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AUSTRON Model 2201A
GPS Satellite Receiver
Unit Serial No. 592AA
User Guide
P/N 12712778-2, Revision B

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MODEL 2201A GPS SATELLITE RECEIVER INTRODUCTION

This user guide is written for personnel operating the Model 2201A GPS Satellite Receiver, Assembly P/N 30411940, manufactured by AUSTRON, Inc.

It contains information about the physical and electrical specifications, installation and operation. Individual module information is given in supplemental user guides provided with the modules.

> **WARNING:** Servicing instructions are to be used only by qualified personnel. To reduce the risk of electric shock, do not perform any servicing other than that contained in the operating instructions unless you are qualified to do so.

AMENDMENT NOTICE

AUSTRON, Inc. makes every attempt to provide up-to-date user guides with the associated equipment. Occasionally, changes are made to equipment wherein it is necessary to provide amendments to the user guide. If any amendments are provided for this document, they are printed on colored paper and will be found at the rear of this user guide.

☞ **NOTE:** The content of any amendments may affect operation, maintenance, or calibration of the equipment.

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1. GENERAL DESCRIPTION

1.1. SCOPE OF SECTION

Section One introduces the AUSTRON Model 2201A GPS Satellite Receiver. Provided here are descriptions of the equipment, its purpose, specifications, operating controls, and indicators. A brief description of the NAVSTAR Global Positioning system follows.

1.2. OVERVIEW OF THE NAVSTAR GLOBAL POSITIONING SYSTEM

The NAVSTAR Global Positioning System, commonly referred to as GPS, is a satellite-based navigation system, which will provide three dimensional, world wide, navigation when it is completed in the early 1990s. In addition to accurate navigation, the signals and data from the satellites provide accurate timing information.

The GPS system consists of three main segments. The first segment is the space segment, which consists of 24 satellites in six different orbital planes. Four satellites in each plane orbit the earth every 11 hours and 58 minutes, at an altitude of approximately 10,900 miles. All satellites transmit data on two frequencies, L1 at 1575.42 MHz and L2 at 1227.60 MHz, which are phase modulated by the data. In addition, the L1 frequency is phase modulated by a short, pseudo random number code (PRN code) called the Coarse Acquisition (C/A) code, and a long pseudo random number code called the Precise (P) code. The L2 frequency is also phase modulated by the P-code (not the C/A code). Each satellite transmits its own unique C/A and P codes, making it possible for receivers to track a specific satellite. The use of these pseudo random sequences causes the power of the carrier to be spread over a broader frequency range, making the signals less susceptible to interference or jamming.

The second part of the Global Positioning System is the ground segment. The ground segment, which consists of several control/monitor stations, monitors the transmissions of all satellites, and uploads new satellite ephemeris and clock-correction data several times a day. This data is generally usable for several hours, but is refreshed approximately every hour.

The third segment is the user segment. Most users of GPS are interested in navigation. There are, however, a growing number of users who are interested in GPS for it's frequency and timing information. The data transmissions, synchronized with the satellite clock, include the current date, time and satellite clock correction parameters, making it possible to generate a local 1 pps which is synchronized to GPS time to within 100 ns. For users of Universal Coordinated Time (UTC), data is included which makes it possible to generate a 1 pps that is within 140 ns of UTC. The UTC corrections are provided by the United States Naval Observatory, which has the responsibility of monitoring the frequency and timing accuracy of the satellites. This provides traceability to UTC (USNO) and to all international time scales through the use of National Institute of Standards and Technology (NIST), BIH and USNO publications.

☞ **NOTE:** The Department of Defense reserves the right to degrade the accuracy of the system at any time. This degradation is called Selective Availability or SA and is on the order of 300 ns timing error and parts in 10^{-9} frequency error. All references to time and/or frequency accuracy in this user guide are for nondegraded periods.

1.3. PURPOSE OF EQUIPMENT

An important piece of equipment in most technical facilities (calibration laboratories, electronics laboratories, etc.) is an accurate frequency standard, because it is often used to calibrate other equipment, make accurate time measurements of physical events and keep accurate time-of-day. As a standard, this frequency source must, itself, be checked and calibrated regularly, with traceability to a national standard of prime importance. The AUSTRON Model 2201A GPS Satellite Receiver provides this calibration capability.

The AUSTRON Model 2201A is an automatic acquisition GPS receiver, capable of tracking up to eight satellites. It is a single channel sequencing receiver, which tracks the C/A (coarse acquisition) code on the L1 carrier frequency (1575.42 MHz). While tracking at least one satellite, it can generate a 1 pps that is synchronized to UTC to better than 140 ns and a 0.1, 1, 5 or 10 MHz output that is accurate to better than 5 parts in ten to the twelfth. If an external 1 pps is connected, the receiver can measure the offset of that signal from UTC to better than 140 ns. An external 1, 5, or 10 MHz can also be connected, and its frequency offset measured to better than 5 parts in ten to the twelfth.

1.4. SPECIFICATIONS OF EQUIPMENT

The following tables provide the physical, electrical and environmental specifications of the AUSTRON Model 2201A GPS Satellite Receiver.

Table 1: Physical Specifications

RECEIVER	
Height	3.5 in (89 mm)
Width	19 in (483 mm) rack mount
Depth	18 in (457 mm)
Weight	18 lbs (10 kg)

Table 2: Electrical Specifications

POWER			
AC	115 Vac (90-130 Vac), 48 Hz to 70 Hz 75 VA warm-up, 60 VA operating (crystal)		
	230 Vac (190-260 Vac), 48 Hz to 70 Hz 75 VA warm-up, 60 VA operating (crystal)		
DC Standby	22-57 Vdc, positive or negative ground, automatic switchover on loss of ac		
DC Power Usage (Watts, 25°C)		Warm-up	Operating
	24V, crystal	≤ 66	≤ 52
	48V, crystal	≤ 84	≤ 70
DATA INPUT	Numeric keypad and push button function keys		

Table 2: Electrical Specifications

DATA OUTPUT	4-line-40-character LCD, and LED status indicators	
TIMING OUTPUTS		
Accuracy (C/A code not degraded)	1 PPS	Within 100 ns of GPS Within 140 ns of UTC
	1 PPM	Within 100 ns of GPS Within 140 ns of UTC
Stability	Both	15 ns rms for 10-second average
FREQUENCY OUTPUTS		
Accuracy (tracking)	< 2.0E–11, 10-second average	

Table 3: Environmental Specifications

TEMPERATURE	
Operating	0 to 50°C
Storage	–20 to 70°C
HUMIDITY	0 to 95%, noncondensing

1.5. CONTROLS, INDICATORS AND CONNECTORS

The following tables give a brief description of all controls, indicators and connectors as referenced in Dwg. No. 12411984. For a more detailed discussion of the operation of the Model 2201A, please refer to Section Three.

Table 4: Front Panel

REF.	DESCRIPTION	FUNCTION
1	LCD	4-line-40-character liquid crystal display, used for data I/O and menus
2	[ALT]	Used for ALTernate function
3	[ESC]	Each time the ESCape key is pressed the LCD backs up one screen until the main screen is reached
4	[MENU]	This key causes the main menu to be displayed
5	[1], [2], [3], [4]	Keys used for entry of data and selection of menu items
6	[ENT]	The ENTer key is used to enable data entry and to accept data entry
7	[CE]	The Clear Entry key causes the last numeric character entered to be erased and the cursor moved left one place
8	[EE]	The Enter Exponent key allows entry of numeric data with exponents
9	ALARM LED	Indicates that no alarms are active while green; indicates that a soft alarm is active while off; indicates that a hard alarm is active while red
10	1 PPS LED	Pulses green once a second while the 1 PPS output is set; pulses red once a second while the 1 PPS output is not set
11	POWER LED	Indicates that a power source is connected and the power switch is in the ON position

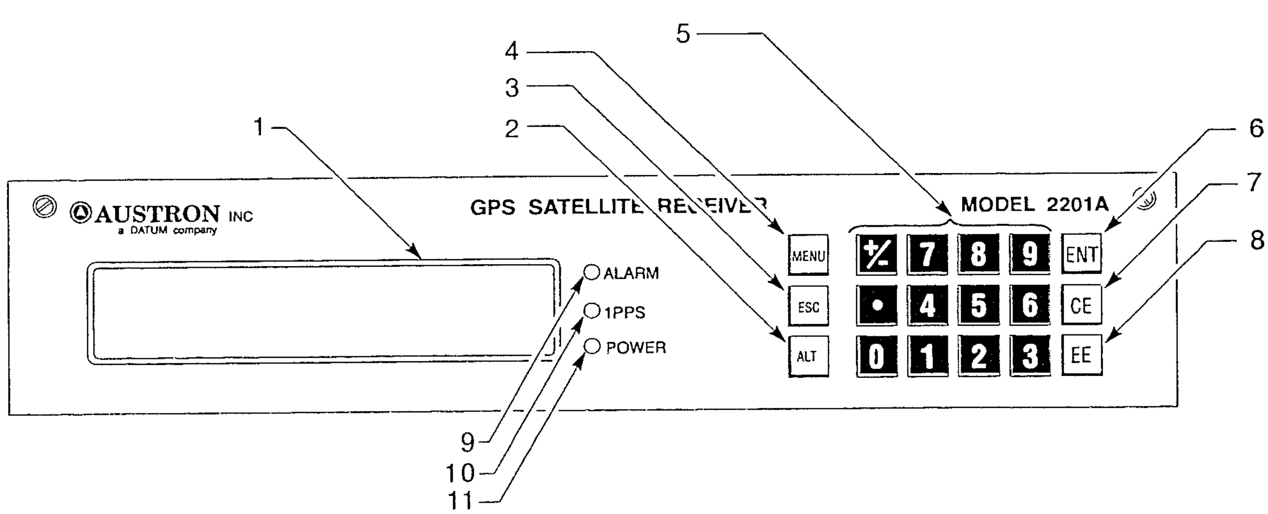

Figure 1: Dwg. No. 12411984 Rev C. GPS Receiver, Controls and Indicators.

Table 5: Rear Panel, Standard Configuration

REF.	DESCRIPTION	FUNCTION
12	Module slots	Four slots, available for options
13	CB1, circuit breaker	Circuit breaker for the positive side of external dc power
14	CB2, circuit breaker	Circuit breaker for the negative side of external dc power
15	DC POWER, Connector	Connector for external dc power
16	F1, AC power fuse	AC power fuse
17	115/230 voltage selector	PCB is rotated for 115 or 230 Vac operation
18	Power, connector	Connector for external ac power
19	ANTENNA, TNC	GPS antenna cable is connected here

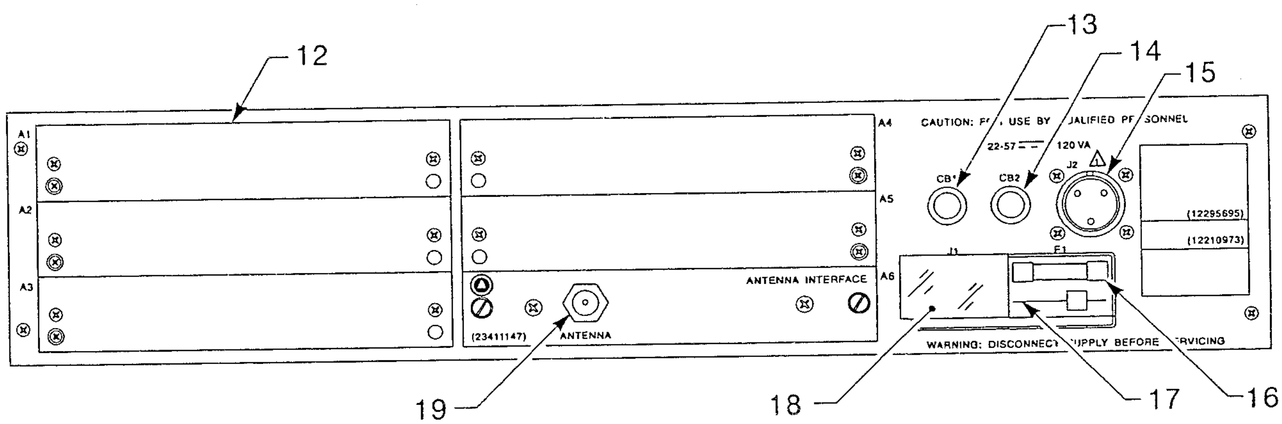

Figure 2: Dwg. No. 12411984 Rev C. GPS Receiver, Controls and Indicators.

Notes

2. INSTALLATION

2.1. SCOPE OF SECTION

Section Two describes the steps required to prepare the Model 2201A GPS Receiver for operation, or for reshipment to another location. Included are steps for unpacking, inspection, and a list of electronic requirements and accessories.

☞ **NOTE:** The Model 2201A GPS Receiver does not have a power switch. Do not make any power connections before reading Section 2.3. MODEL 2201A INSTALLATION.

2.2. UNPACKING AND INSPECTION

2.2.1. Unpacking

The Model 2201A is packed in a shipping box. If the shipping box is damaged, inspect the receiver and other components for visible damage. If anything is damaged, immediately notify both AUSTRON and the carrier making delivery. Keep the shipping containers and packing material for the carriers' inspection.

Carefully remove the receiver and accessories from the shipping container. Verify that the serial number on the receiver matches the number on the packing list. The receiver serial number is on the rear panel. If they do not match, contact AUSTRON immediately. The following items are included in the shipping container:

a. Model 2201A GPS Satellite Receiver, 1 each

b. User Guide, 1 each

c. Mating connector, dc standby, 1 each

d. Three-wire 115 Vac power cord

e. Spare fuse, .375 A, 2 each

f. Spare fuse, .75 A, 2 each

☞ **NOTE:** Locate the antenna that should come with your unit and verify the cable length and antenna as per the Antenna user guide. Report any discrepancies to AUSTRON, Inc.

Locate any optional equipment that should come with your unit, such as spare PCBs, extra user guides, spare integrated circuits, etc. If option modules have been ordered with your receiver, verify they are plugged into the back of the receiver. There should also be a user guide or user guide supplement for each module except for the Antenna Interface Module, P/N 23411147. Report any discrepancies to AUSTRON, Inc.

2.2.2. Initial Inspection

If no exterior damage to the equipment is detected, proceed with an inspection of the interior of the receiver. This must be done before connecting power to the receiver.

☞ **NOTE:** Do not open the antenna. There are no user serviceable parts inside.

Remove the top cover of the receiver by unscrewing the two screws at the back of the cover, then slide the cover toward the back. Examine the interior for loose or broken parts. Verify that all PCBs are securely installed. In the front left section of the chassis, verify that the thumbscrew on the power supply module is tight. If any problems are found, notify AUSTRON immediately. When these checks are complete, replace the top cover.

☞ **NOTE:** Save all boxes and packing material if reshipment is possible.

2.3. MODEL 2201A INSTALLATION

The following paragraphs describe the installation of the Model 2201A GPS Satellite Receiver.

2.3.1. Receiver Installation

Before connecting power to the receiver, follow the installation and customization procedures to ensure proper operation. The Model 2201A operates on a bench or mounted in an equipment rack. If operating on a bench, raise the receiver approximately 1 inch off the bench to allow ventilation into the bottom cover. Do not obstruct the ventilation holes in the top cover. The Model 2201A has no fan and depends on convection cooling.

2.3.2. Rack Mounting

The Model 2201A is shipped with rack ears for mounting in a standard 19-inch equipment rack. If this mounting option is chosen, provide a supporting bar or tray for the rear of the instrument. Provision has also been made for the preferred method of rack mounting using chassis slides (CHASSIS TRACK, C-230-S-116 through 124, or equivalent). When the Model 2201A is installed in a rack, provide space above and below the receiver for convective cooling.

2.3.3. Receiver Power Options

The Model 2201A can be powered by ac or dc sources over a wide range of voltages. It can be connected to an ac source only at voltages of 115 or 230 volts ± 15%; it can be connected to a dc source only with a voltage range of 22 to 57 volts. Also it can be connected to an ac source used as primary power and to a dc source (batteries) used as backup power. The following paragraphs describe the various ways the Model 2201A can be connected to power sources. Before the power is applied to the receiver, carefully read this section to prevent damage to the receiver.

WARNING: While the Model 2201A is connected to a power source, high voltages may be present in the left rear section of the receiver (as viewed from the front). If it is necessary to work in this area, the power cord should be removed to prevent possible injury. Also, the Model 2201A has no power switch. To turn the receiver off, the power cord(s), ac and dc, must be disconnected from the receiver or the power source(s).

1. AC POWER: Before connecting a power cord to the receiver, the small PCB inside the ac power connector on the rear panel must be set for the appropriate voltage. Look through the clear plastic door on the power connector and read the ac voltage setting on the top of the board. The receiver should be shipped from the factory with the board set for 115 Vac so 115 should be visible. If 115 Vac operation is desired, and 115 is visible, skip the next paragraph.

To operate the Model 2201A on 230 Vac, slide the clear plastic door to the left and carefully remove the fuse by pulling the FUSE PULL lever, out and left. Next, carefully remove the circuit board from the connector. Rotate the board 180° (foil side down) so that 230 is right-side-up. Reinstall the board in the connector so that 230 is visible through the plastic window. Locate one of the .375 A fuses supplied with the receiver and install it in the power connector. Slide the plastic window to the right.

☞ **NOTE:** Do not reinstall the .75 A fuse that was removed. Save it for future use if the receiver might be powered from a 115 Vac source.

If the receiver is going to be powered by an ac voltage only, it is recommended that pins B and C on the 3-pin cable connector (supplied) be shorted together, using a piece of 20-22 AWG bus wire, and the connector attached to the DC POWER connector (J2) on the rear panel. Leave pin A disconnected.

2. DC POWER: Remove all power connections to the receiver before continuing with this setup. A 3-pin cable connector is provided with the receiver to connect an external dc power source to the DC INPUT connector (J2) on the rear panel. J2 is connected inside the receiver as follows:

a. Pin A is the positive input
b. Pin B is the negative input
c. Pin C is connected to the chassis

Assemble the cable as follows using 20 AWG stranded wire. If the negative terminal of the dc power source is connected to earth ground, connect Pin A to the positive terminal, and connect Pins B and C to the negative terminal. If the positive terminal of the dc power source is connected to earth ground, connect Pins A and C to the positive terminal, and connect Pin B to the negative terminal.

If dc power is the only power to the receiver, remove the ac power cord. When dc power is used as a backup power source, the voltage must be within the specified 22 to 57 Vdc range. The receiver takes power from the source providing the largest dc voltage and could draw power from the backup dc source if the ac voltage is low and the dc voltage is at the maximum allowed. To correct for this, raise the ac voltage, if possible. Otherwise, the external dc voltage must be lowered.

Before the receiver can be powered it must have an antenna connected. Please refer to the Antenna user guide installation instructions for proper installation of your antenna.

After installing the antenna, route the antenna cable to the receiver avoiding other cables and possible noise sources where practical. Connect the end of the cable to the ANTENNA input on the Antenna Interface Module (P/N 23411147).

> **CAUTION:** Take care not to short the center conductor of this connector to ground and do not attach this connector to anything other than the antenna because of the 15 Vdc present when power is applied. Damage may occur to the Model 2201A or to other instruments.

2.4. OPTION INSTALLATION

Normally, all options ordered at the time the Model 2201A is ordered are installed before the receiver is shipped. Included with the receiver user guide is a user guide supplement for each option ordered. If an option is shipped separately, or if an option is ordered after the receiver is shipped, refer to the user guide that is shipped with each option to find the installation procedure and a discussion of user customization. These user guides contain all information necessary to use the option properly. Store them with the receiver user guide.

