Model Mark V
GPS P(Y) Code
Time and Frequency Receiver

SERIAL NUMBER_____

October 17, 2002

Revision E

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SECTION I: GENERAL INFORMATION

1.1 INTRODUCTION

1.1.1 This manual provides the user of a Mark V GPS P(Y) Code Time and Frequency Receiver all of the information necessary to properly install, operate and utilize all of its features.

1.1.2 The information in this manual includes normal installation procedures as well as any maintenance and adjustment data that may be required to facilitate field repairs.

1.1.3 The purpose of the Mark V is to provide accurate time, frequency and position as derived from Coarse Acquisition (C/A) Link 1 (L1) signals transmitted by the NAVSTAR Global Positioning System (GPS) satellites. When keyed, the Mark V will use Y Code L1 or L2 signals. In addition it provides high resolution measurements of external time and frequency signals applied as inputs to the Mark V versus the GPS reference. The Mark V is usable on a world-wide basis under any weather conditions.

1.1.4 The Mark V is completely automatic in satellite acquisition and time and frequency synchronization. When the unit is first installed (or if the unit is moved more than 100 km, or if the internal battery was discharged), acquisition time is shortened if the operator enters a position accurate to better than 100 kilometers (approximately one degree in latitude and longitude).

1.1.5 The Mark V receiver will operate when the satellites are 10 degrees above the horizon and their signals are not obstructed. Whenever entered position information is less accurate than 10 meters, an unkeyed Mark V will first have to accurately ascertain its antenna position by tracking four or more satellites and performing a long term (24 hours) average of position fixes in order to maintain time and frequency accuracy and stability within specification. From that point on, the Mark V will require only one satellite (above 10 degrees) to maintain valid time and frequency. However, operation to specified stability requires four or more satellites. When no satellites are in view, the Mark V will continue to output its signals using either the internal or external disciplined oscillator. See SECTIONS II and III.

1.1.6 If valid keys are loaded into the Mark V, it can deliver good time and frequency accuracy and stability without long term position averaging, or with fewer than four satellites, once an accurate position is determined. However, when keyed, accuracy and stability will also be improved with long term position averaging and operation with four or more satellites. Keyed operation greatly improves accuracy and stability when moving.

1.2 through 1.10 reserved.

1.11 LIMITED WARRANTY

1.11.1 Each new product manufactured by TrueTime is warranted for defects in material or workmanship for a period of one year from date of shipment ("Limited Warranty"). Defects in material or workmanship found within that period will be replaced or repaired, at TrueTime's option, without charge for material or labor, provided the customer returns the equipment, freight prepaid, to the TrueTime factory under this limited warranty. TrueTime will return the repaired equipment, freight prepaid, to the customer's facility. This one year Limited Warranty does not apply to any software or to any product not manufactured by TrueTime.

1.11.2 If on-site warranty repair or replacement is required, the customer will be charged the then current field service rate for portal-to-portal travel time plus actual portal-to-portal travel charges. There is no charge for on-site warranty repair labor.

1.11.3 Products not manufactured by TrueTime but included as integral part of a system (e.g. peripherals, options) are warranted for 90 days, or longer as provided by the original equipment manufacturer, from date of shipment.

1.11.4 Aside from the Limited Warranty set forth above, TrueTime makes no other warranties, express or implied, of merchantability, fitness for purpose or of any other kind or description whatsoever.

1.11.5 By purchasing any product manufactured by TrueTime, the buyer consents to and agrees with TrueTime that as a result of the exclusion of all warranties, expressed or implied, of merchantability, fitness for purpose, or otherwise, except for the limited one-year warranty for defects in material and workmanship for products manufactured by TrueTime, that the Buyer has the sole responsibility to assess and bear all losses relating to (1) the ability of the product or products purchased to pass without objection under the contract description among merchants and buyers in the trade; (2) the conformity of the product or products to fair average quality within its contract description; (3) the fitness of the product for the ordinary purposes for which such product is used; (4) the consistency of quality and quantity within each unit of product or products and among all units involved; (5) the adequacy of containers, packaging and labeling of the product or products; (6) the conformity of the product, promises or affirmations of fact (if any) made on its label or container; and (7) the conformity of the product to standards of quality observed by other merchants in the trade with respect to products of similar description.

1.12 through 1.20 reserved.

1.21 LIMITATION OF LIABILITY

1.21.1 By purchasing any product from TrueTime the Buyer consents to and agrees that the Buyer's sole and exclusive remedy for any damages or losses incurred by the Buyer as a result of TrueTime's breach of its one-year Limited Warranty for defects in materials and workmanship or otherwise in connection with any

claim respecting the product shall be limited to the repair or replacement of the product or a refund of the sales price of the product.

1.21.2 In no event shall the Buyer be entitled to recover consequential damages or any other damages of any kind or description whatsoever.

1.22 through 1.23 reserved

1.24 PROPRIETARY NOTICE

1.24.1 THIS DOCUMENT, WHETHER PATENTABLE OR NON-PATENTABLE SUBJECT MATTER, EMBODIES PROPRIETARY AND CONFIDENTIAL INFORMATION AND IS THE EXCLUSIVE PROPERTY OF TRUETIME, INC. IT MAY NOT BE REPRODUCED, USED OR DISCLOSED TO OTHERS FOR ANY PURPOSE EXCEPT THAT FOR WHICH IT IS LOANED, AND IT SHALL BE RETURNED UPON DEMAND.

1.25 through 1.30 reserved.

1.31 PHYSICAL SPECIFICATIONS

1.31.1 The Mark V is a 19" rack-mounted product with the following physical specifications:

Mark V Receiver Size:	1.75 in. x 17.0 in. x 17 in. (4.45 cm. x 43.18 cm. x 43.18 cm.)

Standard 19" EIA Rack System, hardware included, slides optional.

Antenna Size:	4.0 in. x 3.75 in. X 1.6 in. (10.16 cm. x 9.53 cm. X 4.07 cm.)

Note: Antenna Units are mounted on a 12 in. long PVC nipple with 3/4" Male Pipe Thread (MPT) on both ends. The above specified overall lengths of the Antenna Units are therefore increased by approximately 11.25 in. when the mounting nipple is included.

Mark V Receiver Weight:	12.0 lb max. (5.45 Kg)
Antenna Weight: (Including mtg. nipple)	1.50 lb (.682 Kg)
Antenna Cable, RG-59:	Standard length = 50 ft. 1.2 lb (.545 Kg)

1.32 reserved

1.33 ENVIRONMENTAL SPECIFICATIONS

1.33.1 The environmental specifications are:

Operating Temperature:	
Antenna:	-55^{o} to +85^{o} C (-67^{o} to +185^{o} F)
Mark V Receiver:	0^{o} to +50^{o} C (+32^{o} to +122^{o} F)
Storage Temperature:	
Antenna:	-55^{o} to +85^{o} C (-67^{o} to +185^{o} F)
Mark V Receiver:	-40^{o} to +85^{o} C (-40^{o} to +185^{o} F)
Humidity:	
Antenna:	100%, condensing
Mark V Receiver:	95%, non-condensing

1.34 reserved

1.35 POWER INPUT SPECIFICATIONS

AC Power:	95-260 VAC, 47 to 440 Hz, < 40 W
DC Power:	120-370 VDC, < 40 W

1.36 INTERNAL BATTERY SPECIFICATIONS

The internal batteries provide standby power to the Mark V memory, and to the Force 22 module. Battery life shown is with the Mark V unpowered.

GPS-XL Battery:

Battery Type: Lithium, 3.5 Volt
Battery Life: 15000 hours
86-741 Battery, maintains Force 22 almanacs, real time clock, and cryptokeys:

Battery Type: Lithium, 3.5 Volt
Battery Life: 7000 hours

1.37 TIMING/FREQUENCY PERFORMANCE SPECIFICATIONS

1.37.1 All performance specifications are valid when the antenna's geodetic position is known within 10 m in WGS-84 and four or more satellites are being tracked under the current conditions of Selective Availability (SA) as experienced at product release in March of 1994. When keyed or during periods without SA, timing performance is improved to the +/- 100 nS level.

The Mark V core GPS receiver specifications are:

Frequency:	1575.42 MHz (LI signal) 1227.60 MHz (L2 signal)
Code:	Coarse Acquisition (C/A) code, P code
When Keyed:	Y Code
Tracking:	Up to twelve satellites.
Acquisition Time:	Less than 2 min. if satellites visible, position correct within 100 km. Position errors greater than 100 km may require 15 min. or longer, with satellites visible. See Section III.
Single Fix Position Accuracy:	Within 25 m (SEP) referred to WGS-84 when tracking four (4) or more satellites with a PDOP < 6. 100 meters (2 dRMS) if SA is enabled and unit is not keyed.
24 Hour Averaged Position Accuracy:	< 10 m. unkeyed < 3 m. keyed

The Mark V timing and frequency specifications are:

1PPS Output Accuracy:	GPS Time <10 nS rms (<100 nS peak) UTC-USNO <10 nS rms (<100 nS peak)

Frequency Accuracy / Stability:
Refer to Manual Section XV, “Disciplined High Stability Quartz Oscillator”

IRIG-B Amp. Mod. Output (STANDARD):

Accuracy:	10 uS to UTC

IRIG-B DC Level Shift Output (OPTION):

Accuracy:	150 nS to UTC, 100 nS when keyed or without SA

External 1PPS Time Interval/Event Timetag Measurement (OPTION):

Resolution:	30 nS, single shot.
Accuracy:	150 nS + 30nS/2

External Frequency Measurement (OPTION):

Resolution:	6×10^{-11} @ 1 second interval
Accuracy:	1×10^{-12}
Stability:	Allan Deviation = 3×10^{-10}/tau

1.38 through 1.40 reserved

1.41 INTERFACE SPECIFICATIONS

1.41.1 The standard serial data port is a bi-directional EIA standard RS-232C interface. RS-485 is available as an option. The specifications are:

Data: Time, day of year through milliseconds, in ASCII characters, output once per second or on request. Also special functions as listed in Section III.

Data Rates: User selectable from 300, 600, 1200, 2400, 4800, 9600 and 19200 bps.

Data Bits: User selectable from 7 or 8.

Parity: User selectable from even, odd or none.

Stop Bits: User selectable from 1 or 2.

Connector: Male 9-pin D subminiature.

Pin Assignment: See Section III.

1.41.2 A combination of up to eight input and output signals may be connected to the Mark V via rear panel mounted BNC connectors. The available output signals are:

1 PPS (STANDARD):
Pulse width: 20 uS
On time edge: Rising
Amplitude: TTL Levels into 50 ohms
Drive: ACMOS

1 kPPS (OPTION):
Pulse width: 50% duty cycle.
On time edge: Rising
Amplitude: TTL Levels into 50 ohms
Drive: ACMOS

Pulse Out (OPTION):
Pulse width: 1 ms
On time edge: Rising
Amplitude: TTL Levels
Drive: HCMOS

Time Code (STANDARD):
Format: Amplitude-Modulated IRIG-B.
Carrier: 1 kHz.
Amplitude: 5.0 Vp-p high, 1.5 Vp-p low, no load.
Output Z: 600 ohms.

Time Code (OPTION):

Format:	DC Level Shift IRIG-B
Amplitude:	TTL Levels
Drive:	HCMOS

1, 5 and/or 10 MHz (OPTION):

Waveform:	TTL (STANDARD), Sinewave (OPTION)
Amplitude:	TTL Levels into 50 ohms (STANDARD),1 Vrms Sinewave into 50 ohms (OPTION)
Drive:	ACMOS

External Oscillator Control Digital to Analog Converter (DAC) Output (OPTION):

Range:	Either -5 to +5 V or 0 to +10 V, jumper selectable
Resolution:	16 bits
Output Z:	100 ohms

Open Collector Alarm Output (OPTION):
Normal state is low impedance to ground. Transitions to high impedance under system alarm condition.

1.41.3 The available input signals are:

Ext. 1PPS Time Interval/Event Timing (OPTION):

Pulse width:	100 ns, min.
Active Edge:	Rising
High Level:	TTL to 10 VDC
Low Level:	TTL
Hysteresis:	50 mV
Impedance:	1K or 50 ohms, user jumper sel.

Ext. Frequency Measurement (OPTION):

Frequency:	1, 5 or 10 MHz
Level:	1 to 5 Vp-p
Impedance:	1K or 50 ohms, user jumper sel.

Ext. Auxiliary Oscillator (OPTION):

Frequency:	1, 5 or 10 MHz
Level:	1 to 5 Vp-p
Impedance:	1K or 50 ohms, user jumper sel.

SECTION II: INSTALLATION

2.1 OVERVIEW

2.1.1 The Model Mark V Time and Frequency Receiver consists of the Mark V Receiver, Antenna Unit and cable. The Mark V is capable of basic operation without any RS-232 connection.

2.1.2 The Mark V GPS P(Y) Code Time and Frequency Receiver is shipped from True Time to customers with the Trimble Force 22 GPS Module removed. The Force 22 GPS Module is separately shipped by Trimble to the customer. Refer to Service Procedure 422-009-002, Installation and Test of the Force 22 Module, included in this manual, for instructions on installation and check out of the Force 22 in the Mark V unit.

2.1.3 Also refer to Service Procedure 422-007-002, Customer Instructions for Handling GPS Mark V P(Y) Receiver, and Service Procedure 422-008-002, Removal of the Force 22 Module, for instructions on handling and shipping the Force 22 Module and the Mark V unit should it be necessary to return them for repair.

2.3 PROCEDURE

2.3.1 Place the Mark V Antenna Unit with an unobstructed view of the sky. Connect the cable between the Antenna Unit and Mark V antenna input connector. If Serial I/O communications are desired, make the necessary connections to your equipment after referring to the Serial Interface information in Section III. The next paragraphs will refer to various keypad I/O functions by number. There are corresponding serial I/O functions. These are thoroughly described in Section III.

The receiver can be powered by 95-260 VAC or 120-370 VDC. See Section I for specific limits on the voltage and frequency ranges.

The power fuse for the AC or DC power input must be the correct amperage rating: 1.0 amp slow-blow. The instrument is shipped configured with the 1.0 amp fuse installed.

2.3.2 With the main power switch to the Mark V off, connect an appropriate AC or DC power source to the Mark V receiver via the keyed power input connector. Turn on the power switch. Within a few seconds, the Mark V will output elapsed time from power-on via Serial I/O Function F08. (Serial I/O inputs will be ignored until the F08 output is terminated with a CONTROL-C character (HEX 03).) Use Function 92 to set Anti-Spoofing to Off to allow the receiver to acquire its initial almanacs. It may require 10 to 15 minutes after power on for the internal oven oscillator to warm up to its operating temperature, and for the PLLs to lock. This may delay the acquisition of the first satellites. If satellites are visible, the output time will switch from elapsed time to UTC time within a few minutes. Once

almanacs have been acquired, if the Mark V has been keyed, Anti-Spoofing may be set to On (Y only). See Section III.

2.3.3 If the Mark V has been placed in AUTO mode via Function 53, the recommended setting for new fixed site installations, it will not phase lock its internal oscillator to the received time signal until it has computed a 3-D position. You may wait up to 15 minutes for the Mark V to independently ascertain its position by acquiring four satellites, or you may speed up the process by using Function 50 to enter the approximate location to an accuracy of 1° (about 100 km) or better.

2.3.4 When the Mark V has phase locked its oscillator to the GPS signals and has set its 1PPS output to the specified accuracy, the terminating character of the Serial I/O F08 continuous time output string will change from a "?" to a "space". If satellites are visible and the Mark V has an accurate position, lock should be achieved within several minutes.

2.3.5 Initially following power-up, the optional open collector alarm output will provide a high impedance to ground. When the Mark V is tracking satellites and is controlling the local oscillator and 1PPS output to within specified accuracy to UTC, this output will provide a low impedance to ground. Thereafter, whenever the Mark V outputs are not within specifications, this output will provide a high impedance to ground.

2.4 through 2.8 reserved

2.9 SPECIAL CONSIDERATIONS FOR EXT. OSCILLATOR CONTROL OPTION

2.9.1 Interconnection between the Mark V and the external oscillator to be controlled must be planned carefully. Of particular importance is the elimination of ground loops made by the connection of the DAC control voltage return and the signal ground shield. Some types of oscillators are particularly susceptible to noise in these loops which can cause missing pulses to occur at the Mark V External Oscillator input signal conditioning circuits.

2.9.2 The recommended connection method is as follows:

1) Provide a single ground path between the Mark V and the External Oscillator.
2) Let that single ground provide the DAC tuning voltage return.
3) Transformer couple the External Oscillator signal into the Mark V so as to break the coaxial ground connection, thereby eliminating that potential loop.

Following these guidelines will provide reliable operation with a wide variety of oscillators.

2.10 through 2.22 reserved

2.23 RACK MOUNTING

2.23.1 The Mark V mounts in a standard 19 inch rack system using the rack mounting brackets provided. These brackets may be attached to the sides of the cabinet. First remove the flat head screws from each side of the instrument. Place the screw supplied with the brackets (part number 241-008-005, 8-32x5/8) through the countersunk holes in the brackets then into the clock and tighten. The unit may now be mounted in a 1-3/4 inch opening in any EIA Standard 19 inch rack system. The optional Rack Mounting Slide Kit includes installation instructions.

SECTION III: OPERATION

3.1 INTRODUCTION

3.1.1 The Mark V Time and Frequency Receiver provides extremely accurate TIME and FREQUENCY that is traceable to the UNITED STATES NAVAL OBSERVATORY (USNO) by use of the NAVSTAR Global Positioning System (GPS). This section provides a complete description of the operation of the Mark V.

3.2 reserved

3.3 GENERAL OPERATION

3.3.1 Every effort has been made to make the operation of the Mark V backward-compatible with the Keypad and Serial I/O functionality of the XL-DC, GPS-DC and GPS-TMS/TMD products, however some differences exist. The three most-used functions (TIME, STATUS and POSITION) have been assigned to front-panel pushbuttons. All remaining functions may be accessed via the front-panel keypad and viewed on a front-panel alphanumeric display or accessed via the Serial I/O interface and viewed on a terminal.

3.4 reserved

3.5 MARK V START-UP

3.5.1 At power up, the unit will present messages on the small front panel display to indicate the version of software installed in the unit, and how to invoke the keypad help function. The first message is the version of the system software. For example:

TRUETIME MK III
sys ver 016

After a few seconds, the display will show:

Press func, 0, 0
for help.

