pendulum

GPS-12, GPS-12R, GPS-12R/HS & GPS-12RG

GPS & GLONASS / GPS Frequency Standards

User's Manual

4031 600 12001
Rev. 04 March 2010

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GENERAL INFORMATION

Warranty

The Warranty Statement is part of the folder *Important Information* that is included with the shipment.

Declaration of Conformity

The complete text with formal statements concerning product identification, manufacturer and standards used for type testing is available on request.

Convention of Notation

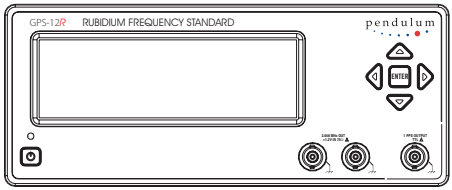
Most information in this manual is common to all models. When the type number is used as a reference to any of them, the designation GPS-12X has been chosen for the sake of simplicity. Otherwise the device is referred to with its proper type number, e.g. GPS-12 or GPS-12RG. Sometimes two type numbers are combined, e.g. GPS-12(R) means GPS-12 and GPS-12R.

Figures illustrating the menu screens are generic. Where necessary, clarifying remarks or additional figures have been included.

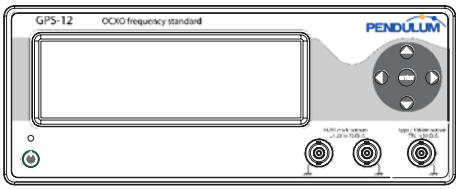
GNSS stands for *Global Navigational Satellite System* and is an acronym that refers to all satellite-based navigational systems. In this manual it means either GPS or GLONASS and is, for example, used in the graphical user interface whenever reference to a particular system is not necessary.

Front Panel Design

The picture illustrating the front panel in Chapter 3 shows the GPS-12, which is the latest addition to this product family, now consisting of three models. During a transition period the other models will be delivered with their present front panels. The two different designs are shown below for informative reasons.



GPS-12R & GPS-12RG.



GPS-12

Chapter 1

Preface

Introduction

Cesium-controlled Frequency via Satellites

The GPS-controlled frequency standards GPS-12(R) and the GLONASS/GPS-controlled frequency standard GPS-12RG deliver a precision frequency and time reference everywhere in the world. They gain their long-term frequency stability from Cesium standards in the navigation satellite systems GPS and GLONASS. They are also designed to provide very high short-term stability and are cost-efficient and extremely accurate frequency standards.

These reference sources are very suitable as frequency standards in the telecommunication and electronics industry. They fit both as stationary frequency references - for instance in test systems and as local references in the design department - and as portable, highly accurate reference sources for field use.

These instruments are off-air frequency standards with an internal architecture according to Figure 1-1. They have one antenna input and a number of optional frequency outputs.

There is also an option for disciplining with an external 1 pps source, e.g. an in-house cesium standard.

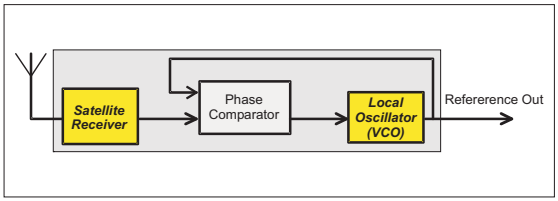


Figure 1-1 *Simplified block diagram of the GPS-12X.*

Optional I/O Boards

The GPS-12X comes as standard with two 2.048/1.544 MHz square wave outputs and one 1 pps pulse output with approx. 10 µs duration. The GPS-12RG has also 3 x 10 MHz and 1 x 5 MHz outputs. See Option 70B below. There are six options to choose from, options 70B, 71B, 72B, 73B, 74B and 79/01. All but the 79/01 allow for four extra frequency outputs to be mounted. Any combination of none, one or two of these units is possible. Only one 79/01can be mounted.

Option 70B gives 3 x 10 MHz and 1 x 5 MHz sine wave outputs, 1 V_{RMS} in 50 Ω. The GPS-12RG is as standard equipped with one such option.

Option 71B gives four sine wave outputs, 1V_{RMS} in 50 Ω, of resp. 10 MHz, 5 MHz, 1 MHz and 0.1 MHz.

Option 72B gives 2 x 2.048 MHz clock outputs, ±1.2 V square wave in 75 Ω, plus 2 x 2.048 Mbps data outputs (G.703:10), for telecommunication testing and clock synchronization.

Option 73B gives 4 x 13 MHz square wave outputs with TTL levels in 50 Ω.

Option 74B gives 2 x 1.544 MHz plus 2 x 1.544 Mbps outputs for SONET applications.

Option 79/01 gives 2 x 10 MHz sine wave outputs, 1 V_{RMS} in 50 Ω, plus 1 x 1 pps output, TTL levels in 50 Ω, plus 1 x 1 pps disciplining input, TTL levels.

Reference Oscillators

The GPS-12 is equipped with an oven-controlled crystal oscillator (OCXO), the GPS-12R has a standard rubidium oscillator, and the GPS-12R/HS has a high-stability, low phase noise rubidium oscillator. The GPS-12RG is also equipped with the latter oscillator.

Two Operating Modes

The *disciplined mode* is the default mode. It eliminates long-term frequency drift, also called aging. As long as there is a valid satellite signal, the local rubidium oscillator is continuously adjusted to minimize the deviation from the satellite-derived reference signal.

The *hold-over mode* is entered either automatically, if the satellite contact is lost, or manually. The automatic adjustment is replaced by the normal aging characteristics of the rubidium oscillator.

The *manual hold-over mode* is mainly intended for the hopefully rare occasions when the satellite contact is sporadic, causing unacceptable mode switching interference.

Portability

By means of Option 78 or Option 78/HS, an internal rechargeable battery unit, it is possible to maintain stability during transportation, as the internal reference oscillator is continuously powered.

Field use without access to AC line power is also practicable.

Option 78/HS has the additional feature of accepting an external 12 V_{DC} supply. Thus it is possible to realize a true uninterruptible power supply (UPS), as the DC source and the AC source can be applied simultaneously. The AC source takes precedence, as long as it is present, and so does the external DC supply over the internal battery, which is kept charged by one of the external sources.

In case of a power line failure you will benefit from double security, if you utilize an external DC source in addition to the AC supply.

Stationary Use

Option 77 makes it possible to apply -48 V_{DC} as an alternative to the standard AC line voltage, thus allowing permanent use as local frequency standard in telephone exchange stations. AC line voltage and -48 V_{DC} can be applied at the same time in order to realize a true uninterruptible power supply (UPS).

Overall Accuracy

The cesium standards of the satellites are controlled by primary frequency standards like the US Naval Observatory, and ultimately to all national standards (e.g. NIST, NPL, PTB, SP etc.).

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Chapter 2

Preparation for Use

Safety Instructions

Introduction

Read this chapter carefully before you install and use the instrument.

This instrument has been designed and tested for Measurement Category I, Pollution Degree 2, in accordance with EN/IEC 61010-1:2001 and CAN/CSA-C22.2 No. 61010-1-04 (including approval). It has been supplied in a safe condition. The user of this instrument must have sufficient knowledge of it. This knowledge can be gained by thoroughly studying this manual, especially the sections on *Safety Precautions* and *Installation* in this chapter.

This instrument is designed to be used by trained personnel only. Removal of the cover for repair or rack-mounting of the instrument must be done by qualified personnel who are aware of the hazards involved. There are no user-serviceable parts inside the instrument.

Safety Precautions

All equipment that can be connected to line power is a potential danger to life. Handling restrictions imposed on such equipment should be observed.

To ensure the correct and safe operation of this instrument, it is essential that you follow generally accepted safety procedures in addition to the safety precautions specified in this manual.

The warranty commitments are rendered void if unauthorized access to the interior of the instrument has taken place during the given warranty period.

Caution and Warning Statements

CAUTION: Shows where incorrect procedures can cause damage to, or destruction of equipment or other property.

WARNING: Shows a potential danger that requires correct procedures or practices to prevent personal injury.

Symbols

Shows where the protective ground terminal is connected inside the instrument. **Never** remove or loosen this screw.

This symbol is used for identifying the functional ground of an I/O signal. It is always connected to the instrument chassis.

Indicates that the operator should consult the manual.

If in Doubt about Safety

Whenever you suspect that it is unsafe to use the instrument, you must make it inoperative by doing as follows:

– Disconnect the line cord.

– Clearly mark the instrument to prevent its further operation.

– Inform your local Pendulum Service Center.

For example, the instrument is likely to be unsafe if it is visibly damaged.

Unpacking

Unpacking Instructions

Check that the shipment is complete and that no damage has occurred during transportation. If the contents are incomplete or damaged, file a claim with the carrier immediately. Also notify your local Pendulum sales or service office in case repair or replacement may be required.

Check List

The shipment should contain the following:

– The frequency standard.

– A line cord.

– A CD with PDF manuals for Pendulum products, e.g. this manual.

– If you ordered one or two of the output options (70B, 71B, 72B, 73B, 74B), or the disciplining option (79/01), or one of the DC supply options (77, 78, 78/HS), they should already be installed. See “Identification” below.

Note 1: The GPS-12R/HS and the GPS-12RG are as standard equipped with one Option 70B.

– If you ordered one of the DC supply options (77, 78/HS), a three-pole power D-sub socket connector is included that mates with the corresponding rear panel pin connector. It is intended for making a wire harness suitable for linking the instrument to an external DC power source.

– Other options you ordered, e.g. antenna (option 01), antenna cable (option 02), rack mount kit (option 22) or carrying case (option 27/27H) are shipped in separate boxes.

– Certificate of Calibration.

Identification

Options installed inside the cover are identified on the rear panel according to the list below. Up to two output boards in any combination can be fitted at the same time. The combined I/O board Option 79/01 is an exception. Only one such board can be fitted. However, it can be combined with any other output board.