2.5. INITIAL RECEIVER POWER UP

Once the proper power selections have been made, the antenna installed and the hardware customized, connect the appropriate power cord(s) to the receiver and verify that the liquid crystal display behaves as described in the following paragraphs.

☞ **NOTE:** The antenna must be connected to the receiver when power is connected for proper operation of the receiver. If it is necessary to change the antenna or antenna cable, receiver power must be cycled.

After a short pause for the microprocessors to reset, the following screen appears:

```
GPS MODEL 2201A AUSTRON, INC
TESTING EPROM OK
TESTING DRAM OK
TESTING FAILSAFE RAM OK
```

During this period the microprocessors are running hardware tests. If problems are detected, appropriate messages are displayed and operation is halted. When the power-up tests are passed, the following screen appears:

```
Waiting for signal processor
```

This screen remains for five to ten seconds. When the second microprocessor is ready, a screen like the following appears:

```
Initializing System Hardware
```

After a pause, dependent on the type and number of options installed in your unit, the following screen appears:

```
TIME : 19:18:17 UTC      MODE : Automatic
DATE : NOV 29 1989       STAT : Idle
Search
FREQ : Carrier           1PPS : UTC/Code
```

This is the main screen showing the time, date, receiver mode, status of the satellite track and search routines, and the 1PPS and FREQuency generation modes. This completes the preliminary setup.

2.5.1. STORAGE AND SHIPMENT

The following paragraphs describe the procedures for storage and shipment of the Model 2201A.

2.5.2. Storage and Shipping Environment

The Model 2201A may be stored or shipped in environments within the following limits:

Temperature:	–20 to 70°C
Humidity:	90%, 60°C
Altitude:	25,000 ft (7,620 m)

> **CAUTION:** Protect the instrument from temperature extremes which cause condensation within the unit.

2.5.3. Shipment

To prepare the Model 2201A for shipment, remove all power connections and remove all other external cables. Verify that the two thumbscrews on each of the rear panel modules are finger tight. Remove the front panel and tighten the thumbscrew on the power supply (left side). On the back of the front panel, approximately in the middle, locate a bracket with a strip of rubber tape. This bracket prevents the large PCBs from being knocked out of their sockets during shipment. Verify that it is present before reinstalling the front panel. If the bracket is not on the panel, place a piece of soft foam rubber between the three large PCBs and the front panel before shipping.

> **CAUTION:** If packing material is placed behind the front panel, it is recommended that a note be taped to the front of the receiver before shipping, indicating that packing material is installed behind the front panel of the receiver, and that it must be removed before power is applied.

Replace the front panel. Install the top and bottom covers and tighten the four screws that hold them in place. Remove chassis slides and pack separately. Enclose the Model 2201A in a suitable water- and vapor-proof plastic bag. Projections, sharp edges and other features which might tear or puncture the plastic, should be padded. Heat seal or tape the plastic bag to ensure a moisture-proof closure. When sealing the bag, keep the trapped air volume to a minimum.

Ensure that the shipping container is a rigid box of sufficient strength and size to protect the equipment from damage. Reuse the original shipping container and packing material if they are still in good condition.

3. RECEIVER OPERATION

3.1. SCOPE OF SECTION

This section describes the operation of the Model 2201A GPS Satellite Receiver. The receiver's menu-based operating system makes it easy for you to control its operation and customize it for your specific applications. After setup the unit requires little attention. Customization parameters are kept in nonvolatile memory, so normal operation resumes after power outages. This section covers basic as well as more advanced operation of the Model 2201A.

3.2. INTRODUCTION

The Model 2201A is designed to provide accurate time and frequency with little or no user input, after setup. After entering the date, coarse time and a coarse position, you can then instruct the receiver to determine its position very accurately, and begin generating accurate time and frequency. An internal oscillator provides the reference required by the hardware. This same reference is corrected by data transmitted by the satellite to provide accurate reference outputs. Timing information is also obtained from the satellite transmissions, and an accurate 1 pps is generated.

With appropriate option modules, the Model 2201A can also be used to measure the accuracy of an external 1 pps with respect to GPS time and Universal Coordinated Time, and measure the accuracy of an external 1 MHz, 5 MHz or 10 MHz reference. When an external 1 pps is connected to the receiver, the time interval between it and the internally generated 1 pps (corrected) is measured and displayed. If an external frequency is connected to the receiver, you can instruct the receiver to measure the frequency error of the external frequency.

3.3. INITIAL STARTUP

The following paragraphs describe preliminary operating procedures.

3.3.1. Software

Power up the Model 2201A by connecting it to an external power source. If the setup procedures described in Section 2.0 have been completed, verify the receiver initializes properly. The following screen appears after a delay:

```
TIME : 15:20:10 UTC   MODE : Automatic
DATE : Jan 10 1990    STAT : Idle Search
FREQ : Carrier        1PPS : UTC/Code
```

The operating system of the Model 2201A is menu based. That is, to input or output data, or to modify the operation of the receiver, menu items are selected from various menus displayed on the receiver's LCD. When a selection is made the result can be data input/output, a receiver operation change, or display of another menu. At all levels, the receiver prompts you to select another menu item or to modify data or receiver operation. When the desired result is obtained, you return to the main display.

The LCD is four lines of 40 characters. In the upper left-hand corner is the title of that screen in uppercase letters. The screen title is the same as the menu selection that was just made. In the upper right-hand corner are the receiver operation and data entry control messages. These messages appear on screens where it is possible to modify the operation of the receiver or where data can be entered. Some examples are (ENT=change) and (ENT=accept). The remainder of each screen shows the menu selections, receiver operation information, or the data requested.

Movement through the receiver menus is controlled by the [MENU] key, the [ESC] (ESCape) key, and the numeric keys. When the [MENU] key is pushed, the top level menu (MAIN MENU) is displayed. No matter where you are in the receiver menus, pushing this key returns you to this menu. Each menu selection has a single digit number. Push the number key of your selection to move to the next level. If you have gone too far or if you have made the wrong selection, you can return to the previous level by pushing the [ESC] key once. By repeatedly pushing this key, you eventually return to the main display.

With the proper use of these twelve keys, you can easily display all calculated or measured data, and recall all receiver operating conditions. If no other keys are used, no enterable data or receiver operating conditions will be changed. When you reach a level where modification is possible, the message, ENT=change, is displayed in the upper right-hand corner. When the [ENT] (Enter) key is pushed, the receiver is put into the Entry mode, making it possible to change data or receiver operation. This reduces the chance that receiver operation is accidentally changed while reviewing calculated or measured data or receiver setup. If the [ENT] key is accidentally pushed, the [MENU] or [ESC] keys cancels the Entry mode and either returns to the main menu ([MENU]) or falls back one level ([ESC]), without changing data or receiver operation.

At various levels in the menus, numeric data can be entered. When numeric data is being entered, the left most digit (as you would normally write it) is entered first, followed by the rest of the digits, proceeding from left to right. The cursor indicates the next position to be entered. The decimal point, if required, is entered in its proper place. If an incorrect digit (or the decimal point) is pushed, the [CE] (Clear Entry) key is used to erase that entry and move the cursor to the left one place. If all digits are erased this way, the cursor stops at the beginning of the data entry field. When the incorrect character has been erased, the correct character is entered and the data entry finished.

If the number being entered is positive, the [+/-] key should not be pushed. The receiver assumes that a number is positive, unless indicated otherwise. If the number is negative, the [+/-] key may be pushed at any time, before [ENT] is pushed. A minus sign appears to the left of the number. Each time the [+/-] key is pushed, the sign of the number reverses.

When the data has been entered on the display as desired, the [ENT] key is pushed. This causes the receiver to accept the entered number. If, before the [ENT] key is pushed, you decide not to make a change, the [MENU] or [ESC] keys can be used to abort the entry and return to the main menu ([MENU]) or back up one menu level ([ESC]). No data is changed.

☞ **NOTE:** Some data entry functions require multiple [ENT] pushes for entering intermediate, multi-digit numbers. In these cases, all data is not accepted until all of the numbers have been entered. When this is done, the prompt, ENT=accept, is displayed in the upper right-hand corner of the display. Until [ENT] is pressed, the [ESC] key may be used to abort the entire entry. For example, position is entered as: latitude ([+/-] degrees [ENT], minutes [ENT], and seconds [ENT]), longitude ([+/-] degrees [ENT], minutes [ENT], and seconds [ENT]), and height (meters [ENT]). After height is entered, ENT=accept is displayed, along with the whole position entry. Until [ENT] is pressed one more time, [MENU] or [ESC] can be used to abort the whole entry.

The [ALT] (ALTernate) key has no specific function at this time, except for entering the keyboard lockout code (see discussion of this function below). Future software revisions may make use of this key. Until that time, pressing this key does nothing.

3.3.2. Hardware

There are two main areas of the Model 2201A hardware with which you should become familiar. They are the front panel and the rear panel. In general the front panel is the user-to-hardware interface, allowing hardware control, data entry and retrieval. These functions are accomplished through the 18-key keypad (input) and the 4-line-40-character LCD (output), which were discussed above.

In addition to the display and keypad, there are three LED indicators on the front panel. The POWER indicator is a green LED which comes on when the receiver is connected to a power source. The top indicator, ALARM, is a two-color LED (green and red). When the ALARM LED is green, none of the selected alarm conditions is active. While it is red or off, at least one of the selected alarm conditions is active (see the discussion of the alarm conditions in this section). A red ALARM LED indicates a hard alarm. A hard alarm indicates at least one of the active alarm conditions is one you designated as critical in your application. A hard alarm also activates the ALARM output on the optional Output Buffer Module on the rear panel. If the ALARM LED is off, at least one soft alarm is active. This type of alarm indicates a situation in which you are interested, but it is not one which would cause a problem in your application.

☞ **NOTE:** It is normal for the ALARM LED to be red or off when power is first applied because the receiver is not yet tracking, the 1 pps has not been set and the internal oscillator is not on frequency. If the ALARM LED is green when power is applied, all of the alarms have been disabled.

The 1 PPS LED is also a two-color LED. While the receiver is tracking at least one satellite and after it sets the internal 1 pps, this LED flashes in green. While the receiver is not tracking a satellite, or when the 1 pps may not be accurate, this LED flashes in red.

The rear panel is generally the hardware-to-hardware interface. It is divided into three main areas, beginning with the power area, located on the right side of the panel as viewed from the rear of the unit. This area contains the ac and dc power connectors, dc circuit breakers and the ac fuse. A detailed discussion of these functions is given in Section 2.0.

In the center area you will find the optional signal I/O modules. These modules buffer the externally generated signals for use by the receiver, and buffer the internally generated signals for external use. You should refer to the appropriate user guide supplements for operating instructions for any options installed. A third module located in this section of the rear panel is the Antenna Interface Module (P/N 23411147). As mentioned in Section 2.0, this module provides power and reference to the antenna and accepts the GPS signal from the antenna.

☞ **NOTE:** The I/O modules can be installed in any order in the top two slots of the middle section of the rear panel. An LCD screen, discussed later in this section, shows the slots in which these modules are installed. The ANTENNA INTERFACE module must always be installed in the bottom slot. A small hole in the bottom right corner of each module panel permits installation of these modules only in the center area of the rear panel.

Also located on the rear panel (left side as viewed from the rear) is the OPTION MODULES area. If one or more options have been ordered with your receiver, they are plugged into this area. You should refer to the appropriate user guide supplements for operating instructions. If no options were ordered, blank panels are installed.

☞ **NOTE:** A small hole in the bottom left corner of each option module panel permits installation of these modules only in the OPTION MODULES area of the rear panel. An LCD screen, discussed later in this section, indicates the order in which these modules are installed.

3.4. GENERAL OPERATING INSTRUCTIONS

3.4.1. Introduction

The following paragraphs discuss some of the selections which can be made from the various menus in a standard receiver. They describe general procedures for customizing the receiver, for finding the receivers current position and for generating time and frequency. Ensure that the installation procedures of Section 2.0 are completed. Later in this section are pages containing all of the screens that can be displayed. Included on those pages are detailed descriptions of the information on each screen. Refer to this section if more information is required concerning receiver operation.

When options are installed, some menus differ slightly from the descriptions in this section because the menus are automatically modified to accommodate the options and their positions in the option slots on the rear panel. If your receiver has options, refer to the user guide supplements for those options for explanations of menu selections which are not discussed here.

3.4.2. Receiver Initialization

The operation of the Model 2201A can be customized to fit many applications. This customization is done by changing the initialization parameters, with which the receiver is shipped. The initialization parameters determine such things as receiver operation when power is turned on, ALARM conditions, interface parameters (for RS-232-C, IEEE-488, etc.), and time and date display formats. A battery-backed random access memory (RAM) retains the initialization parameters while the receiver is turned off and during power failures, eliminating the need to reprogram the receiver each time power is applied. When power returns, these parameters are pulled from the RAM and used to initialize the hardware. Receiver operation then proceeds according to this setup.

3.4.3. Receiver Setup

Begin the customization of your Model 2201A by pressing the [MENU] key. The following screen appears.

```
MAIN MENU

1)Initialization     3)Satellite Info
2)Receiver Status
```

Press [1], Initialization.

```
INITIALIZATION

1)Receiver Setup     3)Option Setup
2)Time Setup         4)Alarms
```

Press [1], Receiver Setup.

```
RECEIVER SETUP
1)SV Select Mode     4)User PPS Offsets
2)Time/Freq Mode     5)PRN Track Lists
3)Receiver Masks
```

Press [1], SV Select Mode. The following screen appears.

```
SV SELECT MODE                (ENT=change)

Mode : Automatic
```

Press the [ENT] key. The following screen appears.

```
SV SELECT MODE
1)Automatic          4)Scheduled
2)Semi-Automatic     5)Positioning
3)Manual
```

There are four main modes of satellite selection for time and frequency generation or measurement which are discussed very briefly here. For a more detailed description of these modes, refer to the SV SELECT MODE screen which is discussed later in this section. In all of these modes, the receiver uses the Current Position, which is stored in battery-backed memory, as the accurate position of the receiver. Later in this section you find a discussion of the positioning capability of the Model 2201A.

The mode is selected during setup of the receiver and is stored in battery-backed memory. When power is applied to the receiver, it returns to the mode selected before power was removed.

The first method of satellite selection is the Automatic mode. In this mode the receiver determines the satellites to track and how long to track them. It then begins to generate time and frequency. No user inputs are required after the receiver is set up the first time. As satellites slip from view and others become visible, the receiver automatically changes satellites to track. It also keeps track of those satellites which are bad to ensure that only those satellites transmitting good data are used for setting time and frequency.

As satellites are added to the constellation, the receiver gets data about the new satellites from existing satellites and automatically adds them to its set of available satellites. This is the mode of choice for most applications, because of its ease of use.

The Semi-Automatic mode is similar to the Automatic mode. The receiver determines the satellites to track and how long to track them. While it is tracking satellites, it automatically generates accurate time and frequency. It changes its tracking list as satellites rise and set, and it ignores those satellites that are sending inaccurate data.

The Semi-Automatic mode differs from the Automatic mode in one major respect. The set of satellites from which the receiver makes its selection is specified by the user. When this mode is selected, the receiver refers to the SEMI-AUTO LIST of satellites to find those satellites that you have decided it should track. It selects satellites from this list that are visible and healthy, and begins tracking. Visible satellites that are not enabled, are ignored. As new satellites are added to the GPS constellation, the receiver learns about them, but does not track them until they are added to the SEMI-AUTO LIST.

This mode is useful if you wish to track only specific satellites. Applications that might use it include studies of the performance of a particular satellite, studies of signal propagation from a satellite to the receiver, and comparisons of time and frequency information between two or more locations.

The third mode is the Manual mode. This mode requires more understanding of GPS than any of the others because the user must not only tell the receiver which satellites to track, but also the current approximate Doppler offset of the satellite signal (frequency shift of the signal due to satellite motion relative to the receiver) and the length of time to track. The receiver tracks the satellites selected until the track length reaches zero. At that time the satellite is removed from the list and it is not tracked again until it is placed back on the list.

The fourth operating mode of the Model 2201A is the Scheduled mode. In this mode the user enters a satellite tracking schedule which tells the receiver which satellites to track, what time of day to begin tracking and how long to track. The receiver then automatically tracks the satellites and repeats the tracking schedule every day. Because the satellites are not in perfect 12-hour orbits (approximately 11 hours and 58 minutes), provision is made for automatically modifying the start-times so that every day, tracking of each satellite in the schedule begins four minutes earlier than the day before. This results in the receiver tracking the satellites at the same point in the sky (same elevation).

The Scheduled mode is useful when you wish to compare times and frequencies between two or more locations. All receivers are instructed to track the same satellites at the same time (common view). By doing this some propagation time corrections applied to the data by the receivers cancel because they are essentially common to all of the receivers in the experiment. This improves the accuracy of the comparison since many of the corrections applied are approximations and they contribute significantly to the error of the measurements. To set up the schedule you must know what satellites are good and when each satellite is visible to all receivers in the common view experiment.

☞ **NOTE:** When in Scheduled mode, the output 1 pps is no longer on-time. It is instead locked to the received signal. To indicate this the 1 pps alarm will come on in Scheduled mode.

For this exercise, select 3 (Manual) to put the receiver in the Manual mode. This prevents the receiver from trying to acquire satellites until we are ready. The LCD returns to the SV SELECT MODE screen, showing the mode selected.

Press [ESC] once to return to the RECEIVER SETUP submenu, then select item 3, Receiver Masks. The following screen appears.

```
RECEIVER MASKS                    (ENT=change)
Elev. Mask       :  5°    Tropo : Use
SV Health        : Use    PDOP  :   5.0
Trk High Elev.   : Yes
```

This screen shows several user selectable, satellite tracking restrictions or masks. For now we are only interested in the first item, Elevation Mask.

The Elevation Mask is the elevation angle to a satellite, below which the receiver will not attempt to track or will stop tracking. If you have an unobstructed horizon and the elevation mask is set to 5° (5° is the recommended minimum), press [ESC] once to return to the RECEIVER SETUP submenu. If the mask is less than 5° or if you do not have an unobstructed horizon, press [ENT] to display the following screen, and change the mask to one that is appropriate for your location.

```
USER PPS OFFSETS

1)Elev. Mask            3)SV Health
2)Tropo                 4)PDOP
```

Select item 1, Elev. Mask.

To determine a suitable elevation mask, look out from the antenna toward the horizon and find the highest obstruction. Measure or estimate the inclination angle from the horizon to the top of that obstruction.

☞ **NOTE:** While you are determining the elevation angle, remember that the satellites are moving and will clear small obstructions fairly quickly. Poles do not present much of a problem for this reason. Buildings, mountains and large, nearby trees, may block large portions of the sky and should be included in the mask angle. Try to maximize the amount of sky available to the antenna.

Enter the new mask angle using the number keys. Press [ENT] to cause the receiver to accept it. When you are done, press [ESC] twice to return to the RECEIVER SETUP submenu.

Next, select item 4, User PPS Offsets. The following screen appears.

```
USER PPS OFFSETS                (ENT=change)
Receiver Delay :           48 ns
Cable Delay    :            0 ns
User Time Bias :            0 ns
```

This screen shows the current value of the receiver delay (entered at the factory), the cable delay, and the time bias applied to the internally generated 1 pps. Receiver Delay should agree with the receiver delay shown on the label on the rear panel. If it does not agree, including the sign, verify that the serial number of the receiver is the same as the serial number written on the cover page of the user guide. If the serial numbers are the same, enter the delay shown on the label. If they are not the same, contact AUSTRON, Inc. You should keep track of this number and make sure that it is properly entered into the receiver to make sure that time and frequency are generated properly.

