

59551A
GPS Measurements
Synchronization Module
and
58503A
GPS Time and Frequency
Reference Receiver

Getting Started Guide

This guide describes how to install and begin to operate the 59551A GPS Measurements Synchronization Module and 58503A GPS Time and Frequency Reference Receiver. The information in this guide applies to instruments having the number prefix listed below, unless accompanied by a “Manual Updating Changes” package indicating otherwise.

SERIAL PREFIX NUMBER: 3548 and above (59551A), 3548 and above (58503A)

Instruments with serial numbers below 3542 may have earlier versions of firmware installed. There are no operator-specific differences in previous versions of firmware.

FIRMWARE REVISION: 3543 and above (59551A), 3543 and above (58503A)

Firmware revision can be identified by using a “*IDN?” command sent to receiver via RS232 port. Refer to this guide for instructions on connecting computer or terminal to this product.

For assistance, contact:

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Warning Symbols Used In This Book



Instruction manual symbol; the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual.



Indicates hazardous voltages.



Indicates earth (ground) terminal.



or



Indicates terminal is connected to chassis when such connection is not apparent.



Indicates Alternating current.



Indicates Direct current

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Guide Organization

Table of Contents lists the beginning of each chapter in the guide, helping you locate information.

In This Guide (this preface) introduces you to the Getting Started guide, and provides general information on the GPS Receivers.

Chapter 1, “Getting Started,” is a quick-start chapter that introduces you to the GPS Receiver with a brief overview of the Receiver’s indicators and connectors. Installation and power-up instructions, and a section that provides sample commands to start operating the Receiver are provided to get you familiar and comfortable with operating the Receiver.

Chapter 2, “Features and Functions,” provides information on Receiver’s features and functions, connecting to computers, and problem solving (that is, a section titled “In Case of a Problem”).

Chapter 3, “59551A Specifications,” lists all of the 59551A specifications and characteristics.

Chapter 4, “58503A Specifications,” lists all of the 58503A specifications and characteristics.

Chapter 5, “Backdating Manual Changes” contains information necessary to adapt this manual to apply to older instruments.

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Description of the GPS Receivers

The 59551A GPS Measurements Synchronization Module

The 59551A GPS Measurements Synchronization Module is a time synchronizing source primarily focused on the power industry's transmission protection and control applications for wide-area synchronization of the electric power transmission systems.

The Module provides highly accurate timing, and if a satellite signal is lost the Module automatically switches to holdover mode that ensures system synchronization for up to 24 hours with some loss of accuracy.

The module provides input/output connectors and ports for the generation of appropriate synchronization signals for a variety of transmission system requirements. Separate front and rear RS-232C ports allow external computers to be connected to the Module for analyzing data or entering commands without interrupting the output signals. Available time tagging inputs allow recording of time of occurrence of incoming edges (timestamping) for failure or sequence-of-events analysis.

The standard 59551A has the following Input/Output connectors:

- two RS-232C serial communication ports (9-pin female rectangular D subminiature on the front panel; 25-pin female rectangular D subminiature on the rear panel)
- an IRIG-B output BNC
- a 1 PPS output BNC
- an Alarm BITE output
- an Antenna N-type connector
- three Time-tag input BNCs
- Power input jack
- Programmable Pulse output BNC

The front panel contains four Light-Emitting-Diode (LED) indicators to indicate that power has been applied (**Power**), the module has tracked and locked on to one or more GPS satellites (**GPS Lock**), the GPS system is operating in holdover mode (**Holdover**), and an error or invalid condition exists due to system fault or reduced accuracy of the outputs (**Alarm**).

The 59551A has no front panel display or keypad entry. Information is remotely entered into and retrieved from the 59551A using a personal computer connected to the rear-panel 25-pin RS-232C port or the front-panel 9-pin RS-232C port.

The 58503A GPS Time and Frequency Reference Receiver

The 58503A GPS Time and Frequency Reference Receiver provides highly accurate time and frequency outputs that can be used as a "house standard" to meet manufacturing, calibration, and development needs. The Receiver can also be used for synchronizing wireless base stations.

The Receiver provides highly accurate timing. If a satellite signal is lost, the Receiver automatically switches to holdover mode, which ensures system synchronization for up to 24 hours with reduced accuracy.

The standard 58503A has the following Input/Output connectors:

- an RS-232C serial communication port (25-pin female rectangular D subminiature on the rear panel)

- a 1 PPS output BNC
- an Alarm output BNC
- 10 MHz output BNC
- an Antenna N-type connector
- Power input jack

The front panel contains four Light-Emitting-Diode (LED) indicators to indicate that power has been applied (**Power**), the module has tracked and locked on to one or more GPS satellites (**GPS Lock**), the GPS system is operating in holdover mode (**Holdover**), and an error or invalid condition exists due to system fault or reduced accuracy of the outputs (**Alarm**).

The 58503A has no front panel display or keypad entry. Information is remotely entered into and retrieved from the 58503A using a personal computer connected to the rear-panel 25-pin RS-232 port.

Options

- Option 1CM Rack Mount 19-inch (483-millimeter)
- Option AXB Rack Mount 23-inch (584-millimeter)
- Option AWM Power Supply (+48 Vdc)
- Option 170 Power Supply (90 – 264 Vac) — 59551A Only
- Option AWR Power Supply (+24 Vdc) — 58503A Only

Accessories Supplied and Available

- 58504A Antenna Assembly
- 58510A GPS Antenna Environmental Cover and Ground Plane
- 58505A Lightning Arrester
- 58506A 50-foot (15.2-meter) Cable Assembly — antenna lead in with TNC-N connectors
- 58507A 100-foot (30.4-meter) Cable Assembly — antenna lead in with TNC-N connectors
- 58508A 175-foot (53.3-meter) Cable Assembly — antenna lead in with TNC-N connectors
- 58509A Antenna Line Amplifier (use with 58506A, 58507A, or 58508A antenna cable)
- 24542G DTE-to-DTE 25-Pin (m) to 9-pin (f) RS-232 Interface Cable
- 24542U DTE-to-DTE 9-Pin (f) to 9-pin (f) RS-232 Interface Cable

NOTE

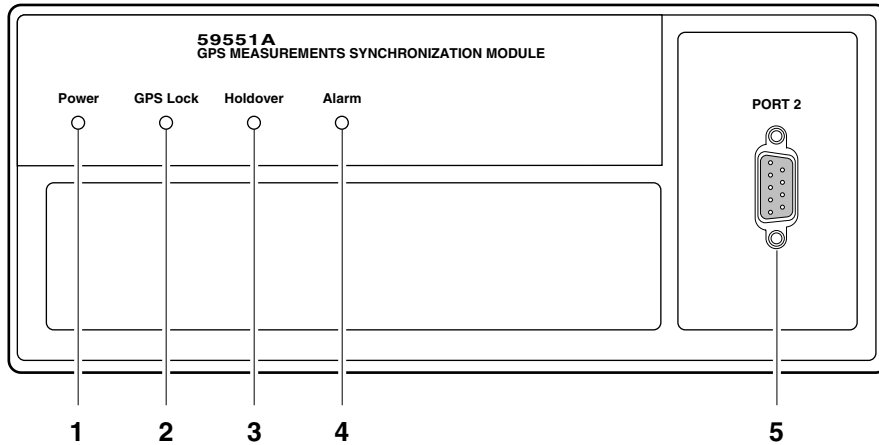
If your PC has a 25-pin serial port use 13242G cable.

- 40242M DTE-to-DCE 25-Pin (m-to-f) RS-232 Interface Cable
- Sat-Stat (59551-13401)

Chapter 1

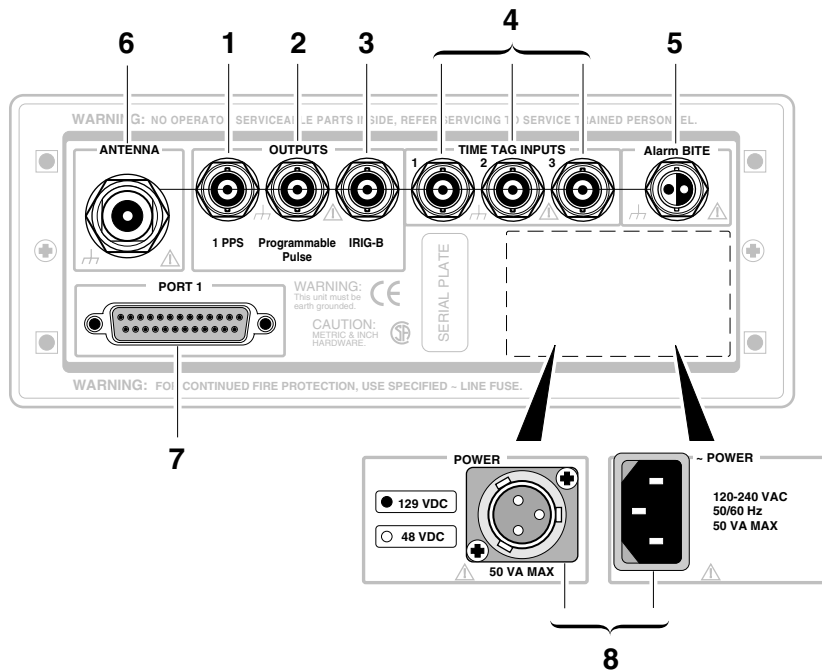
Getting Started

59551A Front Panel at a Glance



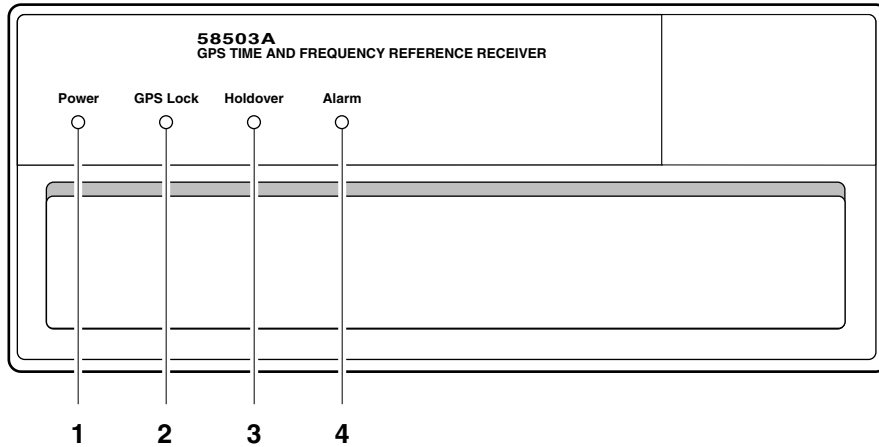
- 1** When the **Power** indicator is lit, it indicates that the proper input power is supplied to the Module.
- 2** When the **GPS Lock** indicator is lit, it indicates that the Module is receiving the GPS signal and is locked on one or more satellite(s).
- 3** When the **Holdover** indicator is lit, it indicates that the Module is NOT locked to the GPS signal. The Module is keeping time based on the internal reference oscillator signal. The internal reference oscillator will determine the accuracy of the 1 PPS signal. (See specification for Accuracy in Holdover in Chapter 3, “59551A Specifications,” in this guide.)
- 4** When the **Alarm** indicator is lit, it indicates that the Module has detected an internal condition that requires attention.
- 5** **PORT 2** RS-232C serial interface port for local monitoring and retrieving data stored in the Module’s memory data.