Option 70B: 4 BNC-connectors mounted in the area designated.

Option 71B: 4 BNC-connectors mounted in the area designated.

Option 72B: 4 BNC-connectors mounted in the area designated.

Option 73B: 4 BNC-connectors mounted in the area designated.

Option 74B: 4 BNC-connectors mounted in the area designated.

Option 77: -48 V_{DC} power supply & rear panel power D-sub connector.

Option 78: Internal 16 V_{DC} rechargeable battery for GPS-12(R)

Option 78/HS: Internal 16 V_{DC} rechargeable battery & rear panel power D-sub connector for ext. 12 V_{DC} source. Intended for GPS-12R/HS and GPS-12RG.

Option 79/01: 4 BNC-connectors mounted in the area designated.

Installation

Supply Voltage

Setting

The GPS-12X frequency standard can be connected to any AC supply with a voltage rating of 90 to 265 V_{rms}, 45 to 440 Hz. The frequency standard automatically adjusts itself to the input line voltage.

Depending on option chosen, the unit can also be supplied by external DC sources, -48 V or +12 V.

Fuse

The secondary supply voltages are electronically protected against overload or short circuit. The primary line voltage side is protected by a fuse located on the power supply unit. The fuse rating covers the full voltage range. Consequently there is no need for the user to replace the fuse under any operating conditions, nor is it accessible from the outside.

CAUTION: If this fuse is blown, it is likely that the power supply is badly damaged. do not replace the fuse. Send the frequency standard to the local Pendulum Service Center.

Grounding

Grounding faults in the line voltage supply will make any instrument connected to it dangerous. Before connecting any unit to the power line, you must make sure that the protective ground functions correctly. Only then can a unit be connected to the power line and only by using a three-wire line cord. No other method of grounding is permitted. Extension cords must always have a protective ground conductor.

WARNING: If a unit is moved from a cold to a warm environment, condensation may cause a shock hazard. Ensure, therefore, that the grounding requirements are strictly met.

WARNING: Never interrupt the grounding cord. Any interruption of the protective ground connection inside or outside the instrument or disconnection of the protective ground terminal is likely to make the instrument dangerous.

Power Switch

This instrument is equipped with a secondary power switch. It disconnects the main power-consuming circuits on the secondary side of the power supply but leaves the rubidium oscillator active in order to retain its long-term characteristics. Line voltage is always present on the primary side.

WARNING: Always consider the instrument active as soon as it is connected to the primary AC power source with a power cord.

Orientation and Cooling

The frequency standard can be operated in any position desired. Make sure the air flow through the ventilation slots are not obstructed. Leave 50 mm (2 in) of space around the instrument.

CAUTION: Never cover the ventilation slots at the right or left side. If the slots are covered, the frequency standard will overheat.

Fan Control

The speed-controlled fan is used for adjusting the temperature inside the frequency standard to compensate for variations in ambient temperature.

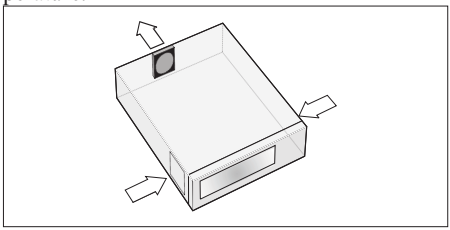


Figure 2-1 *Air flow through the GPS-12X.*

Fold-down Support

For bench-top use, a fold-down support is available for use underneath the frequency standard. This support can also be used as a handle to carry the instrument.

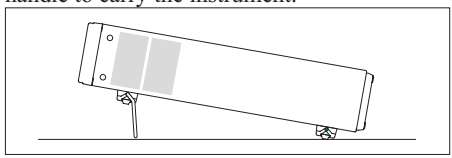


Figure 2-2 *Fold-down support for comfortable bench-top use.*

Rackmount Adapter

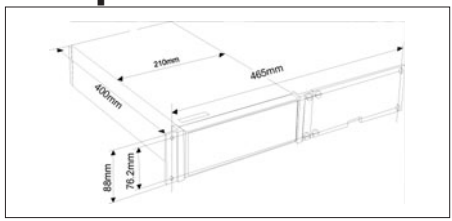


Figure 2-3 *Dimensions for rackmounting hardware.*

If you have ordered a 19 inch rack mount kit for your instrument, it has to be assembled after delivery of the instrument. The rack mount kit consists of the following:

2 brackets, (short, left; long, right)
4 screws, M5 x 8
4 screws, M6 x 8

WARNING: When you remove the cover you will expose live parts and accessible terminals which can cause death.

WARNING: Capacitors inside the instrument can hold their charge even if the instrument has been separated from all voltage sources.

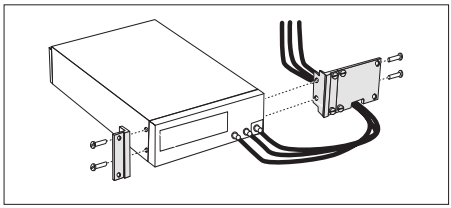


Figure 2-6 *Fitting the rackmount brackets on the counter.*

Assembling the Rackmount Kit

– Make sure the power cord is disconnected from the instrument.

– Turn the instrument upside down. See Figure 2-4.

– Undo the two screws (A) and remove them from the cover.

– Remove the rear feet by undoing the two screws (B).

– Remove the four decorative plugs (C) that cover the screw holes on the right and left side of the front panel.

– Grip the front panel and gently push at the rear.

– Pull the instrument out of the cover.

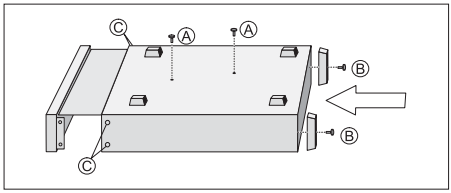


Figure 2-4 *Remove the screws and push the frequency standard out of the cover.*

– Remove the four feet from the cover.

Use a screwdriver as shown in the following illustration or a pair of pliers to remove the springs holding each foot, then push out the feet.

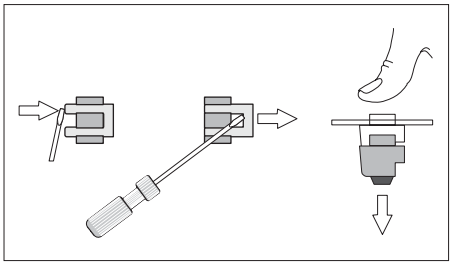


Figure 2-5 *Removing the feet from the cover.*

– Push the instrument back into the cover. See Figure 2-4.

– Mount the two rear feet with the screws (B) to the rear panel.

– Put the two screws (A) back.

– Fasten the brackets at the left and right side with the screws included as illustrated in Figure 2-6.

– Fasten the instrument in the rack via screws in the four rack-mounting holes

The long bracket has an opening so that cables for Input A, B, and C can be routed inside the rack.

■ Reversing the Rackmount Kit

The instrument may also be mounted to the right in the rack. To do so, swap the position of the two brackets.

Antenna Installation

The antenna (option 01), is intended for outdoor mounting on a wall or preferably on a roof. The more free sky that is visible from the antenna's position, the better the satellite contact. There is an antenna mounting kit (Option 01/50) available for this purpose.

The antenna cable is a 20 m (Option 02) or 50 m (Option 02/50), or 130 m (Option 02/130) high quality RG213 cable that connects at one end to the antenna and at the other end to the rear panel of the frequency standard. For installation details and instructions on connecting other antennas/cables than those supplied by Pendulum, please consult the Appendix in this manual.

Connecting to a PC

A PC can be connected to the USB port at the rear of the instrument for firmware download or communication with the optional SW package *GPS-12 Monitor.* A suitable cable should have one USB-A connector (for the PC) and one USB-B connector -for the GPS-12X.

The procedure is described in the service manual, as only trained personnel should do FW upgrades. Erroneous handling of the instrument before and during the download may damage the memory contents and prohibit the completion of the loading process.

Disposal of Hazardous Material

The basic instrument and all optional units except Option 78 and Option 78/HS have no batteries or other parts containing hazardous amounts of substances that require special attention or handling instructions.

Option 78 and Option 78/HS contain a rechargeable NiMH battery pack that serves the purpose of providing uninterruptible power to the instrument. As all batteries, it has a finite lifetime. Although NiMH-based cells are by far less detrimental to the environment than their NiCd-based predecessors, we strongly recommend to dispose of them by controlled recycling.

CAUTION: Make sure the battery pack is recycled according to local regulations.

Chapter 3

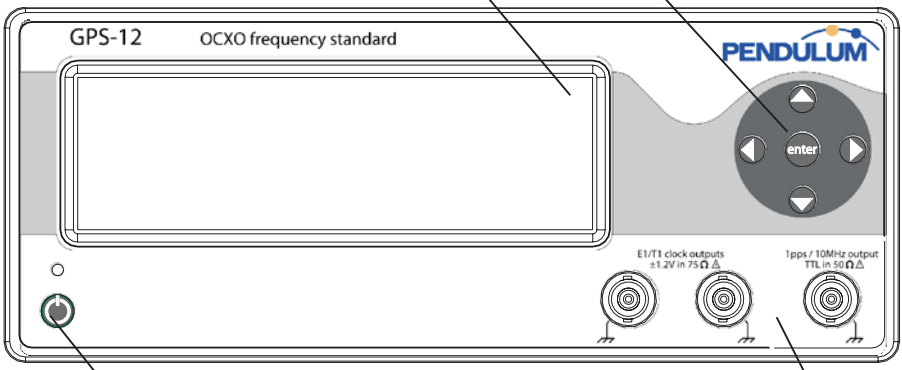
Using the Controls

Front Panel

LCD display with backlight forming the User Interface (UI) together with the **CURSOR** and **ENTER** keys to the right.