The cable delay is the length of time it takes the signal to travel from the antenna to the receiver. The delay for the antenna cable supplied with the receiver is shown on labels at both ends of the cable. The delay is shown in nanoseconds and is entered into the receiver in nanoseconds. If the cable delay is not shown, or if you are supplying your own cable (it must be 400 feet or less in length), the delay can be estimated by multiplying the length of the cable in feet, by 1.58 nanoseconds per foot. This estimate applies to RG58 cable which is the type of cable normally supplied with the antenna. If a different type of cable is used, the delay may not be the same and it should be measured.

To enter the cable delay, press [ENT] to display the following screen.

```
USER PPS OFFSETS

1)Receiver Delay   3)Time Bias
2)Cable Delay
```

Select item 2 (Cable Delay). Enter the delay in nanoseconds, then press [ENT] to cause the receiver to accept it. The receiver returns to the USER PPS OFFSETS submenu. The third item on this screen, Time Bias, should not be changed now. It is discussed later. Press [ESC] three times to return to the INITIALIZATION screen.

3.4.4. Time Setup

From the INITIALIZATION submenu, select [2], Time Setup. The following screen appears.

```
TIME SETUP

1)Time Format      3)Time (UTC)
2)Date Format      4)Date (UTC)
```

The UTC time and date should still be correct because they were set at the factory and are maintained in a battery-backed clock in the receiver hardware.

Press [1] (Time Format) on the TIME SETUP submenu. This screen shows the current format of the time display on the main screen (UTC, GPS or LOCAL TIME) and the time correction to change UTC time to local time. The receiver is shipped from the factory with the UTC format. You can change the format to GPS or Local Time by pressing [ENT] to change, then select the time format you desire. If you select Local Time, you must also enter the correction to convert UTC time to local time. This correction is negative for locations West of Longitude 0°, and positive for locations East of Longitude 0°. It can range from minus 12 hours to plus 12 hours, with a resolution of 1 minute.

> ☞ **NOTE:** Only the time display on the main screen is affected by selecting local time. All other references to time-of-day are in UTC, except for the Scheduled Mode, which uses GPS time.

When the time format has been selected, press [ESC] several times until the TIME SETUP submenu returns.

Next, press [2] (Date Format), on the TIME SETUP submenu to select the format of the date display on the main screen. The receiver is shipped from the factory with Month Day Year selected. Press [ENT] to display the options. For this example, leave the date format as Month Day Year. Press [ESC] several times until the INITIALIZATION submenu returns.

3.4.5. Option Setup

The Option Setup submenu lists the option modules installed in your receiver. A typical receiver is configured with one or more output modules (sine and/or TTL). These modules buffer the internally generated, on-time 1 pps and the corrected reference frequency. One input module may also be installed which accepts and buffers an external 1 pps and external reference frequency for measurement against UTC and GPS. These input/output modules are installed in the center section of the rear panel (locations A4 and A5).

In addition, digital interface modules such as RS-232-C and IEEE-488 may be installed in your receiver. They are located in the right section of the rear panel as viewed from the front (A1–A3).

To examine the hardware setup of the receiver, press [3] (Option Setup) on the INITIALIZATION submenu. A screen similar to the following screen appears.

```
OPTION SETUP         3)A1, Unused $FF
1)A4, Input Buff     4)A2, Unused $FF
2)A5, TTL Out Buff 5)A3, Unused $FF
```

A1 through A5 refer to the module slots in the rear panel. A1 through A3 are the three slots on the right side of the rear panel as viewed from the front of the receiver; A4 and A5 are the top two slots in the center of the rear panel (all slots are numbered from top to bottom). On your screen, Input Buff and TTL OUT may be reversed since they can be in either slot. Selections 3 through 5 should show the options installed in your receiver. For example, selection 4 could be IEEE-488 and selection 5 could be RS-232. If there is no module installed in a slot, Unused is displayed. For this exercise, the setup of the options is not considered. Refer to the user guide supplements for the options installed in your receiver.

3.4.6. The Time and Frequency Mode of Operation

The basic function of the Model 2201A GPS Receiver is to generate an accurate 1 pps and to set the internal oscillator on frequency. It does this while tracking at least one healthy satellite.

There are three ways that time and frequency are generated in the Model 2201A. To find out which mode is currently being used in your receiver, look at the third line of the main screen. When the receiver is shipped from the factory, the third line is as follows:

```
FREQ : CODE          1PPS : UTC/CODE
```

This indicates that the 1 pps is being controlled by the phase information from the satellites. No matter what the internal oscillator is doing, the receiver keeps the 1 pps on-time, relative to Universal Coordinated Time (UTC). The oscillator is adjusted on frequency using the carrier information from the satellites, which results in a frequency lock of the receiver oscillator to the satellites' oscillators. In this mode the unit automatically tracks only the highest elevation satellite. This is to stay on continuous lock so that phase is not accumulated.

If Code and Carrier have not been selected, use the following keystrokes to change the Time and Frequency Mode of receiver operation. Press [MENU], then select [1] (Initialization), [1] (Receiver Setup) and [2] (Time/Freq Mode). A screen like the following appears.

```
TIME/FREQ MODE                        (ENT=change)
                   Freq out     1PPS out
Current Mode:      Code         UTC/Code
Loop Mode    :     Locking
```

This screen shows the current frequency and time adjustment modes and the time reference to which the time is being set (UTC, GPS or Satellite). To change the mode to Code for timing and Carrier for frequency, press [ENT], then select [1] (Select T/F Mode). The following screen appears.

```
TIME/FREQ MODE                          (ENT=accept)
                                       (1=PRV 2=NXT)
                   Freq out        1PPS out
New Mode :         Code            Code
```

Use the [1] and [2] keys to select PRV (previous) and NXT (next), respectively, to scan through the various modes. The modes that are possible include the following:

```
                   Freq out        1PPS out
New Mode  :        Code            Code
New Mode  :        Carrier         Code
New Mode  :        Carrier         Carrier
```

When the screen shows Carrier for the output frequency and Code for the 1PPS, press [ENT] to cause the receiver to accept the new mode.

When [ENT] is pressed, the display returns to the TIME/FREQ MODE menu. If UTC was not selected for the 1PPS and 1PPM reference, select [2] (Ref) and [2] (UTC). Press [MENU] then [ESC], to return to the main screen. Verify that the receiver is now in the Code mode for 1PPS, and the Carrier mode for frequency.

3.4.7. Positioning

Before accurate time and frequency can be generated or measured by the Model 2201A, the coordinates (or position) of the antenna must be determined. This is usually be done by putting the receiver in the Positioning mode and instructing it to determine its own coordinates. By averaging, a position accurate to 20 to 30 meters (spherical) can be calculated in a few minutes. If the latitude and longitude of the antenna are already known to an equal or greater degree of accuracy, these coordinates can be entered as the Accurate position.

☞ **NOTE:** When using an accurate position, remember that height is also important in time and frequency applications. For every foot in height error, there can be 1 nanosecond of timing error (approximately 3 nanoseconds per meter). Height, for GPS, is a distance above or below the reference geoid, where the reference geoid is an approximation for the shape of the earth. If your height is not referenced to this approximation, it will be necessary to convert it before entering it into the receiver, to avoid large errors in the time and frequency calculations. The conversion from one height (i.e., a height above or below mean sea level) to height above or below the reference geoid, is beyond the scope of this user guide.

If the antenna's latitude and longitude are very accurately known, but the height is not (or cannot be easily converted to the height above or below the reference geoid), instruct the receiver to determine the location of the antenna. Then, use the calculated height and the accurately known latitude and longitude as the Accurate position.

There are three ways to establish the antenna position of the Model 2201A. They are,

1. The user enters the known accurate position, which is used for all time and frequency calculations, without change.
2. The user enters an approximate position, then causes the receiver to determine its position.
3. The user enters no position, and instructs the receiver to determine its position.

The first method has already been discussed briefly. Use the second method if an approximate position (within 1 degree) is already known. When an approximate position is entered, the receiver has some idea what satellites are visible and it can usually begin tracking immediately. This shortens the positioning process and, for this reason, it is the preferred method.

Method 3 is chosen when an approximate position cannot be easily obtained. When this method of positioning is chosen, the receiver has no idea what satellites are visible, therefore, it must guess. The Model 2201A picks one satellite and searches until it finds that satellite or until it decides that the satellite is not visible. The receiver then searches for another satellite until one satellite is found. When that happens, the receiver has some idea where it is and can determine what other satellites are visible or when they will be visible. Additional satellites are then located in the same manner until at least four satellites are being tracked. At that time, a position can be calculated.

As you might guess, method 3 usually takes longer than method 2. This procedure is normally used when a receiver is initially installed in a location of unknown position. If you wish to check the position of the receiver later, use the approximate method and enter the previously determined position as the approximate position.

For this example, assume that an approximate position is known. If you know your approximate position, use that, and the receiver measures your position accurately; if not, enter any number you wish just for practice. Begin by pressing [MENU], then select [1] (Initialization), [1] (Receiver Setup) and [1] (SV Select Mode). The following screen appears.

```
SV SELECT MODE                    (ENT=change)

MODE : Manual
```

Press [ENT], then select [5] (Positioning) and [2] (Current Position). The current position stored in battery-backed memory is displayed. Press [ENT] to change the current position. The following screen appears.

```
CURRENT POSITION                  (ENT=accept)
                                  (- is south)
Enter Latitude Degrees:  _
```

The receiver will request that you enter your latitude ([+/-] degrees [ENT], minutes [ENT], and seconds [ENT]), longitude ([+/-] degrees [ENT], minutes [ENT], and seconds [ENT]), and height ([+/-] meters). Be sure to include the proper signs for latitude, longitude and height. For latitude, "+" (or no sign) indicates north and "–" indicates south; for longitude, "+" (or no sign) indicates east and "–" indicates west. Height is the height of the antenna above (+) or below (–) the reference geoid. When height is accepted, the screen shows the current position, except that ENT=change is replaced by ENT=accept. At this time, you have the option of accepting the data by pressing [ENT] or rejecting the data by pressing [ESC] or [MENU]. If [ESC] is pressed, the screen changes to the previous current position. Press [ENT]. The screen should now show the position that was just entered. Press [ESC] once to return to the POSITIONING submenu, then select [1] (Position Mode) to display the following screen.

```
POSITION MODE                     (ENT=change)

Mode   : Accurate
```

Press [ENT] to change the current activity. If you have entered a reasonable approximate position, select [2] (Approx, Auto), to start the positioning function using the entered position. If you did not enter a real position, select [4] (Unknown, Auto) to begin positioning with no approximation. The receiver display returns to the POSITION MODE screen, showing the positioning mode selected.

☞ **NOTE:** Because the Unknown Positioning mode takes a significantly longer time to complete, it is recommended that it be used only if it is not possible to obtain an approximate receiver position. Since the approximate position needs to be determined only to within 1 degree, this should rarely be a problem.

Press [MENU] then [ESC], to return to the main screen. Verify that in the upper right corner of the display, the MODE is Positioning. As acquisition and track progress, the main screen shows the satellites being used. When the position has been determined, the MODE on the main screen changes to the MODE selected for Time/Frequency determination (Manual was previously chosen for this example). Allow the receiver to complete the positioning function. This normally take less than 15 minutes if a suitable satellite constellation is available when positioning begins.

If you already know your position accurately, return to the POSITION MODE screen (use keystrokes, [MENU], [1], [1], [1], [ENT], [5], [1]). Press [ENT] to change the position function, then select [1] (Accurate). Press [ESC] once to go to the POSITIONING submenu and select [2] (Current Position). Enter your accurate position.

To view the current position while it is being measured, press [MENU], then select [2] (Receiver Status) and [1] (Current Position). This screen shows the current calculated antenna coordinates and the Positioning mode selected. In addition, the positioning Count is displayed. These two numbers show the progress of the positioning process.

Each time the receiver calculates and displays a new position, the first, 2-digit number is incremented. Also, the PDOP for that calculation is displayed below Count (PDOP is discussed in greater detail later in this chapter). When the first number reaches 10, the second number begins to increment. When the second number reaches 20, positioning is complete and the receiver returns to the Time and Frequency mode. The Positioning mode is changed to accurate and the measured position is ready to be used for generating time and frequency. You should also record this position in a convenient place for future reference.

☞ **NOTE:** As of January 1993, 4 satellites from the initial launches still remain active, and 17, Block 2 satellites have been launched. It is possible, however, that not enough satellites are visible at the time you start your positioning (positioning requires a minimum of four satellites in view). If this is true, it could be several hours before the receiver can calculate your position. If you do not wish to wait for this function to finish, return to the POSITION MODE submenu (use the keystrokes: [MENU], [1], [1], [1], [ENT], [5], [1], [ENT]) and select [1] (Accurate). This will cause the receiver to use the current position as the accurate position for time and frequency calculations. However, you will eventually have to make the receiver measure your position or you will have to enter your accurate position, before the receiver can generate accurate time and frequency.

3.4.8. Time and Frequency Generation

A major function of the Model 2201A is the generation of time and frequency outputs. The time outputs are 1 pps and 1 ppm, which can be synchronized to within 100 ns of GPS time, or to within 140 ns of UTC time. The frequency output is locked to within 5 parts in 10^{12} of the GPS frequency. These outputs are available through an output buffer, but are accurate only while the receiver is tracking at least one satellite.

As discussed earlier, there are four receiver operating modes for the selection of satellites. They are the Automatic mode, in which the receiver selects the satellites to be tracked; the Semi-Automatic mode, in which the user selects the satellites to be tracked; the Scheduled mode, in which the user selects both the satellites to be tracked and the times to track them; and the Manual mode, in which the user specifies everything.

The easiest mode to use is the Automatic mode. After entering or measuring the Accurate Position, place the receiver in this mode. The receiver begins tracking satellites and generating time and frequency. This is probably the mode of choice for most applications. There are, however, applications where you will want to specify the satellites to track. The following paragraphs discuss the various methods for determining visible satellites.

3.4.9. Selecting Satellites

From the main screen, press [MENU], then select [3] (Satellite Info). The following screen appears.

```
SATELLITE INFO
1)Elevation Plot    4)Plot-Chart Date/Pos
2)Visibility Chart 5)GPS Message
3)PRN Almanac
```

Before you select satellites to track, you must know what satellites are visible and for how long. There are two methods in the Model 2201A for determining when the satellites are visible. These are the Elevation Plot and the Visibility Chart. These two displays require the following information:

1. Almanac data for the satellites to be plotted,
2. a position for which the displays are calculated,
3. a date for which the displays apply.

The almanac data, or coarse orbital information for all satellites, is transmitted repeatedly by each satellite. This data tells the receiver approximately where the satellites are, with respect to the known receiver location, and aids the receiver in acquiring the satellites. When the receiver tracks a satellite for the first time, it receives and decodes the almanac data and stores it in its battery-backed memory. This takes about 15 minutes. After that, every time it tracks a satellite for at least 15 minutes, it automatically acquires the current almanac and updates the old almanac even though an almanac remains usable for months. The Model 2201A is shipped from the factory with a current almanac.

Elevation Plots and Visibility Charts are generated for a specific location and a specific date. The position can be the Accurate Position, entered earlier, or a different position. The date can be the current date or a date in the past or future. The date is important because the satellites rise approximately four minutes earlier each day.

From the SATELLITE INFO menu, select [4] (Plot-Chart Date/Pos). The display shows the position and date used if they are not changed. Press [ENT] to change the position and date. Most of the time you want to use the receivers current position. So, for this example, select [1] (Use Current Pos). If you select [2] (Enter a Position), the receiver asks you for the latitude, longitude and height of a different location. The Elevation Plots and Visibility Charts would then be for that location.

When you have selected the position, the receiver returns to the PLOT AND CHART POSITION screen, showing the position and date. Press [ENT] again to select a date for the plots and charts. For this example, select [3] (Use Current Date).

As with position, you may enter a different date (usually in the future) for generation of the Elevation Plots and Visibility Charts. To do this, select [4] (Enter a Date). The screen shows the date currently being used. Press [ENT], then enter the date desired. When the date, either current or entered, has been set, press [MENU] then [ESC] to return to the main screen.

One method for determining when the satellites are visible at your location is to have the receiver generate the Visibility Chart for each of the satellites in the almanac. These charts show when the satellites will be at or above the Elevation Mask angle. From the SATELLITE INFO menu, select [2] (Visibility Chart). The following screen appears.

```
VISIBILITY CHART                 (ENT=change)
                             (1=PRV 2=NXT 4=LCD)
PRN        : 03                 Date: Current
PRNs to LCD: Empty              Pos : Current
```

This screen shows the satellite number of one of the satellites in the almanac (PRN 03), a list of satellites to chart on the LCD (list shown is empty), the date of the chart (current) and the position to be used (Current). Use the [1] key (PRV) to scan down through the satellites in the almanac; and use the [2] key (NXT) to scan up through the satellites in the almanac. When you come to a satellite you wish to add to the list, press [ENT]. The satellite number appears on the PRNs to LCD list. Up to 4 satellites can be on the list at one time. If you try to add a fifth satellite, the comment, List is Full, is displayed briefly. To remove a satellite from the list, use keys [1] and [2] to locate the satellite number you wish to remove, then press [ENT]. The selected satellite is removed from the list. In general, if the satellite number displayed on the third line is not on the PRNs to LCD List, pressing [ENT] adds it to the list; if the satellite number is already on the list, pressing [ENT] removes it from the list.

An asterisk (*) following a satellite number indicates that the health of that satellite is bad. It may be added to the list and the Visibility Chart plotted. However, unhealthy satellites should not normally be tracked because the data is not suitable for generating or measuring time and frequency.

Put four healthy satellites on the list. Press [4] (4=LCD) to cause the receiver to calculate the Visibility Charts for those satellites. The following screen appears.

```
SATELLITES 12_|.......78901....6789....
           13_|......67890123..........
Wk#: 475   11_|....45678901............
Msk: 5     09_|.....567890....567......
```

For each hour of the date chosen (UTC time, not local time), the elevation of each satellite selected is compared to the elevation mask. If it is greater than or equal to the mask, the least significant digit of the hour is displayed. If it is lower than the mask, a dot is displayed. The hours are numbered from 0 to 23 in the following fashion: 012345678901234567890123. The satellite PRN codes are shown to the left of the chart, along with the GPS week number of the almanac data and the Elevation Mask angle.

In the example above, PRN 12 rises above the mask angle of 5° at approximately 07:00 and falls below the mask angle at approximately 11:00. It rises again at 16:00 and sets at 19:00. PRN 13 has one visible period, from 6:00 to 13:00. Because of the coarseness of the time axis, the actual rise and set times differs from the plot by as much as ± 30 minutes. Take this into account when selecting satellites. For example, begin tracking satellite 12 (see example screen above) around 07:30 and 16:30, and satellite 13 around 06:30.

The second method of satellite determination, is the Elevation Plot. This is a graph of the elevation angle of the satellite versus the time of day (UTC). For a specific location, most satellite have one period each day when they rise to a relatively high elevation (usually greater than 35°), and are visible for five hours or longer. Sometimes, there is a second period when they rise a few degrees (typically less that 5—10°), and are visible for one to four hours.