59551A Rear Panel at a Glance



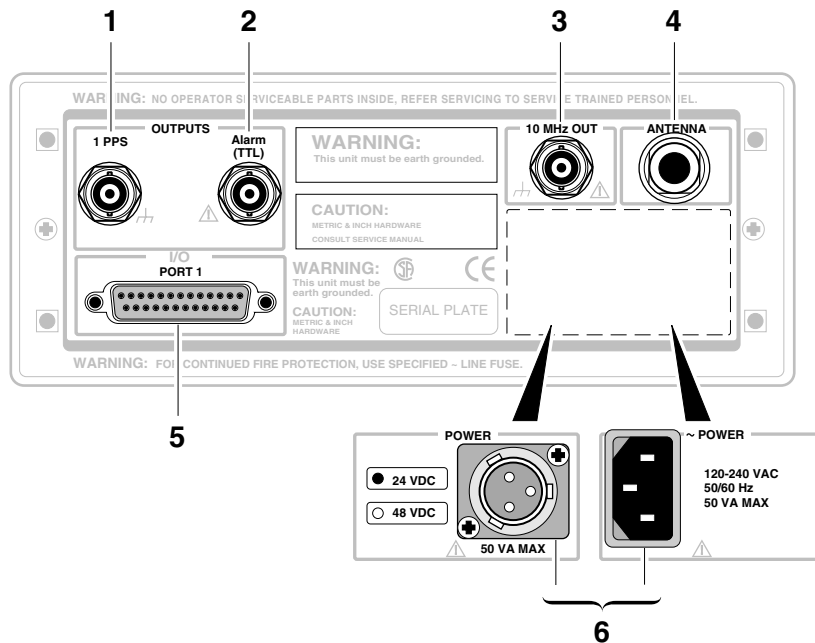
- 1** **1 PPS** connector for outputting a continuous 1 Pulse Per Second signal.
- 2** **Programmable Pulse** output connector for outputting pulses at user-specified time/period.
- 3** **IRIG-B** output for outputting formatted time-code signals. (This signal is used for general purpose time distribution and magnetic tape annotation applications requiring the time of year.)
- 4** **Time tag** input connectors for receiving TTL conditioned time tagging signals.
- 5** **Alarm BITE** (Built-In Test Equipment) output for external devices (such as red light, bell, or horn) to indicate that the Module has detected an internal condition that requires attention. This output goes on and off with the **Alarm** indicator. (Mating connector is Amphenol part number 31-224 [glass-filled Noryl] or 31-2226 [Teflon]).
- 6** N-type (female) **ANTENNA** connector.
- 7** **PORT 1** RS-232C serial interface port for remote control, monitoring, and retrieving of the Module's memory data and upgrading Module software.
- 8** **POWER** input jack.

58503A Front Panel at a Glance



- 1** When the **Power** indicator is lit, it indicates that the proper input power is supplied to the Receiver.
- 2** When the **GPS Lock** indicator is lit, it indicates that the Receiver is receiving the GPS signal and is locked on one or more satellite(s).
- 3** When the **Holdover** indicator is lit, it indicates that the Receiver is NOT locked to the GPS signal. The Receiver is keeping time based on the internal reference oscillator signal. The internal reference oscillator will determine the accuracy of the 1 PPS signal and the 10 MHz reference output. (See specification for Accuracy in Holdover in Chapter 4, "58503A Specifications," in this guide.)
- 4** When the **Alarm** indicator is lit, it indicates that the Receiver has detected an internal condition that requires attention.

58503A Rear Panel at a Glance



1 1 PPS connector for outputting a continuous 1 Pulse Per Second signal.

2 Alarm output for external devices (such as red light, bell, or horn) to indicate that the Receiver has detected an internal condition that requires attention.

3 10 MHz OUT output for user-specific applications.

4 N-type (female) ANTENNA connector.

5 PORT 1 RS-232C serial interface port for remote control, monitoring, and downloading of the Receiver's memory data and upgrading Receiver software.

6 POWER input jack.

Preparing the GPS Receiver for Use

Cable Considerations

When using the antenna and RS-232 cables supplied (or ordered) with the GPS Receiver, you should observe certain precautions. Consult your local electrical and building ordinance codes on how to install RG-213 cables (58506A/507A/508A). Certain codes might require you to put the cables inside a conduit, or to use cables made with a non-toxic fire retardant insulation.

To Assemble and Install the Antenna System

- 1 Assemble the antenna and its accessory parts as shown in figures 1-1 and 1-2.

NOTE

Here are some basic rules to follow when installing the antenna.

- Install the antenna face up (connector down).
- Ensure that reflected signals hitting the antenna are minimal.

Signals reflecting off impervious surfaces (such as buildings and mountains) and hitting the antenna cause “multipath” interference.

The antenna is designed to be more sensitive to signals coming from above the flat face, and to attenuate signals from below, which are assumed to be reflections.

Use the 58510A ground plane with your installation to prevent problems with reflected signals. The ground plane will increase signal selectivity by blocking out some of the reflected signals from below the antenna flat face.

- Keep the antenna above or at the top of impervious surfaces such as canyons, mountains, buildings, or towers for an unimpeded view of the sky. The Receiver scans the sky for a straight-shot look at satellites. An impeded view or a view cluttered with reflected signals (multipath interference) will reduce the antenna's effectiveness and the Receiver's accuracy.
-

CAUTION

58505A Lightning Arrester, shown in Figure 1-2, prevents damage to the GPS Receiver by transient overvoltages from lightning. The arrester **MUST BE** grounded to a very good low-inductance conductor for it to be effective.

Without a good ground the arrester will not be able to discharge the higher voltages to ground and protect the ANTENNA input of the Receiver.

The lightning arrester needs to be grounded using a very low impedance grounding strap. For more information on proper grounding and protection against lightning, see the document by PolyPhaser Corporation® titled *The “Grounds” for Lightning and EMP Protection, Second Edition* by Roger R. Block.

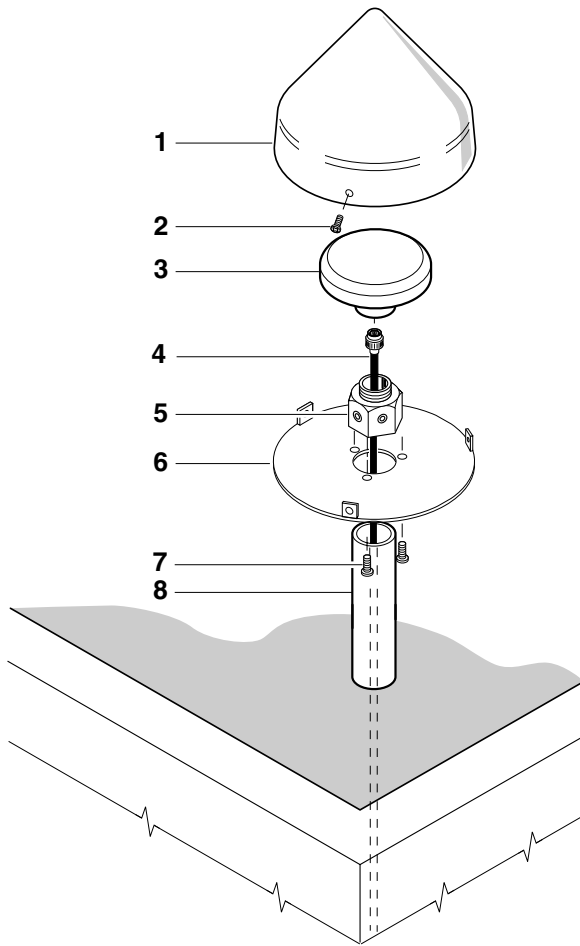
CAUTION

When installing lightning rods, grounding conductors, and grounding electrodes, follow the rules prescribed by the local electrical and building ordinances.

See the subsection titled “ANTENNA” in Chapter 2, “Features and Functions,” of this guide for more information on the antenna.

NOTE

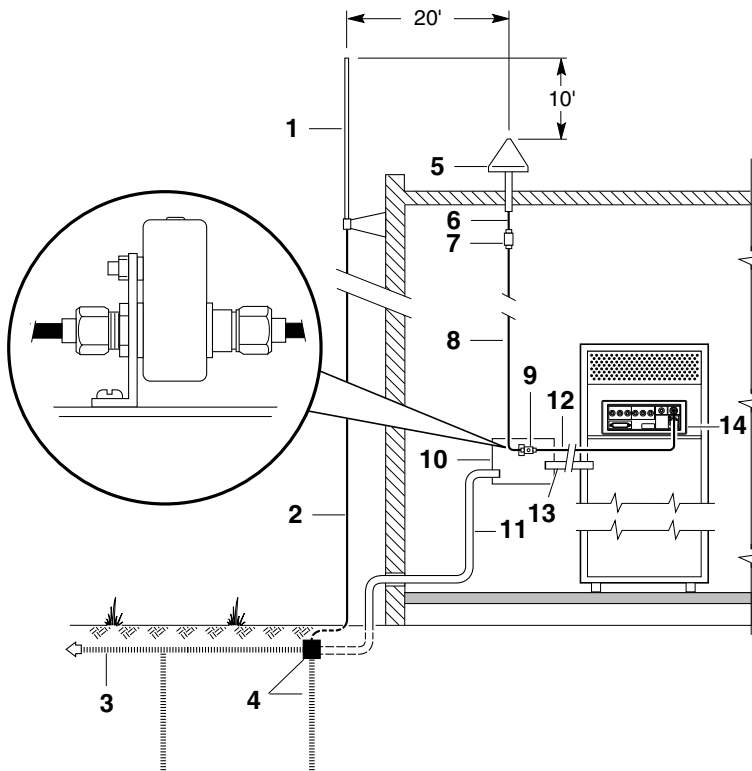
All of the following antenna illustrations (figures 1-1, and 1-2) are conceptual drawings; thus, technical decisions regarding grounds must be made by qualified personnel.



- | | |
|---|---|
| 1 Protective Cover (part of 58510A) | 5 Adapter Nut (supplied with 58504A Antenna Assembly) |
| 2 Screws (part of 58510A) — typically in 3 places | 6 Ground Plane (part of 58510A) |
| 3 58504A Antenna Assembly | 7 Screws (part of 58510A) — typically in 3 places |
| 4 58506A/507A/508A Cable | 8 3/4" Diameter steel pipe (<i>customer supplies</i>)
Note: DO NOT use a plastic pipe. |

Figure 1-1. Conceptual GPS Roof Antenna System

- 2 After completely installing the antenna system, its overall hookup should be similar to Figure 1-2.



- | | |
|---|---|
| 1 Lightning rod* (<i>customer supplies</i>) | 8 58506A/507A/508A Cable Assembly and N to TNC Adapter |
| 2 Grounding conductor (<i>customer supplies</i>) | 9 58505A Lightning Arrester |
| 3 To grounding system (<i>customer supplies</i>) | 10 Primary grounding window (<i>customer supplies</i>) |
| 4 Grounding rod (<i>customer supplies</i>) | 11 1-1/2" copper strap, ≤ 15' long (<i>customer supplies</i>) |
| 5 58504A Antenna Assembly/
58510A Protected Cover and Ground Plane | 12 58506A/507A/508A Cable Assembly and N to TNC Adapter |
| 6 58506A/507A/508A Cable Assembly and N to TNC Adapter | 13 1-1/2" copper strap, ≤ 15' long (<i>customer supplies</i>) |
| 7 Optional Antenna Line Amplifier** | 14 GPS Receiver |

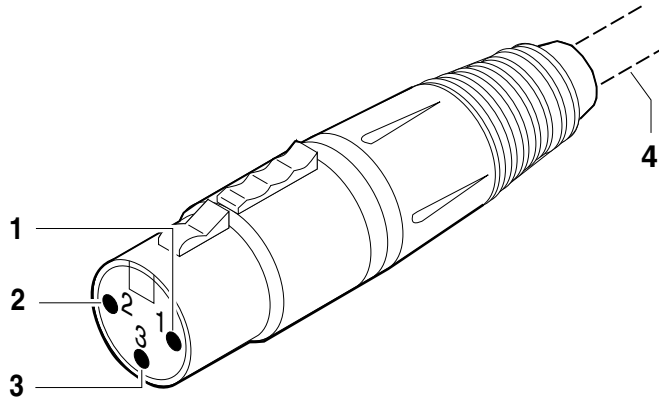
Figure 1-2. Conceptual Assembled Antenna System

* A lightning rod is recommended for high-risk lightning area. Consult your local electrical and building agencies.