The default messages inform the user about Control Mode (*Disciplined* or *Hold-over*), Satellite Status, Alarm, Power Source, User Options and Time/Position.

The **CURSOR** keys (with arrow symbols) are used for moving the cursor, marked by text inversion, around the menus on the display. By pressing the **ENTER** key you either confirm a choice or enter a submenu. Back one step by pressing the **LEFT ARROW** key.



POWER ON / STANDBY key. A secondary power switch that ligths up the red LED above the key in standby mode.

BNC Reference Output Connectors
2 x 2.048 MHz* + 1 x 1 pps / 10 MHz** or
2 x 1.544 MHz* + 1 x 1 pps / 10 MHz**

* The choice is made in the *User Options* submenu.

** Only newer HW versions have the 10 MHz alternative. The choice is made in the *User Options* submenu.

Optional outputs can be found on the rear panel.

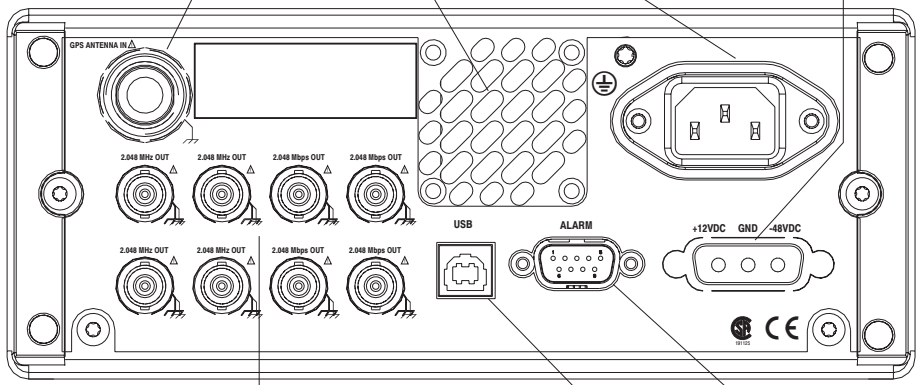
Rear Panel

Antenna cable input (N-contact)

Fan with automatic speed control

Power input 90-265 V, 45-440 Hz

Optional external DC power inputs



Optional Outputs

Option 70B: sine wave
3 x 10 MHz + 1 x 5 MHz

Option 71B: sine wave
1 x 10 MHz + 1 x 5 MHz + 1 x 1 MHz + 1 x 0.1 MHz

Option 72B: square wave
2 x 2.048 MHz +2 x 2.048 Mbps

Option 73B: square wave 4 x 13 MHz

Option 74B: square wave
2 x 1.544 MHz + 2 x 1.544 Mbps

Option 79/01: 1 x 1 pps disciplining input + 1 x 1 pps output + 2 x 10 MHz low-noise outputs

USB port for firmware download from PC

Two relay-controlled alarm loops, one for urgent and one for non-urgent situations.

See page 3-6 for pin configuration.

Functional Description

The GPS-12X series of frequency standards is continuously disciplined by control signals from satellites belonging to the GPS [GPS-12(R)] or the GLONASS/GPS [GPS-12RG] navigation satellite systems. The signals have very low long-term uncertainty ($5*10^{-13}$ per 24h), and are traceable to different national standards for time and frequency at, for instance, the National Institute of Standards and Technology (NIST) via the US Naval Office (USNO). The GPS-12X contains a satellite receiver module, generating a stable 1 pps signal, plus a local voltage-controlled rubidium or crystal oscillator (OCXO) and a high resolution measurement kernel that is continuously phase-comparing the received satellite signal and the local oscillator. This means that the local oscillator is continuously monitored and adjusted.

The GPS-12X can operate in two different modes. Either the local oscillator is free-running with a frequency offset that increases with time, due to aging, or the results of the phase comparisons are used for adjusting the local oscillator, thereby compensating for aging. These two modes are called:

– *Hold-over mode* (free-running local oscillator)

– *Disciplined mode* (monitored and adjusted local oscillators)

Disciplined mode is the default mode. Hold-over mode is automatically entered when the disciplining fails for some reason (e.g. loss of satellite contact). Hold-over mode can also be forced via the User Interface (UI). When the satellite contact is lost, the GPS-12X can not be continuously controlled (intercompared with the satellite reference clocks in real time) and reverts temporarily to hold-over mode specifications.

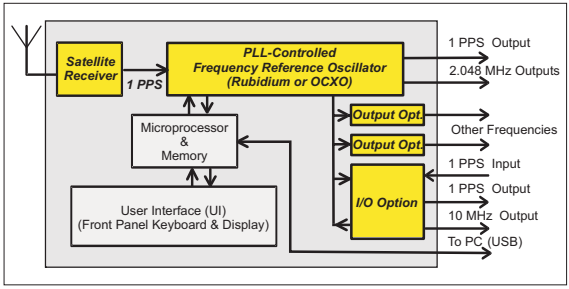


Figure 3-1. *The internal high-stability oscillator of the GPS-12X is continuously compared with and controlled by the satellite receiver.*

User Interface

General Principles

The UI is straightforward. All interaction between operator and instrument takes place by navigating a cursor (marked by text inversion) on the LCD through a set of text-based menus. The navigating tools are just four arrow keys,

UP (▲), **DOWN** (▼), **LEFT** (◀), **RIGHT** (▶), and one **ENTER** key. The different menus are described in the following paragraphs.

Default Menu

This is the menu entered at start-up and shows the current instrument status. Here *RB-osc* is selected, and to the right you can find one of the following short informative texts:

- Warming up
- Unlocked
- Hold-over

- Manual Hold-over
- Disciplined by GNSS
- Disciplined by Ext. Ref.*

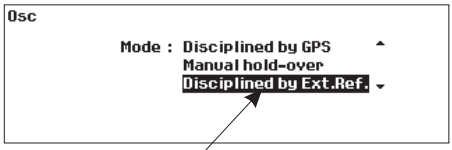
The normal end message after the transitory start-up phase, which usually lasts less than 20 minutes, is *Disciplined by GNSS*. Then we assume that the antenna installation has been performed according to given instructions. If Option 79/01 is installed, and the instrument is disciplined by an external 1 pps reference source, then the message is *Disciplined by Ext. Ref.*

Oscillator Menu

By pressing ▶ you will enter the *Osc* submenu, indicated by the corresponding label at the top left corner:

■ Mode

Here you can change the operational mode of the oscillator. If you want to return to the default menu, press ◀. By pressing **ENTER** or ▶ you will be able to select the mode. Use ▲ or ▼, and confirm your choice by returning to the previous screen. Press ◀.



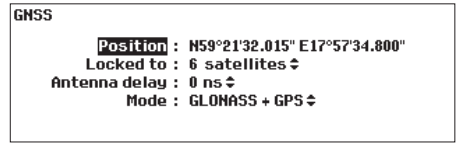
* Available only if Option 79/01 is installed.

■ 1 pps Offset (GPS12R/HS & GPS-12RG

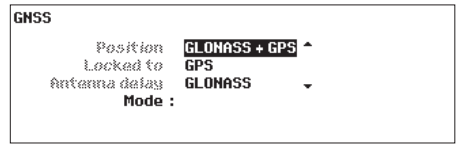
Here you can set the time offset of the 1 pps output signal that is available on the front panel. The range is ±999 ns.

GNSS Menu

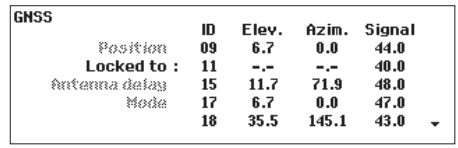
Moving the cursor to *GNSS* in the default menu will bring you to the GNSS submenu after pressing **ENTER** or ▶.



Here you can see your current position and how many satellites that you are locked to. You can also adjust the antenna delay. The GPS-12RG has three operational modes. See the screen below that appears when you enter the *Mode* menu. Select the mode that gives the best performance at your location.



If you want to see a list of all locked satellites and their status you should move the cursor to *Locked to* and then press **ENTER** or ▶. The menu below will be activated.



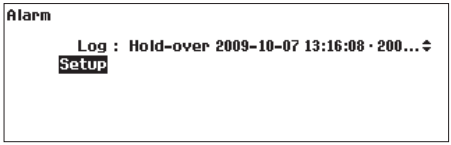
■ Antenna Delay (not GPS-12RG)

In order to compensate for the signal delay introduced by the antenna and its connecting cable, the 1 pps reference signal from the GPS re-

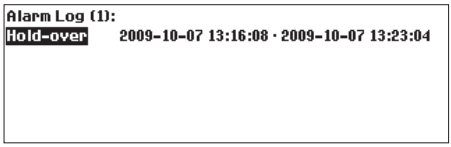
ceiver can be shifted in time from this menu. If you don't know the exact delay, assume an approximate value of 5 ns/m as a rule of thumb.

Alarm Menu

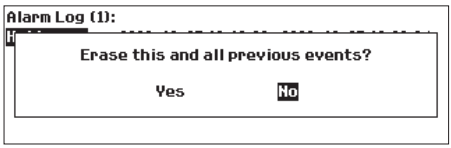
In this menu you can watch and manage the alarm log. You can also set up the alarm behavior.



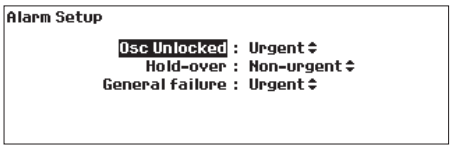
Scroll through the log entries by selecting *Log*. Then press **ENTER** or ▶.



If you press **ENTER** or ▶ once more, you are given the opportunity to erase the log entries.

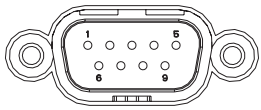


In the alarm *Setup* menu you can choose among a number of alarm sources and decide their alarm level, i.e. *urgent*, *non-urgent*, or *no alarm*.