Then the display will show the version of the clock-specific software:

GPS-XL V1.034
182-6078v008

After a few seconds, the display will show the status display, which will remain until a keypad function is invoked, or the "TIME" or "POSITION" button is pressed.

It should be noted that the text of the version messages will vary from model to model and version to version.

3.5.2 The large numeric display will initially show

A DDD:HH:MM:SS UNLOCK

where:

A	=	Acquisition. Looking for satellite signals.
DD	=	Days
HH	=	Hours
MM	=	Minutes
SS	=	Seconds
UNLOCK	=	Not tracking satellites

3.5.3 After power up, the Mark V will send over the Serial I/O port continuous time with a one second update rate. The format of this output string is described in section 3.285, "SERIAL I/O FUNCTION 08 - CONTINUOUS TIME ONCE PER SECOND ENABLE". Prior to satellite acquisition the time either displayed or sent over the Serial I/O port is battery-backed GPS time. Once satellite signals are acquired the UTC time is displayed, with local offset if this has been selected, and the "A" on the large numeric display will clear and not reappear. The "UNLOCK" will also clear but will reappear if signal is subsequently lost. Similarly, over the Serial I/O port time is sent with local offset and the "?" time quality character will clear to a space character. Sending a CONTROL-C (hex 03) to the Mark V will terminate this continuous time output mode and allow requesting of other information via the Serial I/O commands.

3.6 through 3.8 reserved

3.9 SATELLITE ACQUISITION

3.9.1 Time to first satellite acquisition is dependent upon many factors. The following paragraphs describe some of the possible events that affect satellite acquisition times. Note that satellite visibility at the receiver site will affect acquisition times.

3.9.2 If the time and frequency receiver was tracking satellites immediately prior to a momentary power interruption, satellite reacquisition will be almost immediate with valid UTC time available within 180 seconds.

3.9.3 If the current position is unknown or in error by more than 100 Km, acquisition typically requires from 3 to 15 additional minutes to locate current antenna position, reacquire satellite almanac and ephemeris data, and deliver UTC time. Refer to the AUTO MODE paragraph later in this section for operational details.

3.9.4 If internal battery-backed time and/or almanac data is lost, the time to first satellite acquisition will depend upon which satellites are visible at the time of power-on. The Mark V will attempt to acquire satellites not knowing which satellites are visible. The satellite search will be expanded until a satellite is acquired. After first satellite acquisition, time will be acquired from the satellite and the receiver will return to normal operation. This procedure may take as little as 3 minutes to as long as 15 minutes depending upon current satellite visibility.

3.9.5 To verify the status of the Mark V receiver, a front panel "STATUS" button has been provided. Refer to "STATUS PUSH-BUTTON" in this section.

3.10 through 3.11 reserved.

3.12 UNKEYED OPERATION

3.12.1 Use Keypad Function 92 to make sure that Anti-Spoof Mode is Off. The FORCE 22 GPS module must be keyed and have valid almanacs to operate with Anti-Spoof Mode On.

3.12.2 If the Mark V is installed in a fixed location, use Keypad Function 53 to select AUTO mode, otherwise if it may be moving, select SURVEY DYNAMIC mode. Allow the Mark V to track satellites, acquire almanacs, and lock to GPS. The antenna should have an unobstructed view of the sky. The STATUS display should show the receiver tracking 4 to 12 satellites. With Keypad Function 60, check the signal levels of the satellites being tracked. There should be from 4 to 12, and most of them should have signal levels from 35 to 50 dB (when using a 50-foot cable). They should be L1 CA code, since Anti-Spoofing is Off. Satellite 28 is currently sending P code, which may be seen with Function 60 when it is being tracked.

3.12.3 For best performance when unkeyed in a fixed location, allow the Mark V to average its position for about 24 hours, after which it will switch from AUTO mode to TIME mode. Alternatively, use Keypad Function 53 to place the Mark V in TIME mode, and then use Keypad Function 56 to enter the current antenna position, if it is known to 10 meters or better.

3.13 KEYED OPERATION

3.13.1 Press STATUS and then connect the keyloader to the front panel fill port connector. The display may show 'Keyloader detected'. Activate the keyloader to load the keys. The display should indicate 'Keyloader data read OK'. If it displays 'Keyloader parity error', reload the keys. Disconnect the keyloader.

3.13.2 Using Keypad Function 92, check Cryptokey Status and confirm 'Keys loaded'. If the receiver is tracking satellites, within a few minutes, Cryptokey Status should indicate 'Keys valid'. Again using Keypad Function 92, set the Mission Duration starting date, and the number of days after that date that the keys may be used. Select Mission Duration status, and the Mark V will display the number of hours from now for which keys are valid. This may be less than the Mission Duration

requested if the keys were not good for all of the requested period. Select SAASM Self Test, which should also confirm 'Keys valid'.

3.13.3 When the Mark V is keyed with valid keys, if Anti-Spoofing is Off, it may use CA code, although it will prefer to use P or Y code information. It will, however, perform the Precise Positioning Service corrections to remove the effects of Selective Availability even if it is using CA or P code information. To restrict the receiver to using only Y code information, turn Anti-Spoofing mode On.

3.14 ENABLING ANTI-SPOOF MODE

3.14.1 Once the Mark V has obtained almanacs, and has been keyed with valid keys, use Keypad Function 92 to set Anti-Spoof Mode to 'On (Y-Only)'. With Keypad Function 60, check the signal levels of the satellites being tracked. There should be from 4 to 12, and most of them should have signal levels from 35 to 50 dB. They should be L1 Y code, since Anti-Spoofing is On. Some might be L2 Y code, as the FORCE 22 GPS module performs ionospheric corrections, or if there are stronger signals on L2 than on L1. The Mark V will no longer use CA or P code information after entering this mode.

3.15 ZEROIZING CRYPTOKEYS

3.15.1 If it is necessary to zeroize the cryptokeys, use Keypad Function 92, Zeroize Cryptokeys. See Keypad Function 92 or Serial Function 92 for additional instructions on zeroizing cryptokeys, and on obtaining cryptokey and mission duration status.

3.15.2 When the Mark V is unpowered, the cryptokeys in the Force 22 module are maintained by a backup Lithium battery on the 86-741 board. The status of this battery can be checked using Keypad Function 72, PY Battery Fault Status. See Keypad Function 72 for instructions.

3.15.3 When the Force 22 module is removed from the Mark V, and the 50 pin flex cable assembly is unplugged, the backup battery is disconnected, zeroizing the keys. See Service Procedure 422-008-002 for instructions on removing the Force 22 module.

3.16 through 3.19 reserved

3.20 OPERATIONAL MODES

3.20.1 The Mark V operates under one of three modes: AUTO, SURVEY (OPTION) and TIME. Each mode is described below. Use Keypad or Serial I/O function F53 to change from one mode to another or to determine the current mode. Refer to "KEYPAD FUNCTION 53 - OPERATIONAL MODE ENTRY/REQUEST" or "SERIAL I/O FUNCTION F53 - OPERATIONAL MODE ENTRY/REQUEST" in this section. The out-of-the-box default mode is AUTO. The default on subsequent power-up will be the mode used at the previous power-down.

3.21 reserved

3.22 AUTO MODE

3.22.1 AUTO mode offers a painless solution to GPS receiver start-up and operation. Under AUTO mode, no user input is required to properly complete a Mark V site installation.

3.22.2 AUTO mode requires a minimum of 4 satellites in order to complete the installation process.

3.22.3 After time and frequency receiver installation or whenever it is desired to reinstall the Mark V, select AUTO MODE to begin the installation process.

3.22.4 AUTO mode consists of 3 major processes: 1) Current Position Search, 2) Current Position Averaging and Refinement and 3) Invocation of Time Mode. Time and Frequency data and output signals are available throughout this process, however optimal accuracy and stability are not achieved until step 2) has been completed. With good satellite visibility this occurs following about twenty-four hours of averaging.

3.22.5 Current Position Search: Immediately after invoking AUTO mode, the Mark V clears the position average and then begins a satellite search. **Since invocation of AUTO mode does clear the average position, the time and frequency outputs may be disturbed. Care should be taken not to needlessly invoke the AUTO mode.**

3.22.6 The satellite search begins with 8 satellites. After several minutes, a second set of satellites is searched. The process continues until a satellite is acquired.

3.22.7 Immediately after acquisition, data lock is attempted and the satellite Doppler compensation (the change in the 1.575 kHz frequency due to the apparent satellite velocity, for terrestrial based receivers, typically 0 to ±5 kHz) is adjusted until data can be read from the satellite.

3.22.8 After data lock, GPS time is acquired to the 20 ms level of accuracy, and almanac data loading for the entire constellation begins. At this time the Serial I/O F53 command returns "F53 AUTO: 1 SATS" and the first line of the display indicates "MODE: AUTO 1 SAT", giving the positioning mode of the GPS core unit. The second line indicates "sats ##", giving the Pseudo Random Noise (PRN) number of the satellite being tracked.

3.22.9 During the data loading process, search continues for additional satellites. When a second satellite is acquired and data lock is achieved, the Serial I/O F53 command returns "F53 AUTO: 2 SATS" and the first line of the display indicates "MODE: AUTO 1 SAT", giving the positioning mode of the GPS core unit. The second line indicates "sats ##", giving the PRN number of the highest satellite being tracked. At this time, the position of the Mark V may be placed in the proper hemisphere, narrowing the search for possible SV's.

3.22.10 When a third satellite is acquired, a unique position solution exists given an assumed ellipsoid height near 0 meters. At this time, the Serial I/O F53

command returns "F53 AUTO: 3 SATS" and the first line of the display indicates "MODE: AUTO 2-D", giving the positioning mode of the GPS core unit. The second line indicates "sats ## ## ##", giving the PRN numbers of the three satellites being used in the two-dimensional (2-D) fix. With this position, the remaining visible SV's are determined based on the almanac and the time and are acquired rapidly. Once a 3-D position fix has been determined, synchronization to UTC begins and the first stage of AUTO Mode has almost ended. At this time Serial I/O F53 command returns "F53 AUTO: # SATS", where # is the number of SV's being tracked, which may be as many as 6. The first line of the display indicates "MODE: AUTO 3-D" while the second line indicates "## ## ## ## ## ##", giving the PRN numbers for up to six satellites being tracked.

During the position refinement stage of AUTO mode, the constellation may change such that 3-D fixes are not available. This will be indicated on the status display. *Though these 0-D and 2-D fixes will not go into the position average, they will be used to control the time and frequency outputs of the Mark V*.

When the Mark V is synchronized to UTC using the approximate position found, the unlock and time error annunciators are extinguished, thus indicating the end of the Current Position Search phase of AUTO mode.

3.22.11 Current Position Averaging and Refinement: After completing the first Current Position Search phase of AUTO mode, AUTO mode automatically begins averaging 3-D position fixes, providing an increasingly more accurate and stable time and frequency reference position. The quality of the timing and frequency outputs will improve until a terminal average of approximately twenty-four hours duration has been obtained. At this time, the Mark V returns "F53 TIME: # SATS" in response to Serial I/O F53 command and the first line of the display indicates "MODE: TIME X-D", where X is either 2 or 3 depending upon the satellite visibility. As in AUTO mode, the second line of the display indicates the PRN numbers of the current satellites being used in the TIME solutions.

3.22.12 Invocation of TIME Mode: After the position average is complete, the AUTO mode switches the time and frequency receiver to TIME mode and the averaged position will be used for all future timing solutions. TIME mode inhibits further surveying. The auto installation process is concluded.

3.22.13 The Mark V will remain in TIME mode and will power-up in TIME mode using the averaged position after a power outage. However, after powering up in TIME mode, if the computed positions consistently differ from the previously stored average position by more than 1 Km for a significant period of time, the Mark V will automatically re-initialized itself to AUTO mode and re-establish the position. Otherwise, operator intervention would be necessary to re-invoke AUTO mode.

3.23 through 3.41 reserved.

3.42 SURVEY MODE

3.42.1 When in the SURVEY operating mode the Mark V will repeatedly calculate position and time based on the unaveraged position. The position solutions are not averaged, and multiple satellite averaging techniques for reducing the effects of SA on the time solution are not employed. This mode of operation is appropriate in dynamic or pseudo-static platform applications. Strictly stationary users should use the far more accurate and stable TIME mode. **The specified time and frequency performance levels may not be met when the Mark V is operating in SURVEY mode**.

There are two dynamics choices for SURVEY operation: STATIC and DYNAMIC. STATIC should be used when the mode of operation is pseudo-static, i.e. the unit is periodically transported to a new location and then stationary operation is performed at the new location. In this mode, the GPS core receiver will easily maintain lock under the dynamics experienced during ground transport and will quickly provide accurate time and frequency once at the new site. This mode also supports operation with a single satellite once the position at the new site has been determined. However, if operation while moving is important and the possibility of satellite obstruction exists, STATIC should not be selected as erroneous time and frequency steering data could be used while only a single satellite is visible.

DYNAMIC should be selected when operation is truly dynamic and might possibly include high acceleration or velocity such as might be experienced on-board tactical aircraft. In this mode, satellite visibility must be complete and fall-back to single satellite operation is not supported.

3.43 reserved

3.44 TIME MODE

3.44.1 When in the TIME operational mode, the Mark V disables updating of the reference position average and computes timing solutions based on either the previously averaged position or a reference position which has been input via either Keypad or Serial I/O function F56. However, each position fix update is tested against the reference position to detect possible relocation of the receiver and antenna during the last power off period. If the Mark V determines that it has been moved by more than 1 km, it will automatically set itself into the AUTO mode of operation.

3.44.2 Up to twelve satellites are used for timing solutions, enabling significant reduction of the effects of Selective Availability on the stability and accuracy of the timing and frequency outputs and measurement data. These satellites are chosen to be the highest ones currently available.

3.45 through 3.50 reserved.

3.51 FRONT PANEL INTERFACE

3.51.1 The Mark V front panel is the primary user interface. Input is via three front panel push-buttons and a 16-key keypad. Output is via the one-line ten-character numeric Liquid Crystal Display (LCD) and the two-line 32-character alphanumeric LCD. The alphanumeric display shows status and various function displays. The 0.6 inch high numeric LCD continuously displays time. Colons (:) separate the day-of-year, hours, minutes and seconds.

3.52 reserved

3.53 NUMERIC DISPLAY

3.53.1 The primary function of the numeric display is to display current time. Additionally, the numeric display has the ability to indicate the occurrence of initial time lock, receiver tracking status and, in the case of an unlocked condition, the worst case clock time inaccuracy.

3.51.2 Prior to initial satellite lock, an upper case "A" will be displayed at the far left of the display indicating the receiver has not achieved a locked condition since power-up and thus is still in the initial acquisition mode. When initial time lock has occurred, the "A" will be extinguished and will not reappear until power is cycled.

3.51.3 Prior to initial time lock, an "unlock" enunciator will be visible on the display. This enunciator will extinguish when the clock has confirmed correct day of year, hour, minute and second, and the 1 PPS output is within specifications. This enunciator will reappear whenever satellite lock is lost or measured time error exceeds published specifications.

3.51.4 Whenever the Mark V is not tracking satellites, the timing accuracy of the clock will be dependent upon the accuracy and stability of the currently selected oscillator (internal or external). Time error accumulates depending upon the stability of the oscillator used and the accuracy to which it was set prior to loss of GPS steering information. The Mark V continually calculates an estimate of the "worst-case time error". When the receiver is tracking satellite signals and is operating from a known position, the worst-case error is 200 ns and time is continually displayed on the numeric display.

If lock with all satellite signals is lost, "UNLOCK" shows on the numeric display and the Serial I/O F53 command returns "F53 MODE: 0 SATS", where "MODE" is the current operating mode, i.e. AUTO, SURVEY, TIME. If the time quality indicators are enabled, the display indicates the worst-case time error in a different manner for each of four thresholds. The user may enable, disable and set these thresholds using keypad function 05 or Serial I/O function F05. When the worst-case error calculation reaches the first threshold an asterisk (*) shows on the displays. When the worst-case error calculation increases to the second threshold the asterisk starts flashing. When the calculation increases to the third threshold both colons (:) and the asterisk flash. When the calculation increases to the last threshold the time, the colons and the asterisk all flash.

Similarly for Serial I/O operation, if the time quality indicator character is enabled (see SERIAL I/O FUNCTION 11 - OUTPUT FORMAT ENTRY/REQUEST) then the time string returned by either Serial I/O F08 or F09 will indicate the worst-case time error with a different character for each of four thresholds.

As shipped, for both the display and the Serial I/O Function F08, these indicators are enabled and the default thresholds are:

First threshold - 1 us
Second threshold - 10 us
Third threshold - 100 us
Fourth threshold - 1000 us

New threshold values entered with keypad function 05 or Serial I/O function F05 are retained upon power-down and are the new defaults upon subsequent power-ups.

3.52 through 3.57 reserved

3.58 ALPHANUMERIC DISPLAY

3.58.1 The alphanumeric display is used both to display current clock status and as a means of communicating information accessible through the Mark V list of keypad functions.

3.58.2 When not being used for keypad function operation, the alphanumeric display can be set to display (in real time) the current clock mode and satellite tracking status or current time with calendar day and year. Current position information is also available but, because it requires several screens to display all of the position information, current position information is only updated upon subsequent requests.

3.59 through 3.60 reserved

3.61 TIME PUSH-BUTTON

3.61.1 The large numeric display shows time-of-year continuously. However, pressing the TIME push-button places the equivalent time-of-year and the date on the alphanumeric display. The format of the date is day-of-week, month, day-of-month, year.

3.62 reserved

3.63 STATUS PUSH-BUTTON

3.63.1 The Status Pushbutton is used to place current clock status on the alphanumeric display.

3.63.2 Additionally, PRESSING THE STATUS BUTTON WILL ABORT ANY KEYPAD FUNCTION CURRENTLY IN PROGRESS. If an incorrect function was entered,

or if the alphanumeric display shows something unexpected, pressing the status pushbutton will abort the function with no action taken by the function.

3.63.3 When pressed, the Status Pushbutton places the current clock mode and satellite tracking status on the alphanumeric display.

3.63.4 If the clock is not tracking satellites, the display will show:

STATUS: looking
for Satellites

3.63.5 If the clock has acquired a satellite but has not yet acquired satellite data lock, the display will show:

STATUS: No usable
satellites yet

3.63.6 If the clock has achieved satellite data lock, then the display will show "STATUS:", the current mode ("AUTO", "SURVEY", or "TIME"), the position fix mode ("1 sat", "2-D", or "3-D"), and report up to twelve satellites being tracked.