** See the section titled "ANTENNA Input" in Chapter 2 of this guide for information on when you might want to use a line amplifier.

To Assemble the DC Power Connector (Standard for 59551A; Option AWR for 58503A)

- 1 Note that you will have to assemble your own dc power cable using 18 AWG connecting wires and a three-pin XLR (female) connector plug (shown in Figure 1-3).



- | | |
|-----------------|------------------|
| 1 dc supply (+) | 3 Chassis ground |
| 2 dc return (-) | 4 Cable wires |

Figure 1-3. Three-Pin XLR Plug Pinouts (Front View)

- 2 From the rear of the XLR plug, connect the supply-side wire of the external power supply or battery to pin 1 of the XLR plug. Connect the external battery's return (ground) wire to pin 2, and the chassis ground wire to pin 3 of the XLR plug.
- 3 Observing the correct polarity, attach the other ends of the wires to a proper dc power source to operate the Receiver.

To Connect AC Power

(Option 170 for 59551A; Standard for 58503A)

The ac power module or jack senses incoming voltage and automatically selects the proper setup. Just connect the Receiver to the ac power source using the supplied power cord.

Powering Up the Receiver

Overview of the Power-Up Procedure (What to Expect)

When you power up the GPS Receiver for the first time, you should expect it to run through the following sequence:

- goes through internal diagnostics and all front-panel lights flash,
- acquires and tracks four satellites,
- computes the Receiver's position,
- locks to the 1 PPS (one pulse-per-second) time standard provided by GPS, and
- begin steady-state operation, acting as a source of timing information derived from the GPS standard.

Elapsed time for each step will vary, depending largely on how many satellites your antenna is able to “see” when you power up. If many satellites are visible when you power up, the Receiver will take at least 8 minutes and at most 25 minutes to calculate its position from the constellation of satellites overhead. The derived position will be improved over a period of time by further averaging. When the **GPS Lock** indicator lights, the basic functionality of the Receiver is available; however, optimal performance is delivered later.

To Power Up the Receiver

- 1 Connect the antenna system to the rear-panel **ANTENNA** Type-N connector of the Receiver as described in the instructions given in the subsection titled “To Assemble and Install the Antenna System” on page 1-6 of this chapter

NOTE

Do not apply power to the Receiver unless a fully operational antenna system is connected to the rear-panel ANTENNA input connector. Power applied with no antenna input or a non-functioning antenna will initiate an extended search process that may increase time to reach GPS lock. You can halt the extended search by cycling the Receiver power (you may need to leave power off for greater than five seconds).

- 2 Connect the GPS Receiver to a personal computer (PC) via the rear-panel **PORT 1** RS-232 port using an 24542G interface cable as shown in Figure 1-4.

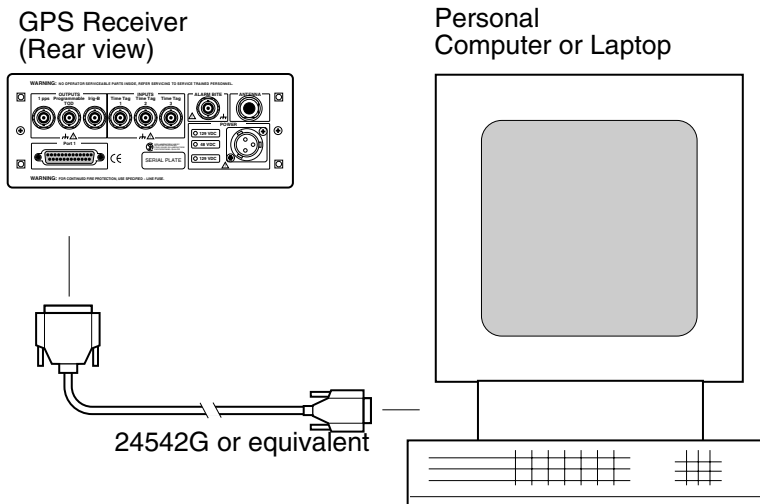


Figure 1-4. Connecting the GPS Receiver to a Computer

3 Turn the PC on.

You will need to run a terminal emulation program on your PC in order to communicate via the RS-232C serial port. Most PCs contain a terminal emulation program, especially PCs with Windows. If your PC does not contain a terminal emulation program, purchase one of the following programs: PROCOMM PLUS (DATASTORM Technologies, Inc.®), PROCOMM PLUS for Windows, Cross Talk (Hayes®), or any other terminal emulation program. (**Note:** Symmetricom is not endorsing any of these products.)

Another option to purchasing and installing a terminal emulation program is to use the SatStat Program. See the section titled “Installing the Timing Receiver Windows User Interface for Continual Status Updates” on page 1-176 for installation and operating information.

4 Set the RS-232 port of your PC to match the following default values:

Pace: NONE
Baud Rate: 9600
Parity: NONE
Data Bits: 8
Stops Bits: 1

NOTE

The RS-232 port configurations of the Receiver and the PC must be the same for communications between the two. Thus, for this power-up procedure, set your PC to match the default values listed above if this Receiver is being powered up for the first time from the factory.

If the default values have been changed, as would be indicated by an error generation or no **scpi>** prompt displayed after pressing Return (or Enter) on your PC, then refer to the subsection titled “If Changes Have Already Been Made to the Serial Port Settings” in Chapter 2 of this guide for more information.

NOTE

Do not apply power to the Receiver unless a fully operational antenna system is connected to the rear-panel ANTENNA input connector. Power applied with no antenna input or a non-functioning antenna will initiate an extended search process that may increase time to reach GPS lock. You can halt the extended search by cycling the Receiver power (you may need to leave power off for greater than five seconds).

-
- 5** Apply the proper power source to the rear-panel **Power** input jack of the Receiver. (See the appropriate subsection titled “To Assemble the DC Power Connector” or “To Connect AC Power” on page 1-10)

The following sequence of events occurs after power is applied to the Receiver.

- a. Only the front-panel Power indicator lights.**
- b. After a moment, the Receiver runs through its self-test diagnostics as indicated by the flashing front-panel indicators.**
- c. After the self test is completed, just the Power indicator remains lit.**

If the **Alarm** indicator lights, a failure may have occurred during the self test. Refer to the section titled “Operating Status” in Chapter 5, “Command Reference,” of the Operating and Programming guide for a complete description of the Alarm capability.

- d. The Receiver begins to search the sky for all available satellites.**
- e. From the computer keyboard, type**

:SYSTEM:STATUS? and press Enter (or Return).

(Confirm that the **scpi>** prompt is displayed after pressing Return. If no prompt or an error-number prompt is displayed, then refer to the subsection titled “If Changes Have Already Been Made to the Serial Port Settings” in Chapter 2 of this guide for more information.)

The computer displays the status screen as shown in the sample status screen in Figure 1-5.

You must re-enter the :SYSTEM:STATUS? command each time you want an updated status screen.

One of the key indicators on the screen is the ACQUISITION status indicator. It shows “GPS 1 PPS CLK Accurate” as soon as satellite information is sufficient.

See the section titled “Reading the Receiver Status Screen” in Chapter 2 of this guide for a description of the information displayed in the status screen.

NOTE

You have been provided a program (SatStat) which provides *continual status updates* of the Receiver Status screen. Your PC must have Windows installed to operate the user interface program. The application is easy to install and operate.

See the section titled “Installing the Timing Receiver Windows User Interface for Continual Status Updates” on page 1-17 for installation and operating information.

```

----- Receiver Status -----
SYNCHRONIZATION ..... [ Outputs Valid/Reduced Accuracy ]
SmartClock Mode _____ Reference Outputs _____
>> Locked to GPS: stabilizing frequency... TFOM      3
Recovery                FFOM      0
Holdover                1PPS TI +20 ns relative to GPS
Power-up                HOLD THR 1.000 us

ACQUISITION ..... [GPS 1PPS CLK Accurate]
Satellite Status _____ Time _____
Tracking: 5           Not Tracking: 4           GPS      03:56:44   1994 DEC 01
PRN  El  Az  SS  PRN  El  Az           1PPS CLK Synchronized to GPS Time
  2  70 337 134   12  11 292           ANT DLY 120 ns
  7  46 188 117   16  24 243           Position _____
 15  33  82  54   *26 Acq..           MODE     Survey: 57.3% complete
 19  28 113  29   31  --  ---
 27  65  91 128
                *attempting to track
ELEV MASK 10           AVG LAT  N  37:19:31.330
HEALTH MONITOR ..... [ OK ]
Self Test: OK | Int Pwr: OK Oven Pwr: OK  OCXO: OK  EFC: OK  GPS Rcv: OK

```

Figure 1-5. Sample Status Screen

- f. When four or more satellites are tracked as will be indicated in the status screen, automatic position computation is initiated.**

- g. Finally, the Receiver goes into steady-state operation (which requires one satellite) and the GPS Lock indicator lights, indicating the Receiver has locked on to the GPS signal.**

After the initial powerup, the Receiver is set for basic operation. That is, the Receiver operating parameters are set to their powerup default values or states.

If you need to customize the Receiver operation, see the section titled “Customizing the Receiver Operation” on page 1-18 for a list of key things you may want to perform to customize the operating parameters of the Receiver.

Installing the SatStat Program for Continual Status Updates

This Windows program provides continual status updates of the Receiver Status screen. Your PC must have Windows installed to operate the user interface application. The application is easy to install and operate.

- 1** Insert the SatStat disk in drive A.
- 2** From the File menu in either the Program Manager or File Manager, choose Run.
- 3** Type **a:setup**, and press Enter (or Return).
- 4** Follow the Setup instructions on the screen.
- 5** To access and operate the Windows application, follow the instructions given in the “Getting Started” Help file.

Customizing the Receiver Operation

Here are some key things you might want to perform to customize the Receiver operation:

- Execute a system preset if someone else has used the Receiver and left it in an unacceptable state.
- Make the Receiver survey if it wasn't already surveying.
- Set the antenna delay.
- Set the elevation mask angle.
- Set the time zone.

See the section titled “Controlling Key Functions Via the Commands — Examples” on the following page for more information.

Controlling Key Functions Via the Commands — Examples

The operation of the GPS Receiver is designed to be as automatic as possible. However, there are several situations where serial interface control is required. The tasks described here are those most commonly encountered.

For each task in this section, you can use either a terminal emulation program or the Timing Receiver Windows User Interface to issue the selected commands. Additional information about the commands is provided in Chapter 4, “Command Quick Reference,” and Chapter 5, “Command Reference,” of the Operating and Programming guide (part number 59551-90002).

To Perform Basic Installation and Simple Customizing

After connecting the Receiver to the antenna, power source, RS-232C port, and after the self test is completed, you may want to complete installation using one or more of the capabilities described below.

- **If required, restore all of the Receiver’s internal settings to their factory shipment values by invoking a system preset.**

After executing the system preset, the Receiver will begin normal operation: it will acquire GPS signals, determine the date, time, and position automatically, bring the reference oscillator ovens to a stable operating temperature, lock the reference oscillator and its output to 10 MHz, and synchronize the 1 PPS output to UTC.

Settings affected by system preset are listed in Chapter 5, “Command Reference,” of the Operating and Programming Guide under the :SYSTEM:PRESET command definition.

The Receiver is preset using the command:
:SYSTEM:PRESET

Note that system preset should be performed only when necessary.

NOTE The “:GPSSYSTEM:” command must be shortened to “GPS:” for serial numbers below 3503A00103 for 59551A and 3504A00135 for 58303A

- **Initiate “surveying”, an automatic determination of the Receiver’s antenna position.**

When “position survey” is invoked, the Receiver is set to ascertain the position of its antenna automatically. This survey is important; correct antenna position data is required for the Receiver to deliver specified performance.