■ Alarm Outputs

Two relay-controlled alarm loops, one for urgent and one for non-urgent situations, are available via a D-sub connector on the rear panel. The normally closed (NC) contacts will open when the respective alarm criteria are met. Figure 3-2 shows the pin configuration.

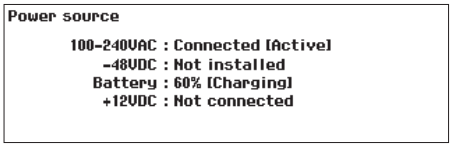


ALARM LEVEL	CIRCUIT (NC)
URGENT	Pins 8-9
NON-URGENT	Pins 1-6

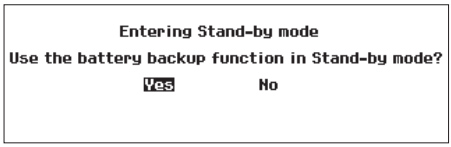
Figure 3-2 *Alarm connector pin configuration.*

Power Source Menu

In this menu you can see what power options are installed and the current status of those options.



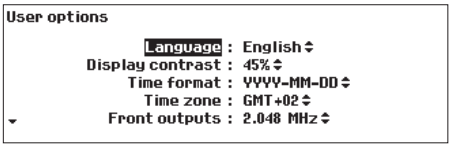
Note: When the unit is about to enter *Standby* mode, and the battery option is installed, the screen below will appear.



Only one of the alternative DC power supply units, Option 77, Option 78 or Option 78/HS, can be installed. All of them can serve as UPS devices, i.e. you can have external (Option 77) or internal (Option 78 and Option 78/HS) battery backup for the AC supply. Option 77 and

Option 78/HS allow external DC voltage feed instead of the standard AC line power feed.

User Options



From this submenu you can configure miscellaneous settings and obtain important data on the instrument and its options.

Note: The sign ▼ at the bottom left corner indicates that additional information can be displayed by scrolling.

■ Language

The instrument UI is prepared for different language modules that can be downloaded over the USB port. The standard module comprises the following languages:

- English
- German (Deutsch)
- French (Français)
- Spanish (Español)
- Turkish (Türkçe)
- Russian (Русский)

There is also a module available containing *Chinese* and *Japanese*. *English* can always be chosen, irrespective of the active language module.

■ Display Contrast

The adjustment range is 0-100 %. The optimum value depends on the angle of view from which the display is observed.

■ Time Format

The following formats are currently available:

- YYYY-MM-DD
- YYYY/MM/DD
- YY-MM-DD
- YY/MM/DD
- DD-MM-YYYY
- DD/MM/YYYY
- DD-MM-YY
- DD/MM/YY
- MM/DD/YYYY

■ Time Zone

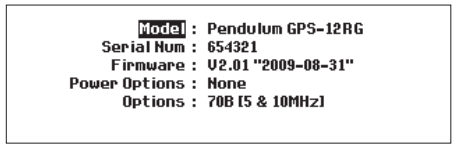
Here you can enter the local time zone to adjust the clock display. The increment is 0.5 h.

■ Front Panel Outputs

Switch between 2.048 MHz and 1.544 MHz.

■ About

Information about the instrument, e.g. installed options and firmware version.



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Chapter 4

GPS-12 Monitor

What is GPS-12 Monitor?

GPS-12 Monitor is an optional software package allowing full remote control and monitoring of the instrument from a PC over the USB-B connector on the rear panel.

Requirements

Hardware

CPU 1 GHz, RAM 256 MB, HD free space 10 MB if Microsoft.NET Framework installed, else 500 MB, USB interface V 1.0 or later, cable with USB-A connector at one end and USB-B connector at the other.

Software

Operating system: Win 2K, XP, Vista, Win7; 32 or 64 bit.

Libraries: Microsoft.NET Framework V 2.0 or later.

Versions

Emulator

By downloading the unregistered version from our website www.pendulum-instruments.com you can get acquainted with the basic features of the instrument without having the actual hardware.

The emulator mode offers the operator the opportunity to choose among a number of different setups. The monitor screen mirrors the real front panel, so you can operate the virtual instrument with the PC mouse just about the same way as you press the keys on the real instrument.

User

If you want to be able to control the GPS-12X remotely, you have to buy a license key that opens up all the features of the monitor program. You don't have to download and install another version of the software. See *License Registration* below.

Installation

Open the downloaded installation file and follow the on-screen instructions given by the installation wizard.

■ Prerequisites

The installer checks the PC for the operating system and the service packs necessary to install the application. It also looks for other necessary programs and verifies your user rights. Any shortcomings are reported. Make sure your PC meets the requirements under *Software* above before starting the installer.

■ License Registration

GPS-12 Monitor is a proprietary application program, so in order to use all features it must be registered by means of a license key entered under the *Help* menu. After entering a correct license key, the program will be restarted automatically in order to recognize and apply the changes.

Main Features

- Collecting and presenting device data.
- Setting up device parameters.
- Taking snapshots of the device screen.
- Uploading firmware and language packs.

- Checking for updates.

Collecting and Presenting Device Data

■ User Mode

GPS-12 Monitor collects and displays data from the GPS-12X. Normally the libraries included in the operating system are enough to run the application. Several instruments can be connected simultaneously for easy selection, but only one at a time can be operated from the application. Switching between *local mode* and *remote mode* is done by toggling the green power key on the monitor screen. Remote mode is indicated by an inverted **R** at the top right corner of the display.

■ Emulator Mode

This mode, selected under *Tools*, is mainly intended for demonstration purposes, as no hardware of any kind is necessary. It allows evaluation of different options, for instance, and is indicated by an inverted E at the top left corner of the display. Use the form under *Tools →Emulator → Options* for selection of options.

Setting Up Device Parameters

Properties and parameters that can be adjusted are grouped in a number of forms named after the headings on the display, e.g. *Alarm options*. Mark the different properties and make the necessary changes. Confirm the complete form by pressing *OK* or discard all changes by pressing *Cancel*.

Some forms, e.g. *GPS / GNSS options*, require that you press the *Edit* button on the toolbar to enter *Edit mode*. Press *Edit* again to return and *OK* to confirm the new values.

Taking Snapshots of the Device Screen

If you are in local mode and want to save the current screen contents as a bitmap picture file, then you can start GPS-12 Monitor and go to *Tools → Snapshot* to catch the moment. Select a suitable file format and save the file.

Uploading Firmware and Language Packs

The firmware is the main program of the instrument, and the language packs are resource files containing strings for menus and values in a number of languages. These files are resident in a Flash EPROM and can be updated when newer versions are available. Go to *Tools →Loader*. Find the new downloaded hex files and upload them one at a time by pressing *Open*. Follow the instructions on the screen.

Note 1: During uploading you must not switch off the instrument or close the application, until the loader reports that it is ready.

Note 2: If running on battery, make sure it is fully loaded before starting the uploading.

Checking for Updates

GPS-12 Monitor is designed to check for newer application software automatically at intervals decided by the user. Go to*Tools → Options →Updates* to set a value between 1 and 30 days. You can also check for updates manually whenever you want by going to *Help → Check for updates*.

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Chapter 5

Performance Check

General Information

WARNING: Before turning on the instrument, ensure that it has been installed in accordance with the Installation Instructions outlined in Chapter 1 of the User's Manual.

This performance procedure is intended for incoming inspection to determine the acceptability of newly purchased instruments, or whenever a quick test is convenient.

Note: The procedure does not check every facet of the instrument. It is concerned primarily with those parts of the instrument which are essential for determining the function of the instrument.

Note: This GNSS-controlled Frequency Reference does not need to be sent away for frequency calibration. The instrument is continuously monitored and adjusted by means of the GNSS signal, as long as there is sufficient satellite contact, and the active operating mode is not *Hold-over*.

It is not necessary to remove the instrument cover to perform this procedure.

Recommended Test Equipment

– DSO with 50 Ω input

– Pendulum CNT-90 timer/counter

– A calibrated 1, 5 or 10 MHz reference source with at least rubidium characteristics.

  The GPS-controlled Pendulum GPS-89 or Fluke 910R is a suitable choice, as it can also be used for the calibration procedure described in Chapter 5, Preventive Maintenance.

Preparations

Connect the antenna, including cable, to the antenna input (rear). Make sure the antenna position is satisfactory.

Power-On Test

Connect the AC power cord to the instrument and the line power outlet. The instrument shall automatically enter *Operating* mode, indicated by the following characteristics:

- The display backlight shall be lit.
- The default screen shall be visible.
  - « Note the message *Warming Up* on the first line.
- The *Standby LED* shall not be lit.
- The fan shall start.

Wait until the instrument shows the messages *Disciplined by GNSS* and *Locked to X satellites*, where X>2. It will normally take less than 20 minutes.

Press the *Power/Standby* key to see if the instrument enters *Standby* mode, indicated by the following characteristics:

- The red *Standby LED* shall be lit.
- The display shall go out.
- The fan shall stop.
- The rubidium oscillator is still powered.

The state of the rubidium oscillator can not be observed directly, but when you power up the instrument again to proceed with the performance check, you can see from the accompanying display message that the *Warming Up* phase is very short. Consequently the startup process will be accelerated accordingly.

Power up your instrument at least 30 minutes before continuing. This will allow the instrument to reach normal operating temperature

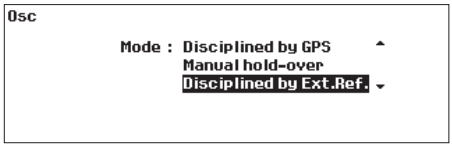
and go into *Disciplined by GNSS* mode with adequate margins.

Front Panel Controls

Keyboard Test

1 Make sure the default menu is visible. See page 3-4. Check that the cursor (marked by text inversion) can be moved upwards and downwards with the UP/DOWN arrows, and that you can enter submenus with the RIGHT ARROW key and return from the submenu with the LEFT ARROW key.

