MiLLennium®
GPSCard™
and Enclosures
(PowerPak® II & ProPak® II)

Guide to Installation & Operation

MiLLennium® GPSCard™ and Enclosures

Guide to Installation & Operation

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This manual is a companion to the *MiLLennium Command Descriptions* manual (NovAtel part number OM-20000041).

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PowerPak Enclosure	One (1) Year
ProPak Enclosure	One (1) Year
GPSAntenna Series	One (1) Year
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There are no user serviceable parts in the MiLLennium 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.

You must obtain a **RETURN MATERIAL AUTHORIZATION** (**RMA**) number by calling NovAtel Customer Service at 1-800-NOVATEL (Canada and the U.S. only or 403-295-4900 before shipping any product to NovAtel or Dealer.

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 all original diskettes along with the defective product in the original packaging to avoid ESD and shipping damage.

CUSTOMER SERVICE

If you require customer service, please provide the following information along with a detailed description of the problem when you call or write:

Serial No. _____ Model No. _____

Software Release No. _____

Date Purchased: _____

Purchased from: _____

User name: _____ Title:_____

Company: _____

Address: _____

City:_____ Prov/State: _____

Zip/Postal Code: _____ Country: _____

Phone #: _____ Fax #: _____

E-mail: _____

MiLLennium interface: Computer type: _____Operating Shell: _____

Other interface used:_____

Please provide a complete description of any problems you may be experiencing, or the nature of your inquiry (attach additional sheets if needed):

_____

_____

_____

_____

_____

You may photocopy and fax this page, call, or mail the above information to the address listed below.

For customer support, contact the NovAtel GPS Hotline at **1-800-NOVATEL** or **403-295-4900**; send a fax to **403-295-4901**; send e-mail to **support@novatel.ca**, or write to:

> **NovAtel Inc.**
> **GPS Customer Service**
> **1120 68 Avenue NE**
> **Calgary, Alberta, Canada**
> **T2E 8S5**

FCC NOTICE

The following statements refer only to a MiLLennium GPSCard in a ProPak II or PowerPak II enclosure, not the card on its own:

The United States Federal Communications Commission (in 47 CFR 15) has specified that the following notices be brought to the attention of users of the PowerPak II and the ProPak II.

"This equipment has been tested and found to comply with the limits for a class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own risk."

"Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment."

Important: In order to maintain compliance with the limits of a Class A digital device, it is required to use properly shielded interface cables (such as Belden #9539 or equivalent) when using the serial data ports, and double-shielded cables (such as Belden #9945 or equivalent) when using the I/O strobe port.

CAUTION !

Handle with Care
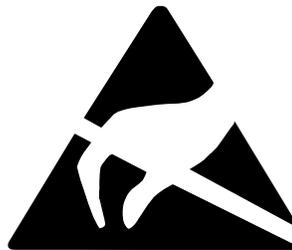
Use Anti-Static Precautions

This warning is especially true for the MiLLennium GPSCard on its own. Please see *Appendix A, Page 31* for handling electrostatic discharge-sensitive (ESD) devices.

Important: ProPak II and PowerPak II incorporate circuitry to absorb most static discharges. However, severe static shock may cause inaccurate operation of the unit.

FOREWORD

Congratulations!

Congratulations on purchasing your MiLLennium GPSCard. The MiLLennium, NovAtel's third-generation GPSCard, is a dual-frequency capable GPS receiver designed for original equipment manufacturer (OEM) applications. This Guide is written for the OEM system integrator.

Scope

This Guide contains sufficient information on the installation and operation of the MiLLennium to allow you to effectively integrate and fully operate it. As such, it is beyond the scope of this Guide to provide details on service or repair. Please contact your local NovAtel dealer for any customer-service related inquiries.

The MiLLennium utilizes a comprehensive user-interface command structure, which requires communications through its serial communications ports. Accompanying this Guide is a *MiLLennium Command Descriptions Manual*, which lists and describes the GPSCard commands and logs. Please remember that since each MiLLennium is shipped from the distributor with a customer-specific list of features, some commands or logs may not be applicable to your model. Other supplementary manuals may be included to accommodate special models and software features with unique functionality. It is recommended that these documents be kept together for easy reference.

Prerequisites

The MiLLennium is an OEM product requiring the addition of an enclosure and peripheral equipment before it can become a fully functional GPS receiver. The *Installation* section of this document provides information concerning installation requirements and considerations for the MiLLennium GPSCard, the PowerPak II and the ProPak II.

What's New in This Edition

This is the third edition of the *MiLLennium GPSCard Guide to Installation and Operation*. This document will be updated periodically to reflect product improvements and enhancements. The changes made since the last edition are:

1. Passive antennas are no longer supported – only active antennas are supported.

2. The MiLLennium GPSCard no longer automatically detects and locks onto an external oscillator signal. This function is now controlled by the EXTERNALCLOCK command, see *Optional User-Supplied External Oscillator, Page 17*.

3. The MiLLennium GPSCard itself is now reverse-polarity protected, i.e. it will not blow up if plugged into the wrong power source but will not function. The GPSCard in a PowerPak II or ProPak II enclosure has always had this feature.

4. The PowerPak II and ProPak II enclosures for the MiLLennium GPSCard are now described in this manual as opposed to having three separate manuals.

1 INTRODUCTION

MILLENNIUM GPSCARD

The MiLLennium GPSCard (see *Figure 1*) consists of a single stand-alone printed circuit board with integrated radio-frequency (RF) and digital sections. It is a high-performance GPS receiver 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 GPS satellites. An active GPSAntenna is required to function. A dual-frequency antenna is needed for dual-frequency operation, which is possible with some MiLLennium models. The MiLLennium can be used for both single-point and differential applications.

Figure 1   MiLLennium GPSCard
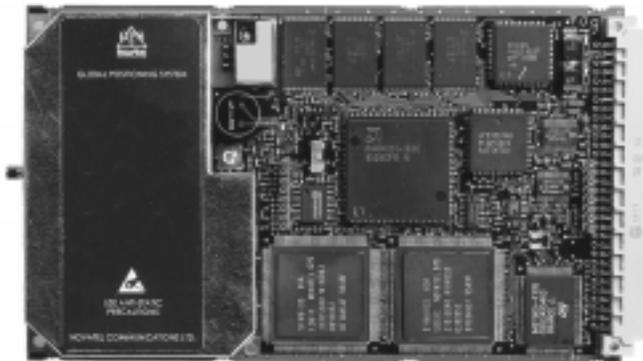
MiLLennium models with dual-frequency capabilities make the following possible:

- longer baselines in differential positioning mode, due to the reduction of atmospheric errors
- faster resolution of carrier-phase ambiguities when performing RTK positioning
- enhanced positioning precision due to the additional measurements

Patented Narrow Correlator tracking technology circuits combined with a high-performance 32-bit CPU make possible multipath-resistant processing at high data update rates. Excellent acquisition and re-acquisition times allow this receiver to operate in environments where very high dynamics and frequent interruption of signals can be expected.

The MiLLennium is fabricated in a "Eurocard" printed circuit board format, utilizing surface-mount manufacturing technology. After integration with a user-supplied 5V DC power source, a mounting structure, an external antenna, and I/O data communications equipment, the MiLLennium is ready for the most demanding surveying, positioning, or navigation applications. It is engineered to provide years of reliable operation.

The MiLLennium offers the OEM developer unparalleled flexibility in areas such as configuration and in the specification of output data and control signals. The available selection of OEM models is based on a common building block, allowing you to fit the receivers more exactly to the application while maintaining the option for a compatible upgrade path.

The following accessories are available from NovAtel Inc. They are designed to make system integration a faster, less expensive and more reliable task:

- Single or dual-frequency GPSAntenna models (survey, aviation, or DGPS reference station with choke-ring ground plane)
- Coaxial and power cables
- PowerPak II (enclosure, power supply and I/O connectors)

- ProPak II (enclosure, power supply and I/O connectors)

The MiLLennium hardware platform supports several different firmware models and configurations. Some possible configurations are:

- L1-only
- L1/L2
- L1 plus WAAS
- L1/L2 plus WAAS
- L1 plus RT-20
- L1/L2 plus RT-2

The features common to all MiLLenniums are summarized in *Table 1*. The functionality of the software is described in the MiLLennium Command Description Manual. There you will also find listings of all data formats and positioning modes supported by the MiLLenium receiver.

Table 1   Common Feature Summary - MiLLennium Models

General
2.5-bit sampling
Narrow Correlator tracking technology
Dual serial ports
"EuroCard" printed circuit board format
Fast re-acquisition
Field-programmable for software upgrades
Port for an optional external clock
Five I/O and timing strobes

For some applications, the MiLLennium PowerPak II and ProPak II are ideal. These are enclosure kits that come complete with mounting and wiring interfaces, and allow immediate operation of the MiLLennium. The ProPak II is designed for rugged operating environments, while the PowerPak II is designed for use under normal conditions.

POWERPAK II

The NovAtel PowerPak II provides a hardware interface between your equipment and the NovAtel MiLLennium GPSCard. When connected to an antenna and a power source, the PowerPak II and MiLLennium together form a fully functioning GPS receiver. This is only one possible application of the PowerPak II; it can also be used by a system integrator to test and evaluate MiLLennium GPSCards.

The PowerPak II is intended for stationary operation in benign surroundings such as those found in a laboratory or on a test bench; it is not designed for environments which feature vibration, dust, moisture or extremes of temperature.

The PowerPak II has these features:

- a mounting enclosure complete with a power converter and PCB interconnect back plane
- GPSolution, NovAtel's graphical user-interface program, and on-line help
- an external automotive cigarette-lighter power adapter
- two serial-data communication ports
- an input/output port for strobe signals
- an input port to which an external power source (+10 to +36 V DC) can be connected
- an input port to which an external, GPSAntenna can be connected
- an input port to which an external oscillator (5 MHz or 10 MHz) can be connected
- a RS232C Y-type null-modem cable to facilitate communications with a PC
- an electrostatic discharge (ESD) wrist grounding strap

Card guides located inside the mounting enclosure hold the MiLLennium in place; it fits into the second slot from the top of the enclosure. It couples to the back plane by means of a 64-pin connector.

The PowerPak II is intended to be used with the following NovAtel accessories and options:

- Model 502, 503, or 512 GPSAntenna - dual-frequency, active antennas designed for high-accuracy applications
- Model C005, C015, or C030 (5, 15 or 30 m length) coaxial cable - to connect the GPSAntenna to the PowerPak II
- GPS-APWR - an AC to DC power converter

For those who have purchased a MiLLennium and PowerPak II enclosure separately, a minor procedure is required to install the MiLLennium and connect a ground wire and two coaxial interconnect cables. This is described in *Appendix C, Page 47.*

PROPAK II

The NovAtel ProPak II is a rugged, reliable enclosure for adverse environments.

The ProPak II has these features:

- rugged shock, water, and dust-resistant enclosure constructed of extruded aluminum sealed by two end-caps.
- two serial communication ports and a strobe port
- optional mounting plate
- one straight and one null-modem serial data cable
- one I/O strobe cable
- one 4-pin LEMO plug connector to cigarette-lighter plug with built-in 3-amp fuse
- NovAtel's *GPSolution* graphical user interface software

The ProPak II is intended to be used with the following NovAtel accessories and options:

- Model 502, 503, or 512 GPSAntenna - dual-frequency, active antennas designed for high-accuracy applications
- Model C005, C015, or C030 (5, 15 or 30 m length) coaxial cable - to connect the GPSAntenna to the ProPak II
- 4-pin LEMO plug connector to 4-pin LEMO plug connector (NovAtel part number: 01016724 [33.5 cm] or 01016725 [0.75 cm])
- Model GPS-APRO Auto-ranging AC/DC converter and power cables

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Note: The unit is sealed to provide protection against adverse environmental conditions; therefore, **any attempt to open the case will impair the water-resistant qualities of the enclosure, and void the warranty.**

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2 HARDWARE CONFIGURATION

MILLENNIUM GPSCARD

The MiLLennium consists of a radio-frequency (RF) and a digital electronics section. Prior to operation, an antenna, power supply, and data and signal interfaces must be connected. The overall system is represented in *Figure 2*. A brief description of each section follows.

Figure 2   MiLLennium System Functional Diagram
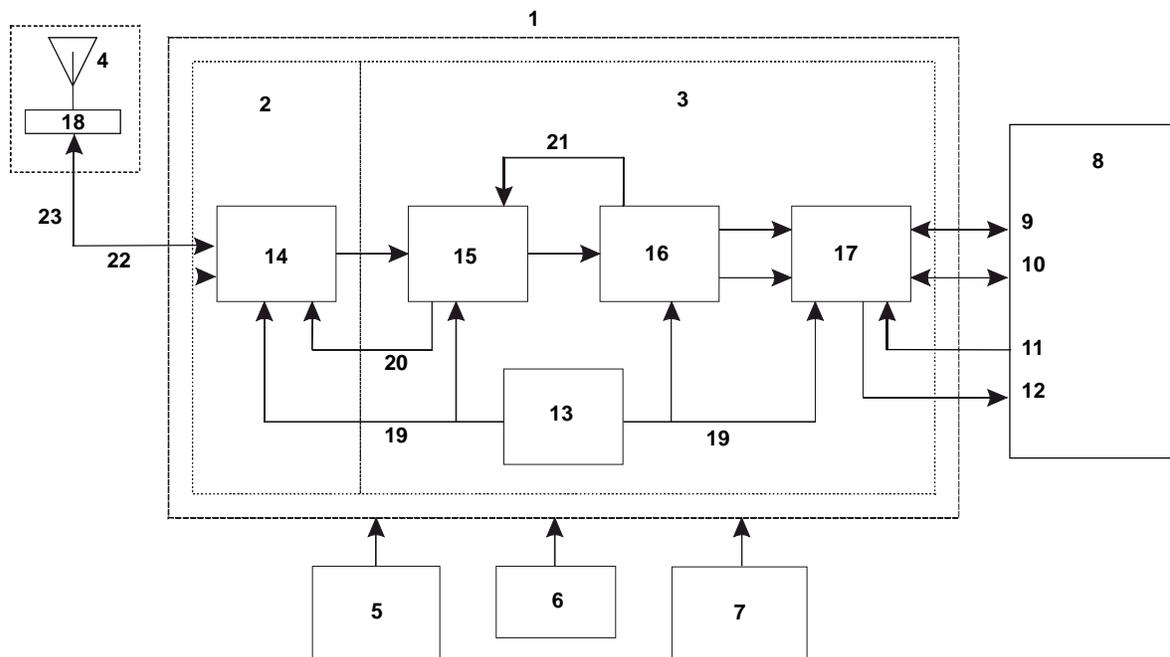
Reference	Description	Reference	Description
1	MiLLennium L1/L2 GPSCard	13	VCTCXO
2	RF section	14	RF-IF sections
3	Digital section	15	Signal processor
4	NovAtel GPSAntenna or user-supplied	16	32-bit CPU
5	Optional user-supplied LNA power (0-30 VDC)	17	System I/O
6	User-supplied power (5 VDC)	18	LNA
7	Optional external oscillator (5 or 10 MHz)	19	Clock signals
8	User-supplied data & signal processing equipment	20	AGC signals
9	COM1	21	Control signals
10	COM2	22	RF and power connectors
11	Input timing strobe	23	Antenna feed
12	Output timing strobe		

ANTENNA

The purpose of the antenna is to convert the electromagnetic waves transmitted by the GPS satellites into RF signals. An active GPS antenna is required; a hardware provision is provided to select an internal or external DC power supply for the active GPS antenna.

An active antenna is required because its low-noise amplifier (LNA) boosts the power of the incoming signals to compensate for the line loss between the antenna and MiLLennium.   The allowable cable loss for an active antenna system is 13.0 dB. Excessive signal degradation will occur if this limit is exceeded and the MiLLennium may not be able to meet its performance specifications.

NovAtel offers a variety of GPSAntenna models. All use low-profile microstrip technology and include band-pass filtering and an LNA.   The GPSAntenna you choose will depend on your particular application and hardware configuration:

L1-Only Antenna Models

- 501 - for surveying applications providing enhanced multipath rejection
- 511 - compact, light and environmentally sealed against rain, ice and lightning strikes
- 521 - delivers optimal performance for airborne, marine and mobile applications
- 531 - for surveying and other kinematic positioning applications

L1/L2 Antenna Models

- 502 - for use in surveying and other kinematic positioning applications (an optional choke-ring ground plane, NovAtel part number A032, is also available for use with this model)
- 503 - for use with high-performance position-reference stations (features a built-in choke-ring ground plane to minimize the effects of multipath interference)
- 512 - for installation on aircraft (features aerodynamic styling)

Each of these models offers 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, 15 and 30 m lengths. High quality coaxial cable should be used because a mismatch in impedance, possible with lower quality cable, produces reflections in the cable that increases signal loss.

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

ANTENNA CONSIDERATIONS

Selecting and installing an appropriate antenna system are important steps to make before operating your GPS receiver. The antenna you choose for your GPS system will depend on the specific positioning application.

The choke-ring ground plane on the GPSAntenna Model 503 will further reduce multipath errors while maintaining a stable phase center (e.g. during geodetic survey-quality positioning). An optional choke-ring (Model A032) is also available for GPSAntenna Model 502.

The MiLLennium has been designed to operate with any of the NovAtel GPSAntenna models. Though it is possible to operate with other GPS antennas, no guarantee is made that the MiLLennium will meet its performance specifications if a non-NovAtel antenna is used.

When installing the antenna system,

- choose an antenna location that has a clear view of the sky to the horizon so that each satellite above the horizon can be tracked without obstruction
- the location should also be one that minimizes the effect of multipath. For a discussion on multipath, please refer to the chapter on "Multipath Elimination Technology" in the *MiLLennium Command Descriptions Manual*

- mount the antenna on a secure, stable structure capable of safe operation in the specific environment

ANTENNA CABLE CONSIDERATIONS

An appropriate coaxial cable is one that is matched to the impedance of antenna being used, and whose line loss does not exceed the recommendation of 13 dB. High quality coaxial cable should be used because a mismatch in impedance, possible with lower quality cable, produces reflections in the cable that increases signal loss. NovAtel offers a variety of coaxial cables to meet your GPSAntenna interconnection requirements. Your local NovAtel dealer can advise you about your specific configuration.

NovAtel provides optional coaxial cables in the following lengths:

- 22 cm interconnect adapter cable (SMB female/TNC bulkhead - female)
- 5 m (Model C005), 15 m (Model C015), or 30 m (Model C030) antenna cable (TNC male/TNC male)

Should your application require the use of cable longer than 30 m, contact the NovAtel Customer Service department and request *Application Note APN-003*, *"Extended-Length Antenna Cable Runs"* before you proceed. Application notes may also be found on the NovAtel website at http://www.novatel.ca.

Any of the GPSAntennas can compensate for up to 13 dB of cable loss; if this limit is exceeded, excessive signal degradation will occur and the MiLLennium may not be able to meet its performance specifications.

Though it is possible to use other high-quality antenna cables, no guarantee is made that the MiLLennium will meet its performance specifications if non-NovAtel-supplied coaxial cable is used.