The Receiver uses data from orbiting satellites to survey; hence, the antenna must be installed and operational for the survey to work. However, if you have a limited view of the sky, you can complete basic installation, then read forward to the section titled “To Install with a Limited View of the Sky” on page 1-20 for a means of overriding the survey operation and entering position data directly.

The survey is an iterative process. The Receiver transits to “Position Hold” when a usable position has been obtained.

Set the Receiver to survey using command:

```
:GPSSYSTEM:POSITION:SURVEY ONCE
```

- **Set the Receiver to compensate for the length of the antenna cable.**

The Receiver can be custom-configured to compensate for the length of the antenna cable. The phase of the Receiver’s internal clock is therefore offset from the GPS standard by the number of nanoseconds of delay introduced by the antenna cable. The amount of error is typically on the order of a few hundred nanoseconds. Should you decide to correct for this error, Table 2-1 in Chapter 2, “Features and Functions,” of this guide provides typical corrections for standard antenna cable lengths.

Set the Receiver to compensate for antenna cable delay using command:

```
:GPSSYSTEM:REFERENCE:ADELAY <seconds>
```

It is normal to observe that the Receiver momentarily goes into holdover after any change in antenna delay.

NOTE

The “:GPSSYSTEM:” command must be shortened to “GPS:” for serial numbers below 3503A00103 for 59551A and 3504A00135 for 58303A

- **Initiate “surveying”, an automatic determination of the Receiver’s antenna position.**

At the factory, and whenever the Receiver is preset, the Receiver is set to seek satellites visible from zenith down to 10 degrees above the horizon — down to an “elevation mask angle” of 10 degrees. The factory elevation mask angle setting is intended to provide a full view of the sky. The Receiver can be custom-configured to use a different elevation mask angle.

Set the Receiver elevation mask angle using the command:

```
:GPSSYSTEM:SAT:TRAC:EMANGLE <degrees>
```

- **Set the Receiver to display local time rather than UTC time.**

Set the offset from UTC time to local time using the command:

```
:PTIME:TZONE <hours>, <minutes>
```

To Install With a Limited View of the Sky, To Bypass Position Survey Operation

- **To bypass position survey operation.**

In order to reach steady-state operation, the Receiver must know the position of the antenna. The Receiver is able to collect enough information from four satellites to compute this position. The “position survey operation” takes in data from the satellites, iterating until the antenna position is known to the required precision.

The Receiver will automatically use its position survey operation on powerup and :SYSTEM:PRESET.

Alternatively, if the antenna position is already known to seconds of arc, and the Receiver cannot see enough satellites, you may manually enter antenna position as shown in the following text.

NOTE

An incorrect value for the position will confuse the Receiver, and will degrade the timing information accuracy or even prevent tracking any satellites.

Set the Receiver antenna position using the command format shown below (For clarity, an example is provided rather than a complex description.):

:GPS:POS N,37,19,32.5,W,121,59,51.2,40.12

Set the required latitude, longitude, and height parameters to represent the latitude (in degrees, minutes, seconds), longitude (in degrees, minutes, seconds), and altitude in meters above sea level (MSL) of the *antenna* (NOT the Receiver).

To Set Up the Antenna

- **Set the Receiver to compensate for the length of the antenna cable.**

Set the Receiver to compensate for the length of the antenna cable using the command format shown below. (For clarity, an example is provided rather than a complex description.)

```
:GPSYSTEM:REFERENCE:ADELAY 180 NS
```

The delay parameter is set to the number of seconds of delay to set the correct antenna delay. Using a suffix, as shown in the example, you can enter delay in nanoseconds (180 nanoseconds is shown.)

- **Initiate “surveying”, an automatic determination of the Receiver’s antenna position.**

Set the Receiver to survey using the command:

```
:GPSYSTEM:POSITION:SURVEY ONCE
```

Chapter 2

Features and Functions

Chapter Contents

This chapter provides features and functions, connecting to computers, and problem-solving information.

This chapter is organized as follows:

- Features and Functions page 2-3
 - Outputs page 2-3
 - RS-232C Serial Port(s), Input/Output (I/O) page 2-6
 - Indicators page 2-8
- Connecting to a Computer or Modem page 2-10
 - To Connect the GPS Receiver to a PC, Laptop, or Modem Via the Rear-Panel DB-25 Serial Port page 2-11
 - To Connect the 59551A to a Laptop Computer Via Front-Panel DB-9 Serial Port page 2-12
- Configuring the RS-232 Port(s) page 2-14
 - If You Need To Make Changes to the Serial Port Settings page 2-14
 - If Changes Have Already Been Made to the Serial Port Settings page 2-15
- Reading the Receiver Status Screen page 2-17
 - SYNCHRONIZATION Section of the Status Screen page 2-17
 - ACQUISITION Section of the Status Screen page 2-19
 - HEALTH MONITOR Section of the Status Screen page 2-23
- In Case of a Problem page 2-25

Features and Functions

You will find that this section makes it easy to look up all the details about a particular feature of the 59551A GPS Measurements Synchronization Module (Receiver) and the 58503A GPS Time and Frequency Reference Receiver.

Outputs

1 PPS (One Pulse Per Second) Output

The Receiver outputs this highly accurate 1 PPS time standard output for user-specific synchronization applications.

In the GPS locked mode, the Receiver outputs a 1 PPS signal derived from the internal oscillator, which is locked and traceable back to Coordinated Universal Time (UTC) as determined by GPS. In the absence of GPS, the 1 PPS signal will continue to exist, but the oscillator will go into a holdover mode in which the SmartClock™ algorithm will compensate for the instabilities in the oscillator. In the holdover mode, the timing 1 PPS accuracy will degrade as the holdover time increases.

Programmable Pulse Output (59551 A Only).

This programmable pulse capability allows you to program the Receiver to output a pulse at a specific time, or a repetitive signal with a period from 1 second to 1 year.

IRIG-B Output (59551A only)

The IRIG-B123 formatted time code signal may be used for general purpose time distribution, and magnetic tape annotation applications requiring time of year.

IRIG-B123 is a one-frame-per-second signal indicating the date and exact time. The output contains both a BCD-coding of day, hour, minute, second, and a binary coding of accumulated seconds since midnight. An example is shown in Figure 2-1. The modulated code uses a 1 kHz carrier.

The sample IRIG-B output shown in Figure 2-1 consists of time-coded pulses that indicate the time as:

173 days into the year,
21 hours into the day
18 minutes into the hour, and
42 seconds into the minute.

The sample IRIG-B BCD output in Figure 2-1 also includes a Straight Binary portion, which consists of time-coded pulses that indicate the time of day as *76,722* seconds into the day, which is the total you would get if you summed up *21* hours, *18* minutes, and *42* seconds.

ANTENNA Input

When an alarm condition exists, the **Alarm BITE** (Built In Test Equipment) relay contact closes, making a closed circuit. This signal may be used to drive an external visual (e.g., red light) or audio device (e.g., horn or bell) when the Receiver detects an internal condition that requires attention.

When power to the Receiver is lost, the Alarm BITE relay contact is open (no alarm condition is indicated).

Alarm Output (58583A Only)

When an alarm condition exists, the **Alarm** output is pulled down to a TTL low. This signal may be used to drive an external visual (e.g., red light) or audio (e.g., horn or bell) device when the Receiver detects an internal condition that requires attention.

10 MHz OUT Output (58583A Only)

This is a 10 MHz output reference signal traceable to UTC (USNO) that you can use as a high accuracy frequency “house standard” for calibration or development needs.

Inputs

Time Tagging Inputs (59551A Only)

The **Time Tag 1**, **Time Tag 2**, and **Time Tag 3** BNC input connections allow you to input time tagging data to the Receiver using one of the following time tagging generators or equipment:

- Sequence of Events Recorders
- Fault Analyzers
- Phasor Measurement Units (PMUs)

The output of these devices are typically TTL pulses. The Receiver is capable of time-tagging any similar TTL rising edge.

Time tagging an event is to record the UTC time at which the rising edge reaches approximately 2.5V.

On each time-tag input, you are allowed to time tag up to 256 events for efficient fault location, network disturbance analysis, and detailed sequence-of-events analysis. The minimum time between events is 1 millisecond.

The resolution and time tagging features of the Receiver make it ideally suited to applications such as phasor measurement, state estimation, stability protection, and adaptive relaying.

ANTENNA Input

The N-type (female) **ANTENNA** connector allows you to connect the 58504A Antenna Assembly to the Receiver. The 58504A is an “active” antenna; a “passive” antenna will not work with the GPS Receiver.

Integral to the 58504A Antenna Assembly is a low noise amplifier (LNA) that is provided for GPS receiver operation with antenna cable lengths up to 175 feet* (53.3 meters). The single coax

* One hundred and seventy-five feet includes the sum total of all of the cables used to connect the antenna to the Receiver (such as the cable between the antenna and line amplifier, the cable between the line amplifier and lightning arrester, and the cable between the lightning arrester and the Receiver).

cable is used to provide signals from the antenna to the Receiver and to supply a dc voltage to the LNA. For longer antenna feed runs, an additional amplifier (58509A Antenna Line Amplifier) is required to allow for lengths greater than 175 feet (53.3 meters). An environmental cover that shields the antenna from wind, rain, and snow, and a ground plane that prevents problems with reflected signals is available as the 58510A.

Refer to Chapter 1, “Getting Started,” in this guide for information on the components of the antenna system and installation instructions.

ANTENNA CABLE LENGTH DELAY. There are two types of cables that we recommend you use to connect your antenna system: RG-213 (Belden® 8267) or Belden 9913.

The RG 213 propagation delay is 1.54 nanoseconds per foot (5.05 ns/meter). The 9913 propagation delay is 1.2 nanoseconds per foot (3.94 ns/meter). Given these delay values per foot you can calculate the delay for your cable length.

Table 2-1 lists the delay values that you need to use with the :GPSSYSTEM:REFERENCE:ADELAY command for the available 58506A, 58507A, and 58508A cable assemblies.

Table 2-1. Delay Values for the 58506A/507A/508A Cables

Cable Model Number	Length	RG 213 or Belden 8267 Antenna Delay Value	Belden 9913 Antenna Delay Value
58506A	50 ft (15.2 m)	77 nanoseconds	60 nanoseconds
58507A	100 ft (30.5 m)	154 nanoseconds	120 nanoseconds
58508A	175 ft (53.3 m)	270 nanoseconds	210 nanoseconds

The nominal delay value is labeled on the 58506A/507A/508A cable.

POWER Input Jack

59551A GPS Measurements Synchronization Module

The **Power** input jack allows you to connect a ± 129 Vdc (standard), ± 8 Vdc, 110 Vac, or 240 Vac power source (depending on which power option the Module contains) to drive the 59551A.

58503A GPS Time and Frequency Reference Receiver

The **Power** input jack allows you to connect a 110 Vac (standard), ± 48 Vdc, or ± 24 Vdc power source (depending on which power option the Receiver contains) to drive the 58503A.

Table 2-2 lists the XLR input jack pinouts. This jack is used for DC power only.

Table 2-2. XLR Jack DC Power Connections

Pin Number	Signal Name
1	dc supply (+)
2	dc return (-)
3	chassis ground

See Figure 1-3 in Chapter 1, “Getting Started,” in this guide for illustration of the XLR jack.

AC operation is an option on the 59551A, but is a standard on the 58503A. See the section titled “To Connect AC Power” for more information.

RS-232C Serial Port(s), Input/Output (I/O)

The 59551A has separate rear-panel (**PORT 1**) and front-panel (**PORT 2**) RS-232C serial interface ports. Thus, one port has to be designated as the “primary” port and the other as the “secondary” port. The operation and configuration of these ports are described in the following paragraphs. More information is provided in the section titled “Configuring the RS-232C Port(s)” in this chapter on page 2-14.

The 58503A has only a rear-panel (**PORT 1**) RS-232C serial interface port.