To view the Elevation Plot for one satellite, press [MENU], then select [3] (Satellite Info) and [1] (Elevation Plot). The following screen appears.

```
ELEVATION PLOT                      (ENT=change)
                               (1=PRV 2=NXT 4=LCD)
PRN  to LCD : 03                  Date: Current
PRNs to PRT : Empty               Pos : Current
```

The screen shows one of the satellites in the almanac (PRN 03). Using the [1] and the [2] key, you can move up and down through the satellite numbers for which the receiver has almanac data. An asterisk following a satellite number indicates that the satellite is currently unhealthy and should not be used for time and frequency. When you find the satellite you wish to graph, press [4] (LCD) to start the plot. A screen, similar to the following, appears.

```
ELV    65_|                    _              Alm.
(DEG)  35_|                 _-  -_            Wk#:
        5_|.........-          -_.........475
PRN#03    |0    4    8    12   16   20   23
```

Satellite elevation is shown on the vertical axis, beginning at the Elevation Mask angle and extending to 90° (30° per line). UTC time is shown on the horizontal axis, beginning at 00:00 and ending at 23:00. It is possible, from this rough graph, to determine the rise and set times of a satellite, and the approximate elevation of that satellite at any time during the pass. Familiarize yourself with the Elevation Plots of a few of the satellites in the almanac, then continue. When you are through, press [MENU], then [ESC].

3.4.10. ALARMS

The operating conditions that the receiver keeps track of and for which it can generate alarms are shown in the ALARMS submenu. To display this menu, press [MENU], then select [1] (Initialization), and [4] (Alarms). The following screen appears.

```
SELECT ALARM                   (ENT=change)
                               (1=PRV 2=NXT)
1PPS Limit 0.3 uSec         Status/Option
Output 1PPS                    Bad/SOFT
```

The alarm description is shown in the lower left corner (line 4). In the lower right corner, Status indicates whether the alarm is currently active or inactive. Words such as Bad, Not Present, Ok, etc. describe the status of the alarm. For Option, there are three possibilities. If IGNORE is selected, that condition never causes an alarm output. You would select this if you did not care about that condition. The HARD option is selected if that alarm condition is very important to your application. In addition to turning the ALARM LED red on the front panel of the receiver, the ALARM output on the Output Buffer Module becomes active, providing a signal for external monitoring equipment. The SOFT alarm option is chosen if you are interested in that condition, but it is not very important to your application. If there is at least one SOFT alarm, the ALARM LED is turned off. The ALARM output on the Output Buffer Module is not turned on.

Just above the alarm description for some alarms you will find the limit above or below which the receiver generates an alarm. In the example shown above, the Output 1PPS alarm becomes active when the internally generated 1 pps is in error by more than 0.3 microsecond.

You scan up and down through the alarms, checking status and setup, by pressing the [1] key (PRV) or the [2] key (NXT). When you find an alarm you wish to change, press [ENT]. The receiver now requests that you SELECT OPTION (upper left corner). Selections 1 through 3 (Hard, Soft, Ignore), set the level of the alarm. Select the alarm level that is appropriate for your application. If there is a limit for the alarm, selection 4 displays the current value. If you wish to change the limit, press [ENT], then either select a limit value or enter a new alarm limit (depends on the alarm).

For this example, set all alarms to IGNORE, except for Output 1PPS. Set that alarm for HARD, which causes the ALARM LED to be red until the receiver is tracking a healthy satellite and the time is set. Later in Section Three there is a complete discussion of all alarms.

3.4.10.1. Tracking Satellites

When you are ready to begin tracking, return to the main menu by pressing [MENU]. Change the receiver operating mode by selecting [1] (Initialization), [1] (Receiver Setup) and [1] (SV Select Mode). Press [ENT], then select [1] (Automatic). The receiver determines what satellites are visible, then begins to acquire them.

Return to the main screen by pressing [MENU], then [ESC]. On line four of the display you will see the PRNs of the satellite(s) being acquired and tracked. Each PRN is followed by the letter A if the satellite is being acquired, and by the letter T if the receiver is currently tracking that satellite. If only one satellite is visible, the receiver stays in the Acquire mode until it locates the satellite or until the satellite drops below the Elevation Mask angle. If two or more satellites are visible, the receiver picks one to acquire. It tries to acquire that satellite for a few minutes. If it has not located it within two to three minutes, the receiver picks another satellite. The receiver cycles through the visible satellites in this fashion until one satellite is located or until all satellites drop below the Elevation Mask angle.

When the receiver acquires the first satellite, the status of the receiver (STAT, second line, on the right side of the display) changes to Set Time and it begins to decode the data from that satellite. When this is done, the status changes to Sequence one to two minutes later and the receiver begins to acquire the rest of the visible satellites.

3.4.10.2. LED Indicators and Receiver Status

Shortly after the receiver begins tracking at least one satellite, the time-of-day and date should be set. You may notice a change in the time on the main screen if the entered time was in error. Also, the 1 pps LED on the front panel should stop pulsing in red and change to green, indicating that the internal 1 pps has been set. The ALARM LED on the front panel, which was red while there was an error in the 1 pps (which was designated as a hard alarm), should now be green, indicating that there are no hard alarms. The Model 2201A will continue to correct time and frequency for as long as it is tracking at least one healthy satellite.

Since the receiver is in the Automatic mode, it will track these satellites until they fall below the Elevation Mask angle or until the receiver's mode of operation is changed. As new satellites rise, they are automatically acquired and tracked. Before continuing with these examples, allow the receiver to track at least one satellite for fifteen minutes to collect the latest almanac data.

While the receiver is tracking, check the status of the receiver's main functions of time and frequency. In addition to the qualitative LED indicators on the front panel, quantitative information is available within the receiver. Press [MENU], then select [2] (Receiver Status). The following screen appears.

```
RECEIVER STATUS
1)Current Position 4)Intern. Osc.
2)Internal T/F     5)Software Version
3)External T/F
```

☞ **NOTE:** The selections on this submenu are determined by the hardware configuration of the receiver. If there is no Input Buffer module installed, selection 3 (External T/F) is removed.

Select [2] (Internal T/F). If the receiver STAT is not yet Sequence, the screen will show either,

```
"No PPS information available"
```

or

```
"No Freq information available",
```

indicating that the receiver has not yet acquired enough information from the satellite to begin setting the time and frequency.

When the receiver has acquired enough data, a screen like one of the following is displayed.

```
INTERNAL 1PPS
 σ    : +1.0099E-08   Off  : +1.3780E-10
ΔT    : +4.3688E-09   tau  :  50.00
ΔT/T  : +8.5142E-13
```

or

```
INTERNAL FREQ
 σ    : +4.9408E-11   Ageing: +8.2059E-09
ΔT    : -1.1940E-08   ET    :  5.432162
ΔF/F  : +1.7250E-10   tau   :  50.00
```

The screen that appears is the one that was displayed last. To toggle between screens, press the [+/-] key.

The INTERNAL 1PPS screen shows the time difference between the previous 1 pps calculation and the current calculation (ΔT). Once the receiver has settled down on the first satellite and has begun to adjust the internal oscillator, this number normally is less than 30 to 50 nanoseconds.

The INTERNAL FREQ screen shows the current measurement of the frequency error of the internal oscillator (ΔF/F). While the receiver is tracking at least one healthy satellite, it continuously corrects the frequency of the oscillator. This number will typically be less than 2.0000E-11. A complete discussion of this screen and the INTERNAL FREQ screen is found in Section 3.7.

3.5. COLD START

The COLD START function of the Model 2201A does not, as its name might imply, refer to a receiver that has just been turned on. Instead, it is a procedure where the receiver acquires and tracks a satellite when it does not have an almanac, old or new. The almanac consists of sets of data, one set per satellite, with which the receiver calculates the approximate position of the satellite, relative to the receiver's current position. The receiver also uses the almanac data to calculate the approximate Doppler for the satellite. If that information is not available, the receiver does not know what satellites are visible, and it must guess. This happens when the fail-safe memory (battery-backed RAM) goes bad, or when it is replaced. Clearing of fail safe also occurs when the software is upgraded in the unit. With normal use, the fail-safe RAM should retain its data for at least ten years.

If a COLD START should ever become necessary, the message, COLD START, is displayed on the STAT line of the display (upper right corner). When this happens, the receiver automatically switches to the Cold Start mode and begins trying to locate a satellite. Since it does not know what satellites are in the constellation, the PRN it picks is a valid one, although not necessarily an active one. If it is unable to locate that satellite within a short time, it picks another. This process continues until the receiver acquires a satellite.

The mode of the receiver, Automatic or Semi-Automatic, determines the set of satellites used for a COLD START. In the Automatic mode, the receiver begins to cycle through all of the possible

PRNs (01-32) looking for a satellite. In the Semi-Automatic mode, the receiver picks only those PRNs that are included on the SEMI-AUTO LIST. If this list is empty, the receiver is not able to acquire a new almanac.

When the receiver locks to a satellite, allow it to track for at least 15 minutes. This should be enough time for it to collect the almanac data for all of the satellites. In normal operation, the receiver automatically updates the almanac while tracking at least one satellite, so a COLD START is rarely necessary.

3.6. KEYBOARD LOCKOUT

Receiver operation can be changed from the front panel by selecting from various menus. At all places where data is to be entered or the operation of the receiver is to be changed, the receiver requires that the [ENT] key be pressed. This reduces significantly the chance that casual button-pushing causes a problem. However, it is sometimes necessary to ensure that receiver operation cannot be interrupted or modified.

For this reason, the Model 2201A has a keyboard lockout function which prohibits entry of data or modification of receiver operation. When the receiver is placed in this mode, the instruction, (ENT=change), is removed from all screens that would otherwise display it. Pressing the [ENT] key produces no response. However, all measured and entered data that is normally displayed, can still be accessed.

To activate the keyboard lockout function, start with the receiver displaying the main screen (Press [MENU] then [ESC], to return to the main screen). Press the [ALT] key once, the [9] key once, and the [EE] key three times. The Model 2201A responds by displaying the letter L (lock) in the lower right-hand corner of the screen. This letter now appears in the same location on all screens, indicating that data entry is locked out. Access data and receiver setup as you normally would.

To deactivate the keyboard lockout function, enter the same sequence used to lock the front panel. That is, [ALT], [9], [EE], [EE], [EE]. Be sure the display is showing the main screen before the sequence of keys is entered. When the receiver recognizes this sequence of keystrokes, it removes the L from the screens and restores the instruction, (ENT=change), to all appropriate screens. It is again possible to enter data and modify receiver operation.

3.7. DESCRIPTIONS OF MENUS AND SELECTIONS

3.7.1. Introduction

The following paragraphs cover complete discussions of the menus, submenus and data I/O is in the Model 2201A GPS Satellite Receiver. The discussions center around the screen that appears at the beginning of each paragraph. Figure 1 shows the menu tree for the Model 2201A.

Following the first screen in each paragraph, find the path you would take to reach that screen. The path begins with MENU, followed by the titles of the submenus through which you would proceed, separated by backslashes. For example, the path to the RECEIVER DELAY screen is specified as,

Path= MENU \ INITIALIZATION \ RECEIVER SETUP \ RECEIVER MASKS.

To get there, press [MENU], then select INITIALIZATION, RECEIVER SETUP AND RECEIVER MASKS. If you start at the RECEIVER MASKS screen, repeated pushes of the [ESC] key takes you backwards through the path to the main screen.

After the path, comes the explanation of the screen. In addition to the screen shown at the beginning of the paragraph, there may be other screens which are displayed which support the function.

At the end of the discussions of some screens, find a list of menu selections and paragraph numbers that are related to this function. These typically are data-entry submenus, where the operating parameters of the function are specified, or other functions that are affected by data entered using the current function. For example, the Semi-Automatic mode of receiver operatiton uses the Semi-Auto List of enabled satellites to select the satellites to track. This list is reached through a menu selection on the PRN TRACK LISTS submenu. Also, changing the Elevation Mask affects the output of the Elevation Plots and the Visibility Charts.

- MAIN MENU
  - INITIALIZATION
    - RECEIVER SETUP
      - SV SELECT MODE — Set satellite select mode
      - TIME/FREQ MODE — Set receiver time/freq mode
      - RECEIVER MASKS — Enter receiver masks
      - USER PPS OFFSETS — Enter 1 pps offsets
      - PRN TRACK LISTS — Enter Semi-Auto and Manual PRN lists
      - RECEIVER TESTS — Run receiver tests (See Section 2 in the Maintenance Manual for tests)
    - TIME SETUP
      - TIME FORMAT — Set time display format
      - DATE FORMAT — Set date display format
      - TIME (UTC) — Enter UTC time
      - DATE (UTC) — Enter UTC date
    - OPTION SETUP
      - A5 SLOT — Set option slot parameters*
      - A6 SLOT — Set option slot parameters*
      - A7 SLOT — Set option slot parameters*
      - A1 SLOT — Set option slot parameters*
      - A2 SLOT — Set option slot parameters*
      - A3 SLOT — Set option slot parameters*
      - A4 SLOT — Set option slot parameters*
    - ALARMS — Configure/view alarms
    - EXT. T/F STATS — Enter number of T/F samples*
  - RECEIVER STATUS
    - CURRENT POSITION — View current position
    - INTERNAL T/F — Display data on int 1PPS/Osc.
    - EXTERNAL T/F — Display data on ext 1PPS/Reference*
    - INTERN. OSC. — Display identity of internal osc.
    - SOFTWARE VERSION — Display software version
  - SATELLITE INFO
    - ELEVATION PLOT — Display elevation plots
    - VISIBILITY CHART — Display visibility charts
    - PRN ALMANAC — Display almanac information
    - PLOT-CHART DATE/POS — Enter date/position for plot/chart
    - GPS MESSAGE — Display satellite message

* – Indicates option dependancy

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Figure 3: GPS 2201A MENU TREE

Notes

3.7.2. SV SELECT MODE

```
SV SELECT MODE                    (ENT=change)

Mode : Semi-Auto
```

Path = MENU \ INITIALIZATION \ RECEIVER SETUP \ SV SELECT MODE

This screen shows the mode of operation of the receiver for satellite selection. The choices made from this screen are stored in battery-backed memory and automatically recalled when power is turned on. Mode choices are shown on the following screen. Press [ENT] to view the satellite selection choices.

```
SV SELECT MODE
1)Automatic            4)Scheduled
2)Semi-Automatic       5)Positioning
3)Manual
```

This submenu lets you change the operating mode of the receiver. As soon as a selection from this menu is made, the screen changes to the main SV SELECT MODE screen, showing the new mode of operation. Receiver operation is now governed by this selection.

The first mode of satellite selection is the Automatic mode. In this mode, the receiver determines the satellites to track, when to begin tracking and when to stop. No user inputs are required after the receiver is set up the first time. As satellites drop below the elevation mask angle and others rise above it, the receiver automatically changes the satellite that it tries to track. It also keeps track of those satellites which are bad to ensure that only those satellites transmitting good data are used for setting time and frequency. As satellites are added to the constellation, the receiver acquires their almanac data from the existing satellites, and automatically adds the new PRNs to its tracking list. This is the mode of choice for most applications because it does not require much knowledge of GPS to obtain accurate time and frequency.

The Semi-Automatic mode is similar to the Automatic mode. The receiver determines the satellites to track and how long to track them. While it is tracking satellites, it automatically generates accurate time and frequency. It changes its tracking list as satellites rise and set, and it ignores those satellites that are sending inaccurate data.

The Semi-Automatic mode differs from the Automatic mode in one major respect. The list of satellites from which the receiver selects is specified by the user. When this mode is selected, the receiver refers to the SEMI-AUTO LIST of satellites to find those satellites that are to be tracked. Refer to the menu selection, PRN TRACK LISTS, in this section for a complete discussion of the SEMI-AUTO LIST.

The receiver selects visible satellites from the SEMI-AUTO LIST and begins tracking. Visible satellites that are not enabled are ignored. As new satellites are added to the GPS constellation, the receiver learns about them, but does not track them until they have been added to the list.

This mode is useful if you wish to track only specific satellites. Applications that might use it include studies of the performance of a particular satellite, studies of signal propagation from a satellite to the receiver, and comparison of time and frequency information between two or more locations.

The third mode is the Manual mode. This mode requires more understanding of GPS than any of the others, because the user must not only tell the receiver which satellites to track, but also the current approximate Doppler offset of the satellite signal. When the satellites specified are no longer visible, the receiver stops tracking and does not start tracking again until told to do so.

The receiver is placed in the Manual mode by selecting Manual from the SV SELECT MODE submenu. Satellites are added to the MANUAL LIST (refer to the discussion of the menu selection, PRN TRACK LISTS, in this section) and the receiver begins acquisition. It is then tracked until the track length is up, or until the satellite sets.

The fourth operating mode of the Model 2201A is the Scheduled mode. Use of Scheduled mode requires an input buffer to apply an external 1 pps signal to the unit. In this mode, the user enters a schedule, telling the receiver which satellites to track, when to begin tracking and how long to track. The receiver then automatically tracks the satellites, and repeats the tracking schedule every day. The start-times in the schedule are automatically changed to four minutes earlier every 24-hours. This accounts for the orbits of the satellites, which are approximately 11 hours and 58 minutes long.

The Scheduled mode is used when you wish to compare times and frequencies between two or more locations. All receivers are instructed to track the same satellites at the same time (common view). The time difference between the external 1 pps is then measured with respect to the selected reference (usually UTC or GPS). By comparing the time difference at one location to the time difference at another location, the time difference between the two locations can be accurately determined.

The main advantage of this approach is the cancellation of errors that are common in both legs of the viewing path. To set up the schedule, you must know what satellites are good and when each satellite will be visible at the same time to all receivers in the common view experiment.

While the receiver is in the Scheduled mode, the output 1 pps is synchronized to the on-time data edges from the satellites. The data edges are delayed 60 to 80 milliseconds relative to UTC/GPS, which is the approximate propagation time from a satellite to the receiver. The time interval between the external 1 pps and the internal 1 pps is measured each second. Every 15 seconds the previous 15 measurements are smoothed with a linear curve fit. The measurement at the middle second of these 15 measurements is estimated from the curve, then corrected for the transmission time to give the time difference between the external 1 pps and the satellite time. This difference is then adjusted to give a time difference between the external 1 pps and GPS, or the time difference between the external 1 pps and UTC. Refer to the discussion of the RECEIVER STATUS screens in this section for more information on the measured data.

☞ **NOTE:** Due to the operation of the output 1 PPS in Scheduled mode, the 1 PPS alarm is set during Scheduled mode as a reminder that the output 1 PPS is not on-time.

Before starting the Scheduled mode, enter the schedule of satellites. Refer to the PRN TRACK LISTS submenu discussion in Section 3.7.6. In particular, follow the directions for entry of the Schedule List. When the Schedule List is ready, start the Scheduled mode by selecting it from the SV SELECT MODE submenu.

The last SV SELECT MODE is the Positioning mode. In this mode, you can enter an accurate position or the receiver can be instructed to calculate its position. If instructed to calculate the position, the receiver selects the satellites to track and then determines its position. When the position has been calculated, it becomes the accurate position used to generate and measure time and frequency, and the receiver automatically returns to the Accurate Position Mode. If a position is entered as an accurate position, it is used immediately for time and frequency generation and measurement.

☞ **NOTE:** All displayed positions are in the WGS-84 coordinate system (World Geodetic System, 1984). All entered positions must also be in the WGS-84 coordinate system.

To enter an accurate position, first select Positioning from the SV SELECT MODE submenu to display the following screen.

```
POSITIONING

1)Position Mode
2)Current Position
```

Select Current Position to view the currently used receiver position. Press the [ENT] key to begin entry of the accurate position. The screen prompts you for latitude degrees, including the sign (where + is north and – is south), latitude minutes and latitude seconds. The [ENT] key is pressed after each part of the latitude entry. If the latitude is known in degrees, minutes and fraction-of-a-minute (±ddmm.mmmm), enter mm.mmmm when the receiver requests minutes. When [ENT] is pressed, the receiver recognizes the decimal point and terminates the latitude entry without asking for seconds. If the latitude is known in degrees and fraction-of-a-degree, enter dd.dddddd. Latitude entry is stopped after the [ENT] key is pressed.