3.64 through 3.70 reserved

3.71 POSITION PUSH-BUTTON

3.71.1 Pressing the POSITION button will cause the location of the antenna to be displayed. The first time the POSITION button is pressed the alphanumeric display will show

LATITUDE N 38 23'55.0"

3.71.2 There may be a delay of several seconds before the latitude appears. This delay is necessary to obtain the current position solution from the core GPS receiver module.

3.71.3 The second time the POSITION button is pressed the display will show

LONGITUDE W 122 42'56.0"

3.71.4 The third time the POSITION button is pressed, the display will show:

Altitude	or	Altitude
+000050 Meters		+000152 Feet

3.71.5 The fourth time the POSITION button is pressed, the display will show:

Pdop
+2.06

which is the position dilution of precision (PDOP).

3.71.6 Each press of the POSITION button will cause the display to scroll through these four readings. The position that is displayed will change slightly each time it is displayed if the unit has adequate satellite visibility. Since these positions are unaveraged single fixes their accuracy is limited by both the geometry of the satellite constellation, and the effects of SA if not keyed. The fixes displayed using this button are equivalent to those returned via either keypad function 50 or Serial I/O Function F50.

3.72 through 3.77 reserved

3.78 KEYPAD OPERATION

3.78.1 The 16-key panel-mounted keypad consists of numeric keys "0" through "9", arrow keys "up", “down”, “right", and "left", a clear key "CLR" and the function/enter key "FUNC/ENTR". Refer to "SELECTING FUNCTIONS AND ENTERING DATA" in this section before attempting function entries. The following rules are for keypad function entry:

A. STATUS, TIME or POSITION should be on the alphanumeric display before starting a function. If not, press the "STATUS" button.

B. It takes several seconds for some functions to appear. If nothing happens after several seconds, press "STATUS", then try again.

C. When pressing keypad buttons, hold the button for 1/4 second to reduce contact bounce and insure the key is recognized. Short "pokes" may result in bad entries.

D. To enter a specific function first press FUNC/ENTR then the function number. Be sure to include the leading zeros for functions less than ten. If the function number is currently unassigned or not implemented the alphanumeric display will show the "Function not implemented" message then revert to STATUS.

E. When entries are complete and the display shows the desired data, press "FUNC/ENTR".

F. The "CLR" key will clear data entered. Example: If you intended to enter an Internal Delay of 865, but notice just prior to pressing the "FUNC/ENTR" that you inadvertently entered 855, press "CLR". The display will revert to the previous value. Then re-enter 865 and press "FUNC/ENTR". To verify your entry, press "FUNC/ENTR" and the appropriate function number and the data will display. To leave this function unchanged simply press the "STATUS" button. Your entry will remain unchanged and the display will have reverted back to "STATUS".

G. Use the left or right arrow keys to move the cursor beneath the character that you wish to edit. Use the up or down arrow keys to scroll through the possible choices for that character.

3.79 reserved

3.80 Selecting Functions and Entering Data

3.80.1 The various keypad functions are listed in the following KEYPAD FUNCTION LIST. Some of these functions are optional and may not be included in your unit. If in doubt as to whether your unit includes a particular function, try it. The alphanumeric display shows the message "Function not implemented" if the function is not in your firmware. NOTE: Most of the functions must be requested again to obtain the most current value.

3.81 reserved

3.82 Keypad Function List

FUNCTION	DESCRIPTION	AS SHIPPED	POWER-UP DEFAULT
00	Keypad Help Function		
01	Time Zone Select	00	Last Entry
02	12/24 Hour Format Select	24	Last Entry
03	Time/Date Entry		
04	Serial I/O Setup	9600,7,1,even	Last Entry
05	Time Quality Enable/Setup	On	Last Entry
06	Keypad Lock Enable	Off	Last Entry
07**	External Oscillator Enable	Off	Last Entry
13	Worst-case Time Error Req.		
14**	Ext Osc Stability Entry/Req.	None	Last Entry
16	Emulation Mode Enable	Off	Last Entry
17**	Slow Code Setup	2,4,6 sec.	Last Entry
18	Software Version Req.		
28**	Time Interval/ Event Timing	Off	Off
29**	External Frequency Meas.	Off	Off
31	Backlight Enable	Off	Last Entry
50*	Position Entry/Req.	Santa Rosa, CA	Last Calc.
51	Cable Delay Entry/Req.	50 ns	Last Entry
52	Distrib. Cable Delay Entry/Req.	00	Last Entry
53	Operational Mode Select	AUTO	Last Entry
55	Altitude Units Select	Meters	Last Entry
56	Average Position Entry/Req.		Last Entry
60	Satellite List Request		
65*	Satellite Select		Last Entry
66	Daylight Savings Enable	Off	Last Entry
68	Set Current Year	Current Year	Last Known
69	Local/Standard/GPS/UTC Time	Local	Last Entry
71	Oscillator Statistics Req.		Last Calc.
72	Fault Status	None	None
73	Display/Set Alarm Status/Control	See Section 3.254	
79	Warm Start/Clear Almanac		
92	P(Y) Functions		Last Entry

* Allow 10 seconds after entering data.
** Optional Function

3.83 KEYPAD FUNCTION DESCRIPTIONS

3.84 Keypad Function 00 - Keypad Help Function

Use keypad function 00 to obtain a short description of all keypad functions available.

Press "FUNC ENTR", then "0" "0". The display will show:

up, down keys
to view list...

Press any key to see the next display:

Func/enter key
to call function

Press any key to see the next display, the first entry in the keypad function description list:

f01: Sets time
zone

Now, the list of available keypad functions can be viewed by pressing the up or down arrow keys. Each entry in the list gives the function number and a short description of the function's purpose. If the "FUNC/ENTR" is pressed, the function being displayed will be invoked. When a function so invoked is finished, the display will revert to "status".

The help function can be exited without invoking a function by pressing the "TIME", "STATUS", or "POSITION" buttons.

3.85 Keypad Function 01 - Time Zone Select

3.85.1 Use function 01 to enter your time-zone offset. The initial out-of-the-box default is 00:00 (UTC). The default upon subsequent power-ups will be the value used before power-down. The acceptable range of offsets are +12:00 to -12:00 hours.

Press "FUNC/ENTR", then "0" "1". The display will show

Time zone hr: min
±00:00

Press the right or left arrow keys to position the cursor beneath the character that you wish to change. Press the up or down arrow keys to scroll through the possible choices. Alternately, directly enter the numbers using the keypad. The cursor will advance to the next digit automatically. When the display shows the desired time-zone offset press "FUNC/ENTR" to enter your choice.

3.86 reserved

3.87 Keypad Function 02 - 12/24 Hour Format Select

3.87.1 Use function 02 to select either the 12-hr or 24-hr time display format. Upon initial out-of-the-box power-up the default is the 24-hr format. Upon subsequent

power-ups the default will be whatever the format was before the previous power-down.

Press "FUNC/ENTR", then "0" "2". The display will show

12/24 hr Format or 12/24 hr Format
24 12

Press the up or down arrow keys to toggle between 24 and 12. When the display shows the desired format, press "FUNC/ENTR" to enter your choice.

3.88 reserved

3.89 Keypad Function 03 - Date and Time Entry

3.89.1 Use function 03 to enter time and date. The initial out-of-the-box default is UTC date and time. The time-of-year before power-down will be the default upon subsequent power-ups.

Press "FUNC/ENTR", then "0" "3". The display will show:

Date-time or Date-time
UTC Local

Press the up or down arrow keys to toggle between "UTC" and "Local" depending on which you intend to enter. When the display shows your choice, press "FUNC/ENTR" again and the display will show:

Date-time
MM/DD/YY

where MM is the month, DD is the day and YY is the year. Press the right or left arrow keys to move the cursor beneath the digit that you wish to change. Press the up or down arrow keys to scroll through the possible choices. Alternately, directly enter the numbers using the keypad. The cursor will advance to the next digit automatically. NOTE: Although an illegal date entry will display, the entry will not be accepted.

Press "FUNC/ENTR" again and the display will show

Date-time
HH:MM:SS

where HH is the hours, MM is the minutes and SS is the seconds.

Press the left or right arrow keys to position the cursor beneath the digit that you wish to change. Press the up or down arrow keys to scroll through the possible choices. Alternately, directly enter the numbers using the keypad.

The cursor will advance to the next digit automatically. Press "FUNC/ENTR" to enter the data. Only valid dates may be entered.

3.90 reserved

3.91 Keypad Function 04 - Serial I/O Setup

3.91.1 Use function 04 to configure the Serial I/O port. The initial out-of-the-box default values are:

Baud Rate - 9600
Data Bits - 7
Parity - even
Stop bits - 1

The default values on subsequent power-ups will be those in use prior to the previous power-down.

Press "FUNC/ENTR, then "0" "4". The display will show

Ser port setup
Baud rate 9600

Press the up or down arrow keys to scroll through the possible baud rate choices. When the display shows the desired baud rate, press "FUNC/ENTR" again and the display will show:

Ser port setup
Data bits 7

Press the up or down arrow keys to toggle between 7 and 8 data bits choices. When the display shows the desired choice, press "FUNC/ENTR" again and the display will show:

Ser port setup
Parity even

Press the up or down arrow keys to toggle between even or odd parity. When the display shows the desired parity press "FUNC/ENTR". The display will show:

Ser port setup
Stop bits 1

Press the up or down arrow keys to toggle between 1 and 2 stop bits. When the display shows the desired choice, press "FUNC/ENTR" to enter all the serial port data.

3.92 reserved

3.93 Keypad Function 05 - Time Quality Enable/Setup

3.93.1 Both the front-panel numeric display and the Serial I/O time output string indicate time quality. Refer to NUMERIC DISPLAY earlier in this section for a complete description of the display's time quality indications. Refer to Serial I/O FUNCTION FO8 - CONTINUOUS TIME ONCE PER SECOND for a description of the time quality indication in the Serial I/O time output string. As shipped the time quality indication is enabled and the thresholds are:

First threshold - 1 us
Second threshold - 10 us
Third threshold - 100 us
Fourth threshold - 1000 us

3.93.2 Use Function 05 to enable or disable the time quality indication or set the worst-case-error thresholds. Press "FUNC/ENTR", then "0" "5". The display will show:

Time quality or Time quality
on off

Press the up or down arrow keys to toggle between "on" and "off". When the display shows the desired state, press "FUNC/ENTR". The display will show:

First tq flag:
00000001000s

or the current value. Press the right or left arrow keys to position the cursor beneath the digit that you wish to change. Press the up or down arrow keys to scroll through the possible digit choices. Alternately, directly enter the numbers using the key pad. The cursor will advance to the next digit automatically. When the display shows the value that you desire for the first time quality threshold, press "FUNC/ENTR". The display will show:

Second tq flag:
00000010000ns

or the current value. Press the right or left arrow keys to position the cursor beneath the digit that you wish to change. Press the up or down arrow keys to scroll through the possible digit choices. Alternately, directly enter the numbers using the key pad. The cursor will advance to the next digit automatically. When the display shows the value that you desire for the second time quality threshold, press "FUNC/ENTR". The display will show:

Third tq flag:
00000100000ns

or the current value. Press the right or left arrow keys to position the cursor beneath the digit that you wish to change. Press the up or down arrow keys to scroll through the possible digit choices. Alternately, directly enter the numbers using the key pad. The cursor will advance to the next digit automatically.

When the display shows the value that your desire for the third time quality threshold, press "FUNC/ENTR".

The display will show:

Fourth tq flag:
00001000000ns

or the current value. Press the right or left arrow keys to position the cursor beneath the digit that you wish to change. Press the up or down arrow keys to scroll through the possible digit choices. Alternately, directly enter the numbers using the key pad. The cursor will advance to the next digit automatically. When the display shows the value that you desire for the fourth time quality threshold, press "FUNC/ENTR" to enter all of the data. The acceptable threshold values are 40000000000 ns to 00000000010 ns.

3.94 through 3.95 reserved

3.96 Keypad Function 06 - Keypad Lock Enable

3.96.1 Use function 06 to enable or disable the keypad. The keypad lock function, when enabled, prevents unauthorized or accidental entries on the keypad. The initial out-of-the-box default is "off". The default upon subsequent power-ups will be the same as it was on the previous power-down.

Press "FUNC/ENTR" then "0" "6". The display will show

Keypad Lock	or	Keypad Lock
on		off

Press up or down arrow keys to toggle between "on" and "off". When the display shows the desired choice, press "FUNC/ENTR". After the keypad lock is enabled, any attempt to enter a function on the keypad (except keypad function 06) will result in the message "Keypad locked" or "Function not implemented".

3.97 reserved

3.98 Keypad Function 07 - External Oscillator Enable (Option)

3.98.1 Use function 07 in conjunction with function 14 to enable or disable Phase Locking to an External Auxiliary Oscillator. The hardware configuration of the Mark V must be able to support this function. The initial out-of-the-box default is "off". The default upon subsequent power-ups will be the same as it was on the previous power-down.

Press "FUNC/ENTR" then "0" "7". The display will show

Ext Oscillator	or	Ext Oscillator
DISabled		ENabled

Press the up or down arrow keys to toggle between "Disabled" and "Enabled". When the display shows the desired choice, press "FUNC/ENTR" to enter your choice.

3.99 reserved

3.100 Keypad Function 13 - Worst-Case Time Error Request

3.100.1 Use function 13 to display the worst-case time error due to oscillator drift during periods when satellites are not being tracked.

Press "FUNC/ENTR", then "1" "3". The display will show:

Time error
Over range

if the unit has not yet acquired valid time or:

Time error ±
00.000 000 200

if the unit is tracking satellites and has acquired valid time. If the Mark V acquired valid time but subsequently lost lock to the satellite signals, then the time displayed and output will begin to drift. This drift is dependent on the stability of the internal oscillator, or the external oscillator if it is enabled, and the accuracy to which it had been set on frequency prior to the outage. The stability of the external oscillator must be entered using the keypad function 14 (see below). The processor calculates and displays in seconds the worst-case time based on the stability of the oscillator in use.

3.101 reserved

3.102 Keypad Function 14 - External Oscillator Parametery Entry / Request (Option)

3.102.1 If the external oscillator is enabled, the parameters of the external oscillator are used to calculate the control coefficients as well as the worst-case time error as described earlier in this section. Use keypad function 14 or Serial I/O function F14 to set or determine the parameters of the external oscillator. The default upon subsequent power-ups will be whatever the values were at the previous power-down.

Press "FUNC/ENTR" then "1" "4". The display will show:
External Osc
FREQ _1 MHz

Press the up or down arrow keys to select either 1, 5 or 10 MHz as the input frequency of the external oscillator. Press "FUNC/ENTR" to enter your choice. Now the display will show:
Ext Osc TUNING
SLOPE ±1.00e-06

Press the up or down arrow keys to toggle the sign of the external oscillator voltage control tuning slope which is entered in units of fractional frequency offset per volt. Press the right arrow key to move to the next digit. Either press the up or down arrow keys or alternately, directly enter numbers from the keypad for each of the remaining digits. The cursor will automatically advance to the next position when a number is entered directly. When the display shows the desired choice, press "FUNC/ENTR" to enter your choice. Now the display will show:

Ext Osc DAC
NOMINAL 0.50

Press the up or down arrow keys or directly enter the values desired for each digit to set the initial starting value of the external oscillator control voltage. The number input here sets the decimal fractional value of the full scale DAC output voltage swing (which may be configured to be either 0 to +10 Volts or -5 to +5 Volts via a jumper on the 87-6XX GPS-XL board, refer to Dwg. No. 87-6XX at the end of this manual) to be used for the initial control voltage setting. Valid input range is 0.00 to 1.00. Once the desired value has been set, press "FUNC/ENTR". The display will show:
Ext Osc TEMP
STAB 5.00e-10

Using the same combination of arrow keys and direct digit entry, set the 0C to 60 C temperature stability of the external oscillator that is being controlled.

This value is used by the Mark V to determine the optimal control loop averaging time so that performance under environmental stress of up to 8.3 C per hour temperature change does not degrade the output frequency stability significantly below that of the GPS system stability.

Inputting of better or worse temperature stability than the external oscillator actually has allows adjustment by the user of the control loop averaging time being used. This may be desirable when the user knows that the environment differs significantly from the rather stringent 8.3 C per hour assumption made by the Mark V.

As an example, if the environment is known to exhibit maximum temperature changes on the order of 1 C per hour and the user would desire more filtering of the de-stabilizing effects of SA from the outputs of the Mark V, a smaller value for the temperature stability of the external oscillator could be entered. The control loop averaging time would then be lengthened relative to the default averaging time assuming the true temperature stability were entered, by the square root of the ratio of the true temperature stability divided by the temperature stability actually entered.

After pressing "FUNC/ENTR" to set the external oscillator temperature stability, the display will show:
Save Ext Osc
Parameters? No

Use the up or down arrow key to toggle the desired action and press "FUNC/ENTR". The external oscillator parameters have now been saved to NVRAM and will be used immediately if the External Oscillator has already been enabled via keypad function 07 or Serial I/O Function F07. Otherwise they will be used when the external oscillator is next enabled.

3.103 reserved

3.104 Keypad Function 16 - Emulation Mode Enable

3.104.1 Use keypad function 16 to enable or disable the emulation mode. When the emulation mode is "off", the Serial I/O port and the IEEE port respond to the "Mark III command set" as described in this section under Serial I/O FUNCTION DESCRIPTIONS and in Section XII under IEEE-488 FUNCTION DESCRIPTIONS. When the emulation mode is "on", the Serial I/O port and the optional IEEE port respond to the "Mark II command set" as described in this section under Serial I/O EMULATION COMMANDS and in Section XII under IEEE-488 EMULATION COMMANDS. The emulation mode cannot be enabled or disabled via either communications port.

The Mark II command set is composed of selected commands used on earlier TrueTime synchronized clocks. Therefore, most Serial I/O programs written for use with these earlier models may be used with this model.

When the emulation is enabled or disabled, the Serial I/O port and the IEEE-488 port will both change modes, even if they are waiting to complete a command. When emulation mode is turned on, or power is applied when emulation is "on", the Serial I/O port will enter MODE C, continuous time once per second, and the default format will be in effect. The IEEE-488 port, however, will wait for a command. When emulation mode is turned off or power is applied to the unit when emulation is "off", the Serial I/O port will enter the F08 command and send time once per second. The IEEE-488 port will abort whatever command is in progress and wait to receive another command.