PORT 1 Rear-Panel RS-232C Serial Interface Port

This 25-pin female subminiature D (DB-25) connector (**PORT 1**), located on the rear panel, is set up as the primary port at the factory.

For the 59551A, which has two serial ports, either the front-panel or rear-panel RS-232C port can function as the primary port. Using a command, you can assign primary port status to either connector.

Primary Port

The functionality described in the following paragraph is delivered by the primary port regardless of which connector is used as the primary.

The primary port allows you full communication with the Receiver. This can be done by connecting any computer with an RS-232C serial interface and suitable terminal emulation software, then sending the correct commands for transmitting or retrieving data. The primary port allows you to customize the Receiver on installation, to change the Receiver’s operating characteristics, to retrieve Receiver state information, and to clear the stored data.

The pins used are described in Table 2-3. Table 2-3. PORT 1 Rear-Panel RS-232C Serial Port Connections

Pin Number	Input/Output	Description
2	Output	Transmit Data (TxD). GPS Receiver output.
3	Input	Receive Data (RxD). GPS Receiver input.
7	_____	Signal Ground (SG)

Refer to the sections titled “Connecting a Computer or Modem” in this chapter, on page 2-10, for wiring diagrams and more information on the RS-232C interface cables.

PORT 2 Front-Panel RS-232C Serial Port (59551A Only)

This 9-pin female subminiature D (DB-9) connector (**PORT 2**), located on the front panel, is set up as the secondary port at the factory. Either the front-panel or the rear-panel RS-232C port can function as the secondary. Using a command, you can assign secondary port status to either connector.

Secondary Port (59551A Only)

The secondary port allows you to retrieve information from the Receiver. This can be done by connecting any computer with an RS-232C serial interface and suitable terminal emulation software, then sending the correct commands for retrieving data. The secondary port does not allow you to change the Receiver's operating characteristics, nor does it allow you to destroy data in time tag memory.

The secondary port does allow you to request instrument state information and timestamp data. The pins used are described in Table 2-4.

Table 2-4. Port 2 Front-Panel RS-232C Serial Port Connections (59551A Only)

Pin Number	Input/Output	Description
2	Input	Receive Data (RxD). GPS Receiver input.
3	Output	Transmit Data (TxD). GPS Receiver output.
5	_____	Signal Ground (SG)

Refer to the sections titled “Connecting a Computer or Modem” in this chapter, on page 2-10, for wiring diagrams and more information on the RS-232 interface cables.

Indicators

Power Indicator

This indicator lights when the input power is supplied to the Receiver. The indicator cannot be set or queried via the serial interface.

GPS Lock Indicator

This indicator lights when the Receiver is locked to one or more GPS satellite signals. The Receiver regularly controls this indication of whether one or more GPS satellite signals is within operating range and therefore the reference oscillator is operating locked to the GPS. The principal Receiver setting that can affect this indication is manual selection of reference oscillator holdover operation.

Holdover Indicator

The Receiver lights this indicator when it is not locked to the satellite’s GPS signal. The Receiver is keeping time based on the internal 10811 oven reference oscillator and its integrated SmartClock™ circuit, which has “learned” the aging and environmental effects on the internal reference oscillator.

NOTE

If the Holdover indicator lights before the Receiver has operated successfully for 24 hours, then the Receiver has not had time to learn the characteristics of the internal reference oscillator. The specification for Timing Accuracy during holdover may not be met. This specification applies only after the Receiver has had sufficient steady-state operation time.

Alarm Indicator

The Receiver lights this indicator to indicate it has detected an internal condition that requires attention.

Refer to the section titled “Operating Status” in Chapter 5, “Command Reference,” of the Operating and Programming guide for a complete description of the Alarm capability.

Connecting a Computer or Modem

To connect the GPS Receiver to a computer or modem, you must have the proper interface cable. Most computers are DTE (Data Terminal Equipment) devices. Since the Receiver is also a DTE device, you must use a DTE-to-DTE interface cable when connecting to a computer. These cables are also called “null-modem” cables.

Most modems are DCE (Digital Communication Equipment) devices; thus, you must use a DTE-to-DCE interface cable.

The interface cable must also have the proper connector on each end and the internal wiring must be correct. Connectors typically have 9 pins (DB-9 connector) or 25 pins (DB-25 connector) with a “male” or “female” pin configuration. A male (m) connector has pins inside the connector shell and a female (f) connector has holes inside the connector shell.

To simplify interface cable selections, the following sections tell you which cables to use.

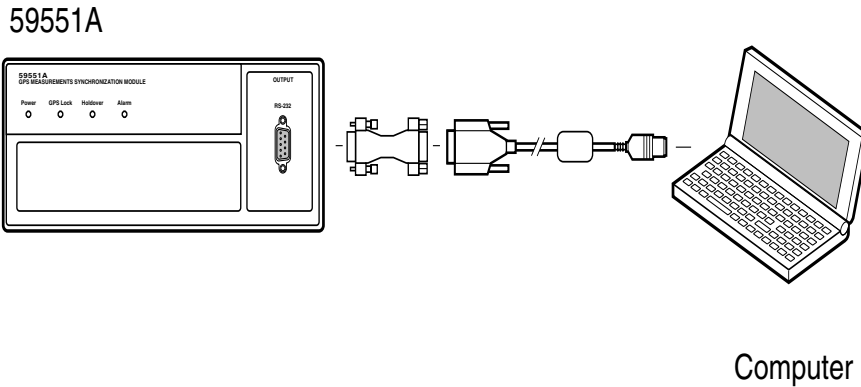


Figure 2-2. Connecting the 59551A to a computer

To Connect the GPS Receiver to a PC, Laptop, or Modem Via the Rear-Panel DB-25 Serial Port

Connecting to the Personal Computer (PC)

Use an 24542G interface cable to connect the Receiver's rear-panel **PORT 1** DB-25 female connector to a PC or laptop as shown in Figure 2-3.

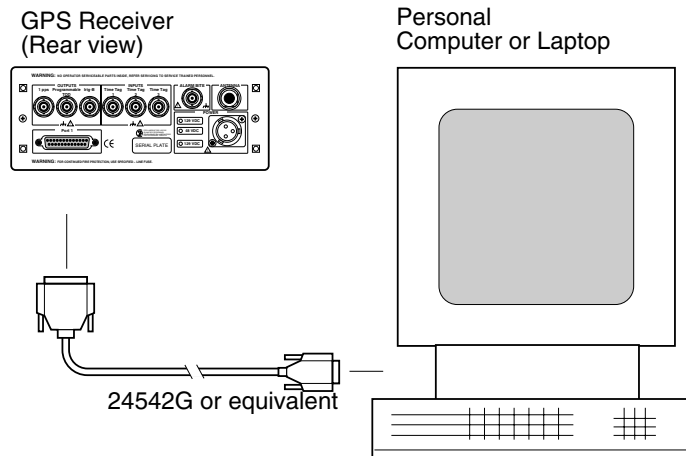


Figure 2-3. Connecting the GPS Receiver to a Computer

Connecting to a Modem

Use an 40242M interface cable to connect the Receiver's rear-panel **PORT 1** DB-25 female connector to a modem, which is a DCE (Digital Communication Equipment) device, as shown in Figure 2-4.

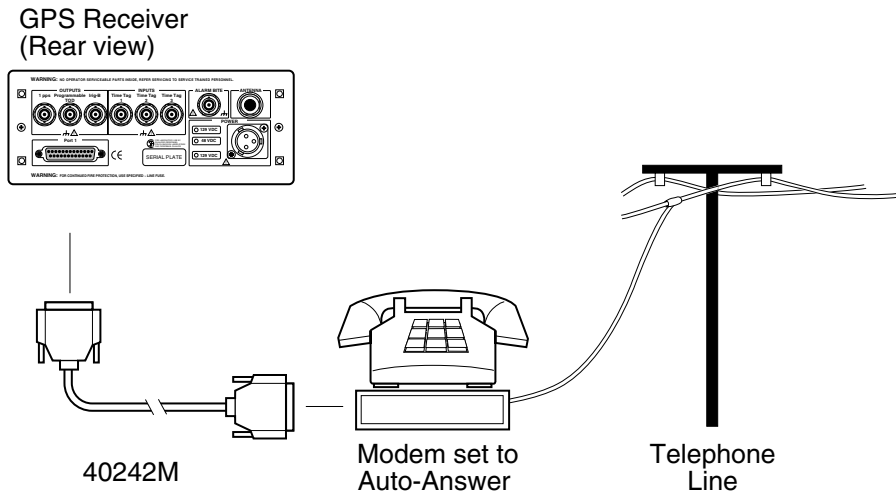


Figure 2-4. Connecting the GPS Receiver to a Modem

To Connect the 59551A to a Laptop Computer Via the Front-Panel DB-9 Serial Port

Use the 9-pin (f) to miniature 9-pin (f) RS-232 interface cable supplied for the OmniBook 300 or laptop computer, and a "straight-through" type of 9-pin male-to-male adapter to connect the 59551A Module's front-panel **PORT 2** DB-9 female connector to a laptop computer as shown in Figure 2-5.

CAUTION

Make sure you use a straight-through adapter. The 9-pin male-to-male adapter should be wired as shown in Figure 2-6. Pins 2, 3, and 5 should not crossover.

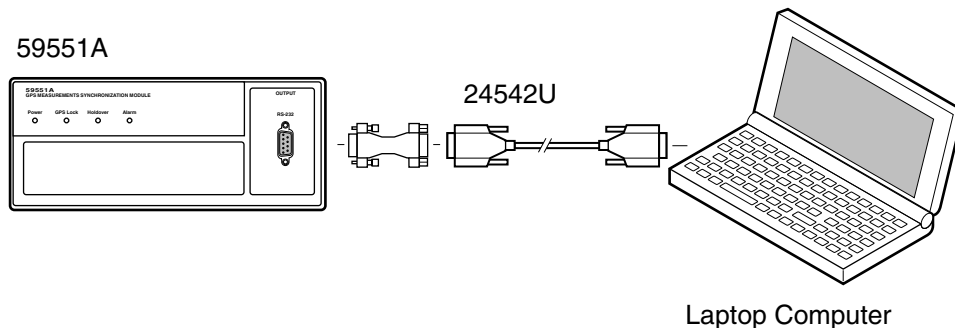
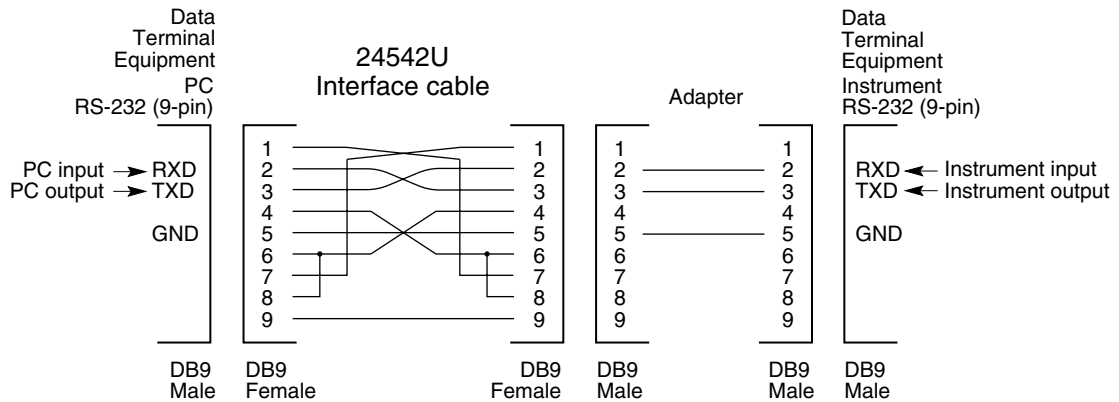


Figure 2-5. Connecting the 59551A to Laptop Computer

If you choose to make your own cable, see figures 2-6 and 2-7.