When the latitude is entered, the receiver prompts you for the longitude degrees, including the sign (where + is east and – is west), longitude minutes and longitude seconds. The [ENT] key is pressed after each part of the longitude entry. If the longitude is known in degrees, minutes and fraction-of-a-minute (±ddmm.mmmm), enter mm.mmmm when the receiver requests minutes. When [ENT] is pressed, the receiver recognizes the decimal point and terminates the longitude entry without asking for seconds. If the longitude is known in degrees and fraction-of-a-degree, enter dd.dddddd. Longitude entry is stopped after the [ENT] key is pressed.

☞ **NOTE:** The sign of a latitude or longitude can only be entered while entering the degrees. This means that if your latitude was – 0° 27′ 14″, you would enter this as [+/-] [0] [ENT] [2] [7] [ENT] [1] [4] [ENT]. The [ENT] key is then pressed to accept the entry.

After the longitude has been entered, the receiver requests the height (in meters) of the antenna. This is the height of the GPS antenna above (+) or below (–) the reference geoid. Enter the height, then press the [ENT] key. The display changes to one like the following.

```
CURRENT POSITION                 (ENT=accept)
New Lat     :  30: 27: 15.468
New Long    : -97: 39: 45.642
New Height  : 232.80 m
```

The newly entered position is displayed and the receiver requests that the [ENT] key be pressed if the position was entered properly. If there is a problem, press [ESC] once to re-enter the position (the previous position is displayed). If the entry is correct, press [ENT] to cause the receiver to accept it.

When the new position has been entered, press the [ESC] key once to return to the POSITIONING submenu, then select [1] (Position Mode). The following screen appears.

```
POSITION MODE                    (ENT=change)

Mode   : Accurate
```

Since the position entered was the accurate position, this screen should indicate that the receiver is in the Accurate Position Mode. If not, press [ENT] to change the mode. The following screen appears.

```
POSITION MODE
1)Accurate              4)Unknown,Auto
2)Approx,Auto           5)Unknown,Semi
3)Approx,Semi
```

Select [1] (Accurate) to change the mode. The screen returns to the POSITION MODE screen, indicating that the Accurate Position Mode has been selected.

In most cases, the position of the receiver is not known accurately enough to produce good time and frequency. So, the receiver has to measure it using one of two methods. In the first method, which is preferred, an approximate position is entered, then the receiver is instructed to refine it. It stays in the Positioning Mode until the position has been measured as accurately as possible.

The receiver, then, automatically changes to the Accurate Position Mode and begins normal time and frequency operation.

For the second method, the receiver is told that the position is unknown and no position is entered. Since the receiver does not know where it is, it does not know what satellites are visible at that time. So, it begins looking for any satellite. As it acquires satellites, it begins to learn something about its position and it can then make estimates about what other satellites are visible. Eventually four satellites are acquired and the position is measured. This method is not preferred, because the receiver must spend time looking for satellites that are not visible, and therefore, it takes longer.

To begin positioning with an approximate position, use the path shown above to go to the SV SELECT MODE screen. Press [ENT] to change the mode, then select Positioning. From the POSITIONING submenu, select Current Position. Press [ENT] to change the position, then enter the approximate position, using the procedures discussed above for entry of an accurate position. The approximate position should be within 1 degree for latitude and longitude. A good approximation of the height of the antenna is its height above or below mean sea level, in meters. If the height of the antenna above sea level is not known, enter 0 for height.

When the height is entered, examine the position displayed, then press [ENT] to cause the receiver to accept it. Press [ESC] once to return to the POSITIONING submenu, then select [1] (Position Mode). Press [ENT] to display the POSITION MODE screen.

```
POSITION MODE
1)Accurate                4)Unknown,Auto
2)Approx,Auto             5)Unknown,Semi
3)Approx,Semi
```

There are two options for measuring the position, using an approximate position as a starting point. The preferred option is Approx, Auto. If this option is selected, the receiver automatically selects healthy satellites from the current constellation. No other user input is necessary.

The second option is Approx, Semi. Before this is selected, it is necessary to place on the SEMI-AUTO LIST, at least four healthy satellites that the receiver is allowed to use for positioning. To do this properly, it is necessary to know what satellites are up, and which satellites at that time give the best geometry for positioning. When the desired satellites have been added to the SEMI-AUTO LIST, select Approx, Semi from the POSITION MODE submenu. Refer to the discussion of the menu selection, PRN TRACK LISTS, in this section.

When the approximate option has been selected, return to the main screen by pressing [MENU] and [ESC], and verify that the receiver is in the Positioning Mode (upper right hand corner). To monitor the progress of the positioning function, press [MENU], then select Current Position. This screen shows the Positioning mode and the currently calculated position (the entered approximate position is displayed until the first calculation is made). Refer to Section 3.7.12 for a discussion of Current Position. Also, you should read the discussion of RECEIVER MASKS, particularly about PDOP, in Section 3.7.4. The setting of PDOP (Position Dilution Of Precision) usually determines the length of time the receiver remains in the Positioning mode.

To begin positioning with an unknown position, use the path shown above to go to the SV SELECT MODE screen. Press [ENT] to change the mode, then select Positioning. From the POSITIONING submenu, select Position Mode. Press [ENT] to change the mode. On the POSITION MODE submenu, you will find two options for positioning from an unknown position. The first option, Unknown, Auto, allows the receiver to choose any satellites from the current constellation. No other user inputs are required.

The second option, Unknown, Semi, works like the Unknown, Auto option except that the receiver must select satellites from the SEMI-AUTO LIST only to calculate the antenna position. That list must be entered by the user and must contain at least four healthy satellites, all of which must be visible at the same time at least once during the day. In addition, the geometry of this group of satellites must give a PDOP that is less-than-or-equal-to the PDOP mask at some time during the track. Select this option after the Semi-Auto List has been entered.

When the receiver is in Unknown positioning, it will process input from the satellites until the receiver position is below 0.5° error. At this time the receiver will automatically change to the Approximate mode and complete positioning in this mode.

Once the positioning function has been started, the receiver stays in that mode until the position has been measured or until the SV SELECT MODE is changed. When the positioning function is finished, the receiver returns to the SV SELECT MODE it was in when positioning was begun and the current position becomes the Accurate position for time and frequency measurement and generation. If the mode is changed, the receiver goes to the new mode and the current position becomes the Accurate position.

RELATED MENU SELECTIONS

1. Receiver Masks, Section 3.7.4
2. PRN Track Lists, Section 3.7.6
3. Current Position, Section 3.7.12
4. PRN Almanac, Section 3.7.18

3.7.3. TIME/FREQ MODE

```
TIME/FREQ MODE                        (ENT=change)
                 Freq out     1PPS out
Current Mode:    Carrier      UTC/Code
Loop Mode    :   Locking
```

Path = MENU \ INITIALIZATION \ RECEIVER SETUP \ TIME/FREQ MODE

There are three modes of receiver operation for the generation of an on-time one-pulse-per-second and for disciplining the internal oscillator. These modes are selected through the screen shown above, and must be set by the user to obtain the desired results for a particular application. While the receiver is tracking at least one healthy satellite, it uses the selected mode to set and keep the 1 pps on-time, and to correct the frequency of the internal oscillator.

On the sample screen above, the Current Mode for disciplining the internal oscillator is the Carrier mode. This means that the receiver is comparing the frequency of the internal oscillator to the carrier frequency of the satellite signal after making a correction for the doppler shift of the received signal. Whenever the unit is in a mode where the frequency control is from carrier information it is automatically forced into Track Highest mode. When the unit is sequencing, the possibility of dead time in the filters is increased (they don't get an input). In a frequency lock, this increases the random walk phase noise that occurs.

On the same screen, the Current Mode for setting the 1 pps is the Code mode. In this mode, the 1 pps is set on-time, using the phase information from the satellite. After the 1 pps is set, it is controlled by this same information to keep it as close as possible to the correct time. It is called the Code mode because the C/A code in the satellite signal is the phase information used to set the 1 pps on-time. The Carrier mode for oscillator correction offers greater sensitivity and, therefore, allows for faster disciplining. The Code mode for setting the 1 pps keeps it continuously on-time while tracking at least one healthy satellite.

The second method for adjusting the frequency of the internal oscillator and for keeping the 1 pps on time is the Code-Code mode. In this mode, the 1 pps is set on-time using the phase information from the satellite signal. After the initial setting of the 1 pps, the phase information is used to control the frequency of the internal oscillator to keep the 1 pps on-time. This results in a phase lock of the oscillator to the 1 pps that is generated from the satellite signal and satellite data. This mode is slower at setting the oscillator on frequency than the Carrier mode, but in some applications it may be preferred. This mode also allows the receiver to track all satellites in view and therefore, can achieve some averaging across satellite biases.

The last mode for time and frequency generation is the Carrier-Carrier mode. In this mode, the oscillator and 1 pps are controlled by the carrier information from the satellites. When this mode is first entered, the 1 pps is phase locked until the phase error has been brought to within 150 nanoseconds of the reference chosen (see discussion below). At this time the receiver changes to a frequency lock using the carrier information. This mode provides for a complete frequency lock of the receiver.

☞ **NOTE:** Operation of the receiver in any mode that uses Carrier information for control automatically sets the internal flag to only track the highest elevation satellite. Refer to the Receiver Masks for more information.

In addition to the Current Mode, the TIME/FREQ MODE screen shows the time reference to which the internal 1 pps is being disciplined, and the status of the Loop Mode. In the example above, the 1 pps is being disciplined to UTC, and the loop is being locked using the mode selected.

Press [ENT] to change the TIME/FREQ mode or the 1 pps reference. The following screen appears.

```
TIME/FREQ MODE

1)Select T/F Mode   3)Loop Lock
2)Ref (1PPS/1PPM)   4)Loop Halt
```

Selection 1 displays the following screen.

```
TIME/FREQ MODE                          (ENT=accept)
                                        (1=PRV 2=NXT)
                    Freq out            1PPS out
New Mode :          Carrier             Code
```

Use the [1] key and the [2] key to scan through the possible modes. When the desired mode is reached, press [ENT] to cause the receiver to accept the selection. If the [ESC] key or the [MENU] key is pressed before [ENT], the mode is not changed.

When selection 2, Ref (1PPS/1PPM), is made, the following screen appears.

```
REF (1PPS/1PPM)

1)GPS                    3)Satellite
2)UTC
```

Selections from this screen set the reference for the generated 1 pps and 1 ppm. If GPS is selected, the pulses will be synchronized to the Global Positioning System. Selection of UTC causes the pulses to be synchronized to Universal Coordinated Time. Selection 3 causes synchronization of the two pulses, to the time at the satellite. When a selection is made, the screen returns to the TIME/FREQ MODE submenu. Press [ESC] once to return to the TIME/FREQ MODE status screen and verify that the mode and pulse reference selections were properly accepted by the receiver.

Selections 3 and 4 concern the internal oscillator. Selection 3, Loop Lock, causes the receiver to lock the oscillator to the satellite signals and data, while tracking at least one healthy satellite. The Loop Mode on the TIME/FREQ MODE screen indicates that the loop is locking. Refer, also, to the discussion of the Internal Oscillator in Section 3.7.14.

Selection 4, Loop Halt, causes the receiver to stop adjusting the electrical tuning (fine frequency adjustment) of the internal oscillator. This condition is active, even while the receiver is tracking a healthy satellite. The oscillator is allowed to change in frequency due to normal ageing. Its current frequency error is shown on the INTERNAL T/F screen (under RECEIVER STATUS).

RELATED MENU SELECTION

Intern. Osc., Section 3.7.14

3.7.4. RECEIVER MASKS

```
RECEIVER MASKS                        (ENT=change)
Elev. Mask       :  5°     Tropo : Use
SV Health        : Use     PDOP  :  5.0
Trk High Elev.   : Yes
```

Path = MENU \ INITIALIZATION \ RECEIVER SETUP \ RECEIVER MASKS

The RECEIVER MASKS screen shows the values of the elevation and PDOP masks, and the operational restrictions for satellite health, tropospheric correction and highest satellite tracking. This information is maintained in battery-backed memory and recalled when power is applied. These functions can have significant effects on satellite tracking, the accuracy of time and frequency generation and measurement, and on the accuracy of the position calculation. Care should be taken when these functions are changed. Press [ENT] to display the following screen.

```
RECEIVER MASKS

1)Elev. Mask        3)SV Health
2)Tropo             4)PDOP
```

☞ **NOTE:** If the Frequency Control mode is any mode other than Carrier, this screen becomes:

```
RECEIVER MASKS
1)Elev. Mask        4)SV Health
2)Tropo             5)PDOP
3)High Elev.
```

Selection 1, Elev. Mask, displays the following screen.

```
ELEVATION MASK                        (ENT=accept)

Current Mask:  5°
Enter Mask  :  _°
```

The ELEVATION MASK screen shows the current Elevation Mask. After the satellite rises above this elevation, and before the satellite falls below it, the receiver is allowed to track that satellite. The default value is 5°, which is the recommended minimum for all tracking, when the antenna has a clear view of the horizon. This value should be increased when there are obstructions which block the satellite signals, to keep the receiver from trying to track a satellite it cannot receive. From a time and frequency standpoint, it is better to track satellites which are higher than 5°

because the ionospheric correction is more accurate. For that reason, it is recommended that the elevation mask be increased to 10°.

The mask may range from 0° to 90° (90° prohibits tracking of all satellites). Enter the mask, then press [ENT] to accept the new mask. The screen returns to the RECEIVER MASKS submenu shown above. Use [CE] to clear a data keystroke; use [ESC] to cancel the entire entry and to back up one screen.

Tropo, displays the following screen.

```
TROPOSPHERIC CORRECTIONS

1)Ignore
2)Use
```

The tropospheric corrections are propagation time corrections that are related to the atmospheric conditions through which the satellite signals propagate. Conditions such as barometric pressure and relative humidity contribute to these corrections. The Model 2201A uses the model for tropospheric corrections provided in the Interface Control Document for the Global Positioning System. For most applications, the receiver should be instructed to use these corrections for time and frequency generation and measurement. Select [2] (Use). This is also the default condition.

There are applications where it may be desirable to instruct the receiver to ignore these corrections. For those applications, select [1] (Ignore) to cause the receiver to set time and adjust frequency without the tropospheric corrections.

☞ **NOTE:** This option should be used with care by those users who are very familiar with GPS and the tropospheric calculations.

The following screen is displayed when High Elev. is chosen (only available in non-carrier type Frequency Control modes).

```
TRACK HIGHEST ELEVATION

1)No
2)Yes
```

This option allows you to tell the receiver to track the satellite with the highest elevation. The receiver examines the available satellites and selects the one that is highest in the sky. That satellite is tracked until it falls below the Elevation Mask or until another available satellite rises above it. When the receiver determines that another satellite is higher, it begins to acquire the new satellite, while still tracking the previous satellite. Two satellites are tracked until the Ephemeris data for the new satellite is acquired. When the receiver is satisfied that the new satellite is providing good data, it stops tracking the original satellite.

Select [1] (No) if you want the receiver to track all healthy satellites that are visible and above the Elevation Mask angle. This option normally is selected when the receiver is in the TIME/FREQ MODE of Code for frequency adjustment (see TIME/FREQ MODE screen discussion). Tracking all available satellites while in this mode averages satellite phase biases and, therefore, provides a better frequency output.

SV HEALTH controls the receivers use of the satellite health information. The following screen appears.

```
HEALTH STATUS

1)Ignore
2)Use
```

Included in the Almanac data from the satellites is the health of each of the satellites in the constellation. This information is acquired by the receiver and kept in battery-backed memory. In normal operation, the receiver does not use a satellite for time and frequency generation and measurementif the health of that satellite is bad. This is the default condition for HEALTH STATUS, and the mode that should be used most often. Select [2] (Use) to cause the receiver to track only healthy satellites.

You can force the Model 2201A to acquire and track unhealthy satellites by selecting [1] (Ignore). While in this mode, the receiver tracks an unhealthy satellite, but it will not use its data to set time or to adjust the frequency of the internal oscillator. Use this mode with care!

The last selection on the RECEIVER MASKS submenu is PDOP. Position Dilution Of Precision (PDOP) is a measure of the accuracy of the positioning calculation. In general, the lower the PDOP, the better will be the position calculation. Its value usually ranges from a low of about 2.0, to a high of 20 to 30. In the Model 2201A, the PDOP can be entered in a range of 0 to 50, with a default value of 5.0.

As the PDOP is lowered, the length of time in a 24-hour period that the satellites form a constellation with that PDOP or lower, gets shorter. This means that if a PDOP mask of 2.0 or lower is entered, there may not be enough time when the PDOP is at or below that mask for the receiver to calculate its position. This will be especially true before the GPS constellation is fully operational. Select PDOP to display the following screen.

```
PDOP MASK                          (ENT=accept)

Current PDOP Mask: 5.0
Enter New Mask   : _
```

Enter a PDOP, then press [ENT] to cause the receiver to accept it. A PDOP of 3.0 to 5.0 usually gives a position calculation that is more than adequate for generating or measuring time and frequency to the receivers full accuracy. Lower values will require more time for the position calculation to be made, and higher values may not give sufficiently accurate position results.

RELATED MENU SELECTIONS

1. SV Select Mode, Section 3.7.2
2. Elevation Plot, Section 3.7.16
3. Visibility Chart, Section 3.7.17

3.7.5. USER PPS OFFSETS

```
USER PPS OFFSETS              (ENT=change)
Receiver Delay :        50 nS
Cable Delay    :       155 nS
User Time Bias :         0 nS
```

Path = MENU \ INITIALIZATION \ RECEIVER SETUP \ USER PPS OFFSETS

The USER PPS OFFSETS screen shows the values of the Receiver Delay, the Cable Delay and the User Time Bias. They are stored in battery-backed memory and are recalled when power is applied.

The Receiver Delay is a residual correction which is measured at the factory and shown on a label on the rear panel. This delay is typically entered into the receiver at the factory, but you should check the entered value and, if necessary, enter the value shown on the label.

The Cable Delay is the time it takes the partially processed satellite signal to travel from the antenna to the ANTENNA input on the rear panel of the receiver. It is necessary that an accurate delay be entered to produce accurate position, time and frequency. Antenna cables supplied with the Model 2201A are measured at the factory. The value is included on labels at both ends of each cable. The delay of the cable used should be entered and checked periodically.

The User Time Bias is an adjustment to the generated 1 pps and 1 ppm, that causes the receiver to output the pulses earlier in time than it normally would if the bias is negative. That is, a User Time Bias of −158 nanoseconds causes the receiver to generate the pulses 158 nanoseconds earlier than on-time pulses. If the pulses have to propagate down 100 feet of coaxial cable, they will be on-time at the end of the cable, 158 nanoseconds after they leave the receiver.

A positive time bias causes the receiver to output the pulses later than it normally would. This might be done if the 1 pps and 1 ppm are to be synchronized to an external event that normally occurs after the on-time pulses.

To make a change to one or all of these offsets, press [ENT]. The following screen appears.

```
USER PPS OFFSETS

1)Receiver Delay  3)Time Bias
2)Cable Delay
```

Select [1] (Receiver Delay) to display the following screen.

```
USER PPS OFFSETS                (ENT=accept)

Current receiver delay:            50 nsec
Enter new delay (nsec):
```

Enter the delay, in nanoseconds, then press [ENT] to accept it. Be sure to enter the proper sign of the delay! Use [CE] to cancel a numeric entry; use [ESC] to cancel the whole entry, and back up one screen.

Select [2] (Cable Delay) to display the following screen.

```
USER PPS OFFSETS                (ENT=accept)

Current cable delay :            155 nsec
Enter new delay (nsec):
```

Enter the delay, in nanoseconds, then press [ENT] to accept. Use [CE] to cancel one data keystroke; use [ESC] to cancel the whole entry and back up one screen.