2 Select *Osc* and press **ENTER** twice. Make sure you see the screen below:



3 Return to the default menu by pressing the LEFT ARROW key twice.

Front Panel Outputs

Connect the reference frequency source to the EXT REF input on the rear panel of the CNT-90 counter and recall the default settings.

2.048 / 1.544 MHz

Select 2.048 MHz via *User Options* and follow the test directions below. Then select 1.544 MHz and repeat the test:

– Connect a DSO with 75 Ω inputs to both the 2.048 / 1.544 MHz outputs, one at a time.

– Verify that the signal is a square wave, and that the low level is -1.2 V ± 10 % and the high level +1.2 V ± 10 %.

– Connect the counter and verify that the frequency is:
2.048 / 1.544 MHz ± 0.002 Hz.

1 pps / 10 MHz

The default value is 1 pps but can be changed to 10 MHz under the menu *User Options* on the start screen. See note.

■ 1 pps

Connect a DSO with 50 Ω inputs to the output. Verify that the signal is a rectangular pulse train with a pulse width of approx. 10, 100 or 133 µs, depending on the oscillator option,and that the low level is <0.9V and the high level >1.8V. Connect the counter and verify that the frequency is 1Hz ± 1 µHz.

■ 10 MHz

Use the same test setup as above. Select 10 MHz under *User Options*. The pulse width should now be approx. 50 ns and the frequency 10 MHz ± 0.01 Hz.

Note: Only newer HW versions have the 10 MHz alternative.

Rear Panel I/O

Option 70B

(3 x 10 MHz & 1 x 5 MHz)

Connect a DSO with 50 Ω inputs to all BNC connectors, one at a time. Verify that the four output signals are sinusoidal and that the voltage is at least 1 Vrms. Connect the counter and verify that the frequency is 10 MHz ± 0.01 Hz resp. 5 MHz ± 0.005 Hz.

Option 71B

(0.1 & 1 & 5 & 10 MHz)

Connect a DSO with 50 Ω inputs to all BNC connectors, one at a time. Verify that the four output signals are sinusoidal and that the voltage is at least 1Vrms. Connect the counter and verify that the frequency is 10 MHz ± 0.01 Hz, 5 MHz ± 0.005 Hz, 1 MHz ± 0.001 Hz and 0.1 MHz ± 0.0001 Hz respectively.

Option 72B

(2 x 2.048 MHz & 2 x 2.048 Mbps)

Connect a DSO with 75 Ω inputs to all BNC connectors, one at a time. Verify that the output signal is a rectangular pulse train with an amplitude of ±1.2 V ± 0.12V. Connect the counter and verify that the frequency at the two clock outputs is 2.048 MHz ± 0.002 Hz. The amplitude at the two data outputs can be checked in the same way. For a quick check of the validity of the encoded HDB-3 data, do like this:

– Connect the data outputs, one at a time, to Input A on the counter and measure according to the procedure below.

– Recall the default settings and make these alterations in the INPUT A menu:

  – **DC** coupling

  – **50** Ω input impedance

  – **Trig 75 %**

– Select **MEAS FUNC** →**Period** → **Single** → **A**

– Select **STAT**istics.

The result should be the clock period time multiplied by four, i.e. 4 x 488 = 1952 ± 2 ns
Standard Deviation σ < 1 ns

Option 73B

(4 x 13 MHz)

Connect a DSO with 50 Ω inputs to all BNC connectors, one at a time. Verify that the signal is a square wave, and that the low level is <0.9 V and the high level >1.8 V. Connect the counter and verify that the frequency is 13 MHz ± 0.013 Hz.

Option 74B

(2 x 1.544 MHz & 2 x 1.544 Mbps)

Connect a DSO with 75 Ω inputs to all BNC connectors, one at a time. Verify that the output signal is a rectangular pulse train with an amplitude of ±1.2 V ± 0.12V. Connect the counter and verify that the frequency at the two clock outputs is 1.544 MHz ± 0.0015 Hz. The amplitude at the two data outputs can be checked in the same way. For a quick check of the validity of the encoded HDB-3 data, do like this:

– Connect the data outputs, one at a time, to Input A on the counter and measure according to the procedure below.

– Recall the default settings and make these alterations in the INPUT A menu:

  – **DC** coupling

  – **50** Ω input impedance

  – **Trig 75 %**

– Select **MEAS FUNC** →**Period** → **Single** → **A**

– Select **STAT**istics.

The result should be the clock period time multiplied by four, i.e. 4 x 648 = 2592 ± 2 ns
Standard Deviation σ < 1 ns

Option 77

(-48 V_{DC} from ext. source)

– Disconnect the line power cord.

– Connect 48 V_{DC} to the power D-sub connector with the plus pole to the ground pin and the minus pole to the pin marked -48VDC. Use the mating D-sub socket connector that is included with the instrument.
– Check that the instrument behaves in the same way as when it is connected to line power only.
– Reconnect the line power cord, and disconnect the 48 V source temporarily.
– Check that the instrument behaves normally.
– Reconnect the 48 V source while the instrument is still operating off line power.
– Check that the instrument behaves normally.
– Disconnect the line power cord and check that the instrument continues to work without interruption (UPS function).

Option 78 & Option 78/HS

(Int. battery backup & ext. 12 V_{DC})

– Connect the instrument to line power and press the *Power/Standby* button to enter *Standby* mode. The red LED above the button shall light up.
– Let the internal battery charge for 3 hours. Then it will reach about 80 % of its capacity.

Note: It will take another 21 hours for the battery to reach full capacity if it was completely discharged from the beginning.

– Disconnect the power cord and switch on the instrument.
– Check that the instrument behaves normally and is operative for about 90 minutes.

■ Option 78/HS only

– Connect 12 V_{DC} to the power D-sub connector with the minus pole to the ground pin and the plus pole to the pin marked +12VDC. Use the mating D-sub socket connector that is included with the instrument.
– Check that the instrument behaves in the same way as when it is connected to line power only.
– Let the internal battery charge for about half an hour.
– Disconnect the 12 V source.
– Check that the instrument continues to work without interruption (UPS function).

■ Both Options

– Reconnect the line power cord.
– Check that the instrument behaves normally.
– Let the internal battery charge for about half an hour.
– Disconnect the line power cord and check that the instrument continues to work without interruption (UPS function).

Option 79/01

(1 x 1 pps in & 1 x 1 pps out & 2 x 10 MHz out)

■ 1 pps In

– Disconnect the GPS antenna.
– Connect a stable 1 pps TTL source to the 1 pps input on the option board.
– Select *External 1 pps* from the Osc submenu on the front panel.
– Return to the main menu.

– Wait until the instrument shows the message *Disciplined by 1 pps*. It will normally take less than 20 minutes.

■ 1 pps Out

The 1 pps output can be tested in the same way as the 1 pps front panel output. See above.

■ 10 MHz Out

The two 10 MHz outputs can be tested in the same way as Option 71B. See above.

Alarm Output

– Make sure the instrument is in Standby Mode.

– Measure the resistance between pin 8 and pin 9 on the D-SUB alarm connector. Expected result: open circuit (near infinity)

– Measure the resistance between pin 1 and pin 6 on the D-SUB alarm connector. Expected result: open circuit (near infinity)

– Switch on the instrument.

– Measure the resistance between pin 8 and pin 9 on the D-SUB alarm connector. Expected result: closed circuit (near zero)

– Measure the resistance between pin 1 and pin 6 on the D-SUB alarm connector. Expected result: closed circuit (near zero)

Chapter 6

Preventive Maintenance

Calibration

Calibration and adjustment in the traditional sense are not necessary as long as the instrument is operating in disciplined mode. Then the internal rubidium timebase is continuously monitored and forced to follow the cesium clocks of the navigational satellites. These clocks are traceable to, for instance, NIST and USNO. Thus the normal aging characteristics of the internal timebase will be concealed.

However, if the device is operating in hold-over mode for long periods, the aging characteristics are no longer concealed. Then you may need to reset the timebase from time to time by letting the device operate in disciplined mode for at least 48 hours. See also next paragraph.

■ Calibration Intervals

Normally it is quite adequate to check the frequency deviation between one of the reference outputs and a corresponding, independent, cesium-controlled reference source once a year, using the procedure described below. Shorter intervals may be necessary if the main operating mode is *hold-over*, and the allowed deviation is less than the specified annual aging. See the timebase specifications to collect the data for these calculations.

■ Equipment

– The DUT (Device Under Test).

– Timer/Counter Pendulum CNT-90.

– A GPS-controlled reference frequency source capable of generating both 2.048 MHz and alternatively 1, 5 or 10 MHz at an amplitude between 0.1 and 5 V_{rms} in 50 Ω. It should also have a traceable calibration history. The Pendulum GPS-89 with Option 72 is apt to the task.

– BNC cables of suitable lenghts.

Note: There are several ways to perform this checkup, depending on available equipment. The setup and procedure described in the next paragraphs are based on the list above.

■ Setup

– Connect the reference source (1, 5 or 10 MHz) to the *EXT REF* input on the counter.

– Connect one of the 2.048 MHz outputs on the front panel of the DUT to *Input A* on the counter.

– Connect the 2.048 MHz reference source to *Input B* on the counter.

– Find a good antenna position, and connect the antenna to the DUT. Power up the DUT and the reference source at least 24 hours before starting the verification procedure. Make sure the GPS contact is established and the system is working within 15 minutes after the DUT was switched on.

– Power up the timer/counter at least one hour before starting the verification procedure.

■ Procedure

Note: Each key depression is not described here. See the Operators Manual for the timer/counter if you need more information.

– Recall the default settings of the counter.

– Set the trigger level to *Man 0.0 V* on both *Input A* and *Input B*.

– Set the measuring time to 10 s.

– Check that the frequency is 2.048 MHz ± 0.01 Hz.