Figures 2-6 and 2-7 illustrate the 24542U cable (9-pin female to 9-pin female connectors) and the 24542G cable (25-pin male to 9-pin female connectors), respectively. Each of these cables are null-modem cables. Note that pins 2 and 3 of the 24542G 25-pin (male) to 9-pin (female) cable, shown in Figure 2-7, DO NOT cross; nevertheless, this cable is a null-modem cable.

Figure 2-6. DB-9 to DB-9 Serial Connection

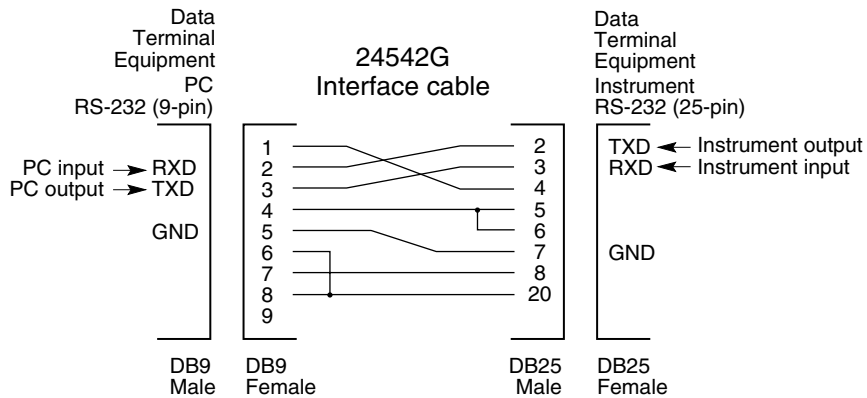


Figure 2-7. DB-25 to DB-9 Serial Connection

Configuring the RS-232C Port(s)

The 59551A has separate rear-panel (**PORT 1**) and front-panel (**PORT 2**) RS-232C serial interface ports; one port is designated as the “primary” port and the other as the “secondary” port. The primary or secondary port assignment is user-selectable, and is discussed in the operating and programming guide.

The 58503A has one RS-232C serial interface port (**PORT 1**) on the rear panel.

Software pacing, baud rate, parity, data bits, and stop bits parameters for each port are user-selectable and independent of the configuration of the other port.

Tables 2-5 and 2-6 list the configuration factory-default values for **PORT 1** and **PORT 2**, respectively.

Table 2-5. PORT 1 Configuration Factory-Default Values

Parameter	Default	Possible Choices
Software Pacing	NONE	XON or NONE
Baud Rate	9600	1200, 2400, 9600, or 19200
Parity	NONE	EVEN, ODD, or NONE
Data Bits	8	7 or 8
Stops Bits	1	1 or 2
Full Duplex	ON	ON or OFF

Table 2-6. PORT 2 Configuration Factory-Default Values (59551A Only)

Parameter	Default	Possible Choices
Software Pacing	NONE	XON or NONE
Baud Rate	9600	1200, 2400, 9600, or 19200
Parity	NONE	EVEN, ODD, or NONE
Data Bits	8	Fixed at 7 when parity is even or odd. Fixed at 8 when parity is none.
Stops Bits	1	Fixed (no choices available)
Full Duplex	ON	ON or OFF

Procedures for configuring the RS-232 ports are provided in the following paragraphs.

If You Need To Make Changes to the Serial Port Settings

CAUTION

If you change the serial port settings, your changes will be stored in the Receiver. Cycling power will not reset to factory defaults. Therefore, if you make a change, it is recommended that you record the settings and keep the record with the Receiver.

If you need to change the serial port settings, for example, to set up for a different computer, use the guidelines given in this section.

Serial port settings are changed by issuing commands.

It is recommended that you issue a single compound command, which simultaneously sets all the serial port parameters. Then connect the other computer and begin using the instrument with the new settings.

NOTE

If you choose to set parameters one at a time, you will make the procedure more difficult. That is, with each change, the instrument will be updated, but your computer will retain its original settings. At each step, you will have stopped serial communications and be forced to modify your PC settings to match the Receiver in order to continue. It is recommended that you make all changes in a single compound command, verify the changes, and record all parameters.

Configuring PORT 1

Complete configuration of **PORT 1** requires that you set *five* parameters. The command line sent in the following example would set the RS-232 port pacing to XON, baud rate to 2400, parity to EVEN, data bits to 7, and stop bits to 2.

```
SYST:COMM:SER:PACE XON; BAUD 2400; PARITY EVEN; BITS 7; SBITS 2
```

Configuring PORT 2 (59951A Only)

Complete configuration of **PORT 2** requires that you set *three* parameters. The command line sent in the following example would set the RS-232 port pacing to XON, baud rate to 2400, and parity to EVEN.

```
SYST:COMM:SER:PACE XON; BAUD 2400; PARITY EVEN
```

If Changes Have Already Been Made to the Serial Port Settings

If you connect your PC, press Return, and do not get a **scpi>** prompt back from the Receiver, your Receiver's serial communication settings may have been modified. You need to systematically step through the data communication settings on your PC until your PC matches the Receiver. The Receiver cannot communicate its settings until this process is complete. Iterate until you are able to verify that settings on your PC match the Receiver.

When you are successful, you will have restored full RS-232 communications, enabling you to query the Receiver's communication settings. Issue the following queries to verify a complete match.

SYST:COMM:SER:PACE?
SYST:COMM:SER:BAUD?
SYST:COMM:SER:PARITY?
SYST:COMM:SER:BITS?
SYST:COMM:SER:SBITS?

Once you establish communications with one serial port, you can query the Receiver for settings of the other port.

Reading the Receiver Status Screen

This section defines the data displayed in the Receiver Status screen. (See Figure 1-5 in Chapter 1 of this guide.)

The status screen has three major sections:

- SYNCHRONIZATION
- ACQUISITION
- HEALTH MONITOR

The SYNCHRONIZATION section of the status screen shows how the Receiver's SmartClock™ circuit is progressing towards its objective, which is to synchronize the Receiver's oscillator to the 1 PPS reference signal produced by the Receiver's internal GPS Receiver Engine.

The ACQUISITION section of the status screen shows how the Receiver's internal GPS Receiver Engine is progressing towards its objective, which is to produce an accurate internal 1 PPS reference signal. It does so through tracking GPS satellites.

The HEALTH MONITOR section of the status screen summarizes the overall health of the product.

SYNCHRONIZATION Section of the Status Screen

SYNCHRONIZATION Summary Line

The **SYNCHRONIZATION** line in the screen summarizes the **SmartClock Status** and **Reference Outputs**. One of three SYNCHRONIZATION messages is shown:

Outputs Invalid while the Receiver is warming up,

Outputs Valid/

Reduced Accuracy while the Receiver is in holdover or is locked but has not achieved steady-state operation, or

Outputs Valid while the Receiver is in steady-state operation.

SmartClock Mode

The SmartClock Mode area of the screen shows the four operating modes:

- Locked to GPS
- Recovery
- Holdover
- Power-up

As shown in the sample status screen in Figure 1-5, a >> symbol indicates the current operating mode.

Locked to GPS indicates that the Receiver is locked to GPS. The front-panel GPS Lock LED will be lit. An advisory message stabilizing frequency may appear for a short time.

This stabilizing frequency ... message indicates the time output (1 PPS) signal is locked and can be used, but the frequency output (10 MHz — 58503A only) is not at its final or stable state (steady-state).

Recovery indicates the Receiver is actively working to become locked to GPS. All conditions

needed to proceed towards a lock have been met. Expect an eventual spontaneous transition to a lock (unless changing external conditions prevent this, such as loss of tracked satellites.)

Holdover indicates the Receiver is waiting for conditions that are needed to allow the process of recovery from holdover to begin. Once these conditions are met, the Receiver will transition on its own to the recovery mode.

When the *GPS 1PPS CLK inaccurate* message follows the **Holdover** label, the internal GPS 1 PPS reference signal is inaccurate.

When the *manually initiated* message follows the **Holdover** label, the Receiver has been placed in holdover by the user. An explicit command is required to initiate an exit from manual holdover.

When the *1 PPS TI exceeds hold threshold* message follows the **Holdover** label, the phase difference between the 1 PPS time output signal and the internal GPS 1 PPS reference signal has exceeded the user-entered holdover threshold value.

When the *Internal hardware problem* message follows the **Holdover** label, a measurement hardware error exists.

The *Holdover Duration* message indicates the duration that the Receiver has been operating in holdover (and recovery). Thus, this message gives you an assessment of the quality of the outputs. The longer the Receiver is in holdover the more degraded the outputs become.

Power-up indicates that the Receiver hasn't yet achieved GPS lock since it has been powered on. The Receiver is measuring the internal reference oscillator's frequency and adjusting it to 10 MHz during this power-up period. Other queries can provide insight as to the cause if the Receiver is remaining in powerup longer than expected.

Reference Outputs

TFOM (Time Figure of Merit) indicates the *accuracy* of the Receiver's 1 PPS output. A low TFOM value indicates a more accurate output. In the sample screen of Figure 1-5, a value of 3 is displayed, meaning that the Time Error ranges from 100 to 1000 nanoseconds. The following table lists the TFOM values that could be displayed and provides the corresponding Time Error.

TFOM Value	Time Error (in nanoseconds)	TFOM Value	Time Error (in nanoseconds)
*0	less than 1	5	$10^4 - 10^5$
*1	1 – 10	6	$10^5 - 10^6$
*2	10 – 100	7	$10^6 - 10^7$
3	100 – 1000	8	$10^7 - 10^8$
4	$10^3 - 10^4$	9	greater than 10^8

* The TFOM values 0, 1, and 2 are not presently used in the 58503A and 59551A products. The 58503A and 59551A products will display TFOM values ranging from 9 to 3, which is consistent with the specified accuracies of each product.

FFOM (Frequency Figure of Merit) indicates the *stability* of the Receiver’s 10 MHz output. The 10 MHz output is controlled by the SmartClock’s Phase-Locked Loop (PLL). Thus, the FFOM value is determined by monitoring the status of the PPL.

In the sample screen of Figure 1-5, the 0 indicates that the SmartClock’s PLL is stabilized. The following table lists and defines the FFOM values that could be displayed.

FFOM Value	Definition
0	PLL stabilized — 10 MHz output within specification.
1	PLL stabilizing
2	PLL unlocked (holdover) — Initially the 10 MHz output will be within specifications. However, when in holdover, the 10 MHz output will eventually drift out of specification.
3	PLL unlocked (not in holdover) — Do not use the output.

1PPS TI indicates the difference (timing shift) between the SmartClock 1 PPS and the internal GPS 1 PPS signals.

HOLD THR (holdover threshold) displays the user-entered time error value, which when exceeded will cause the Receiver to go into automatic holdover.

ACQUISITION Section of the Status Screen

ACQUISITION Line

The **ACQUISITION** line in the screen summarizes the state of the internal six-channel GPS Receiver Engine as indicated by the **Satellite Status, Time** and **Position** area of the screen.

If the Receiver Engine was considered to be synchronized to the GPS signal, the [*GPS 1 PPS CLK Accurate*] message will appear at the end of the **ACQUISITION** line. If the Receiver has not yet synchronized to GPS, the [*GPS 1 PPS CLK Inaccurate*] message will be displayed.

Satellite Status

Two tables that indicate satellite tracking and health and status information for other (predicted) visible satellites are provided in the Satellite Status area of the screen: **Tracking** and **Not Tracking**.

The **Tracking** table indicates the number of satellites the Receiver is tracking. The maximum number of satellites that can be listed in the Tracking table is six since there are six channels available in the Receiver.

The **Not Tracking** table indicates satellites predicted to be visible that are not tracked, and all of the satellites that are assigned to a GPS Receiver Engine channel but are not currently tracked.

The maximum number of satellites that can be listed in the Not Tracking table is twelve.