☞ **NOTE:** If the delay of the cable being used is unknown, an approximation of 1.58 ns per foot for RG58 cable may be used. That is,

Cable Delay = 1.58 X cable length (in feet).

A cable made of RG58, no longer than 400 feet, may be used. Longer cables may show excessive signal loss. A cable of this length will have an approximate delay of 632 ns.

Select [3] (Time Bias) to display the current time bias.

```
USER PPS OFFSETS                (ENT=accept)

Current time bias delay :            0 nsec
Enter new delay (nsec):
```

Enter the desired bias, then press [ENT] to cause the receiver to accept it. Time Bias is limited to ± 9,999,999 nanoseconds (approximately ± 10 milliseconds).

3.7.6. PRN TRACK LISTS

```
PRN TRACK LISTS

1)Semi-Auto List   3) Schedule List
2)Manual List
```

Path = MENU \ INITIALIZATION \ RECEIVER SETUP \ PRN TRACK LISTS

The satellite PRN number, or Pseudo Random Noise number, is the identifier for a particular satellite. Each satellite has a unique PRN number. The PRN Track Lists are simply lists of satellites that are to be tracked in the mode specified.

Semi-Auto List is the first selection on the PRN TRACK LISTS submenu. The following screen appears when this item is selected.

```
SEMI-AUTO LIST                  (ENT=change)
PRN : 02,03,06,11,12,13,14,16,17,19,20
```

This screen shows a list of satellites from which the receiver can select visible, healthy satellites when it is in the Semi-Automatic mode of time and frequency generation and measurement. The user adds to this list only those satellites that are to be tracked. Healthy satellites that are not on this list are ignored by the receiver. The receiver does not have to be in the Semi-Auto mode before the Semi-Auto List can be modified. This list is stored in battery-backed memory.

To add a satellite PRN to the Semi-Auto list, press [ENT] to display the following screen.

```
SEMI-AUTO LIST                  (ENT=accept)
PRN : 02,03,06,11,12,13,14,16,17,19,20

Enter PRN : 00
```

Enter the PRN, then press the [ENT] key. The PRN selected is added to the list on the second line of the display. It is not necessary for the PRN to be in the almanac when it is added to the Semi-Auto List. Until it appears in the almanac, the satellite is not used for time and frequency generation and measurement. The usable range of PRNs is 01 through 32. Up to 24 PRNs can be on the list, which is the maximum number of active satellites expected to be in the GPS constellation at any one time. If an attempt is made to add a 25th PRN to the list, the message, **List is Full**, is displayed briefly, and the PRN is ignored.

To remove a PRN from the Semi-Auto List, enter that PRN, as though you were adding it to the list. The receiver will determine that it is already on the list and remove it. Because of the way this works in the Model 2201A, you should be careful adding satellites to the list. If you attempt to add a PRN that is already on the list, it will be removed and it may not be noticed. Use the [CE] (clear entry) key to erase an incorrect entry, then enter the correct PRN. When PRN entry is complete, press [ESC] to back up one level in the menus, or press the [MENU] key to return to the main menu.

The Model 2201A can be placed in the Manual mode for satellite selection. In this mode, the user tells the receiver what satellites to track, the Doppler correction that should be used and the length of time to track. The Manual List is the list of satellites to be tracked in the Manual mode. Selecting [2] (Manual List) causes the following screen to appear.

```
MANUAL LIST                    (ENT=change)
PRN List   : Empty
```

To change the Manual List, press [ENT] to display the following screen.

```
MANUAL LIST                    (ENT=accept)
PRN List   : Empty
Enter PRN  : 00
```

Key in the desired PRN, then press the [ENT] key. The following screen appears.

```
MANUAL LIST                    (ENT=accept)
PRN List   : Empty
Enter PRN  : 14
Doppler      (Hz): _
```

The doppler is the frequency offset of the satellite's signal, due to the movement of the satellite and the offset of the receiver's internal oscillator. It is normally in the range of ± 5 kHz. Enter the Doppler, then press [ENT]. The receiver responds with the next screen requesting the length of time to track the satellite.

```
MANUAL LIST                    (ENT=accept)
PRN List   : Empty
Enter PRN  : 14
Track Length (s): _
```

The Track Length is normally from 15 minutes to four or five hours. Timing of the Track Length begins when the receiver has acquired the satellite. Enter the length of time, in seconds, that you wish the receiver to track that satellite, then press [ENT].

The receiver returns to the first MANUAL LIST screen, showing the Manual PRN List, with the PRN on it that was just entered. Another PRN may now be added to the list. A maximum of eight satellites may be on the Manual List. An attempt to add a ninth PRN displays the message, **List is Full**.

To remove a PRN from the Manual List, enter that PRN again, as though you were trying to add it to the list. The receiver recognizes that it is already on the list and removes it. When you are through adding and removing satellites from the Manual List, press [ESC] to go back one menu level or press [MENU] to return to the main menu. This list is not stored in battery-backed memory and is, therefore, lost when power is lost.

The Schedule List is used when the receiver is in the Scheduled mode of satellite selection. This list must be entered before the Scheduled mode can function properly. Select [3] (Scheduled List) from the PRN TRACK LISTS submenu to display a screen like the following.

```
SCHEDULE LIST                  (ENT=change)
Next Scheduled time:
No scheduled times
```

or

```
SCHEDULE LIST                  (ENT=change)
Next Scheduled time:
Start: 12:55 (UTC)  Length : 15 min
PRN  : 14
```

Both screens show the next time that a satellite is to be tracked. If no schedule has been entered, the first screen is displayed. If a schedule has been entered, a screen like the second screen above is displayed. On this screen you will find the Start time for the next tracking period (12:55), the length of that track (15 min), and the PRN of the satellite to be tracked (14).

A warning message may also be present on the above screens. These messages are as follows:

Message	Meaning
Warning: Wrong Mode	This means that the unit is not in Scheduled mode and, therefore, the schedule entered or shown is useless.
Warning: No Ext. 1 PPS	Since the purpose of Scheduled mode is to measure the External 1 PPS, this warning is telling you that no measurements will be possible because there is no external 1 PPS present. The unit will start the scheduled satellites, but stop track on the satellite if no External 1 PPS is present before the unit is ready to start making measurements.

"Warning: No EXT. 1PPS" will appear on line 4 of the main front screen if the unit is in Scheduled mode and no External 1 PPS is present. This is to give immediate feedback that no measurements will be made by the unit.

To enter or modify the Schedule List, press the [ENT] key to display a screen like one of the following.

```
SCHEDULE LIST Record-01      (ENT=change)
                             (1=PRV 2=NXT)
    Empty Entry
```

or

```
SCHEDULE LIST Record-07      (ENT=change)
PRN    : 14 Class: 21        (1=PRV 2=NXT)
Start  : 12:55 (GPS)
Length: 15 min
```

When the [ENT] key is pressed, one of the 48 possible Records, or satellite schedules is displayed. The first screen shows a record (Record-01) that is not active. Empty Entry is displayed when the PRN for that record has been entered as 00. The second screen shows an active record (Record-07). At 12:55 (GPS), the receiver is to begin tracking PRN 14, for 15 minutes. The Class of the satellite in this record is 21.

Use the [1] and [2] to scan through the satellite Records. The records are numbered from 1 through 48. However, when a schedule is entered, it is not necessary to enter it in numerical order. The receiver looks at the start time to determine when a satellite is to be acquired and tracked.

To enter a schedule, display the Record number to be programmed, then press the [ENT] key. The following screen appears.

```
SCHEDULE LIST Record-01      (ENT=accept)
PRN    : 00 Class: FF
Start  : 00:00 (GPS)
Length: 15 min
```

The cursor appears under the second digit of the PRN. Enter the PRN of the satellite that you wish to track. If the PRN is entered as a two-digit number, the cursor automatically moves to the second digit of Start (hours). If it is entered as a single-digit number (i.e., 1-9), press the [·] key to advance to Class.

☞ **NOTE:** Use the [•] to advance to the next entry field when not enough digits in the current field have been entered to cause the receiver to advance automatically. Also, use the [•] to move the cursor to a new field on the screen, at any time. This makes it possible to modify parts of the record, without re-entering the whole record. Do not press the [ENT] key for each field. When all of the information on the screen is correct, press the [ENT] key to cause the receiver to accept it.

Enter the Class of the satellite in this record. The Class of the satellites has no meaning, other than that which you give to it. It is a way to group satellites, and the data that is obtained from them, in ways that are meaningful to a particular application. For instance, the Block I satellites could be assigned Class 01, and the Block II satellites could be assigned Class 02. When data is requested from the receiver through a digital interface (RS-232-C, IEEE-488, etc.), it can be requested by Class, thus eliminating data that is not needed at that time. The Class can be any number between 00 and 99. There is also a default class number of FF, which is assigned if no other number is entered.

Next, enter the initial Start time for tracking. This time must be GPS time, not UTC or local time, for proper Scheduled operation. Times from 00:00 to 23:59 are allowed. If two Records have the same Start time, the lowest-numbered record will be used. Normally, the Start times and track lengths are entered so that overlaps do not occur. However, if this happens, the satellite currently being tracked is dropped and the next satellite in the schedule is acquired when its Start time occurs.

If two digits are entered for hours, the cursor moves automatically to minutes. Otherwise, press [•] to move the cursor to the next field. Finish the Start time entry by entering the minutes.

The Length is the time, in minutes, that the receiver is to track the satellite. The minimum track length is 1 minute and the maximum is 79 minutes. It begins when the receiver starts acquiring the satellite and normally ends when the number of minutes entered have passed. In addition to normal time-out, there are three other conditions that stop the track in Scheduled mode. If the receiver does not receive any valid data from a satellite within the first two minutes of acquiring it, the current schedule is terminated. Also, since the only use of the Scheduled mode is for an NIST style time transfer, if there is no 15-second update after the unit has established time, the current schedule is terminated.

There are two ways that there can be no 15-second update in a time transfer. The first is that there is no external 1PPS connected to the unit. The second is that the receiver has lost lock on the satellite for a long enough period to not get any valid data for it in 15 seconds.

The scheduled track of a satellite is also terminated if the Start time for another satellite occurs before the current track is completed. This is not a problem for the receiver, and it can make it easier to determine track lengths if you do not have to make sure that track intervals do not overlap. However, overlaps should be avoided for short track intervals so that sufficient time is allowed for data taking.

When the Record is ready, press the [ENT] key to cause the receiver to accept the data. The screen returns to the SCHEDULE LIST screen (ENT=change, in the upper right-hand corner), showing the data just entered for the Record. Use the [1] and [2] to move to the next Record to be entered or changed. The SCHEDULE LIST is stored in battery-backed memory. When the schedule has been entered, press the [ESC] key once, to return to the SCHEDULE LIST status screen. The next scheduled Start time, track length, and PRN should be shown. Press [MENU] then [ESC], to return to the main screen. This schedule is stored in battery-backed memory.

3.7.7. TIME FORMAT

```
TIME FORMAT                       (ENT=change)

Current Format : UTC
Local Time Corr: -06:00 hours
```

Path = MENU \ INITIALIZATION \ TIME SETUP \ TIME FORMAT

This screen shows the current time format. This is the time-of-day shown on the main screen in the upper left corner. Also shown on this screen is the correction that must be added to or subtracted from UTC to get local time. Options available are UTC time, GPS time and Local time. UTC is Universal Coordinated Time which is the international time scale used by most countries. GPS time is the Global Positioning System time scale transmitted by all GPS satellites. UTC and GPS differ from each other by the number of leap seconds applied to UTC since January 6, 1980, when GPS time officially began. As of January, 1990, there have been 6 leap seconds applied to UTC. That means that GPS time is ahead of UTC by 6 seconds. The Model 2201A automatically acquires the leap second correction from the satellite data and applies it to the received GPS time, to display UTC time-of-day. To change the time format, press [ENT]. The following screen appears.

```
TIME FORMAT

1)UTC Time          3)Local Time
2)GPS Time
```

Select the format desired. If UTC or GPS is selected, the screen returns to the first screen. If Local Time is selected, the following screen appears.

```
LOCAL TIME                        (ENT=change)

Local Time Corr: -06:00 hours
```

The local time correction is the difference between UTC/GPS time-of-day and local time. This time difference follows the various time zones, and is typically a multiple of one hour. In some places, the time differences must be entered down to 15 or 30 minutes. The correction ranges from −12 hours to +12 hours. The sign is positive if the time zone is east of Greenwich England, and negative if the time zone is west of Greenwich. Press [ENT] to change the correction. The following screen appears.

```
LOCAL TIME                          (ENT=accept)

Current Correction          :  -06:00
Enter Correction (hh.mm)    :  -06:00
```

Enter the hours as a two-digit number (leading zero is necessary). When the second hours digit is entered, the cursor shifts to the minutes digit. Enter the minutes as a two-digit number (leading zero is necessary). Finally, enter the sign of the correction.

If the number is correct, press [ENT] to accept the new correction. Use [CE] to clear a data keystroke and use [ESC] to cancel a whole entry and back up one screen. The Time Format data is maintained in battery-backed memory.

3.7.8. DATE FORMAT

```
DATE FORMAT                         (ENT=change)

Format is : MDY
```

Path = MENU \ INITIALIZATION \ TIME SETUP \ DATE FORMAT

Date Format determines the format for the date, displayed in the upper left corner of the main screen. This does not affect the operation of the receiver and is only for user convenience. Press [ENT] to display the selections.

```
DATE FORMAT
1)Month Day Year    4)GPS Week Number
2)Day Month Year    5)Day Of Year
3)Mod. Julian Date
```

Selections 1 and 2 are very common ways of displaying the date. Selection 3, Modified Julian Date, is the Julian date, with the two most significant digits removed. For example, the Julian date for January 1, 1960 is 2,436,934. The modified Julian date for January 1, 1960 is 36,934. This system is often used by astronomers.

GPS Week Number is the number of the current week, where week 1 began January 6, 1980. This is the date format included in the GPS data message. Day Of Year is the number of days since the last day of the previous year, where January 1 is day 1, and December 31 is day 365 or day 366.

When a selection has been made, the screen returns to the first DATE FORMAT screen, showing the selection made. The DATE FORMAT data is maintained in battery-backed memory.

3.7.9. TIME (UTC)

```
TIME (UTC)                    (ENT=change)

Time Is: 07:02:50
```

Path = MENU \ INITIALIZATION \ TIME SETUP \ TIME (UTC)

The current time-of-day (UTC) is shown on this screen. Most operations in the Model 2201A are related to Universal Coordinated Time (UTC), which is maintained in a battery-backed clock. This clock is set at the factory before the receiver is shipped. When the receiver acquires a satellite, the current UTC time is acquired from the satellite data and used to accurately set the internal clock. If the time is not correct to within about 15 minutes, press [ENT] to set it. The following screen appears.

```
TIME (UTC)                    (ENT=accept)

Time Is : 07:02:50
New Time (hh.mm.ss) : 00:00:00
```

Enter a new 24-hour time as three, two-digit numbers. If both digits of each number are entered, the cursor automatically advances to the next field. However, it is not necessary to enter a leading zero. Enter the single digit number, then press the [•]. This causes the cursor to advance to the next field. Each time the [•] is pressed, the cursor moves to the next field. If two digits are entered for seconds, the cursor returns to the hours field.

To set the time accurately, select a time several seconds in the future, then wait before pressing [ENT]. When the time arrives, press [ENT]. The screen returns to the first screen above, with the new time shown. Before pressing [ENT], use [CE] to cancel a data keystroke, and use [ESC] to cancel the whole entry and back up one screen.

☞ **NOTE:** While the receiver is tracking at least one healthy satellite, it gets the correct time-of-day and sets the internal clock. During this time, the TIME (UTC) menu selection on the TIME SETUP submenu does not appear. The internal clock can be changed only while the receiver is not tracking.

3.7.10. DATE (UTC)

```
DATE (UTC)                         (ENT=change)

Date Is : Fri 12 Jan 1990
```

Path = MENU \ INITIALIZATION \ TIME SETUP \ DATE (UTC)

The current UTC date is displayed on this screen. The UTC date is used for many functions in the Model 2201A. It is set at the factory before shipment, and is maintained in a battery-backed clock. Before setting the date, be sure to take into account the time difference between UTC and local time. Press [ENT] to change. The following screen appears.

```
DATE (UTC)                         (ENT=accept)

Date Is : Fri 12 Jan 1990
New Date (mm.dd.yyyy): 01/01/1980
```

Enter the month and day as 2-digit numbers, and enter the year as a 4-digit number. Leading zeros do not have to be entered. If two digits are entered for the month or day, the cursor automatically advances to the next data field. If they can be entered as single digits (January through September, and the first through the ninth), press the decimal point key after the entry to advance the cursor to the next field. Use [CE] to delete a data keystroke and use [ESC] to cancel the whole entry and back up one screen. When the date is as desired, press [ENT] to accept. The screen returns to the DATE (UTC) screen, with the new date shown. For example, to enter the date, May 2, 1990, either of the following sets of keystrokes will produce the correct result:

[0] [5] [0] [2] [1] [9] [9] [0] [ENT]

or

[5] [•] [2] [•] [1] [9] [9] [0] [ENT].

☞ **NOTE:** While the receiver is tracking at least one healthy satellite, it gets the correct date from the satellite data. During this time, the DATE (UTC) menu selection on the TIME SETUP submenu does not appear. The date in the receiver can be changed only while the receiver is not tracking.

3.7.11. ALARMS

```
SELECT ALARM                      (ENT=change)
                                  (1=PRV 2=NXT)
1PPS Limit 0.3 uSec          Status/Option
Output 1PPS                       Bad/SOFT
```

Path = MENU \ INITIALIZATION \ ALARMS

The Model 2201A monitors various functions and can be instructed to generate an alarm if something goes wrong. As long as all enabled alarms are inactive, the ALARM LED on the front panel is green and the ALARM output on the Output Buffer module (an optional module) is in the no alarm state. When at least one enabled alarm becomes active, the ALARM LED turns off or red (depends on the level of the alarm), and the ALARM output may be activated (depends on the level of the alarm). The alarm indication continues until all enabled alarms return to their no alarm states. The ALARM screens allow you to specify which conditions will be displayed (enabled), set the level of importance of each alarm, and check the current status of each alarm.

The first screen displayed when the ALARMS selection is made shows one of several alarms. In the example above, the alarm is for the receiver generated 1 pps. To the right of the alarm is its current status (Bad) and the alarm option (SOFT). On lines 1 and 2, in the upper right-hand corner, are the screen control commands. Keys [1] and [2] are used to scan through the various alarms, while the control command, ENT=change, is displayed. Use [1] and [2] to locate the alarm(s) to be examined or changed.

When the alarm to be changed is located, press the [ENT] key. The following screen appears.

```
SELECT OPTION

1)Hard                   3)Ignore
2)Soft                   4)(alarm limit)
```

The possible options for each alarm are, HARD, SOFT and IGNORE. A hard alarm is a condition that is critical to your application. When it occurs, the ALARM LED on the front panel turns red and the ALARM output on the Output Buffer module is activated. In most applications where one or more alarms are designated as HARD, the ALARM output on the Output Buffer module is connected to an external device. That device either generates a visual or audible alarm by activating a local device, or it indicates to a central monitoring station that an alarm has occurred. The ALARM LED and the ALARM output remain in the alarm condition as long as at least one HARD alarm is active. When the conditions that caused the alarm no longer exist, the red ALARM LED is turned off and the ALARM output is set to the no alarm mode. If no SOFT alarms exist, the ALARM LED is green.