When emulation is "on", the Serial I/O port acknowledges the commands C, T, F, and R. The IEEE-488 port acknowledges the commands T, and F. Note that the ADVANCED IEEE-488 OPTION Assembly 86-386 does not support the emulation of the older units.

The initial out-of-the-box default is "off". The default on subsequent power-ups is whatever it was just before the previous power-down.

Press "FUNC/ENTR" then "1" "6". The display will show

Emulation mode off	or	Emulation mode on

Press the up- or down-arrow keys to toggle between "off" and "on". When the display shows the desired choice, press "FUNC/ENTR" and the command set will change.

3.105 reserved

3.106 Serial I/O Emulation Commands

3.106.1 As a convenience to our customers the TrueTime Mark V emulates most of the Serial I/O port commands of the older GPS-DC Mark II GPS Synchronized Clock. Most customer programs written to interface with the Mark II Serial I/O port will also interface with the Mark V Serial I/O port if the emulation mode is enabled with keypad function 16. Refer to the following Table for the available emulation mode commands.

EMULATION MODE COMMANDS

COMMAND	MODE	DESCRIPTION
C	Mode C	Continuous time, once per second
F	Mode F	Format Time Message
R	Mode R	Reset to default time format and Mode C
T	Mode T	Time on request

When the emulation mode is enabled with keypad function 16, the output defaults to Mode C. If the unit was in the emulation mode at power-down, it will power up in the emulation mode and default to Mode C. If the operator uses FUNCTION 03 to enter time before it appears on the front panel display, then the entered time will output at the Serial I/O port.

3.107 reserved

3.108 Mode C - Continuous Time, Once Per Second

3.108.1 Use Mode C to cause the Serial I/O port to output the time message once each second. Mode C is the power-up default. To request Mode C send the ASCII character C to the Serial I/O port. The format of the output string may be changed with Mode F. The default output string format is:

<SOH>DDD:HH:MM:SSQ<CR><LF>

where

<SOH>	=	ASCII start-of-header character (HEX 01).
DDD	=	three-digit day of year.
:	=	ASCII colon character.
HH	=	two-digit hours.
MM	=	two-digit minutes.
SS	=	two-digit seconds.
.	=	ASCII period character.
Q	=	time quality character (see following).

<CR> = ASCII carriage return character.
<LF> = ASCII line feed character.

The time quality character may be one of the following:

SPACE which indicates a worst-case error less than threshold 1.
. which indicates a worst-case error greater than or equal to threshold 1.
* which indicates a worst-case error greater than or equal to threshold 2.
# which indicates a worst-case error greater than or equal to threshold 3.
? which indicates a worst-case error greater than or equal to threshold 4.

The time quality character prior to satellite signal acquisition will be "?". Refer to Serial I/O FUNCTION F13 - WORST-CASE TIME ERROR REQUEST for an explanation of worst-case error. The carriage return character <CR> start bit begins on the second, +0 to +1 bit period or ±1 ms, whichever is larger.

To halt the output of time once each second send another command character to the Serial I/O port. Non-command characters will be ignored if sent to the Serial I/O port. If the command character C is sent to the Serial I/O port prior to acquisition of time of year, then the port will output time elapsed from power-up once each second. Once correct time has been acquired, the port will output time of year.

3.109 reserved

3.110 Mode F - Format the Time Message

3.110.1 Use Mode F to alter the format of the time output string used in Mode C and Mode T. To set the format send a string of the form:

FDDD<C1>HH<C2>MM<C3>SS<C4>mmmQ

where

F = Mode F command.
DDD = three characters for days.
<C1> = character that will be transmitted between the days and hours.
HH = two characters for hours.
<C2> = character that will be transmitted between the hours and minutes.
MM = two characters for minutes.
<C3> = character that will be transmitted between the minutes and seconds.
SS = two characters for minutes.

<C4>	=	character that will be transmitted between the seconds and milliseconds.
mmm	=	three characters for milliseconds.
Q	=	single character for the time quality.

If an X is used as a character in any character position, including the time quality character position, that position and its data will be omitted from the format. Any other character except a mode command character enables that position in the format.

There are no character transmissions until formatting is terminated. There are three ways to terminate formatting. 1) If a command character is sent before completing the format string, the altered portion of the format is accepted and the remainder of the format is unchanged and the new mode is entered. 2) If an ASCII line feed character (HEX 0A) is sent before completing the format string, the altered portion of the format is accepted and the remainder of the format uses the default and the time is immediately output once in the new format. 3) If all 15 characters of the format string are entered, the port will immediately output time once in the newly selected format. This new format will be used for time output in both Mode C and Mode T.

Note that the milliseconds are not available in Mode C even though formatted. On power-up the format will revert to the default format. Further note that the response of F mode is only accurate to about ±1 sec and is intended only to indicate the current format, not to provide time information.

Sample Entry: F123/12:34:66.789Q
Response: <SOH>360/22:01:25.602*<CR><LF>

Sample Entry: FXXX hh, mm, ss XXXX
Response: <SOH> 22,01,25 <CR><LF>

Sample Entry: FDDDAXXT
Response: <SOH>360A:01:25.602*<CR><LF>

3.111 reserved

3.112 Mode R - Reset to Default and Mode C

3.112.1 Use Mode R to reset to the default format and return to Mode C. Send the command character R to the Serial I/O port and the port will respond by outputting time in the default format once per second. Any previous Mode F format is canceled.

The data and carriage return timing of the initial output string sent immediately following the command character R is not reliable. This is due to internal synchronization with the data rate.

3.113 reserved

3.114 Mode T - Time on Request

3.114.1 Use Mode T to request a single output of time to the nearest millisecond. Send the command character T to the Serial I/O port and the unit will save the time of year as of 9 bits after the center of the start bit of the character T then the port will immediately respond with a single time data string in the current format selected. The Serial I/O port outputs no further data until it receives another command character. The format of the Mode T string may be altered using Mode F. The default format is:

<SOH>DDD:HH:MM:SS.mmmQ<CR><LF>

where

<SOH>	=	ASCII start-of-header character (HEX 01).
DDD	=	three-digit day of year.
:	=	ASCII colon character.
HH	=	two-digit hours.
MM	=	two-digit minutes.
SS	=	two-digit seconds.
.	=	ASCII period character.
Q	=	time quality character as described below.
<CR>	=	ASCII carriage return character.
<LF>	=	ASCII line feed character.

The time quality character may be a:

SPACE which indicates a worst-case error less than threshold 1.
. which indicates a worst-case error greater than or equal to threshold 1.
* which indicates a worst-case error greater than or equal to threshold 2.
# which indicates a worst-case error greater than or equal to threshold 3.
? which indicates a worst-case error greater than or equal to threshold 4.

If a command character T is sent to the Serial I/O port prior to the acquisition of time, then the Serial I/O port will output time elapsed from power up.

3.115 reserved

3.116 Keypad Function 17 - Slow Code Setup (Option)

3.116.1 Use function 17 to control the Slow Code output. This is an optional rear panel BNC connector. This output provides one pulse per minute, primarily for placing timing marks on drum recorders. Each pulse edge is aligned to within a few nanoseconds of the clock's 1 PPS pulse, with the rising edge at the start of a minute. The initial out-of-the-box default values are:

Once per minute pulse 2 seconds long.
Once per hour pulse 4 seconds long.
Once per day pulse 6 seconds long.

The default values upon subsequent power-ups will be those in use just prior to the previous power-down.

Press "FUNC ENTR", then "1" "7". The display will show:

Slow Code minute
pulse 02 sec

or a different number of seconds. This means that the once per minute slow code pulse will be 2 seconds long. Press the right- or left-arrow keys to position the cursor beneath the digit that you wish to edit. Press the up- or down-arrow keys to scroll through the possible digit choices. Alternatively, directly enter the numbers using the keypad. The cursor will advance to the next digit automatically. When the display shows the value that you desire for the pulse width, press "FUNC/ENTR". The display will show:

Slow Code hour
pulse 04 sec

or a different number of seconds. This means that the once per hour slow code pulse will be 4 seconds long. Press the right- or left-arrow keys to position the cursor beneath the digit that you wish to edit. Press the up- or down-arrow keys to scroll through the possible digit choices. Alternatively, directly enter the numbers using the keypad. The cursor will advance to the next digit automatically. When the display shows the value that you desire for the pulse width, press "FUNC/ENTR". The display will show:

Slow Code day
pulse 06 sec

or a different number of seconds. This means that the once per day slow code pulse will be 6 seconds long. Press the right- or left-arrow keys to position the cursor beneath the digit that you wish to edit. Press the up- or down-arrow keys to scroll through the possible digit choices. Alternatively, directly enter the numbers using the keypad. The cursor will advance to the next digit automatically. When the display shows the value that you desire for the pulse width, press "FUNC/ENTR". The display will then return to the status display, completing the entry of the slow code pulse widths.

If the function is aborted by pressing the TIME, STATUS, or POSITION keys before the third press of the "FUNC/ENTR" key, none of the changes will take effect.

Any of the 3 pulses may be set for widths between 0 and 59 seconds. A value of 0 means that the pulse will be absent from the Slow Code output.

3.117 reserved

3.118 Keypad Function 18 - Software Version Request

3.118.1 Use keypad function 18 to obtain information about the current version of the software installed in the unit.

Press "FUNC/ENTR", then "1" "8". The display will show, for example:

TRUETIME Mk III
sys ver 016

Press any of the arrow keys, to change the display to the clock-specific version. For example:

GPS-XL V1.034
182-6078v008

Repeated presses of arrow keys will switch back and forth between the two displays.

The two examples shown indicate that the system software is version 016, and the clock-specific software is version 1.034, PART NO. 182-6078v008.

To return to the status display, press the "FUNC/ENTR", or "STATUS" button.

3.119 through 3.125 reserved

3.126 Keypad Function 28 - Time Interval / Event Timing (Option)

3.126.1 Refer to section 3.398 for specifications on the Time Interval/Event Timing input. Use this function to measure the relationship of either periodic or randomly occurring events to the internal time of the Mark V.

The Time Interval (TI) mode is best suited to periodic events such as measuring an externally applied 1PPS input. In this mode the reported time interval is expressed as the fractional part of a second between the Mark V 1PPS which starts the count and the external 1PPS which stops it.

The Event Timing (ET) mode is suited to randomly occurring events whose time of occurrence is needed to a high accuracy. In this mode, the reported event time is expressed as a complete day-of-year through nanoseconds timetag.

Press "FUNC/ENTR", "2","8". The display will show:

Select TI or ET
Time Interval

Press the up or down arrow key to toggle between the two modes of operation. When the desired mode is displayed, press "FUNC/ENTR" to set it. The display will show one of these formats for the measurements:

TI: .123456789

or

ET: 123:24:12:60
.123456789

Pressing "FUNC/ENTR" will abort measurement and return to the previous menu allowing selection of the TI/ET mode. Pressing any of these keys will abort the TI/ET function: "TIME", "STATUS" or "POSITION".

3.127 reserved

3.128 Keypad Function 29 - External Frequency Measurement (Option)

3.128.1 Refer to section 3.333 "SERIAL I/O FUNCTION F29 - EXTERNAL FREQUENCY MEASUREMENT (OPTION)" for a detailed operating description of this function. The keypad version offers a sub-set of the capabilities available in the Serial I/O version.

This function allows the user to set up periodic high resolution fractional frequency offset measurements of an externally applied 1, 5 or 10 MHz input relative to the GPS disciplined internal or external oscillator. These measurements are then displayed at the user set interval until another key is pressed.

Press "FUNC/ENTR", "2","9". The display will show:

External Freq
10 MHz

Use the up or down arrow keys to select the correct input frequency for the Mark V to measure. Press "FUNC/ENTR" to enter the selection. The display will now show:

Meas Interval
000001 sec

Use a combination of right and left arrow keys and either the up and down arrow keys or direct digit entry to set the frequency measurement interval. Press "FUNC/ENTR" to enter the selection. After completion of the first measurement, the display will show:

ExtFreq XX:XX:XX
+x.xxxxxxxxe-xx

where XX:XX:XX is the time stamp of the endpoint of the displayed measurement and +x.xxxxxxxxe-xx is the fractional frequency offset measurement. These measurements will continually be displayed at the interval

selected until any of these keys is pressed: "FUNC/ENTR", "TIME", "STATUS", or "POSITION".

3.129 reserved

3.130 Keypad Function 31 - Backlight Enable

3.130.1 Use function 31 to turn "on" or "off" the display back light. The backlight is standard on the alphanumeric display and therefore present on all units. However, the backlight for the numeric display is optional and may not be on your particular unit. Function 31 controls both backlights. The initial out-of-the-box default is "off". The default on subsequent power-ups is whatever it was before the previous power-down.

Press "FUNC/ENTR" then "3" "1". The display will show:

Backlight or Backlight
off on

Press the up or down arrow keys to toggle between "off" and "on". When the display shows the desired choice, press "FUNC/ENTR" and the backlight will respond.

3.131 through 3.168 reserved

3.169 Keypad Function 50 - Position Entry / Request

3.169.1 Use keypad function 50 to enter or request the current antenna position. Since function 50 returns the most recent fix computed by the GPS core receiver, not the long term averaged position which is calculated during the AUTO mode of operation and reported via either keypad function 56 or Serial I/O function F56, its use is mainly for initializing the approximate position of the GPS core receiver at new installations or after loss of non-volatile RAM back-up power.

The out-of-the-box default for position is that of the TrueTime factory in Santa Rosa, California. The position on subsequent power-ups will be the same as it was on the previous power-down.

Press "FUNC/ENTR", then "5" "0". The display will show:

Latitude
N 38 23'53.9"

Press the right or left arrow keys to position the cursor beneath the character that you wish to change. Press the up or down arrow keys to scroll through the possible choices. Alternately, numbers may be directly entered using the keypad. The cursor will automatically advance to the next position. When the display shows the desired latitude, press "FUNC/ENTR" and the display will show:

Longitude
W 122 42'53.0"

Press the right or left arrow keys to position the cursor beneath the character that you wish to change. Press the up or down arrow keys to scroll through the possible choices. Alternately, numbers may be directly entered using the keypad. The cursor will automatically advance to the next position. When the display shows the desired longitude, press "FUNC/ENTR" and the display will show:

Altitude
±000055 Meters

Press the right or left arrow keys to position the cursor beneath the character that you wish to change. Press the up or down arrow keys to scroll through the possible choices. Alternately, numbers may be directly entered using the keypad. The cursor will automatically advance to the next position. When the display shows the desired altitude, press "FUNC/ENTR" and all of the new position data will be entered. To abort without changing the initial position data, press the "STATUS" button any time before the final "FUNC/ENTR". If the user attempts to enter a value that is out of the acceptable range the display will show the message

Value error!
re-enter

and the user will be given a chance to re-enter the correct position value.

3.170 reserved

3.171 Keypad Function 51 - Cable Delay Entry / Request

3.171.1 Use function 51 to request or enter a fixed delay to be used to adjust the time outputs. The default is +50 ns. The value is held in NVRAM.

Press "FUNC/ENTR", then "5" "1". The display will show:

Cable delay
±000000050 ns

Press the right or left arrow keys to position the cursor beneath the digit that you wish to change. Press the up or down arrow keys to scroll through the possible choices. Alternately, numbers may be directly entered using the keypad. The cursor will automatically advance to the next position. When the display shows the desired delay, press "FUNC/ENTR" to enter the data. The acceptable range of delays is from +001000000ns to -001000000ns. *Positive delays entered here will advance the Mark V timing outputs while negative delays will retard them.*

3.172 through 3.174 reserved

3.175 Keypad Function 52 - Distribution Cable Delay Entry / Request

3.175.1 Use function 52 to request or enter a fixed delay to be used to compensate the timing outputs for distribution cable delays between the Mark V and the point of use of the timing signals. Antenna cable delay compensation should not be performed using this function. Use function 51 for antenna cable delay. The default is 0 ns. The value is held in NVRAM.

Press "FUNC/ENTR", then "5" "2". The display will show:

Cable delay
±000000000 ns

Press the right or left arrow keys to position the cursor beneath the digit that you wish to change. Press the up or down arrow keys to scroll through the possible choices. Alternately, numbers may be directly entered using the keypad. The cursor will automatically advance to the next position. When the display shows the desired delay, press "FUNC/ENTR" to enter the data. The acceptable range of delays is from +001000000ns to -001000000ns. *Positive delays entered here will advance the Mark V timing outputs while negative delays will retard them.*

3.176 through 3.184 reserved

3.185 Keypad Function 53 - Operating Mode Select

3.185.1 Use function 53 to select the operating mode, either AUTO, SURVEY (OPTION) or TIME. These operating modes are explained in detail at the beginning of this section. The initial out-of-the-box default is AUTO mode. The default on subsequent power-ups is the mode on the previous power-down.

Press "FUNC/ENTR", then "5" "3". The display will show:

AUTO / TIME Mode
AUTO

Press the up or down arrow keys to scroll through the possible operating modes. When the display shows the desired mode, press "FUNC/ENTR" to enter your choice.

When the optional SURVEY mode of operation is available and is selected, either the STATIC or DYNAMIC sub-mode of SURVEY operation must be selected, the display will show:

Dynamic Mode
STATIC

Press the up or down arrow keys to scroll through the possible SURVEY operating sub-modes. When the display shows the desired sub-mode, press "FUNC/ENTR" to enter your choice.

3.186 through 3.198 reserved

3.199 Keypad Function 55 - Altitude Units Select

3.199.1 Use function 55 to select the units that altitude will be expressed in, either feet or meters. The initial out-of-the-box default is meters. The default on subsequent power-ups is whatever the unit was at before the previous power-down.

Press "FUNC/ENTR", then "5" "5". The display will show:

Altitude mode or Altitude mode
Meters Feet

Press the up or down arrow keys to toggle between "Meters" and "Feet". When the display shows the desired units of measure, press "FUNC/ENTR" to enter your choice.

3.200 reserved

3.201 Keypad Function 56 - Average Position Entry / Request

3.201.1 Use keypad function 56 to enter or request the averaged, hence accurate, current antenna position. Its main use is to provide a means of setting an accurate, surveyed position for use in the TIME mode of operation. Positions provided to the Mark V via function 56 should be more accurate than 10 meters, otherwise better results may be obtained via AUTO mode, unless satellite visibility at the site is too poor to provide three dimensional positioning.

The out-of-the-box default for position is that of the TrueTime factory in Santa Rosa, California. The position on subsequent power-ups will be the same as it was on the previous power-down. An averaged position as returned via function 56 which subsequently becomes in error by more than 1 Km, either due to transport of the receiver and antenna or error in the initial entry, will be cleared and recalculated automatically once positioning begins at the new site and the error is detected.