The health and status indicators in the Tracking table are described as follows:

PRN	indicates the assigned, unique pseudorandom noise (PRN) code of a satellite.
El	indicates the predicted elevation angle, from a range of 0 to 90°. The predicted elevation is derived from the almanac.
- -	indicates that the elevation angle is unknown (the almanac did not provide this data).
Az	indicates the predicted azimuth angle, from a range of 0 to 359°. The predicted azimuth angle is referenced to true north, and is derived from the almanac.
- - -	indicates that the azimuth angle is unknown (the almanac did not provide this data).
SS	indicates the strength of the signal, from a range of 0 to 255. A signal strength of 20 to 30 is a weak signal that may not be acquired by the receiver.

The health and status indicators in the **Not Tracking** table are described as follows:

PRN	indicates the assigned, unique pseudorandom noise (PRN) code of a satellite. An asterisk next to the PRN code or satellite indicates that the Receiver is attempting to track it.
El	indicates the predicted elevation angle, from a range of 0 to 90°. The predicted elevation is derived from the almanac.
--	indicates that the elevation angle is unknown (the almanac did not provide this data).
Az	indicates the predicted azimuth angle, from a range of 0 to 359°. The predicted azimuth angle is referenced to true north, and is derived from the almanac.
---	indicates that the azimuth angle is unknown (the almanac did not provide this data).
Ignore	indicates that the user has chosen to remove this satellite from a list of satellites available for tracking.
Not OK	indicates GPS has reported that this satellite is unhealthy.
Acq .	indicates the Receiver is reading timing information from the satellite.
Acq . .	indicates the Receiver is reading the satellite orbiting information.
ELEV MASK	indicates the elevation mask angle in degrees. The Receiver will track only satellites at or above the user-specified mask angle.
*attempting	indicates that the Receiver is attempting to track a satellite and has assigned it to one of the Receiver's six channels. An asterisk appears adjacent to the PRN of the satellite that the Receiver is attempting to track.

Time

When you first power up the GPS Receiver the time and date that is stored in the internal GPS Receiver Engine may not be the actual date. The actual time and date will be valid after one satellite has been tracked by the Receiver.

NOTE

There are two accurate ways to express time (GPS or UTC). GPS time is offset from UTC time by the number of accumulated leap seconds since midnight of January 6, 1980 UTC.

The **Time** area of the status screen provides three types of information: **Time**, **1PPS CLK**, and **ANT DLY**.

Time has four possible modes: *GPS*, *UTC*, *LOCL GPS*, and *LOCAL*.

GPS indicates current time and date collected from a satellite in GPS time.

LOCL GPS indicates GPS time offset for the local time zone.

UTC indicates current time and date collected from a satellite in UTC time.

LOCAL indicates current time and date collected from a satellite in local time offset from UTC (time zone included in computation).

1PPS CLK can indicate several possible advisory messages. These messages are:

Synchronized

to GPS Time 1 PPS locked to GPS, referenced to GPS Time.

Synchronized

To UTC 1 PPS locked to GPS, referenced to UTC.

Assessing

*stability ...*applying 30-second hysteresis to locked 1 PPS signal.

Inaccurate,

*not tracking*not tracking satellites.

Inaccurate,

*no position*in survey mode, but has not calculated a position because of a tracking problem.

Absent or

*freq incorrect*no 1PPS signal; internal GPS Engine is in idle mode.

ANT DLY (antenna delay) displays the user-entered value that is used to compensate for propagation delay of the antenna cable.

Position

Position area of the status screen provides four types of information: **MODE** (hold or survey), **LAT** (latitude), **LON** (longitude), and **HGT** (height).

MODE indicates whether the Receiver is set to **Hold** or **Survey** position mode.

If *Hold* is displayed, for example, the Receiver's antenna position has been provided by the user, or the average position has been found after completion of survey.

If the Receiver is in the position *Hold* mode, the **LAT**, **LON**, and **HGT** "held" position coordinates will be displayed.

If *Survey*: *57.3% complete* is displayed, for example, the Receiver is set to survey mode trying to determine the position of the antenna. The % value indicates the progress of the surveying.

At the beginning of a survey, for example 0% completion, the following "estimated" position coordinates will be displayed:

INIT LAT indicates the estimated latitude (North or South) position of the Receiver in degrees, minutes, and seconds.

INIT LON indicates the estimated longitude (West or East) position of the Receiver in degrees, minutes, and seconds.

INIT HGT indicates estimated height of the Receiver's antenna in meters above mean sea level (MSL).

Once survey starts, the following "average" position coordinates will be displayed:

AVG LAT indicates the average latitude (North or South) position of the Receiver in degrees, minutes, and seconds.

AVG LON indicates the average longitude (West or East) position of the Receiver in degrees, minutes, and seconds.

AVG HGT indicates average height of the Receiver's antenna in meters above mean sea level (MSL).

The possible advisory messages that can be displayed when position mode is **Survey** are:

Suspended: track <4 sats

Suspended: poor geometry

Suspended: 1PPS CLK err

HEALTH MONITOR Section of the Screen

The **HEALTH MONITOR** section of the status screen reports errors or failures of the key hardware functions. The *OK* summary message at the end of the **HEALTH MONITOR** line indicates that no errors or failures were detected. *Error* indicates that one or more hardware tests failed.

For each hardware function, *OK* is reported when it is operating normally; *Err* is displayed when a failure or an error is detected.

Hardware functions are monitored periodically, with the exception of Self Test, which is performed at powerup or when requested.

The health and status indicators in the HEALTH MONITOR section are described as follows:

- Self Test** indicates whether the last self-test completed without errors.
- Int Pwr** indicates whether the output voltages of the +5V, +15V, and -15V power supplies are all within tolerance.
- Oven Pwr** indicates whether the output voltages of the primary and secondary oven (for selected products) power supplies are within tolerance.
- OCXO** When Err is displayed, a problem with the internal reference oscillator circuitry was detected.
- EFC** indicates whether the Electronic Frequency Control voltage for the reference oscillator is within 5% of operating limits.
- GPS Rcv** indicates whether the GPS receiver (engine) is operational.

In Case of a Problem

Hours after powerup, Receiver not establishing GPS lock

Symptom Date, time, and position still show power-up defaults, or these parameters are incorrect.

Receiver Position Mode = Survey.

Receiver cycling from one set of satellites to another.

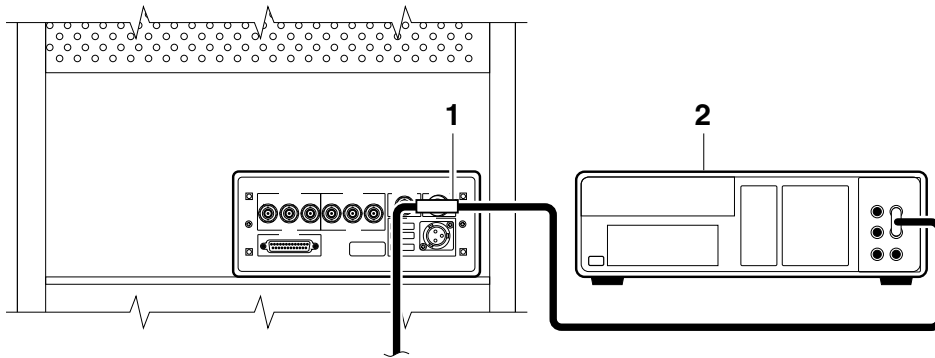
No satellites consistently tracked.

Solution Check antenna:

- Verify antenna has an unobstructed view of the sky — antenna is not under or beside an impervious object.
- Verify antenna is connected.
- Verify antenna is connected properly:
 - cable run not too long.
 - cable with antenna attached neither shorted nor open.
- Verify antenna is being properly driven — *Hint*: (1) Connect Tee-connector to Receiver's rear-panel **ANTENNA** input; connect antenna cable to one end of Tee. Measure a little less than +5 Volts from the other end of the Tee using a digital voltmeter (DVM) as shown in Figure 2-5. If your reading is a lot less than +5 Volts, you will have to determine if the line amplifier or lightning arrester is at fault by using conventional troubleshooting isolation techniques. If the line amplifier and lightning arrester are good, then the antenna may be faulty.
(2) If the Receiver +5 Volts is okay, check +5 Volts at the antenna end of the cable with a voltmeter connected between the center conductor and shell. If insufficient voltage is present, it may indicate that the shield of the cable is not making adequate contact to one of the cable connectors.
- After the antenna connection has been verified, cycle power on the Receiver to facilitate rapid recovery from the fault.

NOTE

Remove the Tee connector and restore antenna connection as loading of the Tee connector will prevent proper reception of the GPS signal by the antenna.



1 Tee-connector

2 DVM

Figure 2-8. Measuring +5 Volts Across Antenna Input

Symptom Same as previous symptoms, except Receiver Position Mode = Hold.

Solution Enable SURVEY mode using specified command.

Receiver not maintaining GPS lock

Symptom Position data incorrect.

Solution Survey to obtain correct position,

or

Correct position data using specified command.

Symptom Position data correct.

Sufficient satellites in view.

No satellites tracked.

Solution If candidate satellites are marked “Ignore” on status screen, disable the feature which ignores satellites.

If candidate satellites are below the mask angle specified on Receiver Status screen, reset the elevation mask angle. Default is 10 degrees — all satellites between the horizon and 10 degrees of the horizon are masked.

Chapter 3

59551A Specifications

Specifications and Characteristics

The specifications and characteristics of the 59551A GPS Measurements Synchronization Module are provided in this chapter.

GPS Receiver Features

Six-channel, parallel tracking GPS engine

C/A Code, L1 Carrier

SmartClock™ technology

Enhanced GPS technology

1 PPS Output

Specifications

Locked

Jitter of leading edge: <750 ps rms with at least one satellite in view, SA on..

Time Accuracy:

<110 ns with respect to UTC (USNO MC) — 95% probability when unit is properly installed, calibrated, and locked to GPS.

Unlocked

Accumulated time error: <8.6 μ s accumulated in 24 hours of unlocked operation. (See Note 1.)

Supplemental Information

- Pulse Width: 26 μ sec.
- Amplitude: >2.4 volts into 50 Ω load. (TTL compatible)
- Connector: BNC
- Rise time: <5 ns

Additional Features

Alarm BITE Output:

Basic unit output: solid state relay (normally open); closed contact indicates system fault or loss of satellite lock. Contact rating 200 Vdc @ 0.5 amps.

Connector: Twin BNC

IRIG-B123 Output Port

BNC connector

Note 1

This specification has a 95% probability, and is based on the availability of four or more GPS satellites during three days of locked operation with a fixed antenna location. The temperature must remain within a 10° C range between 10° C and 40° C.

Note 2

When a quartz crystal oscillator has not been operated for a period of time, or if it has been subjected to severe thermal or mechanical shock, as might be encountered during product shipment, the oscillator may take some time to stabilize. In most cases, the oscillator will drift and then stabilize at or below its specified rate within a few days after

being turned on. In isolated cases, depending upon the amount of time the oscillator has been off and the environmental conditions it has experienced, the oscillator may take up to one week to reach its specified aging rate and to operate without significant frequency "jumps."

A Hewlett-Packard GPS Receiver, when it is initially turned on and locked to the GPS satellite system, will achieve GPS lock within 30 minutes of operation. It has a 95% probability of meeting unlocked (holdover) specifications after two days of locked operation. The longer GPS Receiver (and its quartz oscillator) operates, the better its stability and unlocked (holdover) performance becomes.

Three Time-tag Inputs

Received signal: TTL, 50 Ω .

Time-tag accuracy: same as the accuracy of the 59551A.

Quantization: 100 ns

Input Interface: BNC

Minimum Pos/Neg pulse width: 200 ns

Three time-tag buffers: 256 events each, retrievable via RS-232C.

Minimum time between events: 1 ms

Maximum stamp rate:

1 measurement per ms

Timer/Clock Output

Programmable Pulse Output:

Single pulse at the time programmed via RS-232C port, or repetitive output pulse at a programmable repetition period from 1 second to 1 year.