Note: The coaxial cable should be connected to the antenna and MiLLennium before system power is turned on. If for any reason the cable is disconnected from the antenna or MiLLennium, you must turn off power before reconnecting the cable. This is to prevent the MiLLennium's antenna current-limiting circuit from unnecessarily activating and shutting off power to the GPSAntenna. If this occurs, remove power from the MiLLennium, wait a few moments, and then apply it again.

PRINCIPAL POWER SUPPLY

A single external 5 V DC power supply is all that is necessary to meet the MiLLennium's 7.5 W (typical) power consumption. The power input is reverse-polarity protected.

Note: The MiLLennium will suspend operation if the voltage supplied to it falls outside the input range of 4.875 to 5.25 V DC.

OPTIONAL LNA POWER SUPPLY

The MiLLennium provides power to its GPSAntenna out of the primary 5 V DC input. However, if a different type of antenna is required that is incompatible with this supply, then you could connect an additional power source (≤ 30 V DC) to the MiLLennium. In either case, the power is fed to the antenna through the same coaxial cable used for the RF signals. See jumper P301 in *Chapter 3, I, Figure 3 (Page 18)* and *Figure 4 (Page 21)*.

RF SECTION

The MiLLennium receives the partially filtered and amplified GPS signals from the antenna via the coaxial cable. The RF section does the following:

- filters the RF signals to reduce noise and interference
- down-converts (with further band-limiting) the RF signals to intermediate frequencies (IFs) that are suitable for the analog-to-digital (A/D) converter in the digital electronics section
- amplifies the signals to a level suitable for the A/D converter in the digital electronics section
- receives an automatic gain control (AGC) input from the digital signal processor (DSP) to maintain the IF signals at a constant level

- supplies power to an active antenna through the coaxial cable while maintaining isolation between the DC and RF paths. A hardware jumper configuration is provided to select an internal or external DC power supply for an active GPS antenna. See jumper P301 in the *Chapter 3, I, Figure 3 (on page 18)* and *Figure 4 (on page 21)*.

The RF section can reject a high level of potential interference (e.g., MSAT, Inmarsat, cellular phone, and TV sub-harmonic signals).

DIGITAL ELECTRONICS SECTION

The digital section of the MiLLennium receives down-converted, amplified GPS signals that it digitizes and processes to obtain a GPS solution (position, speed, direction and time). The digital section consists of an analog-to-digital converter, a 32-bit 25 MHz system processor, memory, control and configuration logic, signal processing circuitry, serial peripheral devices, and supporting circuitry. I/O data and timing strobe signals are routed to and from the board via a 64-pin DIN 41612 Type B male connector. Two EIA RS-232C serial communications ports support user-selectable bit rates of 300 - 115,200 bps, with a default of 9600 bps. The digital section does the following:

- converts the IF analog signals to a digital format
- tracks the codes (C/A & P) and carrier phases of the L1 signals (and L2 signals with the appropriate MiLLennium model) of the satellites in use
- performs channel and loop control
- performs position computation
- executes navigation software
- performs database management
- monitors self-test system status
- controls diagnostic LEDs: a red one which only lights up to indicate an error condition, and a green one (the "heartbeat") which blinks on and off at approximately 1 Hz to indicate normal operation.
- controls I/O functions

The strobe signals are described as follows:

- *Mark input:* this signal provides a time tag to the signal processors, which respond to a falling edge of the signal provided from an external device. It can be enabled by you to provide a precise time and data output event.
- *Measure output:* an output measurement rate which generates an active-periodic signal. This output is also routed to the signal processors, where it provides a trigger for the measurement collection.
- *Variable-frequency (VARF) output:* a user-programmable, variable-frequency pulse train
- *PPS output:* a 1 ms pulse repeating at a 1 Hz rate that is used to synchronize the board with external devices.
- *Status output:* an output that changes logic states when a valid GPS position is obtained

You configure the MiLLennium using special commands. In turn, the MiLLennium presents information to you in the form of pre-defined logs in a number of formats. In addition, when two MiLLenniums are linked for differential positioning, the reference and the remote stations can communicate directly through their serial ports.

COMMUNICATION PORTS

The default communications protocol for each port is as follows:

- RS232C
- 9600 bits per second
- no parity
- 8 bits
- 1 stop bit
- no hand shaking
- echo off

Note: The GPSCard *COMn* command can be used to change any of these default settings.

Pin-outs are the same for both serial ports. Both ports utilize standard DE9P connectors. *Table 6 Serial Port Pin-Out Description, Page 50* lists the pin-outs for each serial port configuration.

OPTIONAL USER-SUPPLIED EXTERNAL OSCILLATOR

For certain applications requiring greater precision than what is possible using the on-board 20 MHz, voltage-controlled, temperature-compensated crystal oscillator (VCTCXO), you may wish to connect the MiLLennium to an external, high-stability oscillator. This is only possible with a MiLLennium GPSCard on its own or in a PowerPak II enclosure, not if the MiLLennium GPSCard is in a ProPak II enclosure. The external oscillator can be either 5 MHz or 10 MHz. MiLLennium has built in clock models for OCXO, rubidium and cesium oscillators. You can also set custom clock model parameters for other types of oscillators.

The two commands EXTERNALCLOCK and EXTERNALCLOCK FREQUENCY relate to external oscillator operation, see the *Using the EXTERNALCLOCK Commands* section below. When a MiLLennium is powered on, the external oscillator input is disabled. Therefore, if an external oscillator is never used, these commands are not needed.

Installation consists of simply connecting the cable from the external oscillator to connector P301, *see Figure 3 (Page 18)* and *Figure 4 (Page 21)*, on the MiLLennium. The MiLLennium does not have to be powered down during this procedure. If handling the MiLLennium directly, anti-static practices must be observed; please see *Appendix A (Page 31)* for details.

On the PowerPak II, connect the coaxial cable from the external oscillator output port to the *Ext. Osc*. input port (SMB male jack) on the front panel of the PowerPak II.

Using the EXTERNALCLOCK Commands

The EXTERNALCLOCK command determines whether the MiLLennium uses its own internal temperature-compensated crystal oscillator, or that of an external oscillator, as a frequency reference. It also sets which clock model is used for an external oscillator:

Command	Reference Oscillator	Clock Model
EXTERNALCLOCK DISABLE	Internal	—
EXTERNALCLOCK OCXO	External	OCXO
EXTERNALCLOCK CESIUM	External	Cesium
EXTERNALCLOCK RUBIDIUM	External	Rubidium
EXTERNALCLOCK CUSTOM	External	User-defined parameters

The EXTERNALCLOCK DISABLE command forces the MiLLennium to use the internal oscillator, whether or not there is an external oscillator connected to it. Do not use the EXTERNALCLOCK OCXO, CESIUM, RUBIDIUM or CUSTOM if there is no external oscillator connected to the MiLLennium.

The EXTERNALCLOCK FREQUENCY command sets the MiLLennium to accept either a 5 MHz or 10 MHz external oscillator frequency.

Example: `externalclock frequency 5`
              `externalclock frequency 10`

3 INSTALLATION

Note: This chapter deals specifically with a bare MiLLennium receiver card. For MiLLenium cards in PowerPak II and ProPak II enclosures, see Appendices C and D respectively.

The MiLLennium receiver is an OEM product designed for flexibility of integration and configuration. You are free to select an appropriate data and signal interface, power supply system, and mounting structure. This concept allows OEM purchasers to custom-design their own GPS-based positioning system around the MiLLennium.

This section provides the necessary information for you to install and begin to use the MiLLennium. A typical system configuration is shown in *Figure 3*.

Figure 3   Typical System Configuration
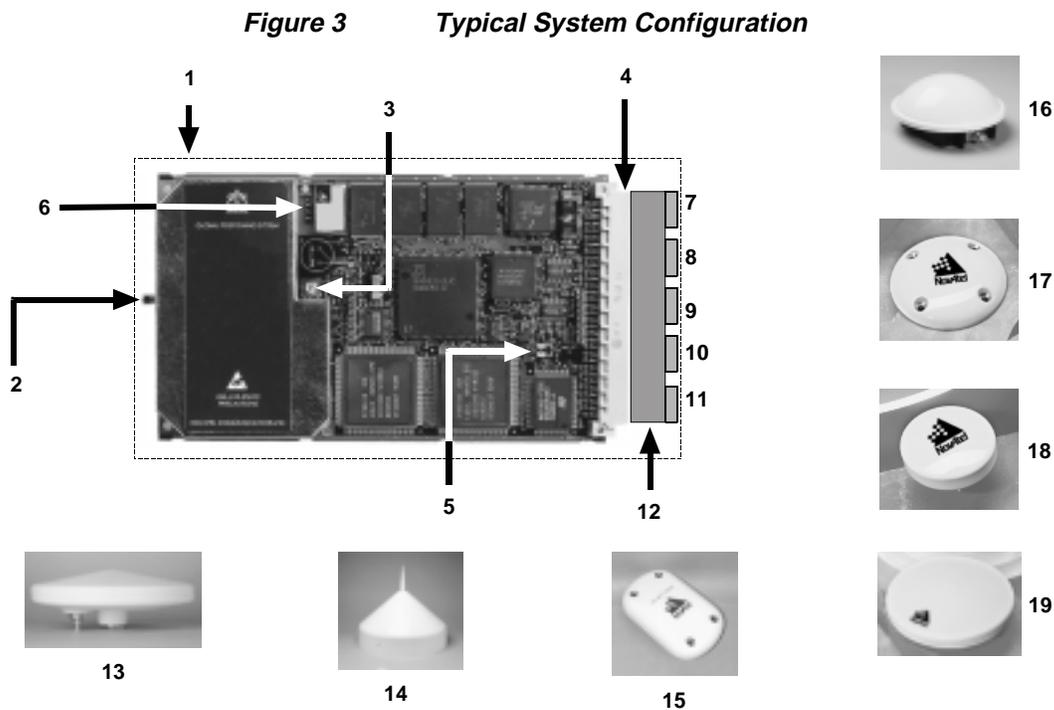
Reference	Description	Reference	Description
1	User-supplied enclosure	9	COM1 (8 pins)
2	RF signal and LNA power; SMB	10	COM2 (8 pins)
	connector P201 (male, right-angle)*	11	Input and output timing strobes (12 pins)x
3	External reference clock input; SMB	12	User-supplied interface; matches item #4
	connector P301 (male, straight)	13	Model 502 GPSAntenna (L1/L2)
4	Power, data & signals connector P1 (male,	14	Model 503 GPSAntenna (L1/L2)
	64-pin, 0.1", DIN 41612, Type B, right-angle)	15	Model 512 GPSAntenna (L1/L2)
5	Status LEDs (green and red)	16	Model 501 GPSAntenna (L1 Only)
6	LNA power jumper P301 (see *Figure 4, Page 21*)	17	Model 511 GPSAntenna (L1 Only)
7	+5 V DC primary power (2 pins)	18	Model 521 GPSAntenna (L1 Only)
8	Optional LNA; DC power (1 pin)	19	Model 531 GPSAntenna (L1 Only)

* To antenna via interconnecting coaxial cable. High quality coaxial cable should be used because a mismatch in impedance, possible with lower quality cable, produces reflections in the cable that increases signal loss.

MINIMUM CONFIGURATION

In order for the MiLLennium to perform optimally, the following additional equipment is required:

- NovAtel GPSAntenna (model will depend on application)
- NovAtel coaxial cable (note that a conversion is required between the male SMB connector on the MiLLennium and the female TNC connector on a GPSAntenna)
- A regulated power supply providing +5 V DC (see *Appendix B, Page 33)* for power regulation specifications)
- A 64-pin 0.1" DIN 41612 Type B female connector as an interface for power, communications and signals
- Data communications equipment capable of RS-232C serial communications

ANTI-STATIC PRECAUTIONS

Electrostatic discharge (ESD) is a leading cause of failure of electronic equipment components and printed circuit boards containing ESD-sensitive devices and components. It is imperative that ESD precautions be followed when handling or installing the MiLLennium printed circuit board. See *Appendix A, Page 31* for more information on ESD precautions.

Leave the MiLLennium in its anti-static packaging when not connected in its normal operating environment. When removing the MiLLennium from the ESD-protective plastic clamshell, follow accepted standard anti-static practices. Failure to do so may cause damage to the MiLLennium.

When you remove the MiLLennium from the original packing box, it is recommended that you save the box and ESD protective plastic clamshell for future storage or shipment purposes.

REMEMBER !

- Always wear a properly grounded anti-static wrist strap when handling the MiLLennium.
- Always hold the MiLLennium by its corners or the RF backplane, and avoid direct contact with any of the components.
- Do not let the MiLLennium come in contact with clothing at any time because the grounding strap cannot dissipate static charges from fabrics.
- Failure to follow accepted ESD handling practices could cause damage to the MiLLennium.
- Warranty may be voided if equipment is damaged by ESD.

INSTALLATION PROCEDURE

Installing the MiLLennium typically consists of the following:

1. mounting the MiLLennium in a secure enclosure to reduce environmental exposure, RF interference, and vibration effects
2. pre-wiring the I/O harness and the 64-pin DIN female connector for power and communications, then connecting them to the MiLLennium
3. installing the GPSAntenna, then connecting it to the MiLLennium (see *Page 14*)
4. installing an optional external oscillator (see *Page 17*)

MOUNTING THE PRINTED CIRCUIT BOARD

Because the MiLLennium is an OEM product, the printed circuit board is not enclosed in a housing structure. This allows flexibility in creating a mounting environment to suit particular product and marketing requirements. The mounting and enclosure must provide the following:

- mounting of external connectors

- protection from hostile physical environments (e.g. rain, snow, sand, salt, water, extreme temperatures)
- protection from vibration conditions
- electromagnetic shielding to protect from hostile RF environments (e.g. nearby transmitters)
- electromagnetic shielding so that the final product itself conforms to RF emissions guidelines
- protection from ESD

The MiLLennium card can be held in place by screws, card rails, or both. Please see *Appendix B, Page 33* for mechanical drawings.

PREPARING THE DATA, SIGNAL & POWER HARNESS

The wiring harness provides the following interconnect functions:

- access to COM1 and COM2 serial communications ports
- access to input and output timing strobes
- power input(s)
- access to control signals

A 64-pin / 0.1" / DIN 41612 / Type B / female connector (e.g. Harting #0902 164 6825, #0902 264 6828, or equivalent) is required to interface with connector P1 on the MiLLennium (see *Figure 3 Typical System Configuration, Page 18*). The connectors you choose for interfacing to the power source(s), COM ports, and strobes will depend on your external equipment requirements. *Appendix E, EDGE-VIEW OF CONNECTOR P1, Page 65* shows the pin names and locations on connector P1.

Note: See *Appendix B, MILLENNIUM TECHNICAL , Page 33* for descriptions of the function of each connector pin.

A MiLLennium GPSCard can function with the same 64-pin connector built for an OEM2 GPSCard (NovAtel's second generation receiver), which makes the upgrade simple. However, an OEM2 GPSCard will *not* function with a connector built for a MiLLennium; this is because several pins on the OEM2 GPSCard are no longer used on the MiLLennium, as shown in *Table 2:*

Table 2   Disabled OEM2 Connector Pins

OEM2 Signal Name	Connector Pin
-12 VDC	3 A
+12 VDC	3 B
SELA1	5 B
SELB1	6 B
NMEA Opto 1	7 B
TXD1(-)/NULL	8 B
SELA2	13 B
SELB2	14 B
NMEA Opto 2	15 B
TXD2(-)/NULL	16 B

External Power

See *Appendix B, Page 33* for external power input connections:

- Digital ground → pins 1A/B (internally connected)
- Vcc, main power (+5 V DC) → pins 2A/B (internally connected)
- Optional external LNA power → pin 4B (≤ 30 V DC) and 4A (GND)

Note: See *Appendix B, Page 33* for specifications concerning external power inputs.

The MiLLennium requires only one regulated power input of Vcc = +5 V DC

It is possible to supply power to the LNA on an active antenna either from the MiLLennium or from an external source. The MiLLennium is factory-configured for operation with any of the GPSAntenna models, in which case no special wiring or configuration is required: the P301 jumper (see *Figure 4*) is normally set for <u>internal</u> operation (pins 1 and 2). The MiLLennium's internal antenna power supply can produce 4.25 - 5.25 V DC at up to 90 mA. If the antenna draws more than 90 mA of current, power to the antenna will be disabled and the antenna self-test status flag set to zero; refer to the RVSA/B log in the *MiLLennium Command Descriptions Manual* for self-test status codes.

Figure 4   LNA Power Jumper P301 – 3 Cases
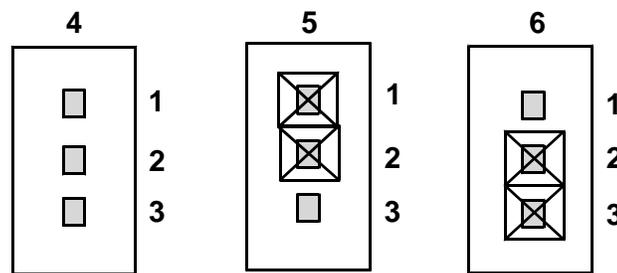
Reference	Description
1	Pin 1
2	Pin 2
3	Pin 3
4	Case 1: No power to LNA
5	Case 2: Internal power source (default)
6	Case 3: External power source

If a different antenna is used whose LNA requires voltage and/or current capacity beyond what the MiLLennium can produce, then the external LNA power option must be utilized - this requires that P301 must be jumpered between pins 2 and 3. The input cannot exceed +30 V DC at 100 mA. When the LNA jumper plug is in the external position, the antenna sensing circuit will cause the self-test status code to always report antenna status as 1 (good). Refer to the RVSA/B log in the *MiLLennium Command Descriptions Manual* for self-test status codes.

If no LNA power required, remove the jumper at P301 completely.

Table 3   Antenna LNA Power Configuration

	P301: plug connects pins 1&2	P301: plug connects pins 2&3	P301: no plug
ANTENNAPOWER = ON	internal power connected to LNA	no external effect	no external effect
ANTENNAPOWER = OFF	internal power cut off from LNA	no external effect	no external effect

The setting of this command will also affect the way the MiLLennium's self-test diagnostics report the antenna's status; please refer to the description of the ANTENNAPOWER command in the *MiLLennium Command Descriptions Manual*.

CAUTION !

- The P301 jumper plug must be jumpered to the external position (pins 2 and 3) <u>before</u> external LNA power is connected to pin 4B of the 64-pin wire harness connector to prevent power from feeding back into the receiver.
- Should it be necessary, due to an extended-length antenna cable, to supply external power to a GPSAntenna or to use an optional in-line LNA amplifier, be careful not to exceed the voltage ratings of either the antenna or LNA.
- No guarantee is made that the MiLLennium will meet its performance specifications if a non-NovAtel antenna is used.

It is recommended that appropriate fuses or current limiting be incorporated as a safety precaution on all power lines used. Use a sufficient gauge of wire to ensure that the voltage at the 64-pin connector is within the MiLLennium's requirements.