To determine or modify the present position press "FUNC/ENTR", "5","6" and the display will show:

Averager Count or Entered Average
XXXXX/90000 Position

Indicating either that the present average position is based on XXXXX position fixes, and that 90000 such fixes will be averaged to complete the accurate position determination or that the current averaged position was entered. Press "FUNC/ENTR" again to display:

Ave. Latitude
N DD MM'SS.S"

By pressing a combination of arrow keys and/or direct digit entry, this latitude may be changed. When it is as desired, press "FUNC/ENTR" to display:

Ave. Longitude
W DDD MM'SS.S"

By pressing a combination of arrow keys and/or direct digit entry, this longitude may be changed. When it is as desired, press "FUNC/ENTR" to display:

Ave. Altitude
+XXXXXX Meters

By pressing a combination of arrow keys and/or direct digit entry, this height above the WGS-84 ellipsoid may be changed. When it is as desired, press "FUNC/ENTR" to display:

Enter average
position? No

This choice will only be made available if the XL-DC is operating in the TIME mode. Use the up or down arrow key to toggle to the desired response and press "FUNC/ENTR" to either cancel entry or complete it.

3.202 through 3.209 reserved

3.210 Keypad Function 60 - Satellite List Request

3.210.1 Use function 60 to list tracked or bad satellites and to see the relative signal strength of the tracked satellites.

Press "FUNC/ENTR", then "6", "0". The display will show:

List sats:
Tracked

Press the up or down arrow keys to toggle between "Tracked" and "Bad". Once the type of list has been selected, press "FUNC/ENTR" again. The display will show:

Tracked Sats:
#14 +41 dB L1 CA

or Bad Sats:
#14

depending on which list was requested. Some other Satellite number may display. When observing Tracked Sats the number following the satellite number is the relative signal strength of that satellite. Additionally the link frequency and code may be displayed. Keyed receivers will use Y code. Each time "FUNC/ENTR" is pressed the display will show the next Tracked or Bad Satellite number. When the list is complete the display will show:

Tracked sats: or Bad sats:
End of list End of list

Press "FUNC/ENTR" again and the display will show the initial display. Press the "STATUS" button to exit function 60.

3.211 through 3.220 reserved

3.221 Keypad Function 65 - Satellite Select

3.221.1 Use function 65 to select specific satellites for the receiver to track and to deselect satellites, i.e. instruct the Mark V to ignore certain satellites. Selections will be retained in non-volatile memory. Subsequent to a power cycle, this function must be executed to reinstate the deselect list. Press "FUNC/ENTR", then "6" "5". The display will show:

Sat# 14 or Sat# 14
Enabled Disabled

or some other satellite number. Press the up or down arrow key to toggle between "Enable" and "Disable". When the display shows the desired choice press "FUNC/ENTR". Each time "FUNC/ENTR" is pressed the display will show the next satellite and whether it is enabled or disabled until all satellites for which the GPS core receiver has data are displayed. Then the display will show:

End Press
Enter to confirm

Press "FUNC/ENTR" to enter your selections. To abort without changing the status of the satellites press the "STATUS" button.

3.222 reserved

3.223 Keypad Function 66 - Daylight Savings Enable

3.223.1 Use function 66 to set the Daylight Savings Time entry and exit times. The initial out-of-the-box default is "Off". The default upon subsequent power-ups will be the selection in use just prior to the previous power-down.

Press "FUNC/ENTR", then "6" "6". The display will show:

Daylight Saving or Daylight Saving
Off Manual

Press the up- or down-arrow key to scroll between the choices. When the display shows the desired choice press "FUNC/ENTR" to enter your choice.

3.223.2 The display and all other time outputs indicate UTC without any DST adjustment if a time-zone offset of 00:00 is selected. Regardless of the time-zone offset there will be no DST adjustment if "Off" is selected for the DST function. Some

local jurisdictions enter and leave DST at times other than those set by U.S. federal law. Therefore, TrueTime has included a "Manual" choice that allows the user to override the times of entry into and exit from DST by selecting his own. If "Manual" is selected for the DST function, the display will show:

Enter dst: 02:00
1st Sun in Apr

or some other entry time and date. Press the right- or left-arrow keys to position the cursor beneath the character that you wish to change. Press the up- or down-arrow keys to scroll through the possible choices. Alternatively, directly enter the numbers using the keypad. The cursor will automatically advance to the next position. The hours may range from 0 to 23. The week may be "1st", "2nd", "3rd", "4th", or "Last". Any day of the week or month may be selected. The above display means that Daylight Savings Time will start at 2 a.m. local time on the first Sunday in April each year. DST transitions may be set to occur at any hour of the day, any day of the week or any month of the year with the following restriction: If either transition is less than 24 hours from the start or end of a year, the transition may not occur at the desired time.

3.223.3 When the display shows the desired entry time and date, press "FUNC/ENTR" again, and the display will show:

Leave dst: 02:00
Last Sun in Oct

or some other entry time and date. Press the right- or left-arrow keys to position the cursor beneath the character that you wish to change. Press the up- or down-arrow keys to scroll through the possible choices. Alternatively, directly enter the numbers using the keypad. The cursor will automatically advance to the next position. The ranges are the same as before but the exit time must be later than the entry time otherwise DST will never be entered. When the display shows the desired exit time, press "FUNC/ENTR" to enter the selections. The data entry may be aborted at any time prior to pressing the last "FUNC/ENTR" by pressing either the "TIME", "STATUS", or "POSITION" keys.

3.223.4 Once the entry and exit times are entered, they will be retained in nonvolatile memory if the clock loses power or is turned off. If the nonvolatile memory is corrupted due to battery failure or any other cause, the entry time will default to 2:00 a.m. on the first Sunday in April and the exit time will default to 2:00 a.m. on the last Sunday of October.

The sequence of the count upon entry into DST is:

01:59:58
01:59:59
03:00:00
03:00:01

assuming the entry time was 2:00 a.m.. The sequence upon exit from DST is:

01:59:58
01:59:59
01:00:00
01:00:01

assuming the exit time was 2:00 a.m.

3.223.5 If the DST function is enabled or disabled when DST is already in effect, the display will take several seconds to respond. Each time zone transitions into and out of Daylight Savings Time independently. This means that if the current time zone just entered DST and the time zone offset is then changed by means of keypad function 01 to a time zone in which the local time of the transition has not yet occurred, the standard time for that zone will be displayed. If the original time zone setting is restored, its time will remain in DST.

3.224 through 3.225 reserved

3.226 Keypad Function 68 - Set Current Year

3.226.1 The GPS week number sent from the satellites has only 10 bits of precision, so that after 1024 weeks from January 6, 1980 (GPS week 0) it rolls back to 0. To correctly calculate calendar dates after this roll point, the software keeps track of the current year so that it can construct an absolute, non-rolling week number since January 6, 1980.

3.226.2 This software release knows that it is already at least 1996, and it will properly handle dates for the next 17 years. In addition, as the clock advances to each new year, the current year is saved and used in the calendar calculations from that point on, so that calculations beyond 2012 are also handled properly. No user intervention is required as long as the clock runs locked to GPS at least once in 5 years to allow the year to be updated.

3.226.3 If after 2012, the current year saved in non-volatile memory is lost, or the clock is not locked to GPS within 5 years of the last year save in non-volatile memory for Function 68, then Function 68 can be used to manually enter the current year. Years prior to 1996 are not accepted, and entering a future year may cause incorrect calendar date calculations.

3.226.4 Press “FUNC/ENTR” “6” “8” and the display will show:

Set current year
1996

The year displayed will be the year saved in non-volatile memory used in the calendar calculations. To change it, enter the current year, then press “FUNC/ENTR”. The display will prompt with:

Save year?
No

To save, use the up arrow key to change “No” to “Yes”, then press “FUNC/ENTR”.

3.227 reserved

3.228 Keypad Function 69 - Select Local / Standard / GPS / UTC Time

3.228.1 Use function 69 to select between UTC, GPS, STANDARD or LOCAL time. The selected time type will be displayed and sent out on the IRIG-B and serial ports. Upon initial out-of-the-box power-up the default is the LOCAL time format. Upon subsequent power-ups the default will be whatever format was last selected.

Press “FUNC/ENTR”, then “6” “9”. The display will show:

Select Time Type
<Time Type>

where <Time Type> is either LOCAL, STANDARD, GPS or UTC.

Press the up or down arrow keys to toggle between LOCAL, STANDARD, GPS and UTC. When the display shows the desired format, press “FUNC/ENTR” to enter your choice.

3.228.2 The time types are:

GPS: The time determined by primary atomic frequency standards. This type of time does not include leap seconds. Therefore, it differs from UTC time.

UTC: Universal Time Coordinated. This time is related to the local solar mean time at Greenwich Meridian. This time is adjusted once in a while to compensate for the earth’s rotational variations.

STANDARD: This time equals UTC plus the local time zone offset.

LOCAL: This time equals STANDARD plus Daylight Saving Time offset, when required.

3.228.3 Standard and Local times require the proper setting of the time zone offset with FUNC 01 (Set Time Zone). In addition, Local time requires that F66 Daylight Savings Time be properly set, if applicable. The 12/24 hour mode (FUNC 02) is applied to all the above time types (GPS, UTC etc.).

3.228.4 When on UTC, STANDARD, or LOCAL time mode, the Mark V 1PPS output is corrected by the GPS-UTC A0 and A1 sub-second correction parameters.

3.229 through 3.233 reserved

3.234 Keypad Function 71 - Oscillator Statistics Request

3.234.1 Use keypad function 71 to request the internal or external (when operating in External Oscillator enabled mode, see function 07) oscillator's phase, frequency offset, drift rate and DAC value. The phase is the instantaneous error in seconds between the oscillator and the control loop zero servo point as reported by the core GPS module. The frequency offset is computed using an averaging time that is equal to the effective averaging time of the oscillator controller. The oscillator drift rate is computed using a 24 hour average and is the daily drift rate of the oscillator. The oscillator DAC value is a signed 16 bit integer that controls the DAC output voltage. It ranges from 32767 to -32768.

3.234.2 "Oscillator phase" is the instantaneous error between the Mark V timing outputs and GPS. Press "FUNC/ENTR" "7" "1" and the display will show:

Osc Phase
-5.788e-09 s

indicating that the Mark V timing was most recently reported to be approximately 6 nanoseconds late. This number has the full effects of Selective Availability superimposed upon it. The oscillator control loop servos the mean of this number to zero.

3.234.3 "Oscillator offset" is the frequency offset or error with respect to the GPS frequency. Press "FUNC/ENTR" and the display will show:

Osc Offset
-2.150e-11

indicating that the internal or external oscillator frequency is less than GPS by approximately 2 parts in 10^{11}.

3.234.4 "Oscillator drift" is the change in oscillator frequency per day. Press "FUNC/ENTR" again and the display will show:

Osc Drift
3.990e-12/DAY

indicating that the internal or external oscillator frequency is changing positively with respect to GPS by approximately 4 parts in 10^{12} per day.

3.234.5 "Oscillator DAC" is the signed 16 bit DAC control integer that sets the DAC output voltage to control the internal or external oscillator. Press "FUNC/ENTR" again to display:

DAC
16368

indicating that the DAC output voltage is at either +2.5 volts or +7.5 volts depending upon whether the GPS-XL DAC range setting jumper JP5 is off or on, respectively.

3.235 through 3.252 reserved

3.253 Keypad Function 72 - Fault Status

3.253.1 Keypad function 72 displays the status of certain fault detectors within the Mark V. These are currently limited to the status of the Antenna feed circuit, the PLL synthesizer lock status and GPS lock status. Press “FUNC/ENTR", "7","2" and the display will show:

Fault Status
Antenna: XXX

where XXX is one of "OK", "Open", or "Short". Pressing the up arrow key or "FUNC/ENTR" will display the next status indicator:

Fault Status
PLL: XXXXXXXX

where XXXXXXXX is either "OK" or "Unlocked". Pressing the up or down arrow key or "FUNC/ENTR" will display the next status indicator:

Fault Status
PY PLL: XXXXXXXX

where XXXXXXXX is either “OK”, “Unlocked”, or “Tune OVR”. “Tune OVR” is an indication that the PY PLL is locked, but near the limits of its tuning range and may need maintenance soon. Pressing the up arrow key or “FUNC/ENTR” will display the next status indicator:

Fault Status
XL Battery: XXX

where XXX is either “OK”, or “Low”. Pressing the up arrow key or “FUNC/ENTR” will display the next status indicator:

Fault Status
PY Battery: XXX

where XXX is either “OK”, or “Low”. It may also display “???” if information on Py battery status has not yet been obtained from the GPS module. Pressing the up arrow key or “FUNC/ENTR” will display the next status indicator:

Fault Status
GPS: XXXXXXXX

where XXXXXXXX is either "Locked" or "Unlocked".

3.254 Keypad Function 73 - Display / Set Alarm Status / Control

3.254.1 This function allows the user to control which conditions will signal an alarm or fault through the 87-6XX GPS-XL sub-assembly open collector output at P46B pin 1, or through relay contacts on 86-336 or 86-379 option boards. The user may also monitor the status of the individual indicators that contribute to the summary alarm outputs.
Keypad Function F73 allows the operator to scroll through the fault conditions that can affect the alarm outputs, and enable or disable each one's contribution to the alarm outputs. The fault condition is sampled on entering each fault display. At any time, the user may exit F73 without changing the alarm mask settings by pressing TIME, STATUS, or POSITION.

Press FUNC/ENTR, then "73", and the screen displays:

Clock Status
GPS: <locked status>

where <locked status> can be "Locked" or "Unlocked", indicating whether the clock is locked to GPS within specifications.

To proceed, press FUNC/ENTR. The next screen displays:

Position Status
<ave. status>

where <ave. status> summarizes the state of the position averaging process, and can be "Full Accuracy", "Position Approx.", "Position Unknown", or "Pos, Time Unknown". When the unit is operated in AUTO mode, and has obtained its first 3-D position fix, the Position Status is "Position Approx.". When the position averaging process is completed, switching the clock into TIME mode, we have reached "Full Accuracy". "Full Accuracy" is also displayed if the unit has a measured 3-D position and is manually switched into TIME mode, or if the operator enters an assumed good position while in TIME mode. When operated in the SURVEY (OPTION) mode and the unit has a measured position, this screen will indicate "Position Approx.".

The remaining items are fault conditions, which can be individually enabled or disabled from affecting the alarm output(s). The <en> field is either "En" or "Dis" and can be toggled with the Up/Down arrow keys to Enable or Disable each fault condition. These mask settings will be changed only if requested at the end of all of the fault items.

Major Alarm: <en>
PLL: <pll status>

<pll status> can be "OK" or "Unlocked". “Unlocked” indicates that either the PLL on the GPS-XL board, or the PLL on the 86-741 board, is unlocked. See keypad Function 72 for information on each.

Major Alarm: <en>
Antenna: <ant. status>

<ant. status> can be "OK", "Short" or "Open". This indicates detection of improper load conditions on the antenna feed.

Major Alarm: <en>
Receiver: <rec. status>

<rec. status> can be "OK", or "Fault". A "Fault" indicates there is some problem with the GPS receiver, such as it is failing to communicate with the host processor.

Major Alarm: <en>
NV RAM: <nvram status>

<nvram status> can be "OK" or "Error". If any checksum errors were found on recalling any non-volatile memory blocks, or one or more blocks were missing and were created with default values, then this <nvram status> will be "Error". This may occur the first time the unit is powered up, or if some options have just been installed and new non-volatile memory blocks have been created for their use.

If <nvram status> is "Error", then the next item will be

Clear NV RAM
fault? <resp>

where <resp> can be toggled between "No" or "Yes" by the Up/Down arrow keys. After the operator has confirmed that all settings are correct this can be used to cancel the error, so that future errors can be caught.

Major Alarm: <en>
Timeout: <timeout status>

<timeout status> can be "OK" or "Fault". "Fault" indicates that the time error has exceeded the time error threshold for more than Timeout seconds.

The timeout delay can be set by the next dialog:

Timeout delay
<timeout> s

where <timeout> is in seconds between 0 and 86400 (1 day), and sets the delay from when the time error threshold is exceeded and when the Timeout fault occurs.

Minor Alarm: <en>
Time Error: <TE status>

<TE status> can be "OK" or "Fault" and indicates that the estimated time error (available through Function F13) exceeds the alarm time error threshold.

The time error threshold is set by the next dialog:

Time threshold
<threshold> ns

where <threshold> is in nanoseconds. If this is set to 0, then the Time Error fault occurs when the clock initially determines it is unlocked.

Minor Alarm: <en>
Tracking: <tracking status>

<tracking status> can be "OK" or "Fault". This generally indicates whether we are receiving and decoding satellite information.

Minor Alarm: <en>
Tuning: <tuning status>

<tuning status> can be "OK" or "Fault". If the 10 MHz oven oscillator is near the limits of the range that it can be steered by the DAC, then <tuning status> becomes "Fault" indicating that the oscillator may need to be checked and readjusted soon. This may also indicate that the PLL oscillator on the 86-741 board may be near its steering range. See keypad Function 72 for more information.

Minor Alarm: <en>
NV Battery: <bat. status>

<bat. status> can be "OK" or "Low". The battery B1, which is used to maintain non-volatile information in RAM on the GPS-XL board when the power is off, is checked at power on. If it is below about 2.0 volts, a "Low" is indicated. The battery should then be replaced. This may also indicate that jumper JP1 has been left off, disconnecting the battery. This may also indicate a battery fault detected in the battery on the 86-741 board. See keyboard Function 72 for more information.

Minor Alarm: <en>
Acquisition: <acq. status>

<acq. status> can be "OK" or "Flt". "Flt" indicates that the unit is still in the process of acquiring initial lock, and that it has not yet locked since power on. "OK" indicates that it has locked at least once, regardless of whether it is currently locked.

If any alarm mask settings have been changed, the next dialog will be:

Save Alarm Mask?
<resp>

where <resp> can be toggled with the Up/Down arrow keys between "No" or "Yes". If the operator answers "Yes", and presses FUNC/ENTR, the alarm enable

settings, timeout delay, and time error threshold requested by the operator are made the current settings and stored in nonvolatile memory.

3.254.2 In Mark V, the 87-6XX GPS-XL sub-assembly open collector alarm output at P46B pin 1 has the following states:

Off	Power off
Off	Error, major or minor enabled alarm fault.
On	Normal, no major or minor enabled alarm faults.