A soft alarm is one that you are interested in, but it is not critical in your application. When it occurs, the ALARM LED on the front panel is turned off. The ALARM output on the Output Buffer module is not activated for a soft alarm. If, while a SOFT alarm is active, a HARD alarm becomes active, the ALARM LED changes from off to red. When a HARD alarm no longer exists, the LED changes back to off if at least one SOFT alarm exists, or to green, if no alarm exists.

The third selection for Option is IGNORE. When IGNORE is selected for an alarm, that alarm is disabled. If all alarms are set to IGNORE, the ALARM LED is turned green and it never changes.

For some alarms, the point at which the alarm becomes active can be entered or selected. This makes it possible to customize the receiver alarm conditions for different applications. If a limit can be specified, it appears on line 3 of the display, above the alarm description. In the example above, the Output 1PPS alarm becomes active when the internal 1 pps is greater than 0.3 microseconds (+ or –) away from the true value.

If an alarm limit can be entered or selected for a particular alarm, the SELECT OPTION display for that alarm shows a fourth selection. When this selection is made, the current alarm limit is displayed. If the limit is to be changed, press the [ENT] key, and enter or select the new limit. When the new limit has been entered, the display returns to the SELECT OPTION screen.

ALARM CONDITIONS

Output 1PPS

The Output 1PPS alarm has two Status conditions, Good and Bad. The alarm status is Good if the output 1 pps is present at the 1PPS output of the Output Buffer module and the receiver has set it to within the 1PPS Limit. For the receiver to determine that the 1 pps is properly set, it must be tracking at least one healthy satellite. If the receiver is not tracking a satellite or if it has not yet set the 1 pps, the alarm status will be Bad. The 1PPS LED on the front panel will also be blinking in red, indicating that the 1 pps is not accurate. If Ignore is chosen for this alarm, the 1PPS LED will always be green.

The alarm limit for the Output 1PPS can be 0.1 microsecond through 999.9 microseconds. If the entered value is less than 0.1 microsecond, the receiver forces the limit to 0.1 microsecond.

Output Freq

The Output Frequency alarm has two Status Conditions, Good and Bad. If the 0.1, 1, 5, 10 MHz output on the Output Buffer module is present, the receiver is tracking at least one healthy satellite and the receiver has had time to set the frequency of the internal oscillator to within the Freq Alarm limit, the status of this alarm is Good and no alarm is generated. If all of the above conditions are not met, the status is Bad and an alarm is generated, provided the alarm Option is set to HARD or to SOFT.

There are several choices for the alarm limit for this alarm. Refer to the FREQ LIMIT submenu for the allowed values.

Tracking

While the receiver is tracking a satellite, the alarm Status is Yes. Otherwise, the Status is No.

Signal Proc

If the Signal Processor hardware is working properly, the Status of this alarm will be Ok. If a problem develops with this hardware, the Status changes to Bad. It may be possible to correct this error by cycling power. If this does not help, there has been a failure in the hardware that must be fixed.

ET Range If the electrical tuning of the oscillator is out of range for more than 45 minutes, this alarm will be changed from OK to Exceeded. This usually means that the unit requires mechanical tuning of the oscillator. Refer to Section 3.8 for more information.

Your receiver may have additional alarms not indicated above. These are generated or only valid with particular option modules installed. For information, refer to the Alarms Section of any option module user guides you may have.

3.7.12. CURRENT POSITION

```
CURRENT POSITION
Lat    : +030:27:15.370  MODE : Accurate
Long   : -097:39:46.000  Count: 01,00
Height : +232.80 m
```

Path = MENU \ RECEIVER STATUS \ CURRENT POSITION

The current position is the last position calculated during a receiver positioning function, or the current accurate position entered through the POSITIONING submenu. The measured position is referenced to the WGS 84 datum, and an entered position is assumed to be referenced to the same datum.

In addition to the current position, this screen shows the current MODE of the positioning function. The Accurate mode means that the receiver has a position, and it is using it for time and frequency generation and measurement. Other possibilities for MODE include Unknown and Approximate. When the Unknown and Approximate positioning functions are complete, the mode automatically returns to Accurate.

Count indicates the state of the positioning function. It consists of two, 2-digit numbers. These numbers give a relative idea of the filtering applied to the input numbers and the numbers of samples for this filter used thus far. If the first number is 01, for example, it indicates the filtering of the inputs is at unity, while a 10 indicates that 10% of the input error is being used. If the unit is performing an approximate position, the numbers are only incremented if the calculated PDOP is less-than-or-equal-to the PDOP mask. If the unit is unknown positioning, the PDOP is calculated and shown but is not compared to the PDOP mask because the unit does not know if the PDOP is valid since it can have such a gross position error. The mode automatically changes when the unit has reached the best possible position for the current mode.

Mode changes possible are: If the unit is in Approximate mode it automatically changes to Accurate Position mode when positioning is complete. In the Unknown mode, the unit changes to Approximate mode when it has reached a solution that is within 1° in the latitude and longitude. Note that while the unit is performing an unknown position, there may be some intermediate results that look to be grossly in error. Not to worry! The unit reaches a stable solution and changes to Approximate mode.

The following conventions are used for latitude, longitude and height:

Latitude	+ is North, – is South.
Longitude	+ is East, – is West.
Height	Can be + or –. It is measured with respect to the reference spheroid, which is usually not the same as local ground level.

In addition to the data shown on the current position screen, there can also be a status message shown on the right half of line 1. If data is being displayed and the right half of line 1 is blank, the receiver is experiencing no errors in positioning. When a problem occurs, however, the right hand side of line 1 will show a number. Following are the interpretations of those numbers:

Number	Meaning
4	Position has been generated from a sub-satellite
8	There is a millisecond ambiguity problem
10	There is a 20 millisecond ambiguity problem
20	The difference vector from the last fix is too large
40	Singular matrix on the frequency data
80	Singular matrix on the time data
200	Bad PDOP
400	Approximate update

☞ **NOTE:** It is perfectly valid to have combinations of these numbers output. To interpret these, simply add the above numbers.
For example, if the right hand side of line 1 shows: Error! #408', this means that the unit has calculated an approximate position, but there appears to be a millisecond ambiguity in the result.

3.7.13. INTERNAL T/F

The INTERNAL 1PPS and INTERNAL FREQ screens are accessed through the INTERNAL T/F menu selection. When this selection is made, one of the three screens shown below is displayed, depending on what screen was displayed last, and what TIME/FREQ mode has been selected (See TIME/FREQ screen for an explanation of this function).

If the following selections were made for Freq out and 1PPS out in the TIME/FREQ MODE

```
Freq out    1PPS out
Carrier     Code
Carrier     Carrier
```

a screen like the one below will be displayed.

```
INTERNAL FREQ
σ     : +4.9408E-11  Ageing: +8.2059E-09
ΔT    : -1.1940E-08  ET    :  5.4322162
ΔF/F  : +1.7250E-10  tau   :  500.0
```

If the following selections were made for Freq out and 1PPS out in the TIME/FREQ MODE

Freq out	1PPS out
Code	Code

a screen like the one below will be displayed.

```
INTERNAL 1PPS
σ     : +4.9408E-11  Ageing : +8.2059E-09
ΔT    : -3.1239E-09  ET     :  5.432872
ΔT/T  : +1.5138E-12  tau    :  500.0
```

If the following selections were made for Freq out and 1PPS out in the TIME/FREQ MODE

Freq out	1PPS out
Carrier	Code
Carrier	Carrier

a screen like the one below will be displayed.

```
INTERNAL 1PPS
σ     : +1.0099E-08  Off  : +1.3780E-10
ΔT    : +4.3688E-09  tau  :  500.0
ΔT/T  : +8.5142E-13
```

Path = MENU \ RECEIVER STATUS \ INTERNAL T/F

Before the receiver has updated any of the filters for the INTERNAL 1PPS or INTERNAL FREQ measurements, the following screen is displayed for the internal 1 pps.

```
INTERNAL 1PPS
No PPS information available
```

For the internal frequency measurement, the following screen appears.

```
INTERNAL FREQ
No Freq information available
```

These screens will be displayed while the receiver has never tracked at least one healthy satellite.

If the receiver has updated the filters, the data for INTERNAL FREQ is displayed as shown above. This screen is visible only when the receiver is in the Carrier-Code or Carrier-Carrier time and frequency modes.

Line 2 of this screen shows the sigma (σ) data and the oscillator Ageing rate. Sigma is a measure of the noise of the carrier frequency measurement. The ageing rate is the measured change in frequency of the internal oscillator per day. As the oscillator ages, it usually gets better and the rate at which the frequency changes, usually decreases.

On line 3 of the display, you will find "ΔT", which is a filtered display of the integration of the incoming frequency errors. To the right of "ΔT" is "ET". This is the electrical tuning voltage of the internal oscillator. The ET voltage can vary from zero volts to +10 volts. It is the means by which the receiver "fine tunes" the frequency of the internal oscillator.

Line 4 of the INTERNAL FREQ screen shows the frequency offset of the internal oscillator (ΔF/F), and the time constant of the internal software loops (tau). The frequency offset is the frequency difference of the internal oscillator relative to the the reference selected. The reference can be either the oscillators on the satellite being tracked, the average GPS frequency, or the Universal Coordinated Time (UTC) reference. The reference is chosen from the TIME/FREQ MODE submenu.

The time constant, tau, starts at a value of 50.0 and gradually increases to a maximum given in the following table as the receiver adjusts the frequency of the internal oscillator to the correct value. It represents a software loop response time of 50.0 to maximum tau seconds.

Oscillator Type	Maximum Tau
1121	500 seconds

The first INTERNAL 1PPS data screen that can be displayed is available only if the TIME/FREQ MODE of Code/Code has been selected. The data shown on this screen is the same as discussed for the INTERNAL FREQ screen, with the following differences. "ΔF/F" has been replaced with "ΔT/T", since the data shown represents a variation of time, over time. Also, "σ" is a measure of the noise of the C/A code tracking of the receiver. Also, "ΔT" is a filtered display of the variation of the incoming time errors.

The second INTERNAL 1PPS data screen that can be displayed, is available when the receiver is in the TIME/FREQ MODEs, Carrier/Code, Carrier/Carrier, External/Code, and External/External. The difference between this screen and the previous INTERNAL 1PPS data screen include:

1. Aging is replaced by Off. Off shows the internal measured difference between what the 1PPS control loop is doing and what the Frequency Control loop is doing.
2. ET was dropped because the C/A Code is not being used to control the frequency of the internal oscillator in this mode.

In addition to the data shown on the INTERNAL FREQ and INTERNAL 1PPS screens, there can also be a status message shown on the right half of line 1. If data is being displayed and the right half of line 1 is blank, the receiver is receiving usable data, and the data being presented is a result of the filtering of that data. Other messages and their meanings are shown below.

Halt This message indicates that oscillator electrical tuning or 1PPS updates are frozen, because there is a problem with the incoming data and/or the TIME/FREQ SELECT mode of the receiver.

Coast If this message is displayed, the receiver is updating the electrical tuning voltage of the oscillator, using only the learned oscillator ageing rate. If the ageing rate is better than 5.0E-7/day, the receiver does not apply the correction and electrical tuning is frozen. If the oscillator in the receiver is a Rubidium, no correction is applied, even for ageing rates worse than 5.0E-7.

User Halt The user has placed the receiver in the Halt mode.

If problems develop and the receiver is not controlling the oscillator and/or 1PPS, the following messages may be displayed on the current screen.

$\Delta > 30\ \sigma$ This indicates that the incoming data is too noisy and that it has greatly exceeded the learned noise of the previous data.

Positioning If the Unknown mode of receiver positioning has been selected, no time and frequency information is generated and this message is displayed.

Empty List This message indicates that no input to the software filters was received within 15 seconds. This may be due to the receiver not tracking at least one healthy satellite, the Ephemeris and Clock correction have not been gathered for a satellite, the satellite being tracked has been declared unhealthy or the user range accuracy is out of range (> 65.0 meters), or the unit is in Approximate positioning mode and is currently tracking enough satellites to perform a position fix.

Time Xfer The unit is performing a time transfer. In this mode, there is no internal time/frequency measurements or control performed.

3.7.14. INTERN. OSC.

```
INTERNAL OSCILLATOR 02
Type  : Crystal Oscillator
Mode  : Software Control
Status: Not Locked
```

Path = MENU \ RECEIVER STATUS \ INTERN. OSC.

The INTERN. OSC. 02 screen shows the type of oscillator installed in the front, right-hand section of the receiver. In the example above, a crystal oscillator is installed. 02 in the screen title is the code for that specific oscillator. There are three types of oscillators available for the Model 2201A. The ovenized crystal oscillator is standard. It will be shipped in the receiver unless a different oscillator is ordered. The second type of oscillator available for the receiver is a Rubidium oscillator. This oscillator will be used when the application requires maximum stability of the output frequency if the receiver portion of the Model 2201A develops a problem (cannot track satellites) or if there are periods when no satellites are available. The third type is a Low Phase Noise Option. The oscillator type is read by the receiver when power is turned on, and is presented here for informational purposes only (no change possible unless the oscillator is replaced).

Also shown on this screen is the current Mode of the oscillator. The mode of the oscillator is determined by the mode selected for time and frequency generation (TIME/FREQ MODE). If CODE-CODE, CARRIER-CODE, or CARRIER-CARRIER is selected, Mode on this screen is Software Control, indicating the receiver is adjusting the frequency of the internal oscillator, while it is tracking at least one healthy satellite.

The fourth line of the display shows the Status of the current Mode of the internal oscillator. For Software Control, the status possibilities are Locked if the receiver is tracking a healthy satellite and adjusting the frequency of the oscillator, and Halt if it is not tracking a healthy satellite.

RELATED MENU SELECTION

Time/Freq Mode, Section 3.7.3

3.7.15. SOFTWARE VERSION

```
SOFTWARE VERSION
GPS MODEL 2201A AUSTRON, INC.
DP: A.00  SP: A.00
Date:   12-June-90
```

Path = MENU \ RECEIVER STATUS \ SOFTWARE VERSION

The SOFTWARE VERSION screen shows the version of the software in your instrument. If you should have a problem with your Model 2201A, you should have the revision numbers and the date of the software in the receiver when you contact AUSTRON, Inc.

The revision numbers are shown on the third line of the display. The revision number of the software on the Data Processor PCB is shown as DP: A.00 in the example above. The revision number of the software on the Signal Processor PCB is shown as, SP: A.00. Line 4 shows the date of the software. Follow the menu path shown above to display the revision numbers of the software in your receiver.

3.7.16. ELEVATION PLOT

```
ELEVATION PLOT                          (ENT=change)
                                   (1=PRV 2=NXT 4=LCD)
PRN  to LCD : 03                       Date: Current
PRNs to PRT : Empty                    Pos : Current
```

Path = MENU \ SATELLITE INFO \ ELEVATION PLOT

The Elevation Plot is a plot of a satellite's elevation for each hour of the day. Use these plots to determine when a particular satellite will be visible and to set up a schedule for the Scheduled mode of satellite selection. One satellite can be plotted at a time on the LCD. If the plot is sent to a printer, up to four satellites can be plotted simultaneously (either a Parallel Printer Interface module, an RS-232 Interface module or an IEEE-488 Interface module must be installed in the receiver and a printer connected). To make these plots, an almanac for the satellite to be plotted must be stored in battery-backed memory.

The ELEVATION PLOT screen above, shows the PRN of the satellite to be plotted on the LCD (03), and the PRNs that are to be plotted on the external plotter (Empty means that no PRNs are to be plotted). The Date and Position for which the plots are to be made are shown in the lower right-hand corner (Current/Current). The Current Date means that the date shown on the main screen is being used; the Current Position is the position shown on the CURRENT POSITION screen. The date and position for this plot can be changed as needed. If a date or position, other than Current, is used, the ELEVATION PLOT screen shows Entered for Date and/or Pos. Refer to the discussion for the PLOT-CHART DATE/POS screen in this section for instructions on how to change this data.

Line two shows the control keys for this screen. The [1] and [2] make it possible to scan through the satellite PRNs in the receiver's almanac. The PRN selected appears on the third line, just to the right of PRN to LCD :. When the [1] is pressed, the PRN changes to the previous PRN in the almanac. The [2] changes to the next PRN. If the satellite selected from the almanac is unhealthy, an asterisk (*) appears to the right of the PRN on line 3.

When the PRN to be plotted on the LCD appears, press [4] (4=LCD) to start the plot. The following screen appears.

```
ELV   70_|                  _                Alm.
(DEG) 40_|                _- -_              Wk#:
      10_|........._-         -_.........524
PRN#03   |0    4    8    12   16   20   23   Hr
```

The satellite elevation is shown on the vertical axis, and the time-of-day, in one-hour steps, is shown on the horizontal axis. When the plot is finished, the screen cursor stops under the current hour of the day (not shown on the example above).

The elevation axis begins at the Elevation Mask angle, and goes up to 90°. In this example, the mask is set to 10°. Depending on the satellite, receiver location, mask angle and the date for which the plot is being done, there can be as many as two periods each day when a satellite is visible. Usually there is one major period when the satellite reaches an elevation of 30° or more, and one period when the satellite does not go higher than 5 to 10°.

The plot usually takes 5-10 seconds if the receiver is not tracking a satellite. The plot can be interrupted at any time by pressing [ESC] or [ENT]. When it is restarted, even for the same PRN, the plot starts over. To make another plot, press the [ESC] key once to return to the ELEVATION PLOT screen.

RELATED MENU SELECTIONS

1. Receiver Masks, Section 3.7.4
2. Plot-Chart Date/Pos, Section 3.7.19

3.7.17. VISIBILITY CHART

```
VISIBILITY CHART                  (ENT=change)
                            (1=PRV 2=NXT 4=LCD)
PRN        : 03                  Date: Current
PRNs to LCD: Empty               Pos : Current
```

Path = MENU \ SATELLITE INFO \ VISIBILITY CHART

The Visibility chart shows the period of time that a satellite is at or above the elevation mask. Unlike the Elevation Plot, the Visibility chart does not show the elevation of the satellite. Charts are usually done for a specific date, either the Current Date or a User-entered date, and for a specific position, either the Current Position or a User-entered position. The data is presented on the LCD, and can be output to an external printer if an optional interface has been installed.

Visibility charts are made by placing the desired PRNs on the PRNs to LCD list, shown on line 4 of the VISIBILITY CHART screen. In the example above, the list is Empty. To add a PRN to the list, use the [1] and [2] to scan through the PRNs in the almanac (1=PRV, 2=NXT). They appear on line 3 of the display. When a desired PRN is displayed, press the [ENT] key to add it to the LCD PRN list (line 4). To remove a PRN from the list, display the PRN on line 3, then press [ENT]. The PRN is removed from line 4. Up to four PRNs can be on the list at one time.

When a PRN is displayed on line 3, its health is also indicated. Unhealthy satellites are followed by an asterisk (*). Their Visibility charts can be displayed, but it is recommended that they not be used for time and frequency until they are healthy. When the PRN for an unhealthy satellite is added to the LCD list, the asterisk is dropped, because of space limitations on the LCD.

The date that is used for the charts is shown on the right half of line 3. In the example above, the Current date will be used. The Current date is the same as that shown on the main screen. It is the default selection for the Visibility chart date. If you wish to display a chart for a different date, refer to the discussion for the PLOT-CHART DATE/POS screen in Section 3.7.19. When a date is entered, Current is replaced by Entered on line 3.

The position that will be used for the charts is shown on the right half of line 4. In the example above, the Current position is used. The Current position is the same position that is displayed on the CURRENT POSITION screen, and is the same position being used for time and frequency generation and measurement. If you wish to display a chart for a different position, refer to the discussion for the PLOT-CHART DATE/POS screen in Section 3.7.19. When a position is entered, Current is replaced by Entered on line 4.