RS232C Communications

The MiLLennium is capable of communications in EIA RS232C serial data format via two ports, COM1 and COM2. See *Appendix B, Page 33* for data connections:

- COM1 → pins 7 - 11, A & B
- COM2 → pins 15 - 19, A & B

Each port has a ground connection, and supports the following signals:

- Data Terminal Ready (DTR)
- Clear To Send (CTS)
- Transmitted Data (TXD)
- Request To Send (RTS)
- Received Data (RXD)
- Data Set Ready (DSR)
- Data Carrier Detect (DCD)

The port settings (bit rate, parity, etc.) are software-configurable. These are further described in *Chapter 4*.

Note: See *Appendix B, Page 33* for further information on data communications characteristics.

Strobe Signals

The MiLLennium has 5 TTL-compatible I/O strobe lines. See *Appendix B, Page 33* for strobe signal connections:

- Variable-Frequency (VARF) Output → Pin 21B
- One Pulse per Second (PPS) Output → Pin 22B
- Measure Output → Pin 23B
- Mark Input → Pin 24B
- Status Output → Pin 25B

Note: See *Appendix B* for further information on I/O strobe characteristics.

---

4 OPERATION

Before operating the receiver for the first time, ensure that you have followed the installation instructions in *Chapter 3*. The following instructions are based on a configuration such as that shown in *Figure 5*.

Figure 5   Typical Operational Configuration
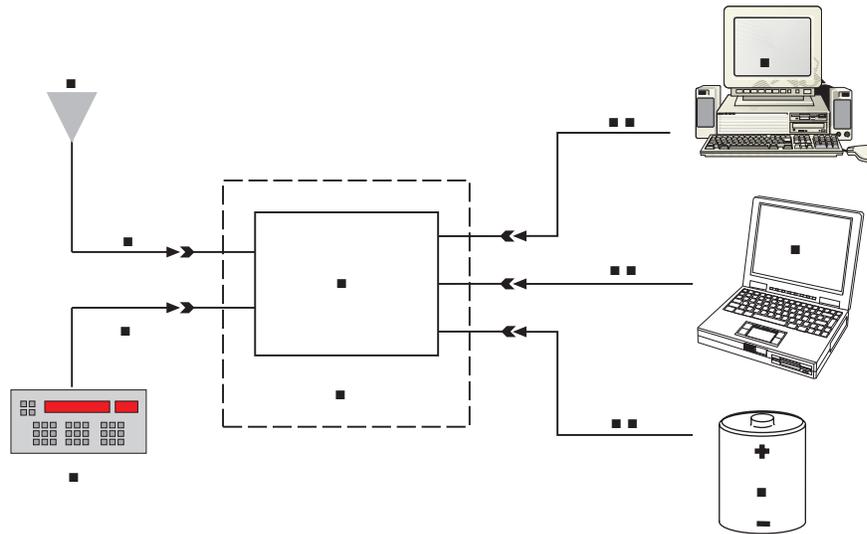
Reference	Description	Reference	Description
1	MiLLennium GPSCard	7	Optional external oscillator
2	Enclosure	8	GPS signal
3	GPSAntenna	9	Clock signal
4	Command source or reference station	10	COM1
5	Data logger or remote station	11	COM2
6	External power source	12	Power

COMMUNICATIONS WITH THE RECEIVER

Communication with the receiver is straightforward, and consists of issuing commands through the COM1 or COM2 port from an external serial communications device. This could be either a terminal or an IBM-compatible PC that is directly connected to a receiver serial port using a null modem cable. For specific information about any of the GPSCard commands and logs, please consult the *MiLLennium Command Descriptions Manual*.

It is assumed that a personal computer is used during the initial operation and testing for greater ease and versatility. Furthermore, it should be understood that communication between the MiLLennium and a computer is achieved by virtue of the GPS firmware that resides within the MiLLennium.

SERIAL PORT DEFAULT SETTINGS

The receiver communicates with your PC or terminal via the COM1 or COM2 serial port. For communication to occur, both the receiver and the operator interface have to be configured properly. The receiver's default port settings are as follows:

• RS232C, 9600 bps, no parity, 8 data bits, 1 stop bit, no handshaking, echo off

Changing the default settings requires using the *COMn* command, which is described in the *MiLLennium Command Descriptions Manual*. It is recommended that you become thoroughly familiar with these commands and logs to ensure maximum utilization of the receiver's capabilities.

Note: Although the receiver can operate at bit rates as low as 300 bps, this may not always be desirable. For example, if several data logs are active (i.e. a significant amount of information needs to be transmitted every second) but the bit rate is set too low, data will overflow the serial port buffers and cause an error condition in the receiver status.

COMMUNICATING USING A REMOTE TERMINAL

One method of communicating with the receiver is through a remote terminal. The receiver has been pre-wired to allow proper RS232C interface with your data terminal. To communicate with the terminal the receiver only requires the RX, TX, and GND lines to be used; handshaking is not required, although it can optionally be used. Ensure that the terminal's communications set-up matches the receiver RS232C protocol.

COMMUNICATING USING A PERSONAL COMPUTER

An IBM-compatible PC can be set up to emulate a remote terminal as well as provide the added flexibility of creating multiple-command batch files and data logging storage files. Any standard communications software package that emulates a terminal can be used to establish bi-directional communications with the receiver.

One can create command batch files using any text editor; these can then be directed to the serial port that is connected to the receiver using a communications software package. This is discussed in greater detail later in this chapter.

GETTING STARTED

Included with your receiver are NovAtel's *GPSolution* and *Convert* programs, together with their user documentation. *GPSolution* is a Microsoft Windows-based graphical user interface that allows you to access the receiver's many features without struggling with communications protocol or writing special software. *GPSolution* automatically recognizes the model of receiver that you are using and adjusts the displays accordingly. *Figure 6* shows a sample *GPSolution* screen. The *Convert* utility is a Windows-based utility that allows you to convert between file formats, and strips unwanted records for data file compilation.

Figure 6   Sample GPSolution Screen
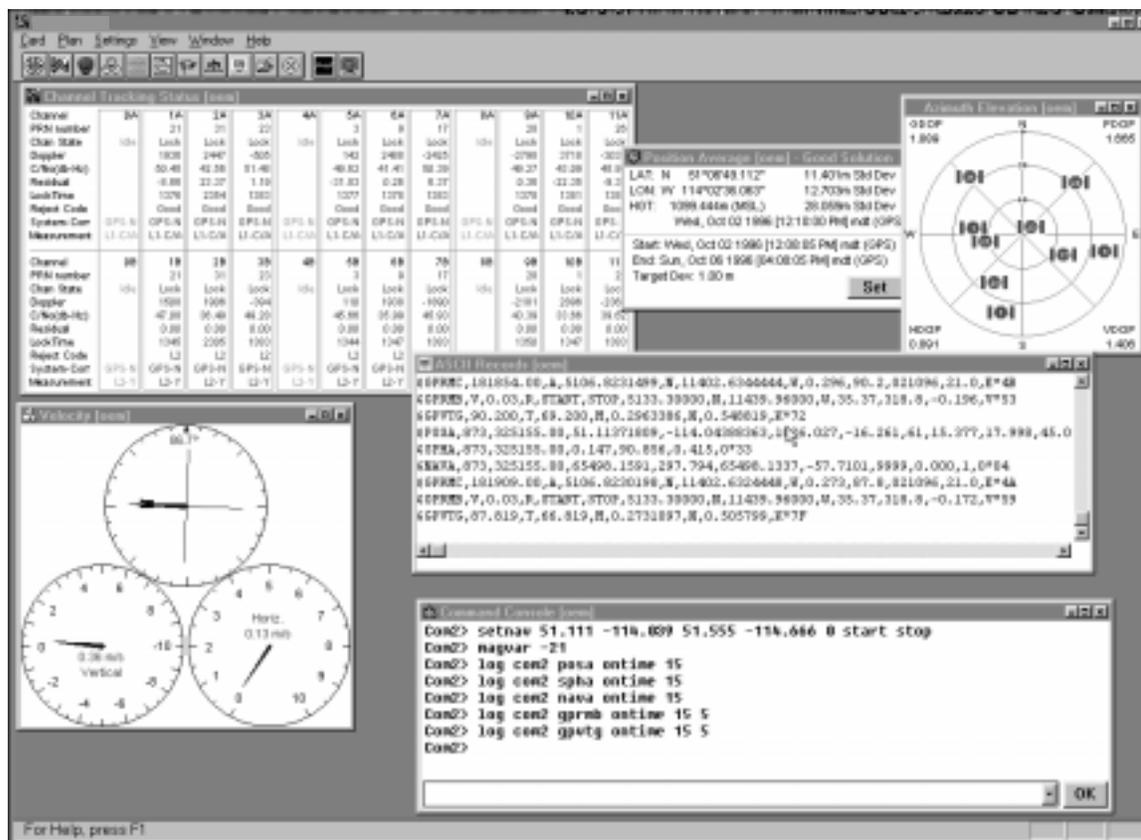
GPSolution is provided to facilitate your interaction with the receiver. However, it certainly is possible to communicate with it through DOS or a Windows-based communications program; this is discussed in greater detail later in this section.

POWER ON

The receiver's software resides in read-only memory. As such, the unit "self-boots" upon power-up and undergoes a complete self-test. If an error condition is detected during a self-test, the self-test status word would change; this self-test status word can be viewed in the RGEA/B/D and RVSA/B data output logs (please refer to the *MiLLennium Command Descriptions Manual*). If a persistent error develops, please contact NovAtel Customer Service.

When the receiver is first powered up, no activity information is transmitted from the COM ports except for the port prompt; the external data communications equipment screen will display one of these two messages:

    Com1> *if connected to COM1 port*,

or

    Com2> *if connected to COM2 port*

Either prompt indicates that the receiver is ready and waiting for command input.

Commands are typed at the interfacing terminal's keyboard, and sent after pressing the terminal's *Return* or *Enter* key.

Note: Most valid commands do not echo a response to a command input; the indication that they have been accepted is a return of the port prompt from the receiver. VERSION, HELP and ? are the only commands that do provide a data response other than the port prompt.

Example:

An example of no echo response to an input command is the FIX HEIGHT command. It can be entered as follows:

```
COM2>fix height 550 [Return]
COM2>
```

The above example illustrates command input to the receiver COM1 port which sets the receiver antenna height as fixed to 550 m above sea level and causes position solutions to be constrained as 2D with height fixed. However, your only confirmation that the command was actually accepted is the return of the **COM2>** prompt.

If a command is incorrectly entered, the receiver will respond with "Invalid Command Name" (or a more detailed error message) followed by the port prompt.

After initial boot up, you may find the following logs useful for observing the receiver activities. While *GPSolution* is the easiest way to do this, you can also use DOS or a Windows-based communications program; examples of both are provided below.

- Use the RCCA log to list the default command settings. After the receiver has been operational for a while, the RCCA log will be useful for indicating status of all current command settings. Displaying the RCCA log after a RESET will show the saved configuration (refer to the SAVECONFIG command in the *MiLLennium Command Descriptions Manual* for more information).
- Use the ETSA log to monitor the channel tracking status.
- Use the SATA log to observe the satellite specific data.
- Use the POSA log to observe the current computed position solutions.
- Use the DOPA log to monitor the dilution of precision of the current satellite constellation.
- Use the RVSA log to monitor the receiver status.
- Use the HELP command to list all available commands.
- Use the HELP LOG command to list all available logs.

Refer to the *MiLLennium Command Descriptions Manual* for procedures and explanations related to data logging.

DOS

One way to initiate multiple commands and logging from the receiver is to create DOS boot-up command files relating to specific functions. This will save time when you want to duplicate test situations and minimize set-up time. Any convenient text editor can be used to create command text files.

Example:

For this example, consider a situation where a PC's appropriately-configured COM1 port is connected to the receiver's COM1 port, and where a remote terminal is connected to the receiver's COM2 port. The PC user wishes to monitor the receiver's activity; the following command file could be used to do this.

1.   Open a text editor on the PC and type in the following command sequences:

```
log com2 sata ontime 15
log com2 etsa ontime 15
log com2 rvsa ontime 60 5
log com2 posa ontime 15
log com2 dopa ontime 15
```

2.   Save this with a convenient file name (e.g. C:\GPS\BOOT1.TXT) and exit the text editor.

3.   Use the DOS *copy* command to direct the contents of the BOOT1.TXT file to the PC's COM1 port:

```
C:\GPS>copy boot1.txt com1
1 files(s) copied
C:\GPS>
```

4.   The receiver is now initialized with the contents of the BOOT1.TXT command file, and logging is directed from the receiver's COM2 port to the remote terminal.

MICROSOFT WINDOWS 3.1 OR HIGHER

As any text editor or communications program can be used for these purposes, the use of Windows 95 is described only as an illustration. The following example shows how Windows 95 accessory programs *Notepad* and *HyperTerminal* can be used to create a hypothetical waypoint navigation boot-file on a PC, and send it to the receiver. It is assumed that the PC's serial port COM1 is connected to the receiver's COM1 port, and that a remote terminal is connected to the receiver's COM2 port.

Example:

1.   Open *Notepad* and type in the following command text:

```
setnav 51.111 -114.039 51.555 -114.666 0 start stop
magvar -21
log com1 posa ontime 15
log com1 spha ontime 15
log com1 nava ontime 15
log com2 gprmb ontime 15 5
log com2 gpvtg ontime 15 5
log com2 rcca ontime 60
```

2.   Save this with a convenient file name (e.g. C:\GPS\BOOTNAV1.TXT) and exit *Notepad*.

3.   Ensure that the *HyperTerminal* settings are correctly set up to agree with the receiver communications protocol; these settings can be saved (e.g. C:\GPS\OEMSETUP.HT) for use in future sessions. You may wish to use XON / XOFF handshaking to prevent loss of data.

4.   From the *Transfer* menu, use the *Send text file* selection to locate this file to be sent to the receiver. Once you double-click on the file or select *Open*, *HyperTerminal* will send the file to the receiver.

The above example initializes the receiver with origin and destination waypoint coordinates and sets the magnetic variation correction to -21 degrees. The POSA, SPHA, and NAVA logs have been set to output from the receiver COM1 port at intervals of once every 15 seconds, whereas the GPRMB and GPVTG NMEA logs have been set to be logged out of the receiver COM2 port at intervals of 15 seconds and offset by five seconds. The RCCA log has been set to output every 60 seconds from the receiver COM2 port.

5 *FIRMWARE UPGRADES & UPDATES*

The MiLLennium stores its program firmware in non-volatile memory, which allows you to perform firmware upgrades and updates without having to return the MiLLennium to the distributor. New firmware can be transferred to the MiLLennium through a serial port, and the unit will immediately be ready for operation at a higher level of performance.

The first step in upgrading your receiver is to contact your local NovAtel dealer. Your dealer will assist you in selecting the best upgrade option that suits your specific GPS needs. If your needs are still unresolved after seeing your dealer then you can contact NovAtel directly through any of the methods described in the *Customer Service* section, *Page 6*, at the beginning of this manual.

When you call, be sure to have available your MiLLennium model number, serial number, and program revision level. This information is printed on the original shipping box as well as on the back side of the MiLLennium itself. You can also verify the information by issuing the VERSION command at the port prompt.

After establishing which new model/revision level would best suit your needs, and having described the terms and conditions, you will be issued with an authorization code (*auth-code*). The auth-code is required to unlock the new features according to your authorized upgrade/update model type.

There are two procedures to choose from, depending on the type of upgrade/update you require:

1. If you are *upgrading* to a higher performance model at the same firmware revision level (e.g. upgrading from a MiLLennium Standard rev. 4.50, to a MiLLennium RT-2 rev. 4.50), you can use the $AUTH special command.

2. If you are *updating* to a higher firmware revision level of the same model (e.g. updating a MiLLennium Standard rev. 4.45 to a higher revision level of the same model, such as MiLLennium Standard rev. 4.50), you will need to transfer new program firmware to the MiLLennium using the *Loader* utility program. As the *Loader* and update programs are generally provided in a compressed file format, you will also be given a file decompression password. The *Loader* and update files can be found on NovAtel's FTP site at http:\\www.novatel.ca, or can be sent to you on floppy disk or by e-mail.

Your local NovAtel dealer will provide you with all the information that you require to update or upgrade your receiver.

UPGRADING USING THE $AUTH COMMAND

The $AUTH command is a special input command which authorizes the enabling or unlocking of the various model features. Use this command when upgrading to a higher performance MiLLennium model available within the same revision level as your current model (e.g., upgrading from a MiLLennium Standard rev. 4.50, to a MiLLennium RT-2 rev. 4.50). This command will only function in conjunction with a valid auth-code assigned by GPS Customer Service.

The upgrade can be performed directly from Loader's built-in terminal emulator, *GPSolution's* Command Line Screen, or from any other communications program. The procedure is as follows:

1) Power-up the MiLLennium and establish communications over a serial port (see *Chapter 4, O, Page 23*)

2) Issue the VERSION command to verify the current firmware model number, revision level, and serial number.

3) Issue the $AUTH command, followed by the auth-code and model type. The syntax is as follows:

   Syntax:

       $auth *auth-code*

where

    $auth   is a special command which allows program model upgrades

    auth-code   is the upgrade authorization code, expressed as *hhhh,hhhh,hhhh,hhhh,hhhh,model#* where the *h* characters are an ASCII hexadecimal code, and the *model#* would be ASCII text

Example:

```
$auth 17cb,29af,3d74,01ec,fd34,millenrt2
```

Once the $AUTH command has been executed, the MiLLennium will reboot itself. Issuing the VERSION command will confirm the new upgrade model type and version number.

UPDATING USING THE LOADER UTILITY

Loader is required (instead of the $AUTH command) when updating previously released firmware with a newer version of program and model firmware (e.g., updating a MiLLennium Standard rev. 4.45 to a higher revision level of the same model, such as MiLLennium Standard rev. 4.50). *Loader* is a DOS utility program designed to facilitate program and model updates. Once *Loader* is installed and running, it will allow you to select a host PC serial port, bit rate, directory path, and file name of the new program firmware to be transferred to the MiLLennium.

TRANSFERRING FIRMWARE FILES

To proceed with your program update, you must first acquire the latest firmware revision. You will need a file with a name such as OEMXYZ.EXE (where XYZ is the firmware revision level). This file is available from NovAtel's FTP site (http:\\www.novatel.ca), or via e-mail (support@novatel.ca). If transferring is not possible, the file can be mailed to you on floppy disk. For more information on how to contact NovAtel Customer Service please see *Page 6* at the beginning of this manual.

You will need at least 1 MB of available space on your hard drive. For convenience, you may wish to copy this file to a GPS sub-directory (e.g., `C:\GPS\LOADER`).

