the actual carrier wave itself. These algorithms are the ones used in real-time kinematic (RTK) positioning solutions - differential systems in which the remote station, possibly in motion, requires reference-station observation data in real-time. Compared to pseudorange algorithms, much more accurate position solutions can be achieved: carrier-based algorithms can achieve accuracies of 1-2 cm (CEP).

Kinematic GPS using carrier-phase observations is usually applied to areas where the relation between physical elements and data collected in a moving vehicle is desired. For example, carrier-phase kinematic GPS missions have been performed in aircraft to provide coordinates for aerial photography, and in road vehicles to tag and have coordinates for highway features. This method can achieve similar accuracy to that of static carrier-phase, if the ambiguities can be fixed. However, satellite tracking is much more difficult, and loss of lock makes reliable ambiguity solutions difficult to maintain.

A carrier-phase measurement is also referred to as an *accumulated delta range* (ADR). At the L1 frequency, the wavelength is 19 cm; at L2, it is 24 cm. The instantaneous distance between a GPS satellite and a receiver can be thought of in terms of a number of wavelengths through which the signal has propagated. In general, this number has a fractional component and an integer component (such as 124 567 967.330 cycles), and can be viewed as a pseudorange measurement (in cycles) with an initially unknown constant integer offset. Tracking loops can compute the fractional component and the change in the integer component with relative ease; however, the determination of the initial integer portion is less straight-forward and, in fact, is termed the *ambiguity.*

In contrast to pseudorange algorithms where only corrections are broadcast by the reference station, carrier-phase algorithms typically “double difference” the actual observations of the reference and remote station receivers. Double-differenced observations are those formed by subtracting measurements between identical satellite pairs on two receivers:

$$ADR_{\text{double difference}} = (ADR_{\text{rx A,sat i}} - ADR_{\text{rx A,sat j}}) - (ADR_{\text{rx B,sat i}} - ADR_{\text{rx B,sat j}})$$

An ambiguity value is estimated for each double-difference observation. One satellite is common to every satellite pair; it is called the *reference* satellite, and it is generally the one with the highest elevation. In this way, if there are *n* satellites in view by both receivers, then there will be *n-1* satellite pairs. The difference between receivers A and B removes the correlated noise effects, and the difference between the different satellites removes each receiver’s clock bias from the solution.

In the RTK system, a *floating* (or *“continuous-valued”*) *ambiguity solution* is continuously generated from a Kalman filter. When possible, *fixed-integer ambiguity solutions* are also computed because they are more accurate, and produce more robust standard-deviation estimates. Each possible discrete ambiguity value for an observation defines one *lane*; that is, each lane corresponds to a possible pseudorange value. There are a large number of possible lane combinations, and a receiver has to analyze each possibility in order to select the correct one. For single-frequency receivers, there is no alternative to this brute-force approach. However, one advantage of being able to make both L1 and L2 measurements is that linear combinations of the measurements made at both frequencies lead to additional values with either “wider” or “narrower” lanes. Fewer and wider lanes make it easier for the software to choose the correct lane, having used the floating solution for initialization. Once the correct *wide lane* has been selected, the software searches for the correct *narrow* lane. Thus, the

searching process can more rapidly and accurately home in on the correct lane when dual-frequency measurements are available. Changes in the geometry of the satellites aids in ambiguity resolution; this is especially noticeable in L1-only solutions. In summary, NovAtel's RTK system permits L1/L2 receivers to choose integer lanes while forcing L1-only receivers to rely exclusively on the floating ambiguity solution.

Once the ambiguities are known, it is possible to solve for the vector from the reference station to the remote station. This baseline vector, when added to the position of the reference station, yields the position of the remote station.

In the NovAtel RTK system, the floating ambiguity and the integer position solutions (when both are available) are continuously compared for integrity purposes. The better one is chosen and output in the receiver's matched-position logs. The "best" ambiguities determined are used with the remote station's local observations and a reference station observation model to generate the remote station's low-latency observations.

Appendix C WAAS Overview

The Wide Area Augmentation System (WAAS) is a safety-critical system that provides a quality of positioning information previously unavailable. The WAAS improves the accuracy, integrity, and availability of the basic GPS signals. In the future, the wide area of coverage for this system will include the entire United States and some outlying areas. At the time of publication, there are two WAAS satellites over the western Atlantic Ocean and the Pacific (PRN 122 and PRN 134 respectively) and one EGNOS satellite over the eastern Atlantic Ocean (PRN 120). WAAS data is available from any of these satellites and more satellites will be available in the future.

The primary functions of WAAS include:

- data collection
- determining ionospheric corrections
- determining satellite orbits
- determining satellite clock corrections
- determining satellite integrity
- independent data verification
- WAAS message broadcast and ranging
- system operations & maintenance

As shown in *Figure on Page 96*, the WAAS is made up of a series of Wide Area Reference Stations, Wide Area Master Stations, Ground Uplink Stations and Geostationary Satellites (GEOs). The Wide Area Reference Stations, which are geographically distributed, pick up GPS satellite data and route it to the Wide Area Master Stations where wide area corrections are generated. These corrections are sent to the Ground Uplink Stations which up-link them to the GEOs for re-transmission on the GPS L1 frequency. These GEOs transmit signals which carry accuracy and integrity messages, and which also provide additional ranging signals for added availability, continuity and accuracy. These GEO signals are available over a wide area and can be received and processed by OEM4 family GPS receivers with appropriate firmware. GPS user receivers are thus able to receive WAAS data in-band and use not only differential corrections, but also integrity, residual errors and ionospheric information for each monitored satellite.