Quantization: 100 ns

Accuracy: same as the time accuracy of the 59551A.

Front Panel Indicators (LEDs):

- Power
- GPS Lock
- Holdover Mode
- Alarm

Remote Interface: (Two RS-232C Ports)

RS-232-C DTE configuration:

PRIMARY PORT

Complete remote control and interrogation of all instrument functions and parameters.

SECONDARY PORT

Interrogation of all instrument functions and parameters.

Factory defaults: baud rate 9600 — 8 data bits, 1 start bit, 1 stop bit, no parity. Other settings are programmable.

Connectors: 9-pin female rectangular D subminiature (DB-9) on front panel, 25-pin female rectangular D subminiature (DB-25) on rear panel.

Time code output is available to a computer immediately preceding the 1 PPS signal for the current second.

Environmental

Specifications

Measurements Synchronization Module (59551A)

Operating: 0°C to +50° C

Storage: -40° C to +80° C

Antenna (58504A)

Operating: -30° C to +80° C

Storage: -40° C to +85° C

Power Requirements

DC Power (standard):

129 Vdc nominal (115 to 140 Vdc operating range).

Option 170: 90 to 132 Vac or 198 to 264 Vac, automatically selected; 50 to 60 Hz.

Option AWM:

\pm 48 Vdc nominal (\pm 37 to \pm 60 Vdc operating range). Less than -46 or +46Vdc required to start.

Input power (all options):

<35 watts (nominal).

Weight and Size

Dimensions:

88.5 mm (3.5 in) H \times 212.6 mm (8.53 in) W \times 348.3 mm (13.7 in) D.
Half-Rack Module

Weight: 3.6 kg (8 lbs).

Surge withstand: Meets IEEE/ANSI C37.90, C37.90.1

Other Information

The standard 59551A does not include a display or a keypad. While not necessary, it may be convenient to track the Receiver's progress during installation and startup by monitoring the satellites being tracked, location (position), time and other parameters. The 59551A, however, is supplied with a small Windows 3.1 program named Timing Receiver Windows User Interface, also called "SatStat", (59551-13401), which can serve to display important parameters. SatStat operates on any PC that can run Windows 3.1, and that has an available serial interface. (An OmniBook is ideal as a small, inexpensive and very portable package.)

SatStat provides several useful functions. It continuously polls the RS-232C interface and displays Receiver information most likely to be of interest. This includes satellites being tracked along with their elevation and azimuth, SmartClock State (locked, holdover, etc.), antenna coordinates, time and frequency figures of merit and other data. In addition, a clock window is provided to display time of day in real time. Finally, SatStat allows you to easily change many receiver parameters, such as antenna delay, by simply picking the item from a pop-up menu and entering a new value. With SatStat and a PC, you can monitor and control many aspects of the Receiver status without developing software.

Achieving accurate time of day requires care in determining cable delays, Receiver bias, position (Lat, Lon, Alt), atmospheric conditions and other parameters which are dependent on each individual installation.

Options and Accessories

Available options and accessories include an antenna, an antenna environmental cover and ground plane, pre-configured cables, a lightning arrester, an antenna line amplifier, a built-in display and ac power. Ask your representative for a copy of the 59551A price list, which included additional pricing and ordering information.

Chapter 4

58503A Specifications

Specifications and Characteristics

The specifications and characteristics of the 58503A GPS Time and Frequency Reference Receiver are provided in this chapter.

GPS Receiver Features

Six-channel, parallel tracking GPS engine

C/A Code, L1 Carrier

SmartClock™ technology

Enhanced GPS technology

10 MHz Output

Specifications

Locked:

Frequency Accuracy: Better than 1×10^{-12} , for a one-day average, 0° to 50° C.

Unlocked:

Holdover aging: $<1 \times 10^{-10}$ per day average frequency change in 24 hours of unlocked operation.
(See Note 1.)

Phase Noise: (Locked)

Offset From Signal (Hz)	SSB Phase Noise (dBc)
1	-85
10	-125
100	-135
1000	-140
10000	-145

Time Domain Stability: (Locked)

(See graph on next page.)

Averaging Time Seconds	Root Allan Variance
0.01	1.5×10^{-10}
0.1	1.5×10^{-11}
1	5×10^{-12}
10	5×10^{-12}
100	5×10^{-11}
1000	5×10^{-11}

Supplemental Information

- Waveform: Sine wave
- Amplitude: >1 volt p-p into a 50Ω load
- Harmonic Distortion: <-25 dBc (Typical)
- Non-harmonic signals: <-60 dBc (Typical)
- Source impedance: 50Ω (nominal)
- Coupling: ac
- Connector: BNC

Note 1

This specification has a 95% probability, and is based on the availability of four or more GPS satellites during three days of locked operation with a fixed antenna location. The temperature must remain within a 10° C range between 10° C and 40° C.

Note 2

When a quartz crystal oscillator has not been operated for a period of time, or if it has been subjected to severe thermal or mechanical shock, as might be encountered during product shipment, the oscillator may take some time to stabilize. In most cases, the oscillator will drift and then stabilize at or below its specified rate within a few days after being turned on. In isolated cases, depending upon the amount of time the oscillator has been off and the environmental conditions it has experienced, the oscillator may take up to one week to reach its specified aging rate and to operate without significant frequency “jumps.”

A Hewlett-Packard GPS Receiver, when it is initially turned on and locked to the GPS satellite system, will achieve GPS lock within 30 minutes of operation. It has a 95% probability of meeting unlocked (holdover) specifications after two days of locked operation. The longer GPS Receiver (and its quartz oscillator) operates, the better its stability and unlocked (holdover) performance becomes.

1 PPS Output

Specifications

Locked

Jitter of leading edge: <750 ps rms with at least one satellite in view, SA on.

Time Accuracy:

<110 ns with respect to UTC (USNO MC) — 95% probability when unit is properly installed, calibrated, and locked to GPS.

Unlocked

Accumulated time error: <8.6 μ s accumulated in 24 hours of unlocked operation. (See Note 1.)

Supplemental Information

- Pulse Width: 26 μ sec.
- Amplitude: >2.4 volts into 50 Ω load. (TTL compatible)
- Connector: BNC
- Rise time: <25 ns

Additional Features

Alarm Output: TTL open collector with internal pull-up resistor. Circuit can sink up to 10 ma. Provides a logic output to allow monitoring of normal (H) and abnormal (L) operation externally and remotely. BNC connector.

Front Panel Indicators (LEDs):

Power
GPS Lock
Holdover Mode
Alarm

Remote Interface:

- RS-232-C DTE configuration: Complete remote control and interrogation of all instrument functions and parameters.
- Factory defaults: baud rate 9600, 8 data bits, 1 start bit, 1 stop bit, no parity. Other settings are programmable.
- Connector: 25-pin female rectangular D subminiature on rear panel.
- Time code output is available to a computer immediately preceding the 1 PPS signal for the current second.

Environmental Specifications

Time and Frequency Reference Receiver (58503A)

Operating: 0°C to +50° C
Storage: -40° C to +80° C

Antenna (58504A)

Operating: -30° C to +80° C
Storage: -40° C to +85° C

Power Requirements

ac power (standard):

90 to 132 Vac or 198 to 264 Vac, automatically selected; 50 to 60 Hz.

Option AWR:

± 24 Vdc nominal. ± 19 to ± 30 Vdc operating range. Greater than ± 23 Vdc required to start.

Option AWM:

± 48 Vdc nominal. ± 37 to ± 60 Vdc operating range. Less than ± 46 Vdc required to start.

Input power (all options):

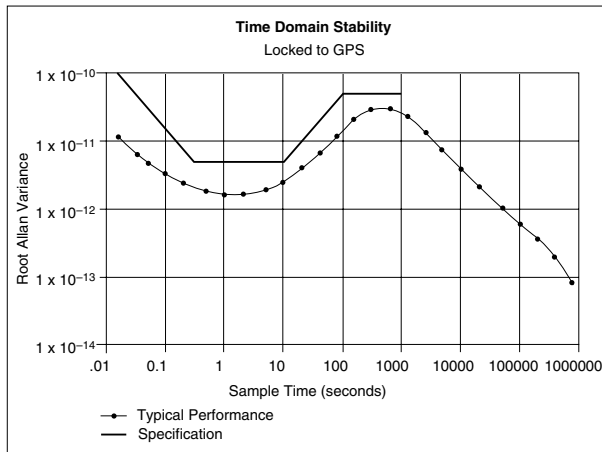
<35 watts (nominal).

Weight and Size

Dimensions:

88.5 mm (3.5 in) H \times 212.6 mm (8.53 in) W \times 348.3 mm (13.7 in) D.
Half-Rack Module

Weight: 3.6 kg (8 lbs).



10 MHz Root Allan Variance

Other Information

The standard 58503A does not include a display or a keypad. While not necessary, it may be convenient to track the Receiver's progress during installation and startup by monitoring the satellites being tracked, location (position), time and other parameters. The 58503A, however, is supplied with a small Windows 3.1 program named Timing Receiver Windows User Interface, also called "SatStat", (59551-13401), which can serve to display important parameters. SatStat operates on any PC that can run Windows 3.1, and that has an available serial interface. (An OmniBook is ideal as a small, inexpensive and very portable package.)

SatStat provides several useful functions. It continuously polls the RS-232C interface and displays Receiver information most likely to be of interest. This includes satellites being tracked along with their elevation and azimuth, SmartClock State (locked, holdover, etc.), antenna coordinates, time and frequency figures of merit and other data. In addition, a clock window is provided to display time of day in real time. Finally, SatStat allows you to easily change many receiver parameters, such as antenna delay, by simply picking the item from a pop-up menu and entering a new value. With SatStat and a PC, you can monitor and control many aspects of the Receiver status without developing software.

Achieving accurate time of day requires care in determining cable delays, Receiver bias, position (Lat, Lon, Alt), atmospheric conditions and other parameters which are dependent on each individual installation.

Options and Accessories

Available options and accessories include an antenna, an antenna environmental cover and ground plane, pre-configured cables, a lightning arrester, an antenna line amplifier, a built-in display and dc power. Ask your representative for a copy of the 58503A price list, which included additional pricing and ordering information.

Chapter 5

Backdating
Manual Changes

Introduction

This chapter contains information necessary to adapt this manual to apply to older instruments.

Manual Changes

This manual applies directly to 59551A GPS Measurements Synchronization Module and 58503A GPS Time and Frequency Reference Receiver with firmware revision 3543 and up.

As engineering changes are made, newer instruments may have serial prefix numbers or firmware revision numbers other than the one shown on the title page of this manual. The manuals for these instruments will be supplied with a “Manual Updating Changes” package containing the required information. Replace the affected pages or modify existing manual information as directed in the pages of the Manual Updating Changes package. Contact the nearest Hewlett-Packard Sales and Support office (listed at the back of this manual) if this change information is missing.

Older Instruments

The following information applies to 59551A GPS Measurements Synchronization Module and 58503A GPS Time and Frequency Reference Receiver whose serial numbers or firmware revision numbers match (or exceed) the serial numbers listed below:

Table 5-1. Manual Backdating

IF INSTRUMENT HAS FIRMWARE REVISION:	MAKE THE FOLLOWING CHANGES TO YOUR MANUAL.
Below 3543	1

Change 1

Page 2-21, SmartClock Mode.

Change paragraphs 3 and 4 to read as follows:

Locked to GPS indicates that the Receiver is locked to GPS. The front-panel **GPS Lock** LED will be lit. One of two advisory messages will be displayed following this label: *stabilizing frequency...* and *frequency is stable*.

The *stabilizing frequency...* message indicates that the time output (1 PPS) signal is locked and can be used, but the frequency output (10 MHz — 58503A only) is not at its final or stable state (steady-state).

Add the following after paragraph 4:

The *frequency is stable* message indicates that the 10 MHz output (58503A only) is stable and you can use it.

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