The file is available in a compressed format with password protection; Customer Service will provide you with the required password. After copying the file to your computer, it must be decompressed. The syntax for decompression is as follows:

Syntax:

    [*filename*] -s[*password*]

where

    filename   is the name of the compressed file (but not including the .EXE extension)

    -s   is the password command switch

    password   is the password required to allow decompression

Example:

```
oem442 -s12345678
```

The self-extracting archive will then generate the following files:

- LOADER.EXE   *Loader* utility program
- LOADER.TXT   Instructions on how to use the *Loader* utility
- XYZ.BIN   Firmware version update file, where XYZ = program version level (e.g. 442.BIN)

USING THE LOADER UTILITY

The *Loader* utility can operate from any DOS directory or drive on your PC. The program is comprised of three parts: *Program Card* (authorization procedure), *Setup* (communications configuration) and *Terminal* (terminal emulator). The main screen is shown in *Figure 7.*

Figure 7   Main screen of LOADER program

If you are running *Loader* for the first time, be sure to access the *Setup* menu (step 3 below) before proceeding to *Program Card* (step 4 below); otherwise, you can skip step 3. The procedure is as follows:

1. Turn off power to the MiLLennium.

2. Start the *Loader* program.

3. From the main menu screen, select **Setup** to configure the serial port over which communication will occur (default: COM1) , and the data transfer rates for both programming (default: 115 200 bits per second) and terminal emulation (default: 9600 bps). To minimize the time required, select the highest serial bit rate your PC can reliably support. *Loader* will verify and save your selections in a file named LOADER.SET, and return to the main menu screen.

4. From the main screen, select **Program Card.**

5. Select the disk drive (e.g., A, B, C, D) in which the update file (e.g. 442.BIN) is located. Select the path where the update program file is located (e.g., C:\GPS\LOADER); the directory from which you started *Loader* is the default path. Select the required update file (e.g. 442.BIN).

6. At the prompt, enter your update auth-code (e.g. 17b2,32df,6ba0,92b5,e5b9,millenrt2).

7. When prompted by the program, turn on power to the MiLLennium. *Loader* will automatically establish communications with the MiLLennium. The time required to transfer the new program data will depend on the bit rate, which was selected earlier.

8. When the transfer is complete, use a terminal emulator such as that in Loader (select **Terminal**) to issue the VERSION command; this will verify your new program version number. When using the terminal emulator in *Loader*, a prompt does not initially appear; you need to enter the command first, which then produces a response, after which a prompt will appear.

9. Exit *Loader* (select **Quit**).

This completes the procedure required for field-updating a MiLLennium.

A ANTI-STATIC PRACTICES

OVERVIEW

Static electricity is electrical charge stored in an electromagnetic field or on an insulating body. This charge can flow as soon as a low-impedance path to ground is established. Static-sensitive units can be permanently damaged by static discharge potentials of as little as 40 volts. Charges carried by the human body, which can be thousands of times higher than this 40 V threshold, can accumulate through as simple a mechanism as walking across non-conducting floor coverings such as carpet or tile. These charges may be stored on clothing, especially when the ambient air is dry, through friction between the body and/or various clothing layers. Synthetic materials accumulate higher charges than natural fibers. Electrostatic voltage levels on insulators may be very high, in the order of thousands of volts.

Various electrical and electronic components are vulnerable to electrostatic discharge (ESD). These include discrete components, hybrid devices, integrated circuits (ICs), and printed circuit boards (PCBs) assembled with these devices.

RECOMMENDATIONS FOR HANDLING ESD-SENSITIVE DEVICES

ESD-sensitive devices must only be handled in static-controlled locations. Some recommendations for such handling practices follow:

- Handling areas must be equipped with a grounded table, floor mats, and wrist or ankle straps.
- A relative humidity level must be maintained between 20% and 80% non-condensing.
- No ESD-sensitive board or component should be removed from its protective package, except in a static-controlled location.
- A static-controlled environment and correct static-control procedures are required at both repair stations and maintenance areas.
- ESD-sensitive devices must be handled only after personnel have grounded themselves via wrist or ankle straps and mats.
- Boards or components should never come in contact with clothing, because normal grounding cannot dissipate static charges on fabrics.
- A circuit board must be placed into an anti-static plastic clamshell before being removed from the work location and must remain in the clamshell until it arrives at a static-controlled repair/test center.
- Circuit boards must not be changed or moved needlessly. Handles or finger holes may be provided on circuit boards for use in their removal and replacement; care should be taken to avoid contact with the connectors and components.
- On-site repair of ESD-sensitive equipment should not be undertaken except to restore service in an emergency where spare boards are not available. Under these circumstances repair station techniques must be observed. Under normal circumstances a faulty or suspect circuit board must be sent to a repair center having complete facilities, or to the manufacturer for exchange or repair.
- Where protective measures have not been installed, a suitable alternative would be the use of a Portable Field Service Grounding Kit. This consists of a portable mat and wrist strap which must be attached to a suitable ground.
- A circuit board in a static-shielding bag or clamshell may be shipped or stored in a cardboard carton, but the carton must not enter a static-controlled area such as a grounded or dissipative bench top or repair zone. Do not place anything else inside the bag (e.g. repair tags).
- Treat all PCBs and components as ESD sensitive. Assume that you will damage the PCB or component if you are not ESD conscious.
- Do not use torn or punctured static-shielding bags. A wire tag protruding through the bag could act as a "lightning rod", funneling the entire charge into the components inside the bag.
- Do not allow chargeable plastics , such as binders, within 0.6 m of unshielded PCBs.
- Do not allow a PCB to come within 0.3 m of a computer monitor.

PRIME STATIC ACCUMULATORS

Table 4 provides some background information on static-accumulating materials.

Table 4	Prime Static Accumulators
Work Surfaces	• formica (waxed or highly resistive) • finished wood • synthetic mats • writing materials, note pads, etc.
Floors	• wax-finished • vinyl
Clothes	• common cleanroom smocks • personal garments (all textiles except virgin wool) • non-conductive shoes
Chairs	• finished wood • vinyl • fiberglass
Packing and handling	• common polyethylene bags, wraps, envelopes, and bubble pack • pack foam • common plastic trays and tote boxes
Assembly, cleaning, test and repair areas	• spray cleaners • common solder sucker • common solder irons • common solvent brushes (synthetic bristles) • cleaning, drying and temperature chambers

HANDLING PRINTED CIRCUIT BOARDS

ESD damage to unprotected sensitive devices may occur at any time. ESD events can occur far below the threshold of human sensitivity. Follow this sequence when it becomes necessary to install or remove a circuit board:

1. After you are connected to the grounded wrist strap, remove the circuit board from the frame and place it on a static-controlled surface (grounded floor or table mat).
2. Remove the replacement circuit board from the static-shielding bag or clamshell and insert it into the equipment.
3. Place the original board into the shielding bag or clamshell and seal it with a label.
4. Do not put repair tags inside the shielding bag or clamshell.
5. Disconnect the wrist strap.

B MILLENNIUM TECHNICAL SPECIFICATIONS

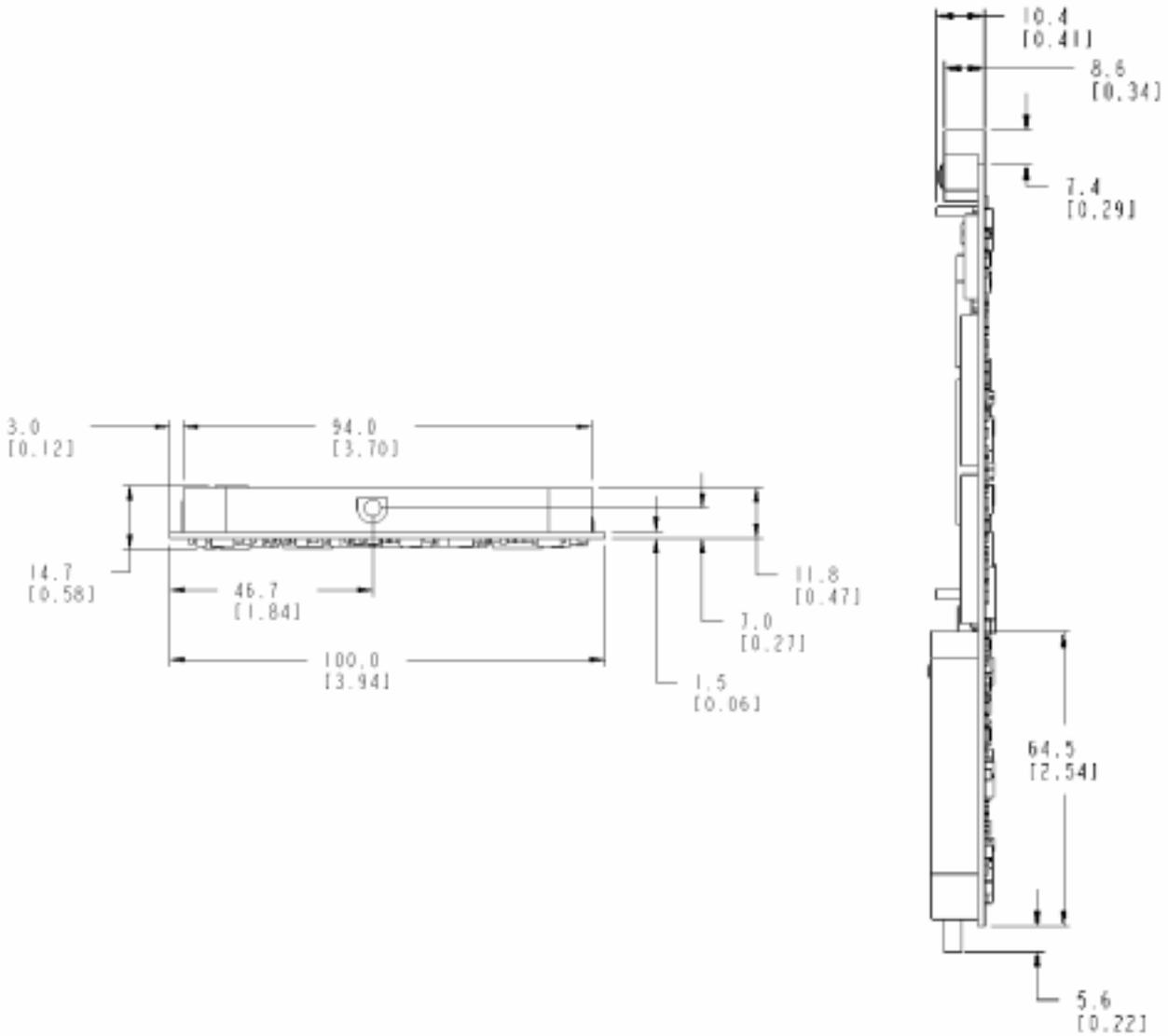| PHYSICAL	
Size	100.00 x 179.9 x 14.7 mm with connector; Eurocard format
Weight	175 grams
MECHANICAL DRAWINGS	

Figure 8   MiLLennium Board Dimensions
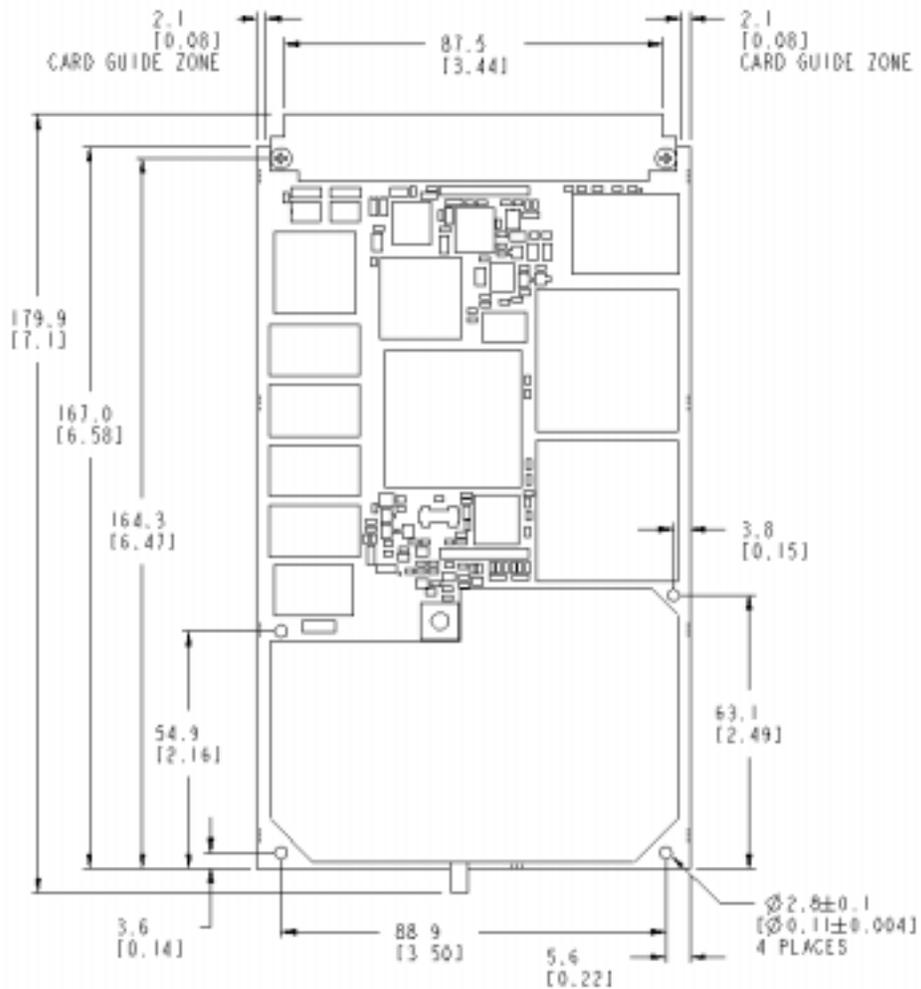
Units: millimeters [inches]

MECHANICAL DRAWINGS (CONTINUED)

Figure 9   L1/L2 Series Side & End Views

Units: millimeters [inches]

ENVIRONMENTAL

Operating Temperature	-40° C to +85° C
Storage Temperature	-45°C to +95°C
Humidity	95% non-condensing (max.)
Altitude	Sea level to 5000 m [may operate above 5000 m in a controlled environment, however is not certified as such]

VIBRATION (Random Profile)						
The MiLLennium will acquire and track satellites while undergoing vibration levels as shown below. This assumes that it is mounted using full-length clamped rail mounts and that no vibrating object is touching it. It also assumes that C/N_O > 45 dB-Hz and that the MiLLennium is in high-dynamics mode. Although not all MiLLennium GPSCards conform to random vibration templates for RTCA/DO-160C, Section 8.6.2 (Curve C template), MIL-STD-202F, Test Condition I (Letter A nominal template), and ASAE EP455, Section 5.15.1 nominal template, many do. It is possible to purchase a pre-screened MiLLennium GPSCard to meet these vibration requests if required. Please consult NovAtel Customer Service for further information. Note that a MiLLennium GPSCard in a PowerPak II or ProPak II enclosure does conform.						
Frequency	< 10 Hz	10 Hz	40 Hz	1000 Hz	2000 Hz	> 2000 Hz
Magnitude (g^2/Hz)	+ 80 dB/decade	0.00125	0.02	0.02	0.005	- 80 dB/decade
Typical Mounting Configuration - Mount the GPSCard securely using screws driven through the card's four corner mounting holes. **Superior Mounting Configuration** - Mount the card using full length clamped rail mounts. Note: The card is sensitive to any external vibration against it.						

ACCELERATION	
Acceleration	6g maximum (sustained tracking)

POWER REQUIREMENTS	
Voltage	4.875 - 5.250 V DC
Allowable voltage ripple	75 mV p-p (max.)
Power	6.75 W (typ.), 7.5 W (max.)

POWER & DATA CONNECTOR ON THE MILLENNIUM	
Connector on MiLLennium	64 pin 0.1" DIN 41612 Type B male right-angle

EXTERNAL CLOCK INPUT ON THE MILLENNIUM	
Connector on MiLLennium	SMB male jack
External Clock Input	Frequency: 5 MHz or 10 MHz CW Input Impedance: 50 Ω nominal Input VSWR: 2.0:1 Signal Level: 4.0 dBm minimum to 10.0 dBm maximum Freq. stability: ±0.5 ppm maximum

RF Input / LNA Power Output		
Connector on MiLLennium	SMB right-angle male jack	
RF Input	1575.42 MHz, 1227.60 MHz	
LNA Power Output		LNA power output is determined by the LNA jumper plug P301 position (internal/external)
	Internal	4.25 - 5.25 V DC @ 0 - 90 mA (current limit 120 $\pm$ 30 mA)
	External	$\leq$ 30 V DC, 100 mA max. (user-supplied)

MiLLen-3151R Performance *(Subject To GPS System Characteristics)*		
Position Accuracy	Standalone	
	SA off	15 m CEP
	SA on	40 m CEP
	Code differential	0.75 m CEP
Post Processed		±5 mm + 1 ppm
Time To First Fix	Cold start	70 s (typical)
Reacquisition	Warm start	1 s (typical)
Data Rates	Raw measurement	20 Hz
	Computed position	10 Hz
Time Accuracy	SA off	50 ns RMS
	SA on	250 ns RMS
Velocity Accuracy	Standalone	0.20 m/s RMS
	Differential	0.03 m/s RMS
Measurement Precision	C/A code phase	10 cm RMS
	Carrier phase	
	Single channel	3 mm RMS
	Differential channel	0.75 mm RMS
Dynamics	Acceleration	6 g
	Velocity	515 m/s max.

MiLLen-3151W Performance *(Subject To GPS System Characteristics)*		GPS Only	GPS + WAAS
Position Accuracy	Standalone: SA on	42 m CEP	3.2 m CEP
	Differential: Code (RTCA/RTCM)	0.75 m CEP	0.75 m CEP
Time To First Fix	Cold start	70 s (typical)	70 s
Reacquisition	Warm start	1 s (typical)	3 s
Data Rates	Raw measurement	20 Hz	2 Hz
	Computed position	10 Hz	2 Hz
Time Accuracy	SA off (RMS)	50 ns	50 ns
	SA on (RMS)	250 ns	50 ns
Velocity Accuracy	Standalone (RMS)	0.20 m/s	0.20 m/s
	Differential (RMS)	0.03 m/s	0.03 m/s
Measurement Precision	C/A code phase (RMS)	10 cm	10 cm
	Carrier phase		
	Single channel (RMS)	3 mm	3 mm
	Differential channel (RMS)	0.75 mm	0.75 mm
Dynamics	Acceleration	6 g	6 g
	Velocity	515 m/s max.	515 m/s max.

MiLLen-RT20 Performance *(Subject To GPS System Characteristics)*		
Position Accuracy	Standalone	
	SA off	15 m CEP
	SA on	40 m CEP
	Code differential	0.75 m CEP
	RT-20 differential	0.20 m CEP
Post Processed		±5 mm + 1 ppm
Time To First Fix	Cold start	70 s (typical)
Reacquisition	Warm start	1 s (typical)
Data Rates	Raw measurement	20 Hz
	Computed position	10 Hz
Time Accuracy	SA off	50 ns RMS
	SA on	250 ns RMS
Velocity Accuracy	Standalone	0.20 m/s RMS
	Differential	0.03 m/s RMS
Measurement Precision	C/A code phase	10 cm RMS
	Carrier phase:Single channel	3 mm RMS
	Differential channel	0.75 mm RMS
Dynamics	Acceleration	6 g
	Velocity	515 m/s max.