When the list of PRNs to be charted on the LCD is complete, press [4] (4=LCD). The following screen appears.

```
SATELLITES 03_|.........9012345........
           06_|....456789......6.......
Wk#: 524   09_|......67890.....678.....
Msk: 10    11_|.....5678901............
```

This chart shows the hours when the satellites are at or above the elevation mask angle. There are 24 places following the PRN, representing the 24 hours in a day. If a satellite is above the elevation mask angle during an hour the number of that hour is printed. If the hour number has two digits, only the least significant digit is printed (14:00 is printed as 4). If the satellite elevation is not above the mask angle, a decimal point is printed. For example, PRN09 is above the mask angle from 06:00 through 10:00, and then again from 16:00 through 18:00. To chart additional satellites, press [ESC] once to return to the VISIBILITY CHART screen, then select new PRNs.

RELATED MENU SELECTIONS

1. Receiver Masks, Section 3.7.4
2. Plot-Chart Date/Pos, Section 3.7.19

3.7.18. PRN ALMANAC

```
PRN ALMANAC
D: C P: C                          (1=PRV 2=NXT)
PRN    : 03   AZ: +156° Elev: 18°
Health: 00000000 bin    Dopp: -4094 Hz
```

Path = MENU \ SATELLITE INFO \ PRN ALMANAC

The PRN ALMANAC screen shows some of the important almanac information for the satellite indicated on line 3 (PRN 03). This data can be useful for determining the current visibility and health of a satellite that you wish to track.

The screen commands for PRN ALMANAC are shown on the right side of line 2. The [1] and [2] are used to scan through the satellite PRNs in the almanac. The [1] changes the screen to the previous PRN in the almanac, and the [2] changes the screen to the next PRN.

On the left side of line 2 you will find the characters, D: C P: C. The D and the P stand for Date and Position, respectively. Because the orbits of the satellites are not exactly 12-hours long, the azimuth, elevation and doppler for a satellite, which are shown on this screen, will be different for a date different from the current date. This information also varies with the position used to calculate them.

Following each of these characters is a status letter. A "C" means that the current data (date and/or position) is being used for the PRN ALMANAC calculations. Most of the time, the current position and date will be used, so the receiver defaults to this when power is applied.

If you wish to see what the azimuth and elevation would be for a satellite at a future date or in a different location, enter the new date and/or position, using the PLOT-CHART DATE/POS commands. When you have changed the date and/or position, return to the PRN ALMANAC screen to see the new data. If a new date or position is entered, the "C" is replaced by an "E", indicating an Entered date or position.

CAUTION: The date and position entered using the PLOT-CHART DATE/POS commands will remain until they are changed again, or power is cycled (receiver defaults to current date and position). This data also affects the Elevation Plots and Visibility Charts. If you enter a date and/or position for a special purpose, you may want to return to the Current Date/Current Position mode when you are through to prevent confusion about the data displayed on the PRN ALMANAC screen.

Line 3 shows the PRN for which the almanac is currently being displayed. In this example, the PRN is 03. The next data on that line is the Azimuth (+156°). The azimuth, which ranges from 0° to 359°, is the horizontal direction to the satellite. Also shown on line 3 is the satellite Elevation angle (18°). The elevation angle is the angle from a line parallel to the ground, to a line from the GPS antenna to the satellite. It ranges from –90° to +90°, where +90° is directly overhead, 0° is at the horizon, and –90° is on the opposite side of the earth. If the elevation angle is positive, and if it is at or above the elevation mask angle, the satellite is considered visible.

The fourth line of the PRN ALMANAC screen shows the satellite Health and the current Doppler. Satellite health is represented by an 8-bit binary number. If all of the bits are zero, the health of that satellite is good. A "1" in any position indicates a possible problem with the satellite. The Model 2201A uses this information to help it decide whether a certain satellite should be acquired. If the almanac indicates that the satellite is unhealthy, the receiver will not attempt to acquire it, even if the satellite is currently healthy. Eventually, the new almanac information for that satellite is acquired by the receiver, while tracking a healthy one. The health information in the almanac is updated, showing that the satellite is now healthy and that it may be acquired.

The following tables give the meanings of each of the bits. On the PRN ALMANAC screen and in the tables, the bits are numbered from left to right, as follows:

```
Health: 0 0 0 0 0 0 0 0
Bit # : 7 6 5 4 3 2 1 0
```

Table 6: NAV DATA HEALTH INDICATIONS

BIT # 7	6	5	PROBLEM DESCRIPTION
0	0	0	ALL DATA OK
0	0	1	PARITY FAILURE — some or all parity bad
0	1	0	TLM/HOW FORMAT PROBLEM — any departure from standard format (e.g., preamble misplaced and/or incorrect, etc.), except for incorrect Z-count, as reported in HOW.
0	1	1	Z-COUNT IN HOW BAD — any problem with Z-count value not reflecting actual code phase.
1	0	0	SUBFRAMES 1, 2, 3 — one or more elements in words three through ten of one or more subframes are bad.
1	0	1	SUBFRAMES 4, 5 — one or more elements in words three through ten of one or more subframes are bad.
1	1	0	ALL UPLOADED DATA BAD — one or more elements in words three through ten of any one (or more) subframes are bad.
1	1	1	ALL DATA BAD — TLM word and/or HOW and one or more elements in any one (or more) subframes are bad.

Table 7: CODES FOR HEALTH OF SV SIGNAL COMPONENTS

BIT # 4	3	2	1	0	PROBLEM DESCRIPTION
0	0	0	0	0	ALL SIGNALS OK
0	0	0	0	1	ALL SIGNALS WEAK*
0	0	0	1	0	ALL SIGNALS DEAD
0	0	0	1	1	ALL SIGNALS HAVE NO DATA MODULATION
0	0	1	0	0	L1P SIGNAL WEAK
0	0	1	0	1	L1P SIGNAL DEAD
0	0	1	1	0	L1P SIGNAL HAS NO DATA MODULATION
0	0	1	1	1	L2P SIGNAL WEAK
0	1	0	0	0	L2P SIGNAL DEAD
0	1	1	1	1	L2P SIGNAL HAS NO DATA MODULATION
0	1	0	1	0	L1C SIGNAL WEAK
0	1	0	1	1	L1C SIGNAL DEAD
0	1	1	0	0	L1C SIGNAL HAS NO DATA MODULATION
0	1	1	0	1	L2C SIGNAL WEAK
0	1	1	1	0	L2C SIGNAL DEAD
0	1	1	1	1	L2C SIGNAL HAS NO DATA MODULATION
1	0	0	0	0	L1 & L2P SIGNAL WEAK
1	0	0	0	1	L1 & L2P SIGNAL DEAD
1	0	0	1	0	L1 & L2P SIGNAL HAS NO DATA MODULATION
1	0	0	1	1	L1 & L2C SIGNAL WEAK
1	0	1	0	0	L1 & L2C SIGNAL DEAD

Table 7: CODES FOR HEALTH OF SV SIGNAL COMPONENTS

BIT # 4	3	2	1	0	PROBLEM DESCRIPTION
1	0	1	0	1	L1 & L2C SIGNAL HAS NO DATA MODULATION
1	0	1	1	0	L1 SIGNAL WEAK*
1	0	1	1	1	L1 SIGNAL DEAD
1	1	0	0	0	L1 SIGNAL HAS NO DATA MODULATION
1	1	0	0	1	L2 SIGNAL WEAK*
1	1	0	1	0	L2 SIGNAL DEAD
1	1	0	1	1	L2 SIGNAL HAS NO DATA MODULATION
1	1	1	0	0	SV IS TEMPORARILY OUT— do not use this SV during current pass**
1	1	1	0	1	SV WILL BE TEMPORARILY OUT—use with caution**
1	1	1	1	0	SPARE
1	1	1	1	1	MORE THAN ONE COMBINATION WOULD BE REQUIRED TO DESCRIBE ANOMALIES (EXCEPT THOSE MARKED BY **)

* 3 TO 6 dB BELOW SPECIFIED POWER LEVEL DUE TO REDUCED POWER OUTPUT, EXCESS PHASE NOISE, SV ATTITUDE, ETC.

The last data on line 4 is the Doppler. Due to the motion of the satellite, relative to the receiver, there is a shift in the frequency of the carrier of the satellite signal. When the satellite is at the horizon and rising, the doppler is close to its maximum positive value (approximately +5 kHz). At the satellite's closest approach, the doppler goes to zero. As the satellite sets on the horizon, the doppler is close to its maximum negative value (–5 kHz). The Model 2201A uses this information to aid in the acquisition of the satellites.

3.7.19. PLOT-CHART DATE/POS

```
PLOT-CHART DATE/POS            (ENT=change)
Lat     : +30:27:15.410       DATE :
Long    : -97:39:45.642       01/30/1990
Height  : +231.08 m
```

Path = MENU \ SATELLITE INFO \ PLOT-CHART DATE/POS

The PLOT & CHART POSITION screen shows the position and date used by the PRN ALMANAC, ELEVATION PLOT, and VISIBILITY CHART functions. If this position and date are not changed before beginning a plot, the last value entered will be used. If you wish to change the position, press [ENT]. The following screen appears.

```
PLOT-CHART DATE/POS

1)Use Current Pos. 3)Use Current Date
2)Enter a Position 4)Enter a Date
```

Item 1 and Item 3 on this submenu select the Current Position and Current Date, respectively. The Current Position is the position shown on the CURRENT POSITION screen (RECEIVER STATUS menu), and the Current Date is the date shown on the Main screen. Most almanac plots and charts will be done using this position and date. The display returns to the original PLOT & CHART POSITION screen, showing the position and date selected.

If item 2 is selected, the receiver will request that a new position be entered. The following screens will be displayed for the entry of latitude.

```
PLOT-CHART POSITION              (ENT=accept)
                                 (- is south)
Enter Latitude Degrees:  _
```

```
PLOT-CHART POSITION              (ENT=accept)
                                 (- is south)
Enter Latitude Minutes:  _
```

```
PLOT-CHART POSITION              (ENT=accept)
                                 (- is south)
Enter Latitude Seconds:  _
```

Enter Degrees as a 1 or 2 digit number (leading zeros are not necessary). Before pressing [ENT], be sure the sign is correct. If the latitude is north, do not press the [+/-] key. If the latitude is south, press the [+/-] key once, to show a minus sign before the Degrees entry. When the Degrees entry is correct, press [ENT]. The receiver responds to [ENT] by placing the Degrees entered on the bottom line of the screen to show that it was accepted. The screen is also changed to show "Enter Latitude Minutes".

Next, enter Minutes as a 1 or 2 digit number (leading zeros are not necessary). Do not press the [+/-] key for minutes. When the entry is correct, press [ENT]. The receiver responds by moving the Minutes to the bottom line with Degrees. The display is also changed to show "Enter Latitude Seconds".

Finally, enter Seconds as 1 or 2 digits of whole seconds, followed by a decimal point and up to 4 additional digits. Do not press the [+/-] key for seconds. When the entry is correct, press [ENT]. The receiver clears the entered Latitude from the bottom line and changes the screen to request Longitude Degrees.

☞ **NOTE:** It is not necessary to enter latitude and longitude as degrees, minutes and seconds. If you know your latitude or longitude in degrees (i.e., 30.24165 degrees), enter the degrees this way. When [ENT] is pressed, entry of that number is done (the receiver does not ask for minutes and seconds). If you know your latitude or longitude in degrees and minutes (i.e., 30 degrees and 27.4285 minutes), enter the degrees and minutes this way. When [ENT] is pressed after the Minutes entry, the entry of that number is done (the receiver does not ask for seconds).

Enter the Longitude in the same manner as the Latitude. Be sure to press the [+/-] key before entering the Degrees if the longitude is "west".

Finally, enter the Height. Be sure to enter the proper sign before pressing [ENT].

The receiver responds to [ENT], after entering the Height, by displaying the whole position entry for your inspection. In the upper right corner of the screen, you will find the command, (ENT=accept). If the position is correct, press [ENT]. The display then returns to the initial PLOT & CHART POSITION screen. If you decide not to change the position, press the [ESC] or [MENU] keys to cancel the entire entry.

To enter a date for the Elevation Plots and Visibility Charts, select item 4, Enter a Date, on the PLOT & CHART POSITION submenu. The following screen appears.

```
PLOT-CHART DATE                (ENT=change)

Date Using : Tue 30 Jan 1990
```

Press the [ENT] key to change the date. The following screen appears.

```
PLOT-CHART DATE                (ENT=accept)

Date Using : Tue 30 Jan 1990
New Date (mm.dd.yyyy): 01/01/1980
```

Enter the New Date as shown on the screen. If two digits, including leading zeros, are entered for the month and day, the cursor automatically advances to the next data entry field. Months and days that can be represented by a single digit (i.e., January through September, and the first through the ninth) can be entered as single digits, without leading zeros. To advance the cursor to the next field after entering a single digit, press the decimal point key once. Thus, the date, March 2, 1990, can be entered using either of the following sets of keystrokes:

[0] [3] [0] [2] [1] [9] [9] [0] [ENT]

or

[3] [•] [2] [•] [1] [9] [9] [0] [ENT].

Any date after January 1, 1980 may be entered. Dates before this date will not be accepted. When the new date has been entered, press [ENT]. The screen returns to the original PLOT & CHART DATE screen.

☞ **NOTE:** The date should be entered correctly. The position, however, can be entered to the nearest degree which simplifies the entry and still gives useful information.

3.7.20. GPS MESSAGE

```
GPS MESSAGE
```

Path = MENU \ SATELLITE INFO \ GPS MESSAGE

Occasionally, messages are included in the satellite data message. When they are, they will be found on this screen. Messages on future events or tests, messages about past problems, and other information of interest to GPS users will be sent from time to time.

3.8. PERIODIC CALIBRATION REQUIREMENT

Most of the internal adjustments of the Model 2201A that are made at the factory, do not have to be readjusted on a regular basis. These adjustments will normally be checked and changed, if necessary, when a serious problem with the receiver develops. They would also be checked and adjusted during preventive maintenance. There is, however, an adjustment that should be checked after the first six months of operation, and every 12 to 24 months after that.

The internal crystal oscillator is very stable and provides a stable frequency while the receiver is tracking a satellite. The receiver corrects the frequency of the oscillator by making adjustments to the oscillator's electrical tuning voltage (ET voltage). This is the oscillator's fine frequency adjustment. In the Model 2201A, the ET typically ranges from 2 volts to 8 volts dc (the maximum range is 0 volt to 10 volts). As the oscillator ages, its natural frequency gradually shifts up or down. To compensate for this, the receiver has to increase or decrease the ET to keep the oscillator on frequency. Eventually, the ET reaches either the upper or lower end of its range, at which point the receiver can no longer control the oscillator, and a coarse frequency adjustment is necessary.

The rate at which the oscillator changes frequency depends on the oscillator and the length of time it has been turned on. When the receiver is shipped from the factory, the ovenized crystal oscillator should change frequency by less than 2E-09 per day. As it ages, this rate typically slows to a range of 5E-11 to 1E-10 per day. That means that after about six months, the oscillator ET will probably be close to its upper or lower limit. If a Rubidium oscillator is installed, it will probably not reach the ET limit for one to two years. After the first year of continuous operation, the oscillator probably does not need to be readjusted more frequently than every one to two years.

3.9. CALIBRATION METHOD

When the internal oscillator is being controlled by the receiver, the Electrical Tuning voltage will be found on the INTERNAL FREQ screen (see Section 3.7.14), while the receiver is tracking at least one healthy satellite. The ET is shown on the right side of the screen. If it is within 10% of the ET range for greater than 45 minutes, the alarm ET range will be set, indicating the need for coarse adjustment.

There are two methods for making this adjustment. The first method takes advantage of an external reference that is known to be accurate to better than 1E-09. If such a reference is available and you have an Input Buffer option installed, connect the reference to the Input Buffer. Set the Input Buffer to the same frequency as the reference (i.e., .1, 1, 5, 10 MHz). Using the instructions in Section 3.7.3, TIME/FREQ MODE, place the receiver in the Loop Halt mode.

Next, return to the main screen by pressing [MENU] then [ESC]. Press the following sequence of keys to enable the receiver tests.

[ALT], [9], [EE], [CE], [ESC].

Press [MENU], then select Initialization, Receiver Setup, Receiver Tests, Oscillator, and ET Control. The following screen is displayed.

```
ET CONTROL
Current ET: 2.379 volts

No valid Frequency Information
```

The current ET voltage going to the oscillator is shown on line 2 of this screen. On line 4, the message, No valid Frequency Information, is displayed if you have not selected the proper input frequency for the Input Buffer, which must match the reference frequency being input to the receiver. When the proper input frequency has been selected, the current oscillator frequency offset is displayed.

The ET must be set to 5.000 volts (center of its range). To do this, press [ENT]. The following screen is displayed.

```
ET CONTROL                          (ENT=accept)
Current ET: 2.379 volts
Enter New ET (volts):
ΔF/F: -8.000E-9
```

Enter an ET of 5.0 volts, then press [ENT]. This sets the electrical tuning of the internal oscillator to the center of its range. If a crystal oscillator is installed, carefully remove the large screw in the front of the oscillator to access the coarse adjustment.

When access to the Coarse Adjustment screw of the oscillator has been obtained, observe the ΔF/F number being displayed on he front panel. Change the Coarse Adjustment screw on the oscillator by small amounts in the direction that gradually reduces the ΔF/F measurement.

> **CAUTION:** Use a nonconductive tool to adjust the Coarse Adjustment screw on the oscillator. Do Not use a regular screwdriver.

When the frequency of the internal oscillator is within ± 5E-10 of the external reference, the calibration is complete. If a crystal oscillator was calibrated, reinstall the large screw in the end of the oscillator.

The second method for calibrating the internal oscillator does not require an external reference. However, this method usually requires a little more time to make the adjustment. Before proceeding, prepare the oscillator installed in your receiver, as discussed above (i.e., remove the screw in the end of the crystal oscillator.

Place the receiver in the Carrier-Code mode, then select Loop Halt for the internal oscillator (refer to Section 3.7.3, TIME/FREQ MODE). The Loop Halt mode will allow the receiver to measure the frequency error of the internal oscillator as compared to GPS, without making adjustments to it. Ensure the receiver is tracking only one satellite.

Return to the main screen by pressing [MENU] then [ESC]. Press the following sequence of keys to enable the receiver tests:

[ALT] [9] [EE] [CE] [ESC].

Next, press [MENU], then select Initialization, Receiver Setup, Receiver Tests, Oscillator, and ET Control. The following screen appears.

```
ET CONTROL
Current ET: 2.339 volts

No valid Frequency Information
```

The current ET voltage going to the oscillator is shown on line 2 of this screen. On line 4 the message, No valid Frequency Information, is displayed if the receiver is not tracking a satellite. When it begins tracking, the current oscillator frequency offset is displayed.

The ET must be set to 5.000 volts (center of its range). To do this, press [ENT]. The following screen appears.

```
ET CONTROL                  (ENT=accept)
Current ET: 2.339 volts
Enter New ET (volts):
ΔF/F: +3.00E-10
```

Enter the new voltage, then press the [ENT] to cause the receiver to accept it.

When the receiver is displaying frequency measurements, begin making small adjustments (less that a tenth of a turn) to the coarse adjustment of the oscillator. Wait about 30 seconds between adjustments for the receiver to measure the frequency. It is important that small adjustments be made, because the receiver may stop tracking the satellite briefly. The receiver quickly relocks, but no frequency information is available until it does, causing the calibration to take longer. Continue making adjustments until the frequency error of the internal oscillator is less than ± 5E-10. When it is within this range, replace the seal screw in the front of the oscillator. This completes the adjustment. Return the receiver to normal operation.