– Change measurement function to *Time Interval A to B*.

– Set *Number of Samples* to 2, *Pacing Time* to 100 s and *Pacing* to *ON* in the *SETTINGS* menu.
– Select *STAT* (statistics) and *HOLD*.
– Press *RESTART*.
  – Wait for the measurement to finish after 100 s (marked by *HOLD* appearing at the upper right corner of the display). Check that *Max* and *Min* are both positive. Otherwise press *RESTART* again to repeat the measurement.
– Note the *P-P* value that equals the absolute difference between the maximum and the minimum time interval error value (Δ_{TIE}), and calculate the equivalent relative frequency deviation $\Delta f = \Delta_{TIE} / 100$.

Acceptance criterion

Δf calculated according to the expression above should be less than 2×10^{-12}.

– Change the DUT mode to *Manual Hold-over*.
– Press *RESTART* and note the intermediate result for sample #1, i.e. before the measurement ends after 100 s.
– Wait 24 h.
– Press *RESTART* and note the intermediate result for sample #1, i.e. before the measurement ends after 100 s.
– Calculate the absolute difference between the two results (Δ_{TIE}).
– Calculate $\Delta f = \Delta_{TIE} / 86400$.

Acceptance criterion

Δf calculated according to the expression above should be less than 5×10^{-12}.

Fan Replacement

If your frequency reference is operating 24h/day, you need to replace the fan every 5 years to maintain high reliability. For part-time applications and low ambient temperatures, an extended service interval is acceptable.

Fan replacement requires no special tools (screwdrivers only). The part number of the replacement fan is 4031 105 02850.

Battery Replacement

There are no batteries in the basic instrument.

Option 78 and Option 78/HS have a NiMH battery pack that is specially adapted to its purpose. It must not be replaced by anything else but the original part, the order number of which is 4031 100 67190.

Replacement is recommended when the battery operating time falls short of one hour, provided the battery pack has been charged in standby mode for at least 24 hours.

Dispose of the old battery pack according to local recycling regulations. See also page 2-8.

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Chapter 7

Specifications

Stability

0.1, 1, 5 & 10 MHz Outputs

■ Locked to GNSS

Allan dev. @ 20-26 °C [1]	OCXO	Standard Rb	HS Rb [2]
(τ = 24 h)	$<5\times10^{-12}$	$<2\times10^{-12}$	$<1\times10^{-12}$
(τ = 100 s)	$<2\times10^{-11}$	$<5\times10^{-12}$	$<3\times10^{-12}$
(τ = 10 s)	$<2\times10^{-11}$	$<1\times10^{-11}$	$<1\times10^{-11}$
(τ = 1 s)	$<2\times10^{-11}$	$<2\times10^{-11}$	$<2\times10^{-11}$
Phase noise dBc/Hz			
(offset) 1 Hz	<-90	<-75	<-85
10 Hz	<-120	<-95	<-125
100 Hz	<-130	<-125	<-135
1 kHz	<-140	<-140	<-145
10 kHz	<-140	<-140	<-145
100 kHz	<-140	<-140	<-145
Warm-up to lock (@ +25 °C)	N.A.	8 min	11 min
Warm-up (@ +25 °C)	15 min to 5×10^{-8}	12 min to 5×10^{-10}	13 min to 1×10^{-9}

■ Hold-Over

	OCXO	Standard Rb	HS Rb [2]
Aging/month [3]	$<1.5\times10^{-9}$	$<5\times10^{-11}$	$<5\times10^{-11}$
Aging/year [3]	$<1\times10^{-8}$	$<2\times10^{-10}$	$<5\times10^{-10}$
Temp. (0 °C... +50 °C)	$<2\times10^{-9}$	$<2\times10^{-10}$	$<1\times10^{-10}$
Allan dev. @ 20-26 °C [1]			
(τ = 100 s)	$<2\times10^{-11}$	$<5\times10^{-12}$	$<3\times10^{-12}$
(τ = 10 s)	$<2\times10^{-11}$	$<1\times10^{-11}$	$<1\times10^{-11}$
(τ = 1 s)	$<2\times10^{-11}$	$<2\times10^{-11}$	$<2\times10^{-11}$

1 pps Output

	OCXO	Standard Rb	HS Rb [2]
Jitter [4] rel. to UTC [5] or GPS [6]	<1 ns rms	<1 ns rms	<1 ns rms
Accuracy [4] vs. UTC [5]	±120 ns	±120 ns	-5 to +45 ns
Hold-over drift per 24 h (within ±2 °C)	<20 µs	<1 µs	<1 µs

Note 1: Allan deviation data given for both GNSS mode and hold-over mode applies after ≥72 h of continuous operation.

Note 2: The GPS-12R/HS also includes the low noise output Option 70B in order to make its extraordinary characteristics available to the user.

Note 3: Long-term frequency stability data given for hold-over mode applies after a 30-day settling period, during which the oscillator has been operating continuously.

Note 4: After ≥72 h of continuous operation.

Note 5: Locked to GNSS.

Note 6: Position Hold.

Standard Reference Outputs

Connector type:	3 x BNC on the front panel
Frequency #1:	2 x 2.048 MHz alt. 2 x 1.544 MHz (user selectable)
Output level:	Square wave ±1.2 V ± 10 % in 75 Ω (G.703:10)
Freq. stability:	See Note 1 on page 7-7
Jitter:	See table on p. 7-3
Frequency #2:	1 x 1 pps / 10 Mpps (user selectable)
Output level:	Appr. 0 V … 5 V unloaded Appr. 0 V … 2.0 V in 50 Ω
Pulse width:	Appr. 10 µs (1 pps & GPS-12R/HS or GPS-12RG) Appr. 133 µs (1 pps & GPS-12R) Appr. 100 µs (1 pps & GPS-12) Appr. 50 ns (10 Mpps)
Freq. stability:	See Note 1 on page 7-7

Alarm Outputs

Connector type:	9-p male D-Sub, 1 loop for urgent alarm, 1 loop for non-urgent alarm
Signal coding:	relay open → alarm mode relay closed → normal mode
Max. switching voltage:	60 V_{DC}
Max. switching current:	200 mA

Options

Option 70B Outputs*

Connector type:	BNC
Frequencies:	3 x 10 MHz + 1 x 5 MHz
Output level:	Sine wave >1 V_{RMS} in 50 Ω
Freq. stability:	See Note 1 on page 7-7

Option 71B Outputs

Connector type:	BNC
Frequencies:	10, 5, 1 and 0.1 MHz
Output level:	Sine wave >1 V_{RMS} in 50 Ω
Freq. stability:	See Note 1 on page 7-7

*Note: The GPS-12R/HS and the GPS-12RG are as standard equipped with one Option 70B.

Option 72B Outputs

Connector type:	BNC
Frequencies:	2 x 2.048 MHz + 2 x 2.048 Mbps
2.048 MHz	
Output level:	Square wave ±1.2 V ± 10 % in 75 Ω (G.703:10)
Freq. stability:	See Note 1 on page 7-7
Jitter:	<0.01 UI
2.048 Mbps:	(G.703)

Option 73B Outputs
(not GPS-12RG)

Connector type:	BNC
Frequencies:	4 x 13 MHz
Output level:	Square wave TTL in 50 Ω (See also Note 2 on page 7-7)
Freq. stability:	See Note 1 on page 7-7
Jitter:	<0.01 UI

Option 74B Outputs

Connector type:	BNC
Frequencies:	2 x 1.544 MHz + 2 x 1.544 Mbps
1.544 MHz Output level:	Square wave ±1.2 V ± 10% in 75Ω (G.703:10)
Freq. stability:	See Note 1 on page 7-7
Jitter:	<0.01 UI
1.544 Mbps:	(G.703)

Option 77

■ External DC Supply (-48 V_{DC})

Connector type:	3-pin power D-sub
Voltage:	-48 V_{DC} ± 10 %

Option 78 & Option 78/HS

■ Internal Backup Battery

Battery type:	NiMH, 16.8 V, 2.3 Ah
Operation time:	(Bat. loaded to 100 %) >2 h[1] or >3 h[2]
Standby time:	>2.5 h[3] or >5 h[4]
Lo bat alarm:	When 5-10 min left
Charging time:	3 h to 80 % of capacity
External DC Supply:*	11.3 - 18 V / 5 - 2.1 A Inlet protected against overvoltage and wrong polarity
Connector type:	3-pin power D-sub

Notes:	1	Opt. 78/HS:	*GPS-12R/HS & GPS-12RG*
		Opt. 78:	*GPS-12R*
	2	Opt. 78:	*GPS-12*
	3	Opt. 78/HS:	*GPS-12R/HS & GPS-12RG*
		Opt. 78:	*GPS-12R*
	4	Opt. 78:	*GPS-12*

Power Source Priority

1. AC line voltage supply
2. *External DC supply
3. Internal battery

*Option 78/HS only: An external 12 V_{DC} source can charge the internal battery as well as power the instrument in normal mode. The battery is also being charged when the instrument is connected to AC line power.

This means that you can get double UPS backup security in case of AC power breakdown, provided an external DC source is also connected.