MiLLen-RT2 Performance *(Subject To GPS System Characteristics)*		
Position Accuracy	Standalone	
	SA off	15 m CEP
	SA on	40 m CEP
	Differential	
	Code (L1, C/A)	0.75 m CEP
	RT-2	0.02 m CEP
Post Processed		±5 mm + 1 ppm
Time To First Fix	Cold start	70 s (typical)
Reacquisition	Warm start	1 s L1, 10 s L2 (typical)
Data Rates	Raw measurement	10 Hz
	Computed position	10 Hz
Time Accuracy	SA off	50 ns RMS
	SA on	250 ns RMS
Velocity Accuracy	Standalone	0.20 m/s RMS
	Differential	0.03 m/s RMS
Measurement Precision	C/A code phase	10 cm RMS
	L2 P code	40 cm RMS
	L1 carrier phase: Single channel	3 mm RMS
	Differential channel	0.75 mm RMS
	L2 carrier phase: Single channel	5 mm RMS
	Differential channel	4mm RMS
Dynamics	Acceleration	6 g
	Velocity	515 m/s

MiLLen-STD Performance *(Subject To GPS System Characteristics)*		
Position Accuracy	Standalone: SA off	15 m CEP
	SA on	40 m CEP
	Differential: Code (L1, C/A)	0.75 m CEP
Post Processed		±5 mm + 1 ppm
Time To First Fix	Cold start	70 s (typical)
Reacquisition	Warm start	1 s L1, 10 s L2 (typical)
Data Rates	Raw measurement	10 Hz
	Computed position	10 Hz
Time Accuracy	SA off	50 ns RMS
	SA on	250 ns RMS
Velocity Accuracy	Standalone	0.20 m/s RMS
	Differential	0.03 m/s RMS
Measurement Precision	C/A code phase	10 cm RMS
	L2 P code	40 cm RMS
	L1 carrier phase: Single channel	3 mm RMS
	Differential channel	0.75 mm RMS
	L2 carrier phase: Single channel	5 mm RMS
	Differential channel	4mm RMS
Dynamics	Acceleration	6 g
	Velocity	515 m/s

MiLLen-WAAS Performance *(Subject To GPS System Characteristics)*		**GPS Only**	**GPS + WAAS**
Codes Tracked		C/A & P	C/A & P
		12 L1/L2	10 L1/L2 & 1 WAAS
Position Accuracy	Standalone: SA on	42 m CEP	3.2 m CEP
	Differential: Code (RTCA/RTCM)	0.75 m CEP	0.75 m CEP
Time To First Fix	Cold start (typical)	70 s	70 s
Reacquisition	Warm start (typical)	3 s L1, 40 s L2	3 s L1, 40 s L2
Data Rates	Raw measurement	10 Hz	2 Hz
	Computed position	10 Hz	2 Hz
Time Accuracy	SA off or differential (RMS)	50 ns	50 ns
	SA on (RMS)	250 ns	50 ns
Velocity Accuracy	Standalone (RMS)	0.20 m/s	0.20 m/s
	Differential (RMS)	0.03 m/s	0.03 m/s
Measurement Precision	C/A code phase	10 cm RMS	10 cm RMS
	L2 P code	40 cm RMS	40 cm RMS
	L1 carrier phase: Single channel	3 mm RMS	3 mm RMS
	Differential channel	0.75 mm RMS	0.75 mm RMS
	L2 carrier phase: Single channel	5 mm RMS	5 mm RMS
	Differential channel	4mm RMS	4mm RMS
Dynamics	Acceleration	6 g	6 g
	Velocity	515 m/s	515 m/s

INPUT/OUTPUT DATA INTERFACE	
Dual RS-232C Serial	Bit rates: 300, 1200, 4800, 9600, 19200, 57600, 115200 bps (9600 bps default)
Signals supported	TX, RX, RTS, CTS, DTR, DSR, DCD
Electrical format	EIA RS232C Standard
INPUT/OUTPUT STROBES	
VARF Output	A programmable variable-frequency output ranging from 0.15 Hz - 5 MHz (refer to the FREQUENCY_OUT command in the *MiLLennium Command Descriptions Manual*), with pulse width from 100 ns to 6.55 ms. This is a normally high, active low pulse. There may be as much as 50 ns jitter on this signal.
PPS Output	A one-pulse-per-second time synchronization output. This is a normally high, active low pulse (1 ms $\pm$ 50 ns) where the falling edge is the reference.
Measure Output	Periodic output at the measurement rate, normally high, active low where the pulse width is 1 ms. The falling edge is the receiver measurement strobe.
Mark Input	An input mark (negative pulse > 55 ns), time tags output log data to the time of the falling edge of the mark input pulse (refer to LOG command syntax – ONMARK in the *MiLLennium Command Descriptions Manual*).
Status Output	Indicates a valid GPS position solution is available. A high level indicates a valid solution or that the FIX POSITION command has been set.
RESETOUT	Polarity- positive pulse ; 140 ms $\leq$ pulse duration $\leq$ 280 ms
\RESETIN	A high to low transition causes a system reset.
The electrical specifications of the strobe signals are as follows:	

Output	Voltage:	Standard TTL levels
	Sink Current:	64 mA
	Source Current:	15 mA
Input	Voltage:	Standard TTL levels
	Current:	$\leq$ 5 mA

Table 5   64 Pin I/O Connector Description

Row B	Descriptions	Pin	Row A	Descriptions
GND	Digital Ground	1	GND	Digital Ground
+5V	Input, power supply	2	+5V	Input, power supply
*	Reserved for future use	3	N/C	
LNA_PWR	Optional external power to antenna other than a standard NovAtel GPSAntenna (jumper plug P301 must be correctly set)	4	GND	Digital Ground
N/C		5	*	For factory use only
N/C		6	*	For factory use only
N/C		7	GND	Digital Ground
N/C		8	DTR1	Data Terminal Ready for COM 1
CTS1	Clear to Send for COM 1	9	TXD1	Transmitted Data for COM 1
RTS1	Request to Send for COM 1	10	RXD1	Received Data for COM 1
DSR1	Data Set Ready for COM 1	11	DCD1	Data Carrier Detected for COM 1
N/C		12	N/C	
N/C		13	*	For factory use only
N/C		14	*	For factory use only
N/C		15	GND	Digital Ground
N/C		16	DTR2	Data Terminal Ready for COM 2
CTS2	Clear to Send for COM 2	17	TXD2	Transmitted Data for COM 2
RTS2	Request to Send for COM 2	18	RXD2	Received Data for COM 2
DSR2	Data Set Ready for COM 2	19	DCD2	Data Carrier Detected for COM 2
N/C		20	N/C	
VARF Output	Variable-frequency pulse train; normally high, active low. The pulse width is from 100 ns to 6.55 ms. Frequency range: 0.15 Hz - 5 MHz.	21	GND	Digital Ground
PPS Output	Normally high, active low, 1 ms ± 50 ns pulse is output at 1 Hz (± 50 ns when clock steering on). Falling edge is used as the reference.	22	GND	Digital Ground
Measure Output	Normally high, active low pulse is 1 ms ± 50 ns wide. Falling edge is used as the reference.	23	GND	Digital Ground

Table 5 (continued)

Row B	Descriptions	Pin	Row A	Descriptions
Mark Input	Normally high, active low input pulse must exceed 55 ns in duration. The falling edge is the reference. TTL or contact closure compatible.	24	GND	Digital Ground
STATUS	High level output indicates 'good solution' or valid GPS position. Low level output indicates 'no solution'.	25	GND	Digital Ground
*	For factory use only	26	GND	Digital Ground
*	For factory use only	27	GND	Digital Ground
\ RESET_IN	Reset TTL signal input from external system; active low.	28	GND	Digital Ground
RESET_OUT	Reset TTL signal output to external system; active high; 140 - 280 ms duration.	29	GND	Digital Ground
*	For factory use only	30	GND	Digital Ground
*	For factory use only	31	GND	Digital Ground
*	Kept high; for factory use only	32	GND	Digital Ground

C POWERPAK II

ENCLOSURE, CONNECTORS AND INDICATORS

The PowerPak II mounting enclosure provides a protective environment for the MiLLennium. The mounting enclosure houses the internal power card, interconnect back plane, and front panel connections for COM1, COM2, strobes, GPSAntenna, external oscillator, and power input. There are two LEDs on the front panel: a red one to indicate the supply of power, and a green one to indicate when a valid position has been computed.

Note: The PowerPak II enclosure is not designed to protect the MiLLennium from environments that feature vibration, dust, moisture or extremes of temperature.

The enclosure is constructed of extruded aluminum. Each end of the enclosure is sealed with an end plate by four mounting screws. The front panel is shown in *Figure 10*.

Figure 10   PowerPak II Front Panel

PCB INTERCONNECT BACK PLANE

The interconnect back plane is a printed circuit board vertically mounted directly behind the PowerPak II front panel. Its purpose is to provide direct interconnection between the MiLLennium, power card, and the front panel input and output connections.

Except for a ground wire and two coaxial interconnect cables, all other input, output, and interconnect connectors are directly soldered to the back plane. The MiLLennium and power card connect directly to the back plane.

INTERNAL POWER CARD

The internal power card is a DC-to-DC power converter providing filtering, fuse protection, and voltage regulation for the MiLLennium. It accepts a single input voltage between the range of +10 to +36 V DC and converts it to the +5 V DC which the MiLLennium requires. The power input is reverse-polarity protected and is protected by a replaceable 2.5-amp fuse.

Note: The MiLLennium will suspend operation if the voltage supplied to the PowerPak II falls outside the input range of 10 to 36 V DC.

The power card is held in place by card guides located inside the mounting enclosure. It fits into the second slot from the bottom of the enclosure. It couples to the back plane by means of a special power connector.

CIGARETTE-LIGHTER POWER ADAPTER

The cigarette-lighter power adapter included with the PowerPak II supplies +12 V DC while operating from an automotive source. On the end of the cord which is inserted into the PowerPak II there is a retaining nut; it threads onto the socket to keep the plug from accidentally being pulled out. A replaceable 2.5-amp fuse is built into the assembly which is inserted into the cigarette lighter. The entire unit is shown in *Figure 11*.

Figure 11   Cigarette-Lighter Power Adapter
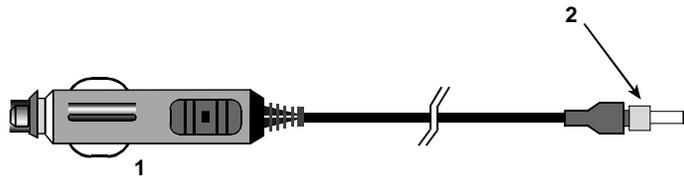
Reference	Description
1	Cigarette lighter adapter
2	Retaining nut

AC TO DC POWER CONVERTER (OPTIONAL)

An optional AC to DC power converter is available for the PowerPak II, which allows you to operate the unit from an AC outlet. The converter is autoranging to accommodate standard line voltages (110 to 220 V AC) and frequencies (50 to 60 Hz). It features a retaining nut on the connector that is inserted into the PowerPak II; when threaded onto the socket, it prevents the plug from accidentally being pulled out. Its output voltage is compatible with PowerPak II requirements. For replacement purposes, the NovAtel part number is *GPS-APWR*.

RS232C Y-TYPE NULL-MODEM CABLE

This serial data cable supplied with the PowerPak II provides a means of communications with a personal computer. As shown in *Figure 12*, the cable is equipped with a 9-pin connector at the PowerPak II end which can be plugged into either COM1 or COM2. At the computer end, both a 9-pin and a 25-pin connector are provided to accommodate most serial (RS232C) communication ports.

Figure 12   Y-Type Null-Modem Cable
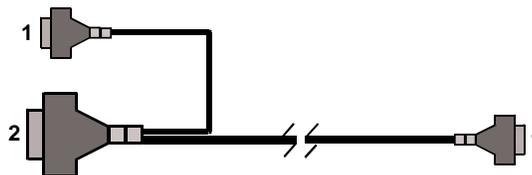
Reference	Description
1	DE9S socket
2	DB25S socket

COMMUNICATION PORTS

The PowerPak II provides communications from two serial ports, COM1 and COM2, see the *Communication Ports* section on *Page 16*.

Pin-outs are the same for both serial ports. Both ports utilize standard DE9P connectors. *Table 6 Serial   Port   Pin-Out Description, Page 50* lists the pin-outs for each serial port configuration.

I/O PORT

The MiLLennium's I/O strobe lines are also available on the PowerPak II front panel through a 9-pin DE9S connector. See *Appendix B, Page 33* for more details about the I/O strobes. The pin-out is in *Table 7 I/O Port Pin-Out Description, Page 50*.

Note that the STATUS signal is what turns *on* or *off* the valid-position LED on the front panel.

ACCESSING THE POWER BOARD FUSE

The power board incorporates a 2-amp normal-blow fuse, located near the rear of the power board. Follow these instructions to check or replace this fuse.

CAUTION !
- Be sure that the power plug is disconnected from the PowerPak II before you attempt to remove the front panel.
- Use the wrist strap to properly discharge static build-up before handling the printed circuit boards.
- Use anti-static precautions whenever the PowerPak II is opened.

To access the power fuse, first remove the four corner screws from each of the front and back panels of the PowerPak II enclosure. Remove the rear panel; then, through this opening, push both the MiLLennium and power card forward as far as you can. This will expose the back plane, MiLLennium, and the power board. Now, from the other end, grasp the exposed edges of the MiLLennium and the power card and gently pull until approximately 3/4 of both cards are extended beyond the front panel opening. The fuse will now be fully exposed for checking or replacement. When finished, push on the front panel until it is seated against the main enclosure; then replace the screws on the front and rear panels. See *Figure 13 Opening the PowerPak II* Enclosure, *Page 45* for more details.

CAUTION !
Do not pull on the front panel in order to remove the MiLLennium and power card from the PowerPak II enclosure; cable damage will result.

Figure 13   *Opening the PowerPak II Enclosure*
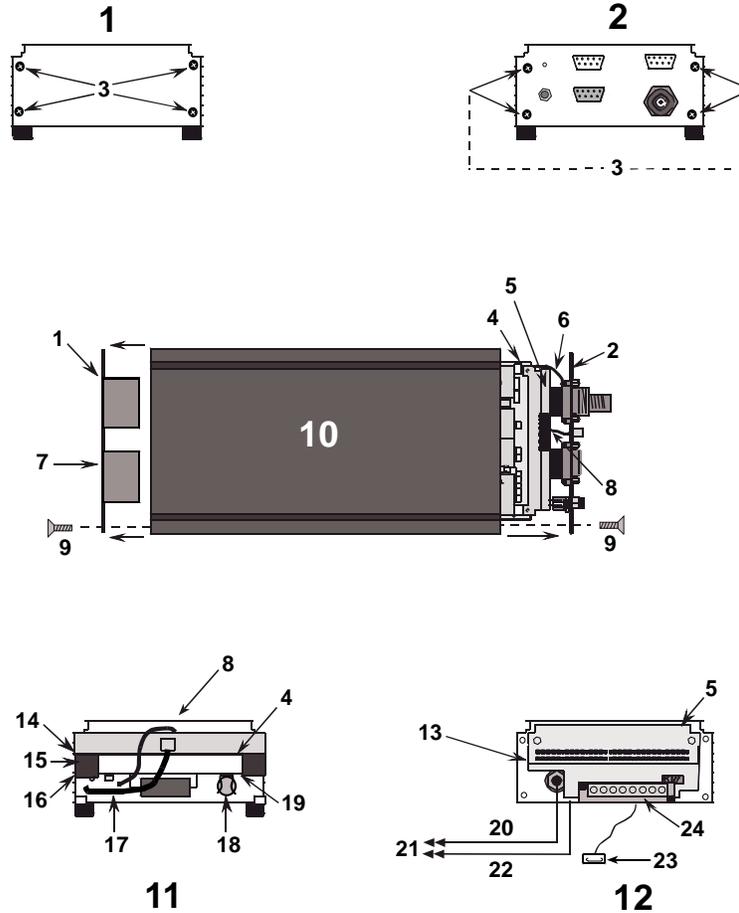
Reference	Description	Reference	Description
1	Back panel	13	GPSCard 64 pin connector P1
2	Front panel	14	Second slot from top
3	Remove screws	15	Spacer bumper
4	GPSCard	16	Second slot from bottom
5	Back plane PCB	17	Antenna cable
6	Ground wire with connector	18	Power fuse
7	Rear bumper	19	Power card
8	External oscillator cable	20	Internal antenna cable (right-angled SMB connector)
9	Panel screw (4 places)	21	To GPSCard
10	PowerPak II (top view)	22	Internal oscillator cable (right-angled SMB connector)
11	Back panel removed (rear view)	23	Spade connector socket on end of ground wire
12	Front panel (back plane view)	24	Power card connector P2

POWERPAK II INSTALLATION

Using the PowerPak II is straightforward. A minimum configuration (*Figure 14   Typical   PowerPak   II*   Installation Configuration) is established with the following set-up:

1. Set up the GPSAntenna.
2. Route and connect the RF coaxial cable between the GPSAntenna and PowerPak II. High quality coaxial cable should be used because a mismatch in impedance, possible with lower quality cable, produces reflections in the cable that increases signal loss.
3. Connect a RS232C communication interface to one of the serial ports of the PowerPak II.
4. Supply power to the input power jack of the PowerPak II.

See *Antenna*, *Page 14* for further information on installation of the GPSAntenna and coaxial cable.