If the processor on the 87-6XX GPS-XL sub-assembly were to fail, resulting in a failure to trigger the watchdog timer, the watchdog timer would reset the processor and attempt to restart the system. During the processor reset, the alarm output transistor open collector would be off, indicating a fault. If the processor were unable to recover and resume triggering the watchdog timer, a succession of watchdog timer timeouts followed by resets would result. At the same time, the open collector alarm output transistor might either be off, or might toggle between off and on following the repeated resets, indicating an alarm condition.

3.254.4 The default alarm mask settings are summarized below:

Major Alarm	Default Alarm Mask
System PLL	Enabled
Synthesizer PLL	Enabled
Antenna	Enabled
Receiver	Enabled
NV RAM	Enabled
Timeout	Disabled

Minor Alarm	Default Alarm Mask
Time Error	Enabled
Tracking	Disabled
Tuning	Disabled
NV Battery	Disabled
Acquisition	Disabled

3.255 Keypad Function 79 - Warm Start

3.255.1 This function issues a reset command to the Trimble Force 22 GPS module. It does not clear stored almanac and ephemeris data, which is retained in battery-backed RAM.

A warm start is indicated when all other diagnostics have failed to return the Mark V to tracking satellites.

Press "FUNC/ENTR", then "7" "9". The display will show:

Warm start?

No

Press the up or down arrow keys to toggle between "No" and "Yes". When the display shows the choice you desire, press "FUNC/ENTR". If you choose "Yes" this will initiate a warm start. To exit this function without performing any action press the "STATUS" key. If you choose “No” the display will show:

Clear almanac?

No

If you select “Yes” this will clear the almanac data in the Force 22 GPS module’s battery backed RAM.

Cryptokeys held in the Force 22 SAASM are not affected by either a warm start or by clearing almanacs.

3.256 Keypad Function 92 - P(Y) Functions

Keypad function 92 displays P(Y) receiver cryptokey status, allows zeroizing cryptokeys, displays mission duration status, allows setting mission duration, allows setting anti-spoof mode, and allows performing a P(Y) receiver SAASM self-test. The up and down arrow keys are used to scroll through these choices, and the FUNC/ENTR key enters the dialog for the displayed choice.

3.256.1 CRYPTOKEY STATUS

Cryptokey status is directly displayed immediately after pressing “FUNC 92”.

Cryptokey status
XXXXXXXXXXXXXX

where XXXXXXXXXXXXXX may be one of “Keys unknown”, “SAASM error”, “No keys”, “Keys loaded”, “Keys valid”, “Insuff. Keys”, and “Valid nnn min.”, and "Need Data Soon".

In addition, “unknown” may be displayed shortly after power up, and “packet timeout” may occur if the receiver does not respond to the request from the clock fast enough.

3.256.2 ZEROIZE CRYPTOKEYS

The zeroize cryptokeys dialog asks for confirmation before proceeding:

Zeroize Crypto-
keys? XXX

where XXX can be “Yes” or “No”. To choose zeroize, select “Yes” using the up or down arrow keys, and then press “FUNC/ENTR”. The response if successful is:

Cryptokeys are
zeroized

or if there is some problem:

Cryptokeys NOT
zeroized

3.256.3 DISPLAY MISSION DURATION STATUS

If “Mission duration status” is selected, the resulting displayed message shows the hours remaining before the receiver stops using the keys. The message displayed is:

MD: XXXXXXXX

where XXXXXXXX can be “not set”, “nnnnn hours set”, “nnnnn hours set; need keys”, “nnnnn hours default”, “nnnnn hours default; need keys”, or “unknown”.

3.256.4 SET MISSION DURATION

The set mission duration dialog asks for confirmation before proceeding:

Set mission
duration? XXX

where XXX can be “Yes” or “No”. To set, select “Yes” using the up or down arrow keys, and then press FUNC/ENTR. First the starting date is entered:

Mission start
date mm/dd/yy

and then the mission duration from this starting date is set:

Mission duration
nnn days

The response if successful is:

Mission Duration
Entry Accepted

or if there is some problem:

MD Error:
XXXXXXXXXXXXXXX

where XXXXXXXXXXXXXXX can be “Invalid date”, “Previously set”, “Waiting for time”, “Rejected, no keys”, “Zeroize & retry”, or “SAASM error”.

If the mission duration has not been set within one hour of loading the keys, it will default to 240 days.

If the clock is turned off within one hour of loading the keys without first setting the mission duration, it will default to 1 day.

3.256.5 SET ANTI-SPOOF MODE

If “Set anti-spoof mode” is selected, the dialog displays the receiver’s current mode:

```
Set Anti-Spoof
mode:  XXXXXXXXXXX
```

where XXXXXXXXXXX can be “Off”, “On (mixed)”, or “On (Y-only).

If AS mode is turned “Off”, non-encrypted CA or P code information may be used. This is the only way to synchronize the clock if it is not keyed. However, if the receiver is keyed, it will still use Y code in this mode, providing SA-free steering information to the clock.

If AS mode is “On (mixed)”, and the receiver is keyed, it will prefer Y code satellite information, but may use unencrypted P code information if that is available. No CA code information will be used.

If AS mode is “On (Y-only)”, only Y code satellite information will be used. The receiver must be keyed to use this information. The receiver must have almanacs to operate with Anti-Spoof mode ON. If it does not have almanacs, and Anti-Spoof mode is ON, it may track satellites, but it will not acquire almanacs. Almanacs may be acquired with Anti-Spoof mode OFF, in a non-hostile environment.

The anti-spoof mode setting is retained in the battery backed RAM on the GPS-XL board.

3.256.6 SAASM BUILT-IN SELF TEST

When “Run SAASM Self Test” is selected, the P(Y) code receiver is commanded to perform a self test of the SAASM function. After the test is run a status message is displayed:

```
Self test status
XXXXXXXXXXXXX
```

where XXXXXXXXXXXXX can be “No keys”, “Keys loaded”, “Valid keys”, or “SAASM failed”.

In addition, “unknown” may be displayed shortly after power up, and “packet timeout” may occur if the receiver does not respond to the request from the clock fast enough.

3.257 SERIAL I/O INTERFACE

3.257.1 The SERIAL I/O port can be connected to a terminal or computer. These instructions assume that a terminal is connected.

The SERIAL I/O connection, data format and functions are explained in the following sections.
NOTE: As a convenience to our customers the TrueTime Mark V emulates most of the Serial I/O commands of the earlier GPS-DC Mark II Synchronized Clock. Most customer programs written to interface with the Mark II Serial I/O port will also interface with the Mark V Serial I/O port if the emulation mode is enabled with keypad function 16 (see manual section 3.104). When emulation is "on", the Serial I/O port acknowledges the commands C, T, F, and R. Refer to Serial I/O EMULATION COMMANDS in manual section 3.106.

3.258 through 3.259 reserved

3.260 RS-232 / RS-485 Connection

3.260.1 The male 9-pin D connector (DB-9P) provides a serial, asynchronous, bi-directional data port. This Serial I/O data port is factory configured with either RS-232 (STANDARD) or RS-485 (OPTION) signal levels. The RS-232 output is compatible electrically and mechanically with the EIA Standard RS-232C as described for **data terminal equipment (DTE)**. A copy of the RS-232 Standard is available from Electronic Industries Association, Engineering Department, 2001 Eye Street, NW, Washington, D.C. 20006. This reference is suggested for any user of this system as it is the industry accepted standard for this interface system.

3.261.2 Messages are sent and received using ASCII coded characters in most standard data rates and formats. The mating D connector for P4 is a female 9-pin (DB-9S). If a 9 to 25 pin adapter cable is used, the Serial I/O pin assignments are as follows:

	9- to 25-PIN ADAPTER CABLE		SIGNAL DESCRIPTION
	DB-9P	DB-25P	
OPEN	1	8	DCD, CARRIER DETECT
IN	2<----------	3	RxD, RECEIVED DATA
OUT	3---------->	2	TxD, TRANSMITTED DATA
OPEN	4	20	DTR, DATA TERMINAL READY
GND	5---------<>	7	SC , SIGNAL GROUND
OPEN	6	6	DSR, DATA SET READY
OPEN	7	4	RTS, REQUEST TO SEND
OPEN	8	5	CTS, CLEAR TO SEND
OPEN	9	22	RI , RING INDICATOR

When configured for RS-485 operation, the I/O connections are:

	9- to 25-PIN ADAPTER CABLE		SIGNAL DESCRIPTION
	DB-9P	DB-25P	
IN-	1----------<----------8		RxD-, RECEIVED DATA
IN+	2----------<----------3		RxD+, RECEIVED DATA
OUT+	3---------->----------2		TxD-, TRANSMITTED DATA
OUT-	4---------->----------20		TxD+, TRANSMITTED DATA
GND	5---------<>----------7		SC , SIGNAL GROUND
OPEN	6.....6		DSR, DATA SET READY
OPEN	7.....4		RTS, REQUEST TO SEND
OPEN	8.....5		CTS, CLEAR TO SEND
OPEN	9.....22		RI , RING INDICATOR

3.262 reserved

3.263 Serial I/O Data Format

3.263.1 The default Serial I/O format, as shipped, is:

Data Rate: 9600 bits/second
Word Length: 7 bits
Parity: Even
Stop Bits: 1

The format cannot be changed via the Serial I/O port. Factory or keypad (see "KEYPAD FUNCTION 04 - SERIAL I/O SETUP") configured formats available are:

Baud Rates: 300, 600, 1200, 2400, 4800, 9600,19200
Word Lengths:7 or 8 bits
Parity: Even, odd or none
Stop Bits: 1 or 2

3.264 reserved

3.265 Serial I/O Function List

3.265.1 Most of the functions available via the Mark V front panel keypad are also available via the Serial I/O interface. Some Serial I/O functions have no keypad counterpart. Initially at power-up the Serial I/O port outputs time once per second as described in function F08 until it receives a control-C character (HEX 03). Then any of the following commands may be used:

COMMAND	FUNCTION
F01	Time Zone Entry/Request
F02	12/24 Hour Format Entry/Request
F03	Time/Date Entry/Request
F05	Time Quality Enable/Setup
F06	Keypad Lockout Enable
F07	External Oscillator Enable (OPTION)
F08	Continuous Time Once Per Second Enable
F09	Time on Request Enable
F11	Time Output Format Entry/Request
F13	Worst-case Time Error Request
F14	External Oscillator Parameter Entry/ Request (OPTION)
F15	Exclusive Use Enable
F17	Slow Code Setup (OPTION)
F18	Software Version Request
F26	Programmable Pulse Out (OPTION)
F28	Time Interval/Event Timing (OPTION)
F29	External Frequency Measurement (OPTION)
F50	Position Entry/Request
F51	Cable Delay Entry/Request
F52	Distribution Cable Delay Entry/Request
F53	Operational Mode Entry/Request
F55	Altitude Units Entry/Request
F56	Average Position Entry/Request
F60	Satellite List Request
F65	Satellite Select
F66	Daylight Savings Enable
F68	Set Current Year
F69	Select Local/Standard/GPS/UTC Time
F71	Oscillator Statistics Request
F72	Fault Status
F73	Display/Set Alarm Status/Control
F79	Warm Start/Clear Almanac
F92	P(Y) Functions

3.266 reserved

3.267 General Input and Output Format

3.267.1 Data may be sent to or requested from the Serial I/O port by using various function commands and ASCII character strings. In general those functions which request status or data fit the form:

F<FUNC#><CR>

where

F	=	ASCII character F or f.
<FUNC>	=	two-digit function number.
<CR>	=	ASCII carriage return character (Hex 0D).

The format for both data input and data output strings is:

F<FUNC#>[<SEP><FIELD>]<LT>

where

F	=	ASCII character F or f.
<FUNC>	=	function number.
<SEP>	=	one or more separator characters: either space, comma or tab.
<FIELD>	=	data entry or request.
<LT>	=	line terminator, either a carriage return and line feed for output strings or a carriage return only for input strings.
[]	=	encloses a phrase that is repeated as often as necessary.

Output strings from the Serial I/O port are kept to fixed lengths whenever possible. This means that numeric values will often contain many leading blanks. Numeric values are right justified so that the least significant digit is always in the same position in the string. Quantities that can be positive or negative will have a sign even if positive. This is done to simplify the task of programming computer systems that receive the data. The formats of the output strings are designed so that it is possible to request the state of a function and save the response string. Later that string can be sent to the unit to restore the original state of that function.

Input strings sent to the unit may be of variable length. The number of separators between fields may be varied. Numeric values may be entered with or without leading zeros. Where a sign is allowed, it may be omitted for positive quantities. String fields (such as "on" or "off") may be entered in upper or lower case, as can the "F" that starts all Serial I/O commands. All commands may be ended with a carriage return alone or by a carriage return line feed combination. Some fields of some commands are optional, and may be replaced by a semicolon. If a field is so replaced, the corresponding value will be left unchanged.

Incorrect entry may result in an error message as described under "SERIAL I/O ERROR MESSAGES" in this section. Correct entries are acknowledged with OK<CR><LF>.

3.268 reserved

3.269 Exclusive Use

3.269.1 To facilitate remote operation, the unit has the ability to grant "exclusive use" to one of the control ports (currently the IEEE 488 port or the Serial I/O port). The front panel keypad cannot be granted exclusive use. At most, one port at a time can have exclusive use until sent a command to release it or until the unit loses power. At power-on or when exclusive use is off any port or the front panel has free access. When a port has exclusive use the front panel keypad and all other

ports cannot change any of the setup parameters. They can, however, request the current parameters.

Example:
If the serial port has exclusive use and "FUNC/ENTR" "0" "1" is pressed on the keypad, the current time zone will be displayed. If "FUNC/ENTER" is pressed, attempting to set the time zone, an error message displays and the time zone displays again. To exit the function use the "TIME", "STATUS", or "POSITION" button.

Example:
If the IEEE port has exclusive use and "F02<cr>" is entered on the serial port, the port will respond with the current setting of the 12/24 hour mode. If "F02 12<cr> is entered, it is an attempt to change the 12/24 hour mode and the message:

ERROR 04 EXCLUSIVE USE<cr><lf>

will be returned, indicating that the serial port is not allowed to change this item.

3.270 reserved

3.271 SERIAL I/O FUNCTION DESCRIPTIONS

3.272 Serial Function F01 - Time Zone Entry / Request

3.272.1 Use Serial I/O function F01 to select or determine the time zone offset. To request the offset send F01<CR> to the Serial I/O port. The port will respond with the following character string:

F01<SEP><SIGN><HH>:<MM><LT>

where

F	=	ASCII character F.
01	=	function number.
<SEP>	=	one or more separator characters: either space, comma or tab.
<SIGN>	=	either no character or + for positive offsets or - for negative offsets.
<HH>	=	one - or two-digit hours offset from +12 to -12 hours.
:	=	ASCII character for a colon.
<MM>	=	two-digit minutes offset.
<LT>	=	line terminator, either a carriage return and line feed for output strings or a carriage return only for input strings.

Sample request: F01<CR>
Response: 4:30<CR><LF>

To set the time zone offset send a character string with the following format:

Sample entry: F01 -8:00<CR>
Response: OK<CR><LF>

Sample Request: F01<CR>
Response: 8:00<CR><LF>

3.273 reserved

3.274 Serial Function F02 - 12/24 Hour Format Entry / Request

3.274.1 Use Serial I/O function F02 to request or set the time display format. To determine the format send F02<CR> to the Serial I/O port. The port will respond with the following character string:

F02<SEP><HH><LT>

where

F	=	ASCII character F.
02	=	function number.
<SEP>	=	one or more separator characters: either space, comma or tab.
<HH>	=	12 or 24.
<LT>	=	line terminator, either a carriage return and line feed for output strings or a carriage return only for input strings.

Sample request: F02<CR>
Response: F02 12<CR><LT>

To select 24 hour format, send the following character string:

Sample entry: F02 24<CR>
Response: OK<CR><LF>

3.275 reserved

3.276 Serial Function F03 - Time / Date Entry / Request

3.276.1 Use Serial I/O function F03 to enter or request time and date. To request time and date send F03<CR> to the Serial I/O port. The port will respond with the ASCII character string:
F03<SEP><TYPE><SEP><mm>/<dd>/<yy><SEP><HH>:<MM>:<SS><LT>

where

F	=	ASCII character F.
03	=	function number.
<SEP>	=	one or more separator characters: either space, comma or tab.

<TYPE>	=	either LOCAL or UTC.
<mm>	=	one- or two-digit month.
/	=	ASCII character slash.
<dd>	=	one- or two-digit day.
<yy>	=	two-digit year.
<HH>	=	one- or two-digit hours.
:	=	ASCII character for a colon.
<MM>	=	two-digit minutes.
<SS>	=	two-digit seconds.
<LT>	=	line terminator, either a carriage return and line feed for output strings or a carriage return only for input strings.

Sample request: F03<CR>
Response: F03 UTC 01/07/91 02:48:29<CR><LF>

Sample request: F03 LOCAL<CR>
Response: F03 LOCAL 01/07/91 7:48:29<CR><LF>

Sample request: F03 UTC<CR>
Response: F03 UTC 01/07/91 2:48:29<CR><LF>

To set the time zone offset send a character string with the format above to the Serial I/O port. Either the date MM/DD/YY or the time HH:MM:SS may be omitted if they are replaced with a semicolon (;). Only valid dates are acceptable.

The following entry sets the local date and time.

Sample entry: F03 LOCAL 10/3/03 20:07:04<CR>
Response: OK<CR><LF>

The following entry uses semicolons to omit the time type and date fields, thus setting the UTC time, and leaving the date unchanged.

Sample entry: F03 ;; 3:06:48<CR>
Response: OK<CR><LF>

3.277 reserved

3.278 Serial Function F05 - Time Quality Enable Setup

3.278.1 Use function F05 to enable or disable the time quality indicators or to set the four worst-case-error thresholds. Both the front-panel numeric display and the Serial I/O output string indicate the time quality.

Refer to NUMERIC DISPLAY earlier in this section for a complete description of the display's time quality indications. Refer to "SERIAL I/O FUNCTION F08 - CONTINUOUS TIME ONCE PER SECOND" for a description of the time quality indication in the Serial I/O time output string. As shipped the time quality indicators are enabled and the thresholds are set to 1000ns, 10000ns, 100000ns, and 1000000ns. The unit will retain the values in use at power-down and use them for subsequent power-ups.