Option 79/01

■ Reference Outputs & Disciplining Input

Connector type:	BNC
Outputs:	2 x 10 MHz + 1 x 1 pps
Input:	1 pps for ext. disciplining
10 MHz output level:	Sine wave >1 V_{RMS} in 50 Ω
1 pps output level:	Square wave TTL in 50 Ω (See also Note 2 on page 7-7)
1 pps input level:	Square wave TTL LO lvl ≤0.8 V, HI lvl ≥2.0 V Impedance approx. 1 kΩ
Freq. stability:	See Note 1 on page 7-7

Controls

User Interface:	LCD supported by 4 cursor keys and 1 ENTER key
Power:	Secondary STBY key

LED Indicator

Standby Mode:	Red LED above the key is ON
Power ON Mode:	Red LED above the key is OFF

GNSS Receiver

Trimble	Resolution-T [GPS-12(R)]
IRZ	MNP-M3 [GPS-12RG]
Antenna connector:	Type N, female
Power out:	+5 V, 0.1 A on center conductor for feeding active antenna and line amplifiers
Channels	
Trimble:	12, parallel tracking
IRZ:	16, parallel tracking
Carrier, code:	L1, C/A

Antenna (Option 01/00)

Type:	active GPS only, L1 band
Operating temperature:	-40°C to +70°C
Height:	81 mm (3.2”)
Weight:	230 g (8 oz.)
Gain:	>30 dB
Connector:	TNC

Antenna (Option 01/90)

Type:	active, combined GLONASS/GPS L1 band
Operating temperature:	-40°C to +85°C
Dimensions:	100 x 45 mm
Gain:	>30 dB
Connector:	TNC

Antenna Cable (Option 02)

Type:	RG213
Length:	20 m, 50 m & 130 m
Connectors:	type N and TNC (male)
Attenuation:	approx. 0.4 dB/m @ 1.6 GHz
Cable delay:	approx. 5.05 ns/m

PC Connection

Interface:	USB 1.1
Connector:	USB, type B, female
Purpose:	FW loading & remote monitoring and control. See Option 29/12 (GPS-12 Monitor) and Chapter 4.

Fan

Internal with temperature-controlled speed.

Display

Monochrome LCD with backlight. Resolution 320 x 97 pixels.

Notes

1. See frequency stability specs for the relevant oscillator type and operating mode (GNSS-locked or hold-over).

2. Approximately 0 - 5 V into an open output, 0 - 2 V into a 50 Ω load.

Environmental Data

Temperature:	0°C...+50°C (operating) -40°C...+70°C (storage)
Humidity:	95% RH, 0°C..+30°C (operating & storage)
Altitude:	<4600 m (operating) <12000 m (storage)
Vibration:	3G @ 55 Hz per MIL-T-28800D, Class 3, Style D
Shock:	Half-sine 40G per MIL-T-28800D, Class 3, Style D. Bench handling.
Safety:	Compliant with CE: EN 61010-1 2:nd edition, Cat II, Pollution degree 2
EMI:	Compliant with CE: EN61326-1 (1997), A1 (1998), A2 (2001), A3 (2003); EN55022B; EN50082-2

Dimensions and Weight

WxHxD:	210 x 108 x 395 mm
Weight:	Net 3.1 kg (6.6 lbs), shipping 4.1 kg (8.8 lbs) (excl. batteries)

Power Consumption

Line voltage:	90...264 V
Line frequency:	45...440 Hz
Power	
GPS-12:	<40 W at warm-up <30 W cont. operation
GPS-12R(G):	<60 W at warm-up <35 W cont. operation

Ordering Information

GPS-12:	2 x 2.048 / 1.544 MHz + 1 x 1 pps / 10 MHz std. outp. OCXO frequency reference Receiver for GPS
GPS-12R:	2 x 2.048 / 1.544 MHz + 1 x 1 pps / 10 MHz std. outp. Std Rb frequency reference Receiver for GPS
GPS-12R/HS:	2 x 2.048 / 1.544 MHz + 1 x 1 pps / 10 MHz std. outp. + 3 x 10 MHz + 1 x 5 MHz rear panel std. outputs HS Rb frequency reference Receiver for GPS
GPS-12RG:	2 x 2.048 / 1.544 MHz + 1 x 1 pps / 10 MHz std. outp. + 3 x 10 MHz + 1 x 5 MHz rear panel std. outputs HS Rb frequency reference Receiv.for GLONASS/GPS

Options

Opt. 70B:[1]	3 x 10 MHz + 1 x 5 MHz outputs
Opt. 71B:	0.1 + 1 + 5 + 10 MHz outp.
Opt. 72B:	2 x 2.048 MHz + 2 x 2.048 Mbps outputs
Opt. 73B:[2]	4 x 13 MHz outputs
Opt 74B:	2 x 1.544 MHz + 2 x 1.544 Mbps outputs
Opt 77:	-48 V external DC supply
Opt 78:[3]	Internal battery backup
Opt 78/HS:[4]	Internal battery backup w. external DC connector for charging and continuous operation
Opt 79/01:	1 x 1 pps disciplining input + 1 x 1 pps output + 2 x 10 MHz outputs

Notes:	1	Standard in the GPS-12R/HS and the GPS-12RG
	2	Not GPS-12RG
	3	GPS-12(R)
	4	GPS-12R/HS & GPS-12RG

None of the options above is retrofittable, which means that they must be ordered for factory installation together with the basic unit.

Up to two of the options designated 7XB can be fitted at the same time in any combination, e.g. 2 x Option 70B or Option 71B + Option 74B.

Note: Only one Option 79/01 can be fitted. If Option 79/01 is ordered, only one additional 7XB option can be ordered.

Included Accessories

Users Manual in PDF on CD
Calibration certificate
18 months warranty

Optional Accessories

Option 22/90:	19” rack mount kit
Option 27:	Soft carrying case
Option 27H:	Heavy duty hard transport case
Option 29/12:	GPS-12 Monitor, Control & Monitoring SW
Option 01/00:	GPS only antenna
Option 01/90:	GLONASS/GPS antenna
Option 01/50:	Antenna mounting kit
Option 02:	Antenna cable, 20 m
Option 02/50:	Antenna cable, 50 m
Option 02/130:	Antenna cable, 130 m
Option 90/10:	Calibration certificate with protocol
Option 90/00:	Calibration certificate Hold-over aging/week
Option 95/03:	Extended warranty 3 years
Option 95/05:	Extended warranty 5 years
Option OM-12:	Printed Users Manual (PDF file included as standard)

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Chapter 8

Appendix

Antenna Installation

Introduction

When installing an antenna for the satellite controlled frequency standards GPS-12X, some basic facts should be considered, relating to antennas and radio reception properties. The theoretical and practical discussions below will help you to make the right decisions.

Pendulum supplies satellite antennas and an antenna mounting kit as well as cable assemblies of different lengths. Other system components that may be necessary to meet your requirements are readily available from vendors of GNSS antenna equipment.

It is important to observe that deviations from the recommended normal solution may severely impair the performance of the overall system, unless the user has acquired the knowledge necessary to design a configuration of his own. General guidelines to good system design are given in this section of the handbook, but the user is entirely responsible for adequate performance in this case.

Available Options for Antenna Installation

Option 01/00: GPS antenna w. Type TNC fem. connector

Option 01/90: GLONASS/GPS antenna w. Type TNC fem. connector

Option 01/50: Antenna mounting kit for wall or pole mounting.

Option 02: Antenna cable, 20 m (Opt. 02/20), 50 m (Opt. 02/50) and, 130 m (Opt. 02/130) with Type TNC male connector at one end and Type N male at the other.

General Guidelines to Good Antenna Location

The general rule that applies to all installations working in or near the microwave frequency bands is that it should be possible to see the transmitter from the receiver antenna position. When dealing with terrestrial radio communication it is a great advantage to place both the transmitter antenna and the receiver antenna as high as possible. The effective line-of-sight distance increases with the square root of the height above ground.

The satellite-based transmitters are, however, moving targets in the sky and require in part new rules of thumb. Moreover, you need at least see more than two satellites simultaneously, irrespective of the point of time, to get stable time readings. The receiver can have contact with 12 GPS or 16 GLONASS satellites at the same time, but in practice three is enough for timing purposes, when the receiver is stationary.

It is not certain that an elevated location is an advantage, unless it is the only way to see as much of the sky as possible including the horizon in most directions. On the contrary, location on the ground could be more efficient from a technical point of view if you do not have to consider certain negative factors like the risk of physical damage and the influence of snow and ice on the antenna efficiency.

Other conditions to be taken into account are multi-path reception and interference from high-frequency signal sources nearby. All these

considerations could force you to find a place for the antenna situated far from the receiver and high above ground level. We will discuss these matters presently, but the implication in brief is that new system components may have to be introduced, like low-loss coaxial cables and line amplifiers.

Coping with Interference

There are mainly two sources of interference that may affect the location of the antenna. They will be treated below. Careful inspection of the proposed site can often reveal the most apparent ones.

■ Multi-path Reception

Reflections from metal surfaces nearby can cause the wanted signal to enter the antenna from two or more directions with more or less equal strength. Then the phase relationship determines whether the resulting signal will be amplified or attenuated. At worst it can vanish. Since the GNSS satellites are not stationary the conditions can be compared to the fading problem on the shortwave bands. The directive sensitivity of the antenna resembles a hemisphere with its base plane going horizontally through the antenna, provided it is mounted vertically on top of a mast. Therefore you must avoid locations near reflective surfaces beside or above the antenna.

■ High-frequency Interference

Strong signal sources in the vicinity, like cellular radio transmitters, can cause interference or saturation in the antenna amplifier. Even though the systems do not operate at the same frequency the problem has still been observed from time to time and must not be neglected.

Standard Configuration

The majority of installations can do with the standard configuration, consisting of one satellite antenna, one 20-m antenna cable, and the frequency reference itself, the GPS-12X. In many cases, the distance between the antenna and the receiver could be less than 20 m. Normally excessive cable length is easy to tolerate. Do not shorten the cable, unless absolutely necessary, because the high antenna gain of 36 dB requires the signal to be attenuated by at least 6 dB before entering the receiver.

Deviations from the Standard Configuration

■ General Principles

The system configurations that cannot directly use the standard options provided by Pendulum can be listed in different ways. One simple method of classification used here is to isolate a number of cases and treat them separately. If several steps have to be taken to arrive at a solution that satisfies all requirements, then it should be possible to derive the individual components from the list by means of combination. The method is illustrated by some practical examples later in this chapter.