Figure 14   Typical PowerPak II Installation Configuration
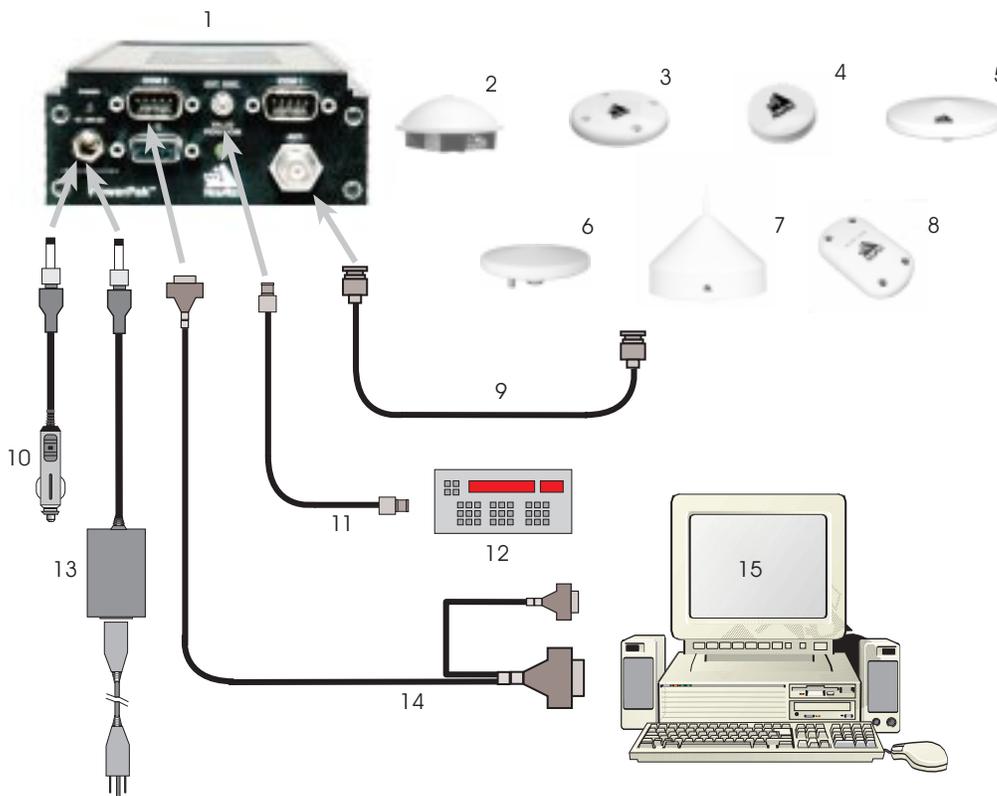
Reference	Description	Reference	Description
1	PowerPak II	9	RF antenna cable
2	GPSAntenna model 501	10	Cigarette lighter adapter
3	GPSAntenna model 511	11	External oscillator cable
4	GPSAntenna model 521	12	External oscillator
5	GPSAntenna model 531	13	Optional AC/DC power converter
6	GPSAntenna model 502	14	Y-type null-modem data cable
7	GPSAntenna model 503	15	User interface
8	GPSAntenna model 512		

CONNECTION TO AN EXTERNAL OSCILLATOR

Connect the coaxial cable from the external oscillator output port to the *Ext. Osc*. input port (SMB male jack) on the front panel of the PowerPak II. See the *Optional External Oscillator* section on *Page 17.*

INSTALLING THE MILLENNIUM

If you Purchased a MiLLennium and PowerPak II separately, installing the MiLLennium is described in the steps listed below.

<hr>

CAUTION !
- Be sure that the power plug is disconnected from the PowerPak II before you attempt to remove the front panel.
- Use the wrist strap to properly discharge static build-up before handling the printed circuit boards.
- Use anti-static precautions whenever the PowerPak II is opened.

<hr>

To open the PowerPak II:

1. Remove the four corner screws from each of the front and back panels of the PowerPak II enclosure (refer back to *Figure 13Opening the PowerPak II* Enclosure*, Page 45* for more details).

2. Remove the rear panel; then, through this opening, push the power card forward as far as you can. This will expose the back plane and the power board.

3. From the other end, grasp the exposed edges of the power board and gently pull until it comes out completely. The front panel and back plane will be attached to it.

To attach the ground connector to the MiLLennium:

4. Find the ground wire which comes out of the backplane (refer back to *Figure 13Opening the PowerPak II Enclosure, Page 45* for more details). This wire will be connected to the MiLLennium by the end of this procedure.

5. Remove the screw from the Pin 1 end of the 64-pin connector on the MiLLennium GPSCard (see *Figure 16 Installing the Ground Connector on the MiLLennium, Page 48*).

6. Insert this screw through the loop in the tongue of the spade connector plug which should be plugged into the socket on the end of the ground wire. Reinsert the screw into the 64-pin connector, so that the spade connector plug is attached to the solder side of the MiLLennium, points towards the 64-pin connector and angles away from the card (see *Figure 16, Page 48*).

7. Slide the spade connector socket of the loose end of the ground wire, onto the spade connector plug on the MiLLennium.

8. Insert the MiLLennium into the 64-pin connector on the backplane. It should be above the power card, and have the ground wire attached to it.

To attach the two coaxial interconnect cables:

9. The antenna RF interconnect cable is the shorter of the two coaxial cables. One end of this cable is attached to the front panel of the PowerPak II enclosure; attach the right-angled SMB connector on the other end to the SMB male jack (P201) on the edge of the MiLLennium (see *Figure 15 Connections on the MiLLennium, Page 48* and *Figure 16 Installing the Ground Connector on the MiLLennium, Page 48*).

Figure 15   Connections on the MiLLennium
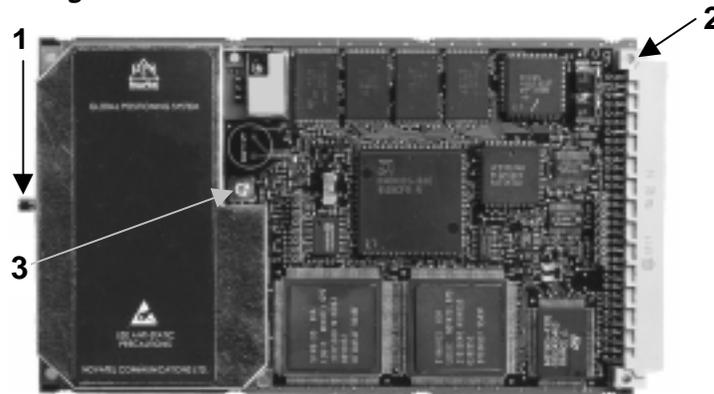
Reference	Description
1	SMB connector for antenna RF cable (P201)
2	Screw for ground connection (on back of card)
3	SMB connector for external oscillator (P301)

Figure 16   Installing the Ground Connector on the MiLLennium
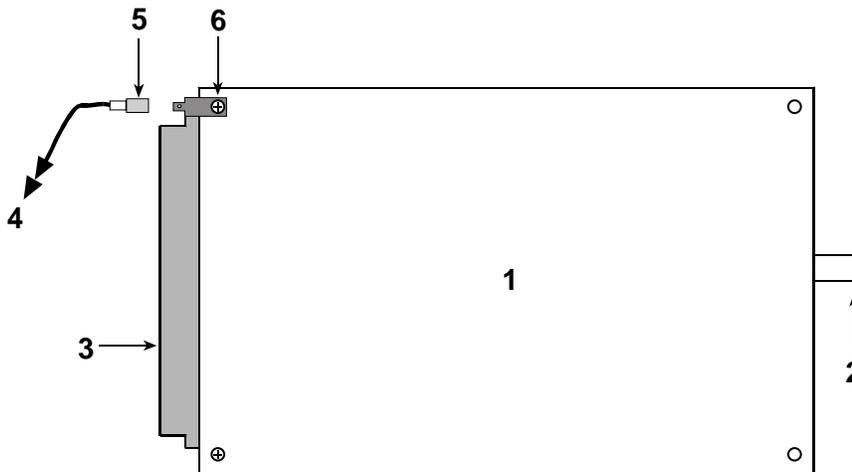
Reference	Description	Reference	Description
1	Back of MiLLennium	4	Ground wire from back plane
2	SMB connector (P201)	5	Spade connector socket
3	64-pin connector	6	Screw through loop in tongue of spade connector plug

10. The external oscillator interconnect cable is the longer of the two coaxial cables. One end of this cable is attached to the front panel of the PowerPak II enclosure; attach the right-angled SMB connector on the other end to the SMB male jack (P301) on the component side of the MiLLennium (see *Figure 15, Page 48*).

To insert the MiLLennium and the power card into the enclosure:

11. Align the edges of the cards so that the MiLLennium begins to go into the second slot from the top of the enclosure, and the power card begins to go into the second slot from the bottom of the enclosure. This will compress the rubber spacers between the two cards.

12. Slowly but firmly, push on the front panel until it is seated against the body of the enclosure. Replace the back panel, and the four screws in each of the panels. Ensure that the coaxial cables are not caught between the edges of the printed circuit boards and the rubber bumpers on the back panel.

This procedure is now complete.

POWERPAK II TECHNICAL SPECIFICATIONS

INPUT/OUTPUT CONNECTORS	
Antenna input	TNC connector 4.25 - 5.25 V DC, 90 mA max 50 Ω nominal impedance
Power	2.1 mm plug, centre positive (+10 to + 36 V DC), with screw-on retaining nut
External oscillator input	SMB male jack Frequency: 5 MHz or 10 MHz CW Input Impedance: 50 Ω nominal Input VSWR: 2.0:1 Signal Level: 0.0 dBm minimum, 13.0 dBm maximum Freq. stability: ±0.5 ppm maximum
COM1, COM2 Strobes	DE9P connector DE9S connector
PHYSICAL	
Size	210 x 111 x 47 mm
Weight	980 g (including MiLLennium card)
ENVIRONMENTAL	
Operating Temperature	-40° C to +60° C
Storage Temperature	-40°C to +85°C
Humidity	Not to exceed 90% non-condensing
Altitude	Not to exceed 5000 meters above sea level

DIMENSIONS
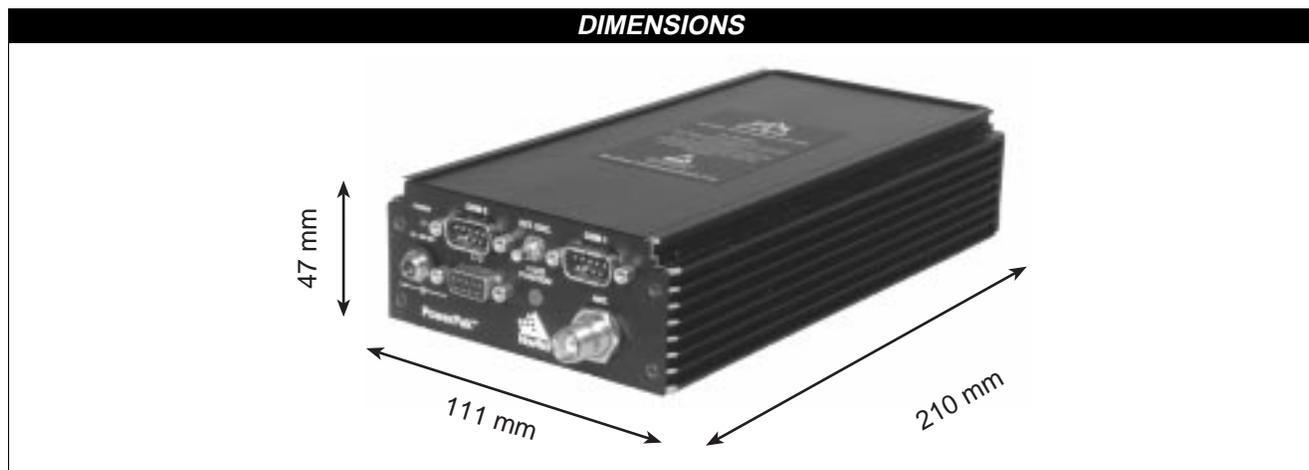
PORT PIN-OUTS

Table 6   Serial Port Pin-Out Description

Connector Pin No.	RS232C Signal	Signal Description
1	DCD	Data Carrier Detected
2	RXD	Received Data
3	TXD	Transmitted Data
4	DTR	Data Terminal Ready
5	GND	Digital Ground
6	DSR	Data Set Ready
7	RTS	Request to Send
8	CTS	Clear to Send
9		Not connected

Table 7   I/O Port Pin-Out Description

Connector Pin No.	Signal Name	Signal Description
1	VARF	User-selectable frequency
2	PPS	One pulse per second
3	MSR	Measure output
4	MKI	Mark input
5	STATUS	Valid GPS solution available
6	GND	Digital ground
7	GND	Digital ground
8	GND	Digital ground
9	GND	Digital ground

CABLES

CIGARETTE LIGHTER ADAPTER CABLE

Reference	Description
1	Universal tip
2	2.5-amp slow blow fuse
3	Spring
4	Positive line
5	Negative line (has text printed on it)
6	Shrinkable tubing
7	Positive
8	Negative
9	Retaining nut

Y-TYPE NULL-MODEM CABLE
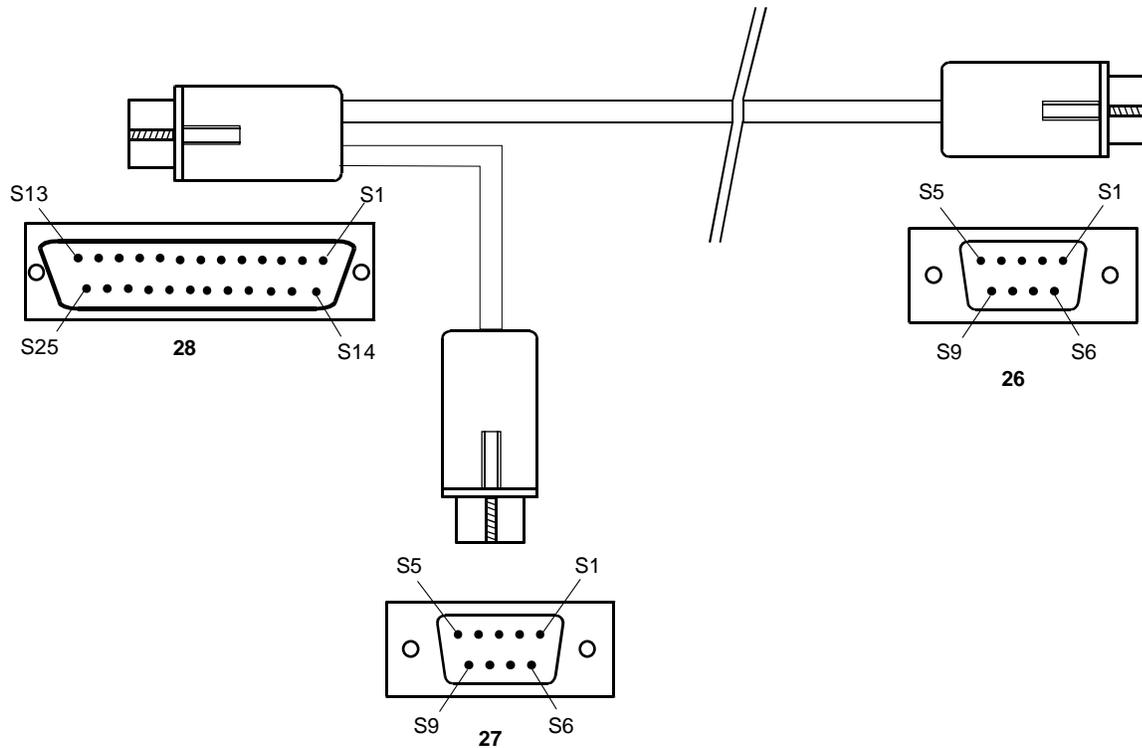
Wiring Table:

CONNECTOR	PIN NUMBER						
From DB25S (28)	2	3	4	5	6 & 8	7	20
To DE9S (26)	2	3	8	7	4	5	1 & 6
To DE9S (27)	3	2	7	8	1 & 6	5	4

Reference	Description
26	DE9S (Female)
27	DE9S (Female)
28	DB25S (Female)

D PROPAK II

ENCLOSURE, CONNECTORS AND INDICATORS

The ProPak II mounting enclosure provides a more protective environment for the MiLLennium than the PowerPak II. The mounting enclosure houses the internal power card, interconnect back plane, and front panel connections for COM1, COM2, strobes, GPSAntenna, external oscillator, and power input. With shock resistant design and environmentally sealed end-caps and connectors, the ProPak II is designed with harsh environments in mind. This makes it suitable for avionics, naval, and other applications where the PowerPak II does not provide sufficient protection.

The ProPak II features front and rear end-caps (*Figures 17 & 18*), each with appropriate indicator lights and connectors. The front end-cap indicator glows *red* when power is on, and changes to *green* when a valid position is computed.

Figure 17   ProPak II Front End-Cap
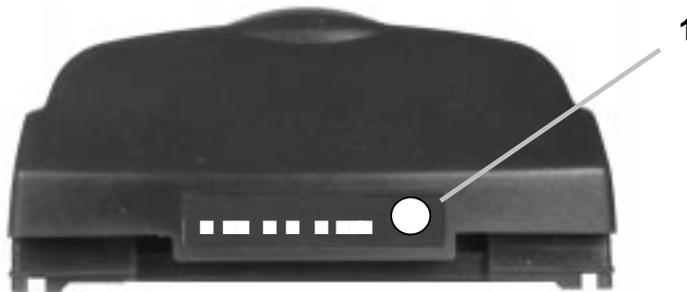
Reference	Description
1	Power/position validity indicator

On the rear end-cap there are connections for the I/O strobe signals, COM1 & COM2 serial ports, power input, and RF input from the GPSAntenna. There is an LED above each serial port connector. If an LED glows *red*, data is being received by the ProPak II on that port, while if an LED glows *green*, data is being transmitted by the ProPak II on that port.

Figure 18   ProPak II Rear End-Cap

COM Port Indicator[1]	Status
Red	Receiving
Green	Transmitting
Yellow	Both of the above

INPUT POWER CABLES

As shown in *Figure 19 Power Cables, Page 53* there may be up to three power cables supplied with the ProPak II:

- 4-pin LEMO plug connector to cigarette-lighter plug with built-in 3-amp fuse (NovAtel part number 01016446)

Optional Accessories

- 4-pin LEMO plug connector to autoranging AC/DC converter, and AC power cord (NovAtel part number GPS-APRO)

- 4-pin LEMO plug connector to 4-pin LEMO plug connector (NovAtel part number 01016724 [33.5 cm] or 01016725 [75 cm])

These cables allow you to power the ProPak II from either an automotive DC source, an AC source or an optional battery (NovAtel part number 01016698).

Figure 19   Power Cables
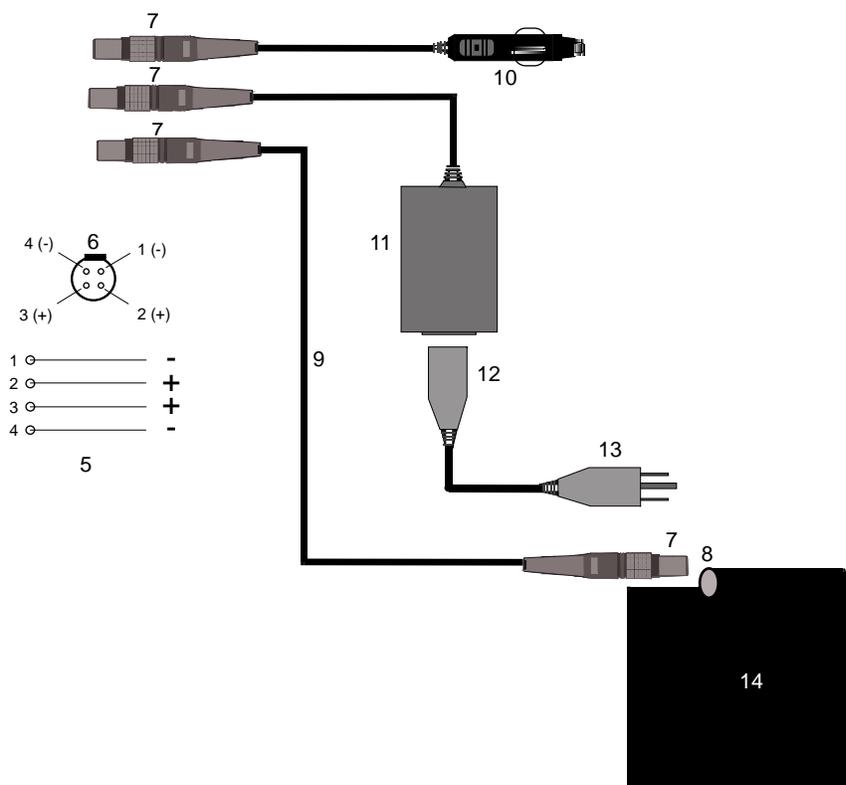
Reference	Description	Reference	Description
1	Brown (GND)	9	Optional battery power cable
2	Orange (+10.7 to +32 V DC)	10	Automotive cigarette-lighter adapter
3	Red (+10.7 to +32 V DC)		with 3-amp slow-blow fuse
4	Black (GND)	11	Auto-ranging AC/DC converter
5	4 conductor cable	12	AC socket
6	Red marker at top of connector	13	AC plug
7	Female LEMO plug	14	Optional Battery
8	Male LEMO socket		

SERIAL DATA CABLES

Two serial data cables are supplied to connect the ProPak II to a PC or modem. They are described as follows:

- straight cable: 10-pin LEMO plug to 9-pin D-connector (DE9P plug); *Appendix B* contains wiring and pin-out information on this cable*.* This is used to connect the ProPak II to a modem or radio transmitter to propagate differential corrections. Its NovAtel part number is 01016383.