3.278.2 To determine if the indicators are enabled and what the thresholds are, send F05<CR> to the Serial I/O port. The port will respond with the ASCII character string

F05<SEP><state><SEP><flag><SEP><flag><SEP><flag><SEP><flag><LT>

where

F	=	ASCII character F.
05	=	function number.
<SEP>	=	one or more separator characters: either space, comma or tab.
<state>	=	ON or OFF.
<flag>	=	one error threshold in nanoseconds, 1 to 11 digits with or without leading zeros.
<LT>	=	line terminator, either a carriage return and line feed for output strings or a carriage return only for input strings.

Sample request: F05<CR>
Response: F05 ON 00000001000 00000010000 00000100000 00001000000

To enable, disable or set the thresholds of the time quality indicators send a character string with the following format:

Sample: F05 ON 00000001000 00000010000 00000100000 00001000000
Response: OK<CR><LF>

Acceptable threshold value range: 00000000010ns to 40000000000ns.

Sample entry: F05 ON 100 200 500 1000
Response: OK<CR><LF>

Note that although leading zeros are not required for data entry they will be included in any data response.

3.279 through 3.280 reserved

3.281 Serial Function F06 - Keypad Lockout Enable

3.281.1 Use Serial I/O function F06 to enable or disable the keypad lockout feature. As shipped the keypad lockout is disabled. The state of the keypad lockout on subsequent power-ups will be the same as it was on the previous power-down. To determine if the keypad lockout is enabled send F06<CR> to the Serial I/O port. The port will respond with the ASCII character string:

F06<SEP><STATE><LT>

where

F	=	ASCII character F.
06	=	function number.
<SEP>	=	one or more separator characters: either space, comma or tab.
<STATE>	=	ON or OFF.
<LT>	=	line terminator, either a carriage return and line feed for output strings or a carriage return only for input strings.

Sample request: F06<CR>
Response: F06 OFF<CR><LF>

To enable keypad lockout send the following string:

Sample entry: F06,ON<CR>
Response: OK<CR><LF>

3.282 reserved

3.283 Serial Function F07 - External Oscillator Enable (Option)

3.283.1 Use Serial I/O function F07 to enable or disable Phase Locking to an External Auxiliary Oscillator. The Mark V jumpers JP6, JP3 and JP4 must be configured to support the desired operation set with this command. The state of the external oscillator on subsequent power-ups will be the same as it was on the previous power-down. To determine if the external oscillator is enabled send F07<CR> to the Serial I/O port. The port will respond with the ASCII character string:

F07<SEP><STATE><LT>

where

F	=	ASCII character F.
07	=	function number.
<SEP>	=	one or more separator characters: either space, comma or tab.
<STATE>	=	ON or OFF.
<LT>	=	line terminator, either a carriage return and line feed for output strings or a carriage return only for input strings.

Sample request: F07<CR>
Response: F07 ON<CR><LF>

To enable or disable the external oscillator send a character string with the following format:

Sample entry: F07 OFF<CR> or F07 ON<CR>
Response: OK<CR><LF>

3.285 Serial Function F08 - Continuous Time Once Per Second Enable

3.285.1 Internal Trimble Force 22 time will output once per second at the Serial I/O port if command string F08<CR> is sent to the port prior to acquisition of satellite signals. Time-of-year will output once per second after acquisition of satellite signals. Character transmission is continuous with the end of the stop bit of one character coinciding with the beginning of the start bit of the next character. The time output string format may be changed with Serial I/O function F11. The default output string format is:

<SOH>DDD:HH:MM:SSQ<CR><LF>

where

<SOH>	=	ASCII Start-of-Header character (HEX 01).
<CR>	=	ASCII Carriage Return character (HEX 0D).
<LF>	=	ASCII Line Feed character (HEX 0A).
DDD	=	day-of-year.
HH	=	hours.
MM	=	minutes.
SS	=	seconds.
:	=	colon separator.
Q	=	time quality character.

The time quality character may be a:

SPACE which indicates a worst-case error less than threshold 1.
. which indicates a worst-case error greater than or equal to threshold 1.
* which indicates a worst-case error greater than or equal to threshold 2.
# which indicates a worst-case error greater than or equal to threshold 3.
? which indicates a worst-case error greater than or equal to threshold 4.

The time quality character prior to satellite signal acquisition will be "?". Refer to SERIAL I/O FUNCTION F13-WORST-CASE-TIME ERROR REQUEST. The carriage return character <CR> start bit begins on the second, +0 to +1 bit time or ±1 ms, which ever is larger. Time will continue to output once per second until the port receives a CONTROL-C character (HEX 03). Until it receives a CONTROL-C the port will ignore all other input.

3.286 reserved

3.287 Serial Function F09 - Time On Request Enable

3.287.1 When the Serial I/O port receives the command string F09<CR> it waits for a request in the form of an upper-case ASCII character T to output the time-of-day string. After a T is received, the current time is saved (with a resolution of 1ms) in a buffer and is then transmitted to the port. The port will continue to respond with time-of-day each time it receives a T until this function is canceled by sending a CONTROL-C character (HEX 03) to the port (all other input will be ignored until then). The default output string is as follows:

<SOH>DDD:HH:MM:SS.mmmQ<CR><LF>

where

<SOH>	=	ASCII Start-of-Header character (HEX 01).
<CR>	=	ASCII Carriage Return character (HEX 0D).
<LF>	=	ASCII Line Feed character (HEX 0A).
DDD	=	day-of-year.
HH	=	hours.
MM	=	minutes.
SS	=	seconds.
mmm	=	milliseconds.
:	=	colon separator.
Q	=	time quality character. Refer to function 08 for values.

Sample entry: F09<CR>
Second entry: T
Response: <SOH>128:20:30:04.357*<CR><LF>

3.288 reserved

3.289 Serial Function F11 - Time Output Format Entry / Request

3.289.1 Use Serial I/O function F11 to request or enter the time output string format that is used by Serial I/O functions F08 and F09.

The format upon power-up will be the format that was in use just before power-down. To request the return of the present format send F11<CR> to the Serial I/O port. The string returned will contain X's in the positions that are omitted in the time output string.

When shipped, the format string will be set to the "null" string, causing the strings of the F08 and F09 outputs to take on their default values.

EXAMPLE F08: <SOH>DDD:HH:MM:SSQ<CR><LF> (Once per second time output mode)

Note: Milliseconds are never present in the output of F08 mode regardless of the format string entered with F11.

EXAMPLE F09: <SOH>DDD:HH:MM:SS.mmmQ<CR><LF> (Time on demand output mode)

Where

<SOH>	=	ASCII Start-of-Header character (HEX 01).
<CR>	=	ASCII Carriage Return character (HEX 0D).
<LF>	=	ASCII Line Feed character (HEX OA).
DDD	=	day-of-year.
HH	=	hours.
MM	=	minutes.
SS	=	seconds.
.	=	ASCII decimal point.
mmm	=	milliseconds.
:	=	colon separator.
Q	=	time quality character position. characters for this position are: ‘’, ’.’, ’*’, ’#’, and ’?’

If non-volatile memory is corrupted due to battery failure or other cause the format string will be set to the "null" string.

When the unit returns the current format string in response to "F11<CR>" (as shown in the following example) the first character after the "F11" is always a blank and is not part of the format string but is only a separator.

Sample request: F11<CR>
Response: F11 <CR><LF>

The following text assumes that the format has been previously set to DDD::MMmSSQ.

Sample request: F11<CR>
Response: F11 DDD:XX:MMmSSXXXXQ<CR><LF>

This means that the response from F09 would be:
<SOH>122::24m55*<CR><LF>

To omit a character, other than <SOH> <CR> or <LF>, from the output string send a string of the form:

F11<SEP>DDD:HH:MM:SS.mmmQ<CR>

with an upper case "X" in place of the character that you wish to omit. The <SOH>, <CR> and <LF> characters in the output strings of F08 and F09 are not subject to control by F11. <SEP> is one character only, either a space, comma or tab. Any character other than an upper case "X" in a numeric position will not affect the output of that position. The colons (:) or decimal point (.) , however, may be replaced with any single ASCII character except null (HEX 00), carriage return, or line feed.

Sample entry: F11 XXXXXXXMMMSSS.mmmX<CR>
Response: OK<CR>
F08 string output: <SOH>12M34S<CR><LF>
F09 string output: <SOH>12M34S.567<CR><LF>

The above format means that days hours and the first two colon separators are suppressed and the third and fourth separators are "M" and "S".

Sample entry: F11,HHH;XX;mm:SS,mmmQ<CR>
Response: OK<CR>
F08 string output: <SOH>123;;55:45*<CR><LF>
F09 string output: <SOH>123;;55:45,678*<CR><LF>

The above format means that hours are deleted, the first two separators are semicolons instead of colons and the third separator is a comma instead of a period.

If the format string entered with F11 is terminated early with a carriage return, the remaining characters are enabled and assume their default values.

Sample entry: F11<TAB>XXX|<CR>
Response: OK<CR>
F08 string output: <SOH>|10:45:01*<CR><LF>
F09 string output: <SOH>|10:45:01.234*<CR><LF>

The above format means that days are deleted, the first separator is a vertical bar and all other characters are enabled and assume their default values.

When entering a new format string the character after "F11" is required but is ignored. To enter a "null" format string send "F11" followed by a space, followed by a carriage return.

Sample entry: F11 <CR>
Response: OK<CR>
F08 string output: <SOH>DDD:HH:MM:SSQ<CR><LF>
F09 string output: <SOH>DDD:HH:MM:SS.mmmQ<CR><LF>

The above format means that all characters and separators are enabled and assume their default values.

If the current format string is "null", F11 will return a space character followed by a carriage return.
Sample entry: F11<CR>
Response: F11 <CR>

The format string below explicitly enables all characters and has the same effect as a "null" format string:

Sample entry: F11 DDD:HH:MM:SS.mmmQ<CR>
Response: OK<CR>

F08 string output: <SOH>DDD:HH:MM:SSQ<CR><LF>
F09 string output: <SOH>DDD:HH:MM:SS.mmmQ<CR><LF>

3.290 reserved

3.291 Serial Function F13 - Worst-Case Time Error Request

3.291.1 Use Serial I/O function F13 to request the estimated worst-case time error. Refer to keypad FUNCTION 13 - WORST-CASE TIME ERROR earlier in this section for an explanation of worst-case time error. The worst-case time error while tracking satellites is always 00.000000200 seconds in AUTO or TIME mode. Time error begins to accumulate when the receiver loses contact with the satellite signal. The Mark V calculates the worst-case time error based on the stability of the time base in use, either the internal or external oscillator, and the time elapsed since loss of lock. The Serial I/O port will report this calculated error when it receives the string F13<CR> and responds with the following ASCII character string:

F13<SEP><ERROR><CR><LF>

where

F	=	ASCII character F.
13	=	function number.
<SEP>	=	one or more separator characters; either space, comma or tab.
<ERROR>	=	calculated worst-case error in seconds
<CR>	=	carriage return character.
<LF>	=	line feed character.

Sample request: F13<CR>
Response: F13 02.000000000<CR><LF>

3.292 reserved

3.293 Serial Function F14 - External Oscillator Parameter Entry / Request (Option)

3.293.1 Use Serial I/O function F14 to set or determine the external oscillator parameters. These parameters are used to properly configure the input circuitry and to calculate the control coefficients for disciplining the external oscillator. The settings on subsequent power-ups will be the same as they were on the previous power-down. To request the present values send F14<CR> to the Serial I/O port. The port will respond with the ASCII character string

F14<SEP><frequency><SEP><tuneslope><SEP><dacnominal><SEP>
<tempstab><CR><LF>

where

F	=	ASCII character F.
14	=	the function number.
<SEP>	=	one or more separator characters: space, comma or tab.
<frequency>	=	the external oscillator frequency in MHz, either 1, 5, or 10
<tuneslope>	=	signed fractional frequency offset/volt sensitivity of the external oscillator frequency control input in scientific format: sX.XXEsXX
<dacnominal>	=	decimal fraction of DAC full scale voltage for nominal DAC setting which corresponds to center frequency of the external oscillator: .XX
<tempstab>	=	unsigned peak-peak change in fractional frequency offset of the external oscillator over the range of 0 C to +60 C in scientific format: X.XXEsXX
<CR>	=	ASCII carriage return character (HEX 13)
<LF>	=	ASCII line feed character (HEX 10)

Sample request: F14<CR>
Response: F14 1 -2.12E-11 .50 3.00E-09<CR><LF>

To enter the external oscillator parameters send a character string with the following format:

Sample entry: F14 5 1.00E-09 .25 5.00e-08<CR>
Response: OK<CR><LF>

3.294 reserved

3.295 Serial Function F15 - Exclusive Use Enable

3.295.1 At times it is advisable to prevent entry of data via the front panel or the IEEE port. When the exclusive use function is enabled by the Serial I/O port, data entries may be made only via the Serial I/O port. The front panel display and the IEEE Port will still respond to requests for data even if the Serial I/O port has exclusive use. Use Serial I/O function F15 to enable or disable or request the state of the exclusive use function. As shipped the exclusive use function is disabled. The state of the exclusive use function on subsequent power-ups will be off. To enable or disable this function send a string of the form:

F15<SEP><STATE><CR>

where

F	=	ASCII character F.
15	=	function number.
<SEP>=		one or more separator characters: either space, comma or tab.
<STATE>	=	OFF if no port has exclusive use, OTHER if some other port has exclusive use, SELF if the Serial I/O port has exclusive use or ON if enabling the Serial I/O port.
<CR>	=	carriage return character

The state will change or, if another port has exclusive use, the port will respond with the string:

ERROR 04 EXCLUSIVE USE<CR><LF>

Sample request:	F15<CR>	(This asks for the state)
Response:	F15 OFF	
Sample entry:	F15 ON<CR>	(This enables exclusive use)
Response:	OK<CR><LF>	
Sample request:	F15<CR>	(This asks for the state)
Response:	F15 SELF	

3.296 reserved

3.297 Serial Function F17 - Slow Code Setup (Option)

3.297.1 Use Serial I/O function F17 to request or set the pulse widths of the optional slow code output.

This output provides one pulse per minute, primarily for placing timing marks on drum recorders. The once per minute, once per hour and once per day pulses can each be set to a different length, or the same length with this function. The lengths can range from 0 to 59 seconds, whole numbers only. A length of 0 means that the pulse is absent.

Each pulse edge is aligned to within a few nanoseconds of the time and frequency receiver's 1 PPS pulse, with the rising edge at the start of a minute.

To determine the current pulse widths, F17<CR> to the Serial I/O port. The port will respond with the ASCII character string:

F17<SEP><MIN><SEP><HR><SEP><DAY><LT>
where

F	=	ASCII character F.
17	=	function number.
<SEP>	=	one or more separator characters: either space, comma or tab.

<MIN> = length in seconds of the once per minute pulse.
<HR> = length in seconds of the once per hour pulse.
<DAY> = length in seconds of the once per day pulse.
<LT> = line terminator, either a carriage return and line feed for output strings or a carriage return only for input strings.

Sample request: F17<CR>
Response: F17 02 04 06<CR><LF>

To set pulse lengths of the slow code output, send a character string with the following format:

Sample entry: F17 1 2 03<CR>
Response: OK<CR><LF>

This will set the once per minute pulse to 1 second width, the once per hour pulse to 2 seconds, and the once per day pulse to 3 seconds.

When shipped, the unit is set to have pulse widths of 2, 4, and 6 seconds for the minute, hour, and day pulses respectively. The widths will be retained when the unit is not powered.

3.298 reserved

3.299 Serial Function F18 - Software Version Request

3.299.1 Use Serial I/O function F18 to obtain information about the current version of the software installed in the unit.

Send the string:
F18<CR>

The unit will respond with a string no longer that 80 characters.

example:
TRUETIME Mk III sys ver 016 GPS-XL v1.034 182-6078v008<CR><LF>

This string indicates that the system software is version 16, the clock specific software is version 1.034, part number 182-6078v008.

3.300 through 3.319 reserved.

3.320 Serial Function F26 - Programmable Pulse Output (Option)

3.320.1 Use Serial I/O Function F26 to enter or request the parameters for the Programmable Pulse Output, with resolution down to one millisecond. Refer to manual section 3.414 for specifications on the Programmable Pulse Output.

3.320.2 To set the Programmable Pulse Output parameters, send a string to the Serial I/O port in this format:

F26<SEP><START TIME><SEP><STOP TIME><CR><LF>

where

F	=	the ASCII character F.
26	=	the function number.
<SEP>	=	one or more separator characters: either space, comma or tab.
<START TIME>	=	a time to start the pulse, formatted like: <DAY>:<HOURS>:<MIN>:<SEC>.<MSEC>
<STOP TIME>	=	a time to stop the pulse, formatted like: <DAY>:<HOURS>:<MIN>:<SEC>.<MSEC>
<CR>	=	ASCII Carriage Return character.
<LF>	=	ASCII Line Feed character.

and

<DAY>	=	the 3-digit day of year.
:	=	the ASCII colon character.
<HOURS>	=	the 2-digit hours, in 24 hour form.
<MIN>	=	the 2-digit minutes.
<SEC>	=	the 2-digit seconds.
.	=	the ASCII decimal point character.
<MSEC>	=	the 3-digit millisecond.

Sending F26 by itself will return the current Programmable Pulse Output time setting.

Sample request: F26<CR>
Response: F26 123:18:33:23.324 124:23:32:43.321<CR><LF>

The user can specify both a Start Time and a Stop Time, in which case the rising edge will occur at the Start Time, and the falling edge will occur at the Stop Time. The times specified are compared with local time, which is UTC adjusted by the local offset. Leading zeros are required.

For example:

Sample entry: F26 001:00:00:00.000 002:00:00:00.000<CR>
Response: OK<CR><LF>

This will produce a 1 day pulse on January 1.

Invalid times are rejected with the error message:

ERROR 02 SYNTAX

The user may place an 'X' in any digit position, in which case the Start Time (or Stop Time) will be any time that matches the non-'X' digits. This can be used to produce repetitive pulses from once per year up to 100 per second.

Sample entry: F26 XXX:XX:X0:00.000 XXX:XX:X1:00.000<CR>
Response: OK<CR><LF>

This will emit a 1 minute pulse every 10 minutes, aligned with multiples of 10 minutes.

If only the Start Time is specified, a 1 millisecond pulse is generated with the rising edge starting at that time.

Sample entry: F26 XXX:XX:30:00.000<CR>
Response: OK<CR><LF>

This will generate a 1 millisecond pulse on the half hour.