The most important design parameter is the cable loss at the receiving frequency. There are a number of cable types to choose from, but for the sake of simplicity one normal and one low-loss type have been selected:

Cable type	Attenuation per 100 m
Standard (RG-213)	Approx 40 dB
Low loss (LMR400)	Approx 17 dB

The common laboratory cable RG-58 has been excluded, as its losses only allow relatively

short distances between antenna and receiver. It is more flexible, however, and might be utilized with care, if you are fully aware of its characteristics.

Remaining parameters to consider are:

Antenna gain:	+36 dB (option 01)
Guard band:	±3 dB
Total external gain at the receiver input:	+11dB … +33 dB

When designing your own antenna installation, you must check that the gain at the receiver input is within limits according to the above table. That is, you must check that:

+ antenna gain	+ antenna gain
- total attenuation	- total attenuation
+ total amplification	+ total amplification
- guard band	+ guard band
≥ +11 dB	***≤ +33 dB***

■ Case Classification

The distance between antenna and receiver exceeds 20 m but not 55 m

– Use a coaxial cable of type RG-213 or cascade two or three pieces of option 02 by means of adapters. Note that normal adapters are not weatherproof and should be placed indoors. Normally there is little to gain by using a low-loss cable in this case, but see example #1 below. RG-213 is more inexpensive and flexible.

The distance between antenna and receiver exceeds 55 m but not 130 m

– Use a low-loss coaxial cable of type LMR 400 or equivalent.

The distance between antenna and receiver exceeds 130 m but not 245 m

– Use a line amplifier with a nominal gain of 20 dB plus low-loss coaxial cable of type LMR 400 or equivalent. The amplifier must accept a fixed +5 V supply voltage fed through the central conductor of the coaxial cable. The maximum input power for linear operation should be at least –6 dBm, and the noise figure should be less than 2 dB.

The distance between antenna and receiver is in the range 245-360 m

– Use two cascaded line amplifiers (20 dB each) plus low-loss coaxial cable of type LMR 400 or equivalent.

Better protection against lightning strikes needed

Lightning protection is a wide field and cannot be covered more than superficially in this manual. If the building is situated in a risk area, a general survey of the overall house protection might be needed. Especially lightning rods near the GPS antenna mounting mast should be inspected. Make sure that the antenna is far from being the highest point and, as a precaution, ground the mounting mast as if it were part of the ordinary lightning rod system.

There are several conditions that may call for a separate lightning arrester to support the built-in antenna protection.

– The cable length outside the building exceeds
15 m.

– An elevated antenna position with no efficient lightning rods nearby.

– Areas where the frequency of thunderstorms is significantly higher than normal.

– Extra safety wanted due to sensitive and/or expensive equipment being connected to the GPS timebase system.

A lightning arrestor should be mounted inside the building close to the cable entry point.

Harsh environmental conditions

Snow and ice on the surface of the antenna can significantly reduce the effective sensitivity by as much as 6 dB. You could, for instance, utilize an electrically heated radome to house the antenna unit, to avoid the attenuation effects of this environmental influence.

Other weather conditions having negative influence on the system sensitivity are heavy rain and fog. The attenuation effects are normally covered by the 3 dB guard band, used in the calculations.

■ Four Practical Examples

Example 1

Requirements

Cable length:	52 m (5 m indoors)
Lightning arrester:	yes
Climatic conditions:	normal

Solution

The cable length indoors, i.e. after the lightning arrester, must be at least 8 m, otherwise the protective function may not be guaranteed. So, you have to make the cable 3 m longer indoors. The effective cable length will be 55 m instead. This is the upper limit for the standard RG-213 cable, under normal climatic conditions.

Calculation of total gain at the receiver input, using a RG-213 cable with an attenuation of 0.40 dB/m (40 dB per 100 m), under *normal environmental conditions*:

Antenna gain:	+36 dB
Cable loss:	-22 dB (-55 * 0.40)
Guard band:	-3 dB
Total gain:	+11 dB (36-22-3)

This gain figure is exactly at the lower permissible level at the receiver input.

Example 2

Requirements

Cable length:	55 m (50 m indoors)
Lightning arrester:	no
Climatic conditions:	snow and ice

Solution

The cable length 55 m is the upper limit for the standard RG-213 cable, under *normal environmental conditions.*

But snow and ice on the surface of the antenna can attenuate the signal by 6 dB.

Let us calculate total gain at the receiver input for a RG-213 cable, taking the snow and ice factor into consideration:

Antenna gain:	+36 dB
Harsh weather:	-6 dB
Cable loss:	-22 dB (-55 * 0.40)
Guard band:	-3 dB
Total gain:	+5 dB (36-6-22-3)

The latter figure should be in the range 11 – 33 dB, so the additional 6 dB loss due to extreme weather conditions requires the use of a low-loss cable, e.g. LMR400, having an attenuation of 0.17 dB/m (17 dB per 100m). This gives the following total gain:

Antenna gain:	+36 dB
Harsh weather:	- 6 dB
Cable loss:	-9 dB (-55 * 0.17)
Guard band:	-3 dB
Total gain:	+18 dB (36-6-9-3)

This gain value is well within the acceptable range.

Example 3

Requirements

Cable length:	130 m (120 m indoors)
Lightning arrester:	no
Climatic conditions:	normal

Solution

As this cable length suggests the use of a line amplifier, let us check that the total gain at the receiver input does not exceed the maximum value allowed, +33 dB.

Antenna gain:	+36 dB
Amplifier gain:	+20 dB
Cable loss:	-22 dB (-130 * 0.17)
Guard band:	+3 dB
Total gain:	+37 dB (36+20-22+3)

This calculation means that if the weather is fine and the antenna gain is at its positive tolerance level, then the signal should be attenuated by at least 4 dB to avoid overloading the receiver input. An external 6 dB attenuator directly on the input connector takes care of the problem.

As the cable length outside the building is not more than 10 m (limit 15 m) a lightning arrester is not compulsory.

Example 4

Requirements

Cable length:	325 m (120 m indoors)
Lightning arrester:	yes
Climatic conditions:	snow and ice

Solution

This is a typical two-amplifier configuration. A worst-case calculation using a LMR400 cable gives:

Antenna gain :	+36 dB
Amplifier gain:	+40 dB (+20 +20)
Cable loss:	-55 dB (-325 * 0.17)
Guard band:	-3 dB
Harsh weather:	-6 dB
Total gain:	+12 dB (36+40-55-6-3)

In other words, 325 m is close to the upper limit of the cable length, if the weather conditions are much worse than average. Otherwise you could expect another 35 m. It is not recommended to cascade more than two amplifiers to obtain even greater cable lengths due to the risk of saturation or other non-linear behavior. If need be, use a single, tuned amplifier designed for the calculated total gain.

Since the cable length outside the building is substantial, it is strongly recommended to use a lightning arrester, even if the location of the antenna is well protected from direct lightning strikes. Induced high voltages must not be neglected. Sensitive equipment without over-voltage protection can easily be destroyed in this way.

Auxiliary Components on the Market

This is a summary of system components that may be necessary to complete an installation tailored to your individual needs. These components are supplied by a large number of manufacturers worldwide.

If any of these parts have to be mounted outdoors, make sure they have an adequate temperature range. They must also be specified as weatherproof. Otherwise they have to be housed in boxes that can withstand the local climatic conditions.

■ Coaxial Cables

– Used for transferring the RF signal from the antenna unit to the receiver, sometimes via other system components. Active devices like line amplifiers and the antenna unit itself are also supplied with DC power through this cable.

Only high-quality 50 Ω cables should be used, preferably RG-213 for normal use and LMR 400 when long distances have to be bridged.

■ Coaxial Adapters

– Used for interconnecting system components employing different connector standards.

All major connector manufacturers also supply a large variety of adapters. Note that most adapters require additional protection if mounted outdoors or in places with high humidity.

■ Line Amplifiers

– Used for compensation of cable losses.

Normally wide-band amplifiers with moderate gain are used, but in special cases tuned high-gain amplifiers may be more suitable, for example when very long cable lengths are necessary.

Maximum two amplifiers can be inserted in the signal path before the loss seen from the antenna exceeds 6 dB. The distance between the antenna and the first line amplifier should be as short as possible and not more than about 35 m, giving a loss of 35*0,17 ≈ 6 dB, if a low-loss cable is used.

If this basic rule is followed, the noise figure of the total system is almost entirely set by the first amplifier stage, in this case the active antenna itself. The noise of the line amplifiers can then normally be neglected.

■ Power Splitters

– Used for dividing the signal from the antenna between two or more timing receivers.

There are both passive and active splitters, the latter often being line amplifiers with more than one output. A passive power splitter has a fixed insertion loss, for instance 6 dB with the resistive type, whereas the active types often have no loss or even a low gain.

■ Attenuators

– Used for adapting the signal level at the input of the receiver input.

There are both fixed and variable attenuators available.

■ Lightning Arresters

– Passive devices for diverting over-voltages to ground, thus protecting sensitive equipment connected to the output of the lightning arrester.

Such a device should be mounted inside the building close to the cable entry point. It requires a good ground connection through a 4 AWG copper wire or a braided copper strap

with the corresponding cross-section area. It must be a minimum cable length of 8 m after the lightning arrester to guarantee its proper function.

Remember that the antenna and the lightning arrester primarily protect the equipment later in the chain. They may be destroyed themselves. Consequently it is recommended to keep these components as replacement parts, if minimum downtime is important.

■ Mounting Masts

– Used for securing the antenna unit. At the same time the coaxial connectors are protected from both mechanical and environmental influence.

Pipes with 1-14 UNS thread, suitable as masts, can often be obtained from retailers selling boat gear.

Pendulum offers the accessory option 01/50, an antenna mounting kit for wall or pole mounting.

Chapter 9

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Chapter 10

Service

Sales and Service Offices

Customer support and instrument service as well as additional information on Pendulum-branded products can be obtained from Pendulum Instruments. Use the addresses below:

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