- null-modem cable: 10-pin LEMO plug to 9-pin D-connector (DE9S socket); *Appendix B* contains wiring and pin-out information on this cable. This is used to connect the ProPak II to a serial (RS232C) communication port on a terminal or computer. Its NovAtel part number is 01016329.

The 10-pin plug on each cable can be plugged into either the COM1 or COM2 port on the ProPak II.

For field replacement of the LEMO connector, please consult *Appendix G, REPLACEMENT PA,* for a list of the manufacturers' part numbers.

I/O STROBE PORT CABLE

The I/O strobe lines can be accessed by inserting the 8 pin LEMO connector of the I/O strobe port cable (NovAtel part number 01016330) into the I/O port. *Appendix B* contains wiring and pin-out information on this cable. The other end of the cable is provided without a connector so that you can provide an application-specific one; the jacket insulation is cut away slightly from the end but the insulation on each wire is intact. The *Input/Output Strobes* section of *Appendix B*, *MILLENNIUM TECHNICAL ,*

ProPak II*, Page 57* contains descriptions of each of the I/O strobes, along with their electrical specifications.

For field replacement of the LEMO connector, please consult *Appendix E*, *REPLACEMENT PA*, for a list of the manufacturers' part numbers.

Note that the STATUS line is used to toggle the valid-position LED on the front end-cap between red (power on) and green (valid position).

PROPAK II INSTALLATION

Installing the ProPak II is a straightforward process. As shown in *Figure 20*, *Page 55* a minimum configuration is established with the following set-up:

- Set up the GPSAntenna.
- Route and connect coaxial cable between the GPSAntenna and ProPak II.
- Connect an RS232C communication interface to one of the serial ports of the ProPak II. The supplied null modem cables are intended for RS232C communications only.
- Connect the output of the optional power converter to the input power jack of the ProPak II.

Figure 20　　*ProPak II Installation Configuration Possibilities*

Note:　　The autoranging AC/DC converter and AC power cord do not come with the ProPak II but are optional accessories.
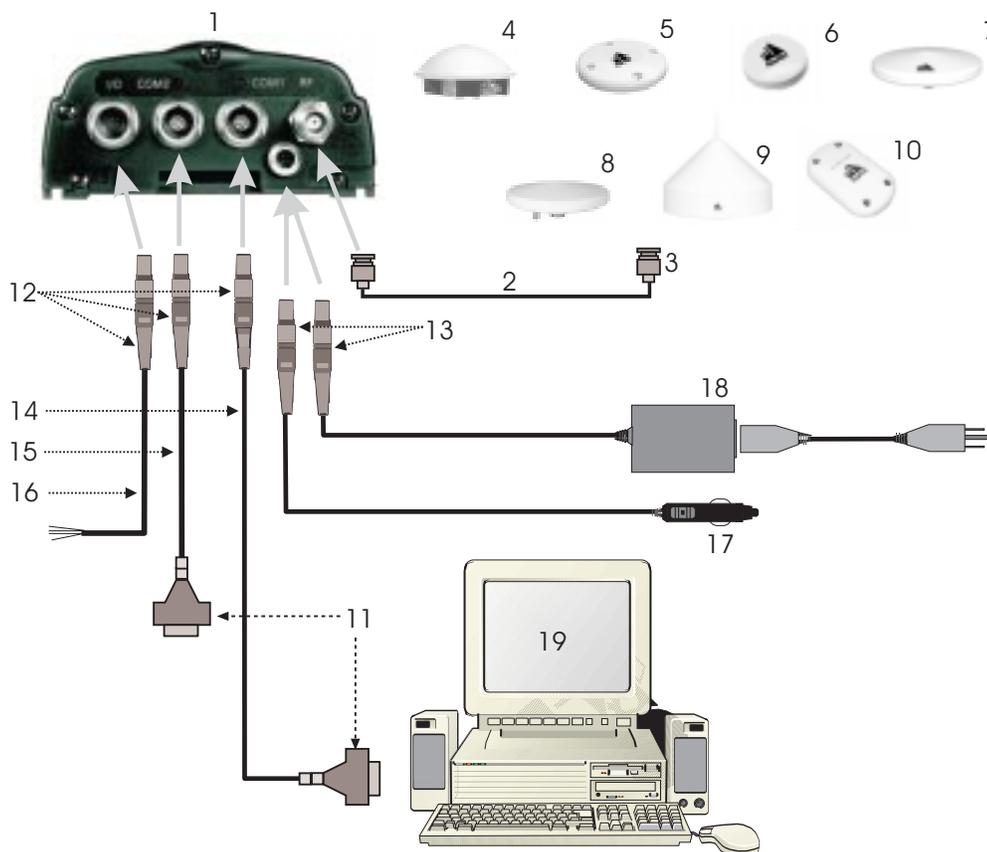
Reference	Description	Reference	Description
1	Back of ProPak II	13	Female LEMO plug
2	RF antenna cable	14	Null-modem serial data cable (female connector
3	RF antenna connector		attaches to user-supplied operator interface)
4, 5, 6, 7	GPSAntenna model 501, 511,	15	Straight serial data cable (male connector attaches
	521, 531 (L1-only)		to user-supplied modem or radio transmitter)
8, 9, 10	GPSAntenna model 502, 503,	16	I/O strobe cable
	512 (L1/L2)	17	Automotive cigarette-lighter adapter
11	DB9 connector	18	Auto ranging AC/DC converter
12	Male LEMO socket	19	Operator interface
13	Female LEMO plug		

Figure 21   Typical Operational Configuration
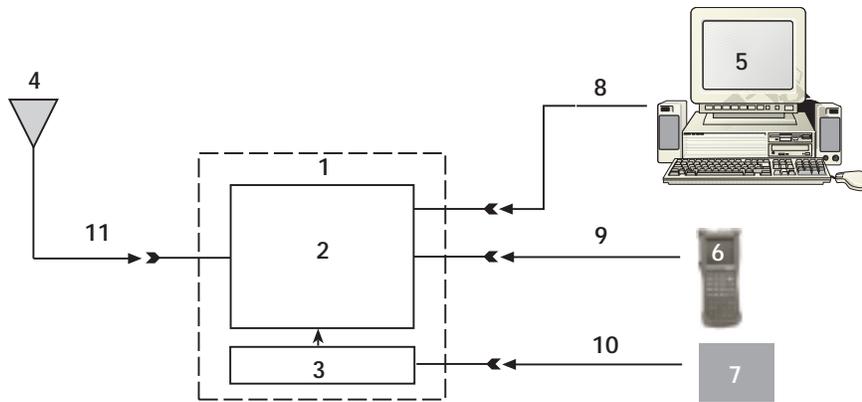
Reference	Description		Reference	Description
1	ProPak II enclosure		7	External power source
2	MiLLennium GPSCard		8	COM1
3	Power converter		9	COM2
4	NovAtel GPSAntenna		10	+10 to +36 V DC
5	Command source or reference station		11	GPS signal
6	Data logger or remote station			

CABLE CONNECTION CONSIDERATIONS

The connectors that are used to mate the cables to the ProPak II have a locking mechanism that requires 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 COM1/COM2 serial port cable has a different connector (10 pin) than the I/O cable (8 pin).
- Line up the red dot on the connector shell with the red index mark on the receptacle on the ProPak II.
- Insert the connector until it seats with a click; it is now locked in place.
- To remove a cable, grasp the connector by the knurled ring and pull (see *Figure 22*). DO NOT PULL DIRECTLY ON THE CABLE.

Figure 22   Removal of Connectors

ANTENNA AND ANTENNA CABLE

Please see the *Antenna* section on *Page 14*.

POWER SUPPLY CONSIDERATIONS

The ProPak II incorporates a DC-to-DC power converter providing filtering, automatic reset circuit protection, and voltage regulation. It accepts a single input voltage between the range of +10 to +36 V DC, which can be supplied either from an automotive DC source or by the optional autoranging AC/DC converter which operates over a range of 110 - 220 V AC and 50 - 60 Hz. The power input is reverse-polarity protected.

Note: The ProPak II will suspend operation if the voltage supplied to it falls outside the input range of 10 to 36 V DC.

MOUNTING CONSIDERATIONS

A mounting kit has been provided to facilitate mounting the ProPak II to a surface, please see *Optional Mounting Bracket, Page 58*.

PROPAK II TECHNICAL SPECIFICATIONS

PHYSICAL	
Size:	251 mm x 130 mm x 62 mm
Weight:	1.3 kg
ENVIRONMENTAL	
Operating Temperature	-40° C to +55° C
Storage Temperature	-40°C to +85°C
Resistance Characteristics	Dust tight, water tight
Humidity	5% to 95% RH (non-condensing) at +40°C
Altitude	Sea level to 5,000 m [may operate above 5,000 m in a controlled environment, however is not certified as such.]
POWER REQUIREMENTS	
Voltage	+10 to +36 V DC
Power	12 W (typical)
RF INPUT / LNA POWER OUTPUT	
Connector on ProPak II	TNC female
RF Input	1575.42 MHz, 1227.60 MHz
Power Output to LNA	4.25 - 5.25 V DC @ 0 - 90 mA. **Note:** if the antenna draws current above this limit, power to the antenna will be disabled and the antenna self-test status flag will be set to zero. Refer to the RVSA log in the *MiLLennium Command Descriptions Manual* for more information.

OPTIONAL MOUNTING BRACKET

The mounting kit includes the following materials:

- four self-tapping screws (#10-16 x ½″ LG)
- two wood screws (#10 x ¾″ LG)
- four flat screws (M3 x 8, 90° countersink)
- aluminum mounting plate (see *Figure 24* for exact dimensions)

First, the mounting plate needs to be attached to the ProPak II enclosure. As shown in *Figure 23*, there are two channels running the length of the bottom of the ProPak II enclosure. In each of these channels there are two rectangular nuts, held in place by grub screws. These four nuts are factory-positioned so that the mounting plate can be attached to the ProPak II enclosure using the four flat screws. Please ensure that the four flat screws are mounted from the countersunk side of the mounting plate.

Once the plate has been attached to the ProPak II enclosure, the entire assembly can then be mounted onto a surface using either the four self-tapping screws through the screw-mount holes, or the two wood screws through the quick-mount holes.

Note: This mounting kit is not designed for use in high-dynamics or high-vibration environments. Contact NovAtel Customer Service if your application requires the ProPak II to be mounted in these types of environments.

Figure 23 **Mounting Bracket**
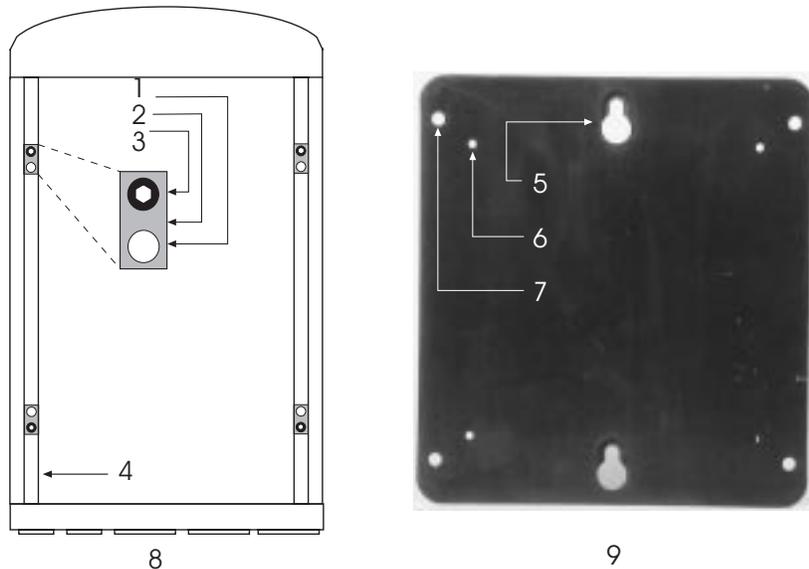
Reference	Description		Reference	Description
1	Thread for flat screw		6	Holes to mount plate to enclosure using flat screw
2	Rectangular nut			
3	Grub screw		7	Holes to mount assembly to a surface using self-tapping screws
4	Channel			
5	Quick-mount holes to mount assembly to surface using wood screws		8	Back of receiver enclosure
			9	Front of mounting plate

Figure 24   Mounting Bracket Drill Holes – Dimensions

4 x 5 DIA.
THROUGH

RAD 6.0
2 PLACES

4 x 3.1 DIA.
6.0 x 90 DEG.C'SINK
FARSIDE

148.2

155.2

158.2

176.4

7.5

9.0

28.2

18.2   12.2

21.4

80.0

138.6

152.5

160.0

NOTE:

All dimensions in millimeters
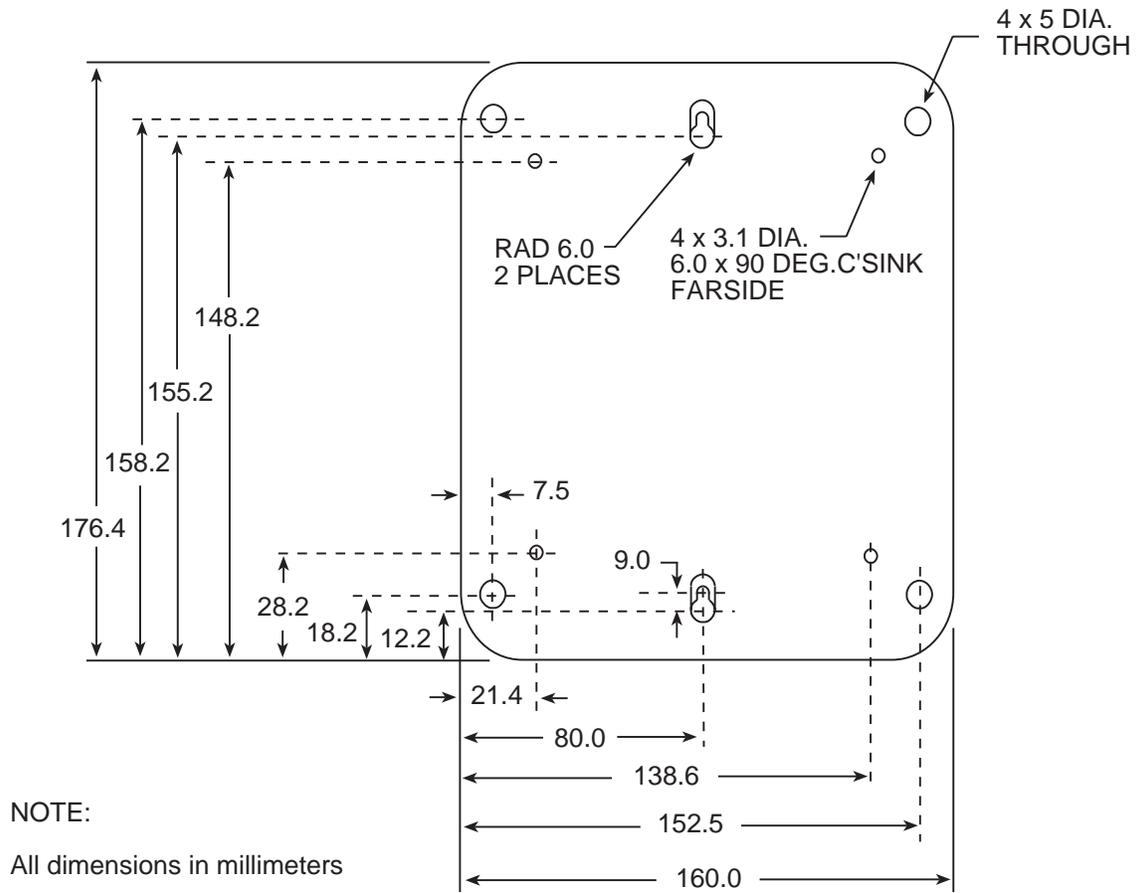
PROPAK II PORT AND CABLE PIN-OUTS

STRAIGHT SERIAL PORT CABLE
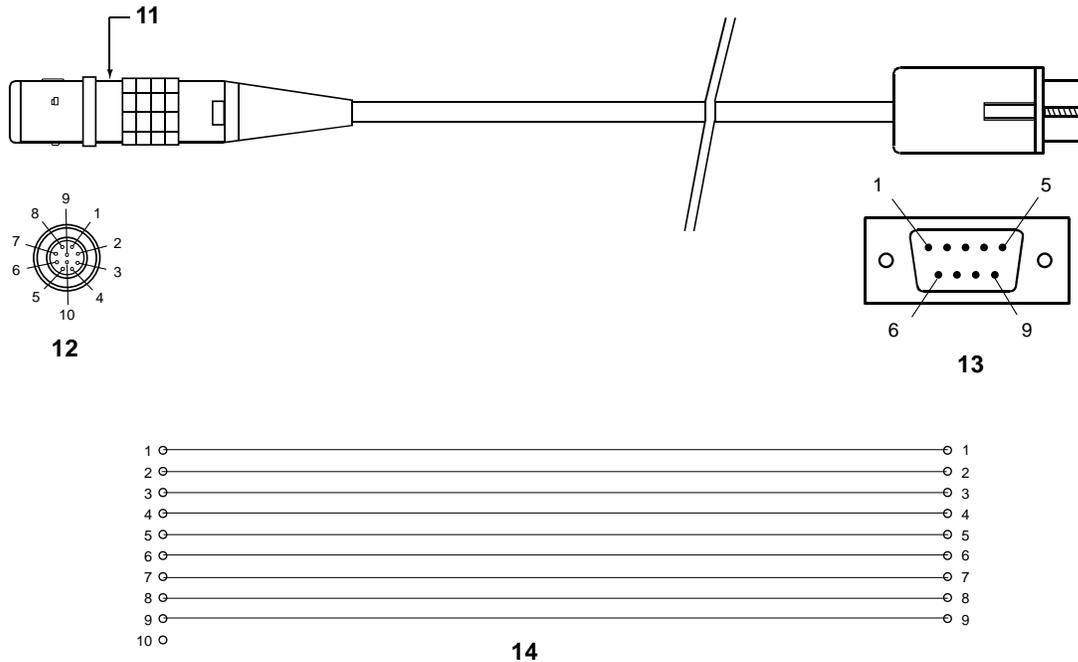
Table 8   Straight Cable Pin Configurations