The signal broadcast via the WAAS GEOs to the WAAS users is designed to minimize modifications to standard GPS receivers. As such, the GPS L1 frequency (1575.42 MHz) is used, together with GPS-type modulation - e.g. a Coarse/Acquisition (C/A) pseudorandom (PRN) code. In addition, the code phase timing is maintained close to GPS time to provide a ranging capability.

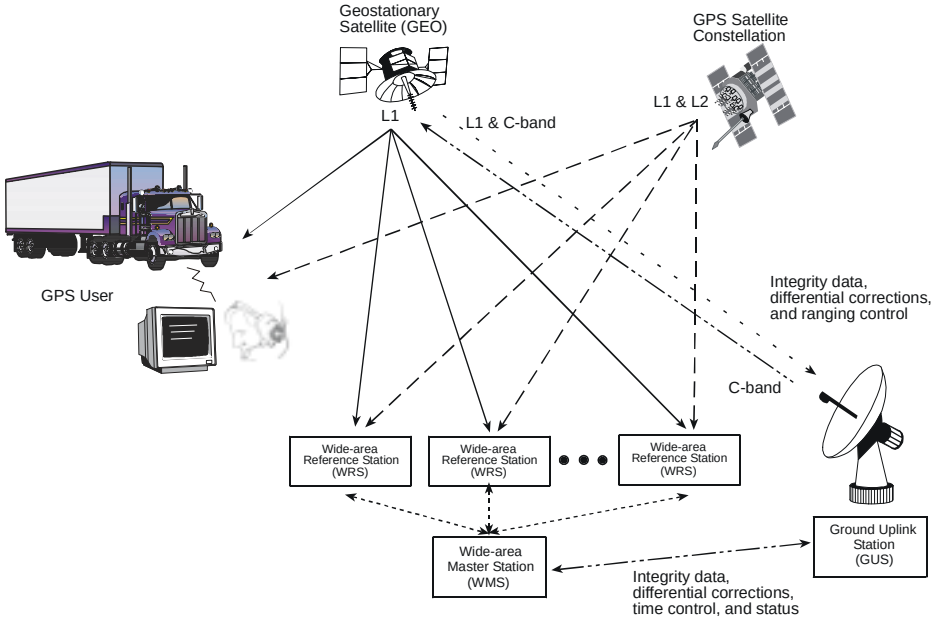


Figure 85: The WAAS Concept

C.1 MPC with the WAAS Option

The L1L2W model of the MPC is equipped with the WAAS/EGNOS option. The ability to simultaneously track two WAAS satellites, and incorporate the WAAS/EGNOS corrections into the position, is available in this model.

This model can output the WAAS data in log format (RAWWAASFRAMEA/B, WAAS0A/B-WAAS27A/B), and can incorporate these corrections to generate differential-quality position solutions. Standard WAAS/EGNOS data messages are analyzed based on RTCA standard DO-229B Change 1 Minimum Operational Performance Standards for GPS/WAAS airborne equipment.

A WAAS/EGNOS-capable MPC will permit anyone within the area of coverage to take advantage of its benefits.

C.1.1 WAAS Commands and Logs

The command WAASCORRECTION, enables the use of the WAAS corrections in the position filter. In order to use this command, first ensure that your receiver is capable of receiving WAAS corrections.

Several WAAS specific logs also exist and are all prefixed by the word WAAS except for the RAWWAASFRAME log.

The PSRDIFFSOURCE command sets the station ID value which identifies the reference station from which to accept psuedorange corrections. All DGPS types may revert to WAAS, if enabled using the WAASCORRECTION command.

Consult *Volume 2* of the OEM4 Users' Guide for more details on individual WAAS commands and logs.

Appendix D Replacement Parts

The following are a list of the replacement parts available for your NovAtel GPS receiver. Should you require assistance or need to order additional components, please contact your local NovAtel dealer or Customer Service representative.

Table 5: MPC Power Cable

Part Description	NovAtel Part
MPC power cable assembly	01017085

Table 6: Accessories and Options

Part Description		NovAtel Part
Modulated Precision Clock (MPC)		MPC
Euro4 GPSCard		Euro4
PC Software CD		01016826
Optional OEM4 GPSCard Command Description Manual Volume 1, Installation and Operation		OM-20000046
OEM4 GPSCard Command Description Manual Volume 2, Commands and Logs		OM-20000047
Optional NovAtel GPSAntennas:	**Model 600** (L1/L2)	GPS-600
	Model 501 (L1 only)	GPS-501
	Model 511 (L1 only)	GPS-511
	Model 521 (L1 only)	GPS-521
	Model 502 (L1/L2)	GPS-502
	Model 503 (L1/L2)	GPS-503
	Model 512 (L1/L2)	GPS-512
Optional RF Antenna Cable:	5 meters (16.4’)	C005
	15 meters (49.2’)	C015
	30 meters (98.4’)	C030
	22 cm (8.66”) interconnect adapter cable	GPS-C002

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