LEMO Pin No.	RS232C Signal	Wire Color Code	DE9P Pin No.
Pin 1	DCD	Brown	Pin 1
Pin 2	RXD	Black	Pin 2
Pin 3	TXD	Red	Pin 3
Pin 4	DTR	Orange	Pin 4
Pin 5	GND	Yellow	Pin 5
Pin 6	DSR	Green	Pin 6
Pin 7	RTS	Blue	Pin 7
Pin 8	CTS	Violet	Pin 8
Pin 9	NULL	Gray	Pin 9
Pin 10		White (Not used)	

Reference	Description
11	Red marker at top of connector
12	LEMO 10-pin plug (male)
13	DE9P (male)
14	10-conductor wire

NULL MODEM SERIAL PORT CABLE
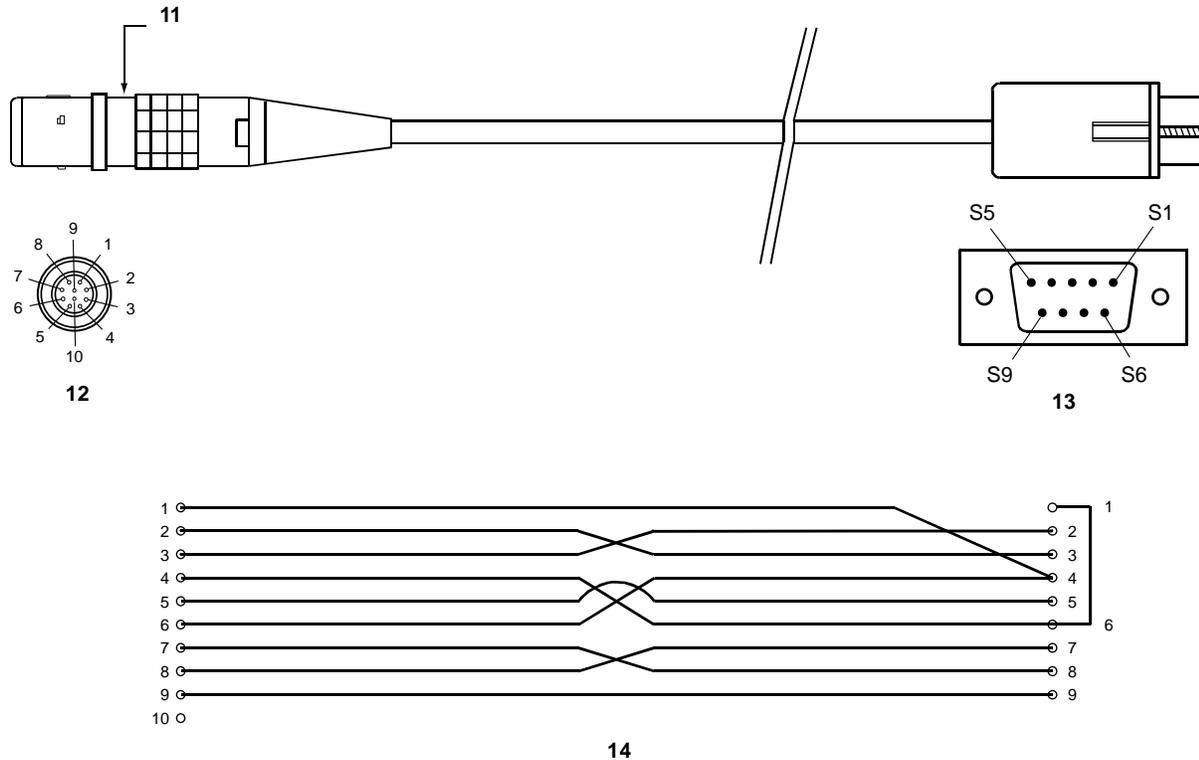
Table 9   Null Modem Cable Pin Configurations

LEMO Pin No.	RS232C Signal	Wire Color Code	DE9S Pin No.
Pin 1	DCD	Brown	Pin 4
Pin 2	RXD	Black	Pin 3
Pin 3	TXD	Red	Pin 2
Pin 4	DTR	Orange	Pin 6
Pin 5	GND	Yellow	Pin 5
Pin 6	DSR	Green	Pin 4
Pin 7	RTS	Blue	Pin 8
Pin 8	CTS	Violet	Pin 7
Pin 9	NULL	Gray	Pin 9
Pin 10		White (Not used)	Pin 1 jumpered to Pin 6

Reference	Description
11	Red marker at top of connector
12	LEMO 10-pin plug (male)
13	DE9P (male)
14	10-conductor wire

I/O PORT CABLE
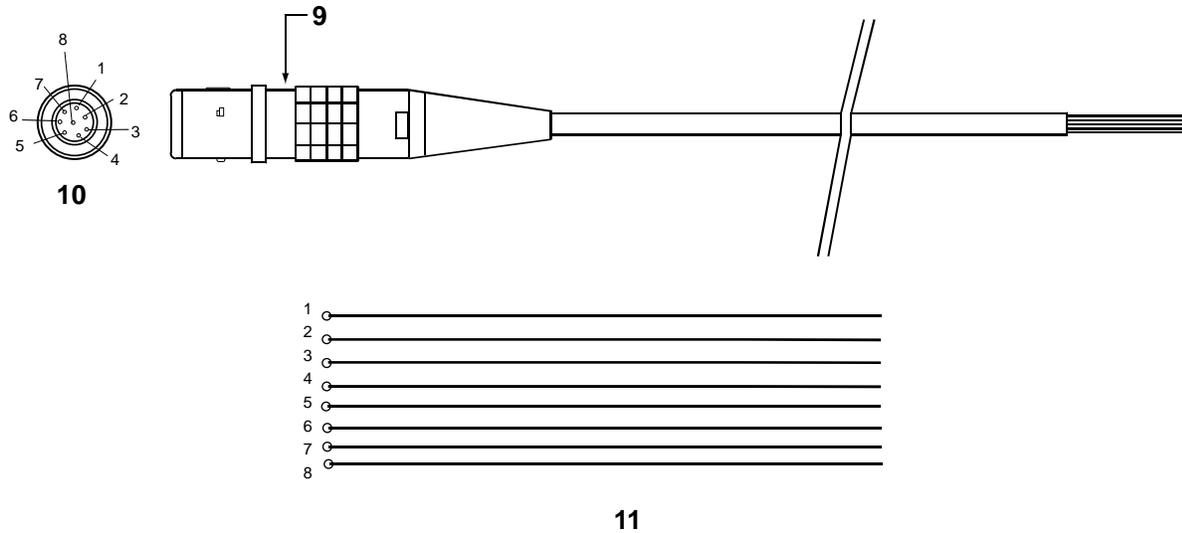
Table 10   I/O Port Pin-Out Description

LEMO Pin Number	Pin Description	Wire Color Code
Pin 1	VARF, variable-frequency	Brown
Pin 2	1PPS, one pulse per second	Black
Pin 3	MSR, measure output	Red
Pin 4	MKI, mark input	Orange
Pin 5	STATUS , valid solutions available	Yellow
Pin 6	GND	Green
Pin 7	GND	Blue
Pin 8	GND	White

Reference	Description
9	Red marker at top of connector
10	LEMO 8-pin plug (female)
11	8-conductor wire

STRAIGHT POWER CABLE
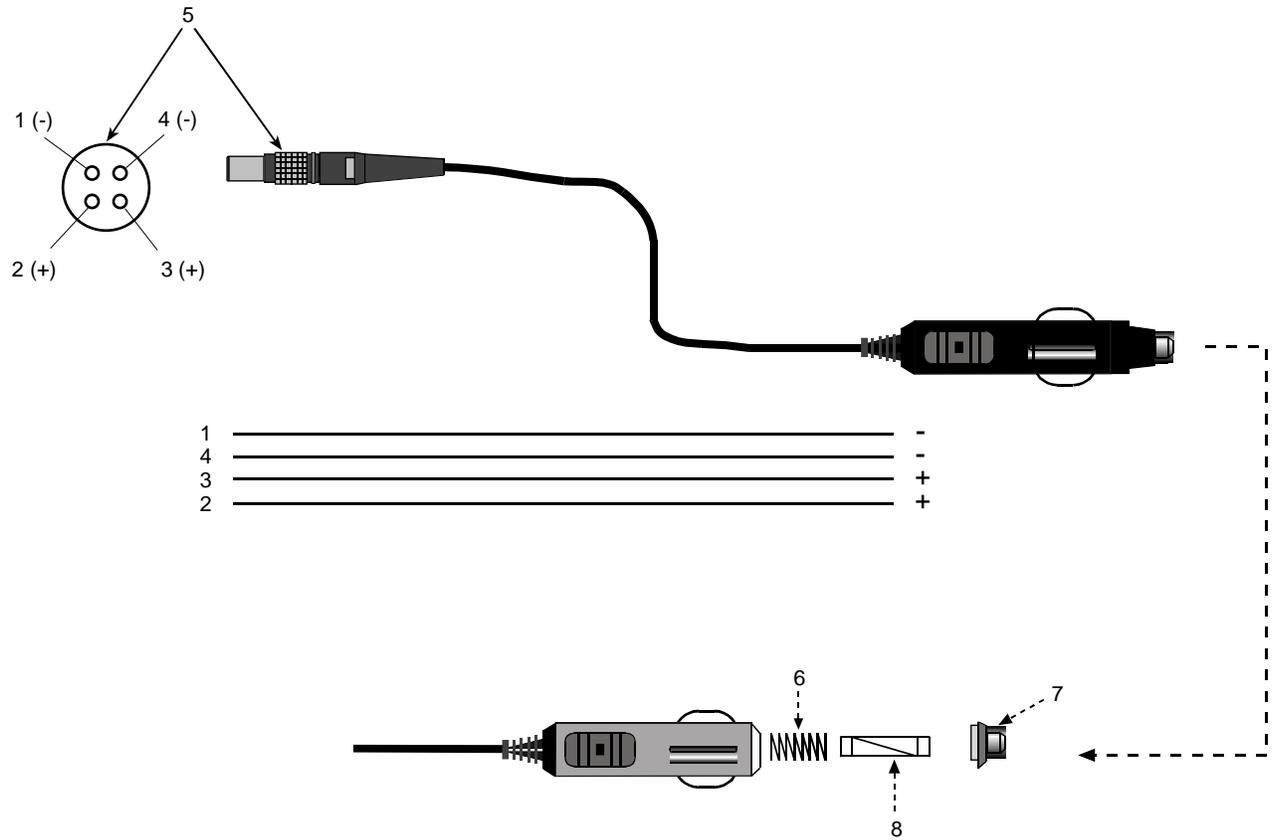
Reference	Description	Reference	Description
1	Brown - GND	5	Red marker at top of connector
2	Orange + +10 to +36 V DC	6	Spring
3	Red + +10 to +36 V DC	7	Universal tip
4	Black - GND	8	3-amp slow-blow fuse

OPTIONAL AUTO-RANGING AC/DC CONVERTER AND POWER CORD
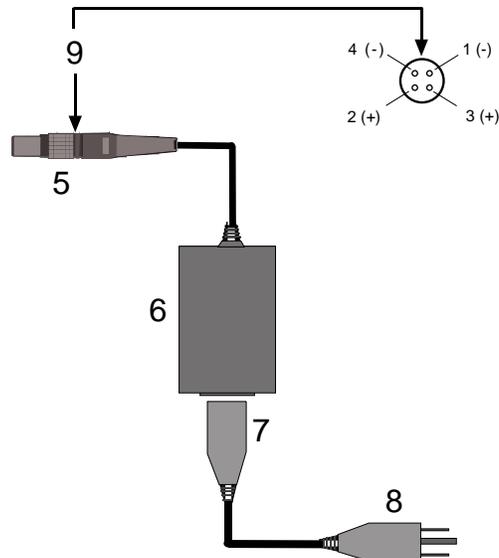
LEMO Pin Number	Signal	Color Code
1	Negative	Black
2	Positive	White
3	Positive	Red
4	Negative	Green

Reference	Description
5	Female LEMO plug
6	Auto-ranging AC/DC converter
7	AC socket
8	AC plug
9	Red marker at top of connector

E EDGE-VIEW OF CONNECTOR P1
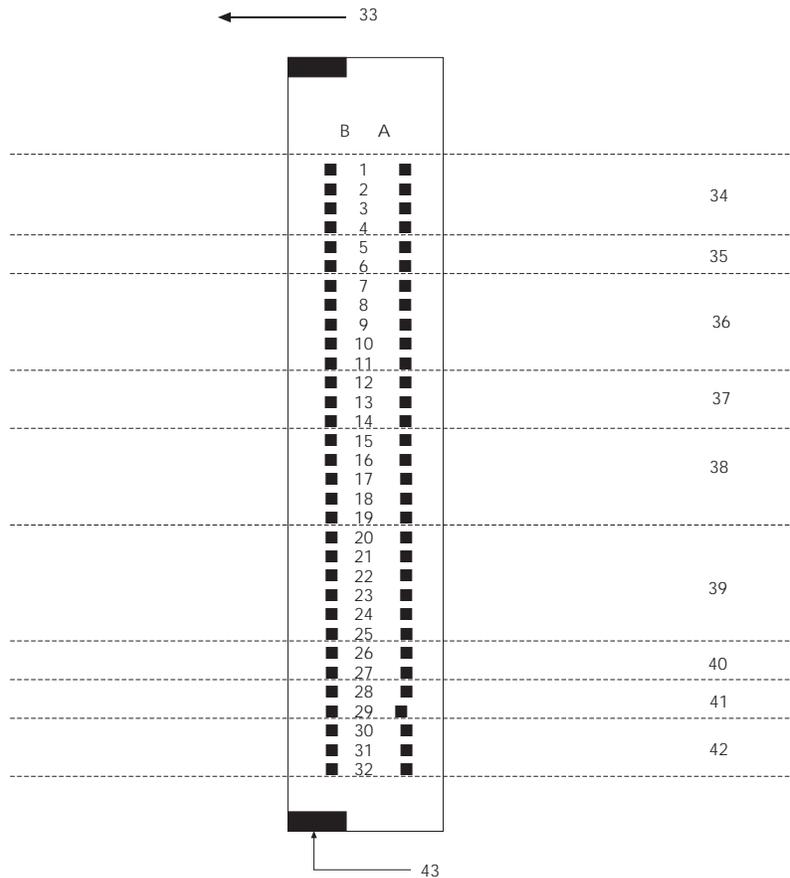
Pin Number	Description	Pin Number	Description
1A, 1B, 4A, 7A,15A, 21A-32A	GND	19A	DCD2
2A, 2B	Vcc	19B	DSR2
3A, 5B-8B, 12A, 12B-16B, 20A, 20B	N/C	21B	VARF
3B	Reserved for future use	22B	PPS
4B	External LNA Power	23B	Measure Out
5A, 6A, 13A, 14A, 26B, 27B, 30B-32B	Factory Use	24B	Mark In
8A	DTR 1	25B	Status
9A	TXD1	28B	Reset In
9B	CTS1	29B	Reset Out
10A	RXD1	33	Component Side of GPSCard
10B	RTS1	34	Power
11A	DCD1	35, 37, 40, 42	Factory Use
11B	DSR1	36	COM1 (RS-232C)
16A	DTR2	38	COM2 (RS-232C)
17A	TXD2	39	Strobes
17B	CTS2	41	Control
18A	RXD2	43	Keying Tab
18B	RTS2		

F *SOME COMMON UNIT CONVERSIONS*

Listed below are several commonly used equivalents between the SI (Système Internationale) units of weights and measures used in the metric system, and those used in the imperial system.

Distance

1 metre (m) = 100 centimetres (cm) = 1000 millimetres (mm)

1 kilometre (km) = 1000 metres (m)

1 international foot = 0.3048 metre

1 US survey foot = 0.3048006096 metre

1 statute mile = 1609.3 metres

1 nautical mile = 1852 metres

Temperature

degrees Celsius = (5/9) x [(degrees Fahrenheit) – 32]

degrees Fahrenheit = [(9/5) x (degrees Celsius)] + 32

Volume

1 litre (l) = 1000 cubic centimetres (cc)

1 gallon (Imperial) = 4.546 litres

1 gallon (US) = 3.785 litres

Weight

1 kilogram (kg) = 1000 grams

1 pound = 0.4536 kilogram (kg)

G REPLACEMENT PARTS

The following is a list of the replacement parts and accessories available for the MiLLennium and its enclosures. Should you require assistance or need to order additional components, please contact your local NovAtel dealer.

Part Description		NovAtel Part Number
ProPak II :	I/O strobes cable (*Figure 20, Page 55*)	01016330
	Straight serial data cable (*Figure 20, Page 55*)	01016383
	Null-modem serial data cable (*Figure 20, Page 55*)	01016329
	Power cable assembly (*Figure 20, Page 55*) : LEMO 4-pin plug to cigarette-lighter plug	01016331
	Optional power cable assembly (*Figure 19, Page 53*): LEMO 4-pin plug to LEMO 4-pin plug 33.5 cm	01016724
	75.0 cm	01016725
	Optional power cable assembly (*Figure 19, Page 53*): AC/DC converter to LEMO 4-pin plug, c/w AC power cord	GPS-APRO
	Optional Battery Assembly (*Figure 19, Page 53*)	01016698
	Optional Battery Charger	GPS-ACDL
	Optional Mounting Bracket (ProPak II, see *Page 58*)	70015024
PowerPak II (*Figure 14, Page 46*):	Y-type null modem cable	60715062
	Cigarette lighter power adapter	01014989
	Optional AC/DC power converter	GPS-APWR
Other:	MiLLennium Command Descriptions Manual	OM-20000048
	Optional Model 501 L1-only antenna	GPS-501
	Optional Model 511 L1-only antenna	GPS-511
	Optional Model 521 L1-only antenna	GPS-521
	Optional Model 531 L1-only antenna	GPS-531
	Optional Model 502 L1/L2 antenna	GPS-502
	Optional Model 503 L1/L2 antenna	GPS-503
	Optional Model 512 L1/L2 antenna	GPS-512
	Optional 22cm interconnect adapter cable (SMB female/TNC bulkhead – female)	GPS-C001
	Optional 5m coaxial antenna cable (Model C005)(TNC male/TNC male)	GPS-C005
	Optional 15m coaxial antenna cable (Model C015)(TNC male/TNC male)	GPS-C015
	Optional 30m coaxial antenna cable (Model C030)(TNC male/TNC male)	GPS-C030

H INDEX

R

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Y

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