Either the Start Time or the Stop Time may be replaced with a semicolon, in which case that item will be unchanged by the command.

Sample entry: F26 ; XXX:XX:10:00.000<CR>
Response: OK<CR><LF>

This will leave the Start Time set to whatever it was before, and will change the Stop Time to 10 minutes after the hour.

If both the Start Time and the Stop Time match the current time, then the pulse is turned off.

Sample entry: F26 XXX:XX:XX:XX.2XX XXX:XX:XX:XX.XXX<CR>
Response: OK<CR><LF>

The pulse would normally be turned on every second at 200 milliseconds, but the Stop Time also matches then, so the pulse will stay off.

To clear the output regardless of the time:
F26 000:00:00:00.000 XXX:XX:XX:XX.XXX

To set the output regardless of the time:
F26 XXX:XX:XX:XX.XXX 000:00:00:00.000

Initially on power on, the default Pulse Out setting is:
F26 000:00:00:00.00 000:00:00:00.000

Since the day is day 000, the Start and Stop times never match.

When the power is turned off, the current setting is saved in non-volatile memory, to be restored when it is next turned on.

3.321 to 3.329 reserved.

3.330 Serial Function F28 - Time Interval / Event Timing (Option)

3.330.1 Refer to manual section 3.398 for specifications on the Time Interval/Event Timing Input.

3.330.2 Use Serial I/O Function F28 to request a time interval measurement or event times. Send a string of the form:

F28<SEP><MODE><CR>

to the Serial I/O port where

F	=	the ASCII character F.
28	=	the function number.
<SEP>	=	one or more optional separator characters; either space, comma or tab.
<MODE>	=	either TI for Time Event or ET for Event Timing. This field is optional with the default being ET.
<CR>	=	a carriage return character.

If the mode was TI, the port will respond with a string of the form

<NSEC><CR><LF>

where

<NSEC>	=	the 9-digit subsecond string
<CR>	=	a carriage return character.
<LF>	=	a line feed character.

The interval is expressed as a decimal fraction of seconds. The port will continue to update and output an interval measurement once each second until the Serial I/O port receives a CTRL-C character (HEX 03).

Sample entry:	F28 ti<CR>
Response:	.123456700<CR><LF>
Meaning:	The interval is 0.123456700 seconds

If the mode was ET, the port will respond with a string or strings of the form

<DAY>:<HOUR>:<MIN>:<SEC>.<NSEC><CR><LF>

where

<DAY>	=	the 3-digit day of year.
:	=	the ASCII colon character.
<HOUR>	=	the 2-digit hours.
<MIN>	=	the 2-digit minutes.
<SEC>=	=	the 2-digit seconds.
<NSEC>	=	the 9-digit subsecond string
<CR>	=	a carriage return character.
<LF>	=	a line feed character.

Up to ten events each second may be timed if the events are continuous. A burst of 100 events within 1.0 sec may be recorded. The resolution is 30 ns. Send a CTRL-C to exit this mode.

Sample entry: F28 ET<CR>
Response: 111:22:33:44.123456700<CR><LF>

3.331 through 3.332 reserved

3.333 Serial Function F29 - External Frequency Measurement (Option)

3.333.1 Refer to section 3.395 for information concerning the External Frequency Measurement input. Use Serial I/O function F29 to set the measurement mode, input frequency and measurement interval parameters and to view the current settings and the measurement data.

This function provides the capability to measure the frequency of an externally applied 1, 5 or 10 MHz signal very accurately with respect to the disciplined Mark V oscillator. The resolution of the measurements is 6 parts in 10^{11} divided by the Measurement Interval. The range of fractional frequency offset from the nominal input frequency which may be measured is +/- 500 PPM. The Measurement Interval may be specified in integer seconds over the range of 1 to 100,000 seconds.

Function 29 offers three modes of operation:

OFF	=	No measurements are reported in this mode.
QUERY	=	Measurements are reported only when requested in this mode.
PERIODIC	=	Measurements are continuously output at the specified interval in this mode until a CTRL-C is sent.

3.333.2 The measurement technique uses a heterodyne phase error multiplier approach to achieve high resolution at short sample periods. An important feature of this implementation is that "zero dead time" frequency measurements are performed. In essence the position in Mark V internal time of a zero crossing of the

externally applied frequency being measured is recorded, or "timestamped", once per measurement interval with 60 picosecond resolution. (In the QUERY mode of operation, the reception of the measurement request string causes a timestamp to be performed, rather than at a fixed repetitive rate as in the PERIODIC mode of operation). In addition, the number of zero crossings between successive timestamps is also recorded.

When it is time to perform a measurement, either because the selected interval in PERIODIC mode has elapsed or a QUERY mode measurement request has been received, the previous measurement timestamp is subtracted from the current one and the difference is divided by the number of zero crossings between these two timestamps. This result is the average period of the external frequency being measured over the interval. The reciprocal of this period is then compared to the nominal frequency to determine the fractional frequency offset. The timestamp reported with the resulting measurement is the ending timestamp of the two phase readings used to make the measurement. Since this ending timestamp is now the beginning timestamp for the next measurement, there is no "dead time" present in the measurements.

The reported timestamp resolution is sufficient to allow integrating the fractional frequency offset measurements to fully recover the relative phase of the external frequency source being measured versus the disciplined Mark V internal or external oscillator.

To view the current settings, send a character string of the form:

F29<CR>

where

F	=	the ASCII character "F"
29	=	the function number
<CR>	=	the ASCII carriage return character, HEX 0D

The Serial I/O port will respond with:

F29<SEP><MODE><SEP><FREQ><SEP><INTERVAL>
<CR><LF>

where

<SEP>	=	a separator character, either space, comma or tab.
<MODE>	=	either OFF, QUERY or PERIODIC.
<FREQ>	=	the input frequency in MHz, either 1, 5 or 10. This field is not sent if the mode is OFF.
<INTERVAL>	=	the measurement interval in seconds, a decimal integer in the range of 1 to 100000. This field is not sent if the mode is OFF or QUERY.

To configure function F29, send a string in this format:

F29<SEP><MODE><SEP><FREQ><SEP><INTERVAL><CR>

If the MODE being set is OFF, then the Serial I/O port will respond with:

OK<CR><LF>

Otherwise, the Serial I/O port will respond with:

F29<SEP><TIMESTAMP><SEP><MODE><SEP><FREQ><SEP><INTERVAL><CR><LF>

where

<TIMESTAMP> = dayofyear:hours:minutes:seconds.subseconds in this fixed format: ddd:hh:mm:ss.nnnnnnnnn

This timestamp is the initial phase timestamp. It is used to compute the first fractional frequency offset measurement that follows either a QUERY or PERIODIC update.

3.333.3 In the PERIODIC mode of operation, measurements are continually output at the specified measurement interval until a CTRL-C character (HEX 03) is received. Reception of the CTRL-C character automatically sets the F29 mode to OFF. In PERIODIC mode, all characters sent to the Mark V will be ignored until CTRL-C is received. This mode is suitable for long term automated observation of the performance of an external frequency standard or for the calibration of free running timebase oscillators.
In the QUERY mode of operation, a measurement is computed and output each time that this string is received:

F29<SEP>F<CR>

where

F = the ASCII character "F".

In this mode, the measurement interval is the time in integer seconds between receptions of the above string. This mode is useful in matching the data rate of some other process that is concurrently being logged and is not necessarily periodic or synchronized with the Mark V.

3.333.4 The measurement returned in either the QUERY or PERIODIC modes is sent in this format:

F29<SEP><TIMESTAMP><SEP><FFO><CR><LF>

where

<FFO>= fractional frequency offset of the input frequency relative to its nominal frequency in this fixed field scientific notation format:

sX.XXXXXXXXXXEsXX

Sample command: F29 PERIODIC 10 100<CR>
Response: F29 124:23:08:10.000956789 PERIODIC 10 MHz 100 SEC<CR><LF>
Result: A 10 MHz input frequency is continually measured and reported over 100 second measurement intervals.

Sample measurement sent either from PERIODIC mode or on request from QUERY mode:

F29 123:21:37:56.000894320 -2.89345678245E-04<CR><LF>

3.334 through 3.337 reserved

3.338 Serial Function F50 - Position Entry / Request

3.338.1 Use Serial I/O function F50 to enter or request the current antenna position. Since function F50 returns the most recent fix computed by the GPS core receiver, not the long term averaged position which is calculated during the AUTO mode of operation and reported via Serial I/O function F56, its use is mainly for initializing the approximate position of the GPS core receiver at new installations or after loss of non-volatile RAM back-up power.

The out-of-the-box default for position is that of the TrueTime factory in Santa Rosa, California. The position on subsequent power-ups will be the same as it was on the previous power-down. To determine the present position send F50<CR> and the Serial I/O port will respond with the following continuous one line string:

F50<SP><SIGN><SP><DEG>d<MIN>'<SEC>"<SP><SIGN><SP><DEG>d<MIN>'
<SEC>"<SP><SP><SP><SP or -><ALT><UNITS><SP>pdop<SP><PDOP><LT>

where

F	=	ASCII character F (f or F for input string).
50	=	function number.
<SP>	=	ASCII space character.
<SIGN>	=	N or S for latitude; E or W for longitude; or + or - for longitude, latitude or altitude (-) corresponds to S or W. or no character, <SP> for + altitude.

<DEG>	=	two-digit degrees for latitude or three-digit degrees for longitude.
d	=	ASCII character d (d or D for input string). (Always d in output string).
<MIN>	=	two-digit minutes.
'	=	ASCII character '(' m or M for input string). (Always ' in output strings).
<SEC>=		two-digit seconds.
"	=	ASCII character "(" s or S for input string). (Always " in output string).
<ALT>	=	altitude in feet or meters.
<UNITS>	=	unit of altitude, either a M or m for meters or F or f for feet depending on the units selected with keypad function 55 or Serial I/O function F55.
<PDOP>	=	3 or 4 digit value of the position dilution of precision.
<LT>	=	line terminator, either a carriage return and line feed for output strings or a carriage return only for input strings.

Sample request: F50<CR>
Response: F50 N 38d23'51.3" W 122d42'53.2" 58m pdop 2.69<CR><LF>

To enter a position send a character string with the following format. Latitude, longitude or altitude may be omitted in the string provided they are replaced with a semicolon (;) character. The altitude units may be feet or meters.

Sample entry: f50 n 38d23'51.3" w 122d42'53.2" 10m<CR>
Equivalent: F50 + 38D23M51.3S + 122D42M53.2S +10M<CR>
Response: OK<CR><LF>

Sample request: F50<CR> (after sending above string)
Response: F50 N 38d23'51.3" W 122d42'53.2" 10m pdop 2.69<CR><LF>

Sample entry: f50;;40m (with values from example above)
Equivalent: F50 ; ; 40M
(no change to latitude or longitude - altitude now 40m)
Response: F50 N 38d23'51.3" W 122d42'53.2" 40m pdop 2.69<CR><LF>

NOTE: Altitude must be included in the position entry string - either a value or a (;) must be entered or a syntax error will occur (causing the entered string to be ignored).

3.339 reserved

3.340 Serial Function F51 - Cable Delay Entry / Request

3.340.1 Use Serial I/O function F51 to enter or request the cable delay. The default is 50ns. Typical delays for RG-58 and RG-59 cables are approximately 1.4 nS/foot. The value is held in NVRAM. To determine the present value send

F51<CR> to the Serial I/O port. The port will respond with the ASCII character string in the following format:

F51<SEP><SIGN><DELAY>ns<LT>

where

F	=	ASCII character F (f or F for input string).
51	=	the function number.
<SEP>	=	one or more space characters.
<SIGN>	=	either + or -
<DELAY>	=	1 to 9 digit delay from +001000000ns to -001000000ns.
ns	=	nanoseconds (ns or NS for input string).
<LT>	=	line terminator, either a carriage return and line feed or output strings or a carriage return only for input strings.
<SP>	=	ASCII space character.

Sample request: F51<CR>
Response:
F51<SP><SP><SP><SP><SP><SP><SP><SP>+50ns<CR><LF>

To enter a 1 millisecond cable delay send the following character string:

Sample entry: F51<SP>1000000NS<CR>
Response: OK<CR><LF>

Sample request: F51<CR> (using entry from above)
Response: F51<SP><SP><SP>+1000000ns<CR><LF>

3.341 reserved

3.342 SERIAL FUNCTION F52 - DISTRIBUTION CABLE DELAY ENTRY/REQUEST

3.342.1 Use Serial I/O function F52 to enter or request the distribution cable delay for compensating the timing outputs for delays between the GPS-XL and the point of use of the timing signals. Antenna cable delay compensation should not be performed using this function. Use function F51 for antenna cable delay. The default is 0 ns. Typical delays for RG-58 and RG-59 cables are approximately 1.4 nS/foot. The value is held in NVRAM. *Positive delays entered here will advance the Mark V timing outputs while negative delays will retard them.*

To determine the present value send F52<CR> to the Serial I/O port. The port will respond with the ASCII character string in the following format:

F52<SEP><SIGN><DELAY>ns<LT>

where

F	=	ASCII character F (f or F for input string).
52	=	the function number.
<SEP>	=	one or more space characters.
<SIGN>	=	either + or -
<DELAY>	=	1 to 9 digit delay from +001000000ns to -001000000ns.
ns	=	nanoseconds (ns or NS for input string).
<LT>	=	line terminator, either a carriage return and line feed for output strings or a carriage return only for input strings.
<SP>	=	ASCII space character.

Sample request: F52<CR>
Response:
F52<SP><SP><SP><SP><SP><SP><SP><SP>+50ns<CR><LF>

To enter a 1 millisecond cable delay send the following character string:

Sample entry: F52<SP>1000000NS<CR>
Response: OK<CR><LF>

Sample request: F52<CR> (using entry from above)
Response: F52<SP><SP><SP>+1000000ns<CR><LF>

3.343 reserved

3.344 Serial Function F53 - Operational Mode Entry / Request

3.344.1 Use Serial I/O function F53 to select the operational mode, either AUTO, SURVEY STATIC (OPTION), SURVEY DYNAMIC (OPTION) or TIME. For an explanation of these modes refer to section 3.20, "OPERATIONAL MODES". The power-up default is the mode in use at the previous power-down. To request the present mode send F53<CR> to the Serial I/O port. The port will respond with the ASCII character string:

F53<SEP><MODE>:<SEP><#><SEP>SATS<LT>

where

F	=	ASCII character F.
53	=	function number.
<SEP>	=	one or more separator characters: either space, comma or tab.
<MODE>	=	AUTO, SURVEY STATIC, SURVEY DYNAMIC or TIME.
:	=	ASCII colon
<SEP>	=	space
<#>	=	number of SV's being tracked
<LT>	=	line terminator, either a carriage return and line feed for output strings or a carriage return only for input strings.

Sample request: F53<CR>
Response: F53 SURVEY STATIC: 6 SATS<CR><LT>

To enter TIME mode send the following character string:
Sample entry: F53<SP>TIME<CR>
Response: OK<CR><LF>

Sample request: F53<CR>
Response: F53 TIME: 5 SATS<CR><LF>

3.345 through 3.347 reserved.

3.348 Serial Function F55 - Altitude Units Entry / Request

3.348.1 Use Serial I/O function F55 to select the units of the altitude, either feet or meters. The out-of-the-box default is meters. The units upon subsequent power-ups will be the same as they were on the previous power-down. To request the units presently in use, send F55<CR> to the Serial I/O port. The port will respond with the ASCII character string:

F55<SEP><UNITS><LT>

where

F	=	ASCII character F.
55	=	function number.
<SEP>	=	one or more separator characters: either space, comma or tab.
<UNITS>	=	FEET or METERS.
<LT>	=	line terminator, either a carriage return and line feed for output strings or a carriage return only for input strings.

Sample request: F55<CR>
Response: F55 METERS<CR><LF>

To select feet send the following character string:

Sample entry: F55<TAB>FEET<CR>
Response: OK<CR><LF>

Sample request: F55<CR>
Response: F55 FEET<CR><LF>

3.349 reserved

3.350 Serial Function F56 - Average Position Entry / Request

3.350.1 Use Serial I/O function F56 to enter or request the averaged, hence accurate, current antenna position. Its main use is to provide a means of setting an accurate, surveyed position for use in the TIME mode of operation. Positions

provided to the Mark V via function F56 should be more accurate than 10 meters, otherwise better results may be obtained via AUTO mode, unless satellite visibility at the site is too poor to provide three dimensional positioning.

The out-of-the-box default for position is that of the TrueTime factory in Santa Rosa, California. The position on subsequent power-ups will be the same as it was on the previous power-down. An averaged position as returned via function F56 which subsequently becomes in error by more than 1 Km, either due to transport of the receiver and antenna or error in the initial entry, will be cleared and recalculated automatically once positioning begins at the new site and the error is detected.
To determine the present position send F56<CR> and the Serial I/O port will respond with the following continuous one line string:

F56<SP><SIGN><SP><DEG>d<MIN>'<SEC>"<SP><SIGN><SP><DEG>d
<MIN>'SEC>"<SP><SP><SP><SP

or -><ALT><UNITS><SP><SOURCE><LT>

where

F	=	ASCII character F (f or F for input string).
56	=	function number.
<SP>	=	ASCII space character.
<SIGN>	=	N or S for latitude; E or W for longitude; or + or - for longitude, latitude or altitude (-) corresponds to S or W. or no character, <SP> for + altitude.
<DEG>	=	two-digit degrees for latitude or three-digit degrees for longitude.
d	=	ASCII character d (d or D for input string). (Always d in output string).
<MIN>	=	two-digit minutes.
'	=	ASCII character '(' m or M for input string). (Always ' in output strings).
<SEC>	=	two-digit seconds.
"	=	ASCII character "(" s or S for input string). (Always " in output string).
<ALT>	=	altitude in feet or meters.
<UNITS>	=	unit of altitude, either a M or m for meters or F or f for feet depending on the units selected with keypad function 55 or Serial I/O function F55.
<SOURCE>	=	the source of the position in one of two formats:

COUNT <NNNNN> / 90000

NNNNN is the total number of fixes in the average, 90000 is the total number of fixes required to complete the position average process.

ENTERED

Indicates that the current averaged position was obtained via operator entry.

<LT> = line terminator, either a carriage return and line feed for output strings or a carriage return only for input strings.

Sample request: F56<CR>
Response: F56 N 38d23'51.3" W 122d42'53.2" 58m 49001/90000

To enter a position send a character string with the following format. Latitude, longitude or altitude may be omitted in the string provided they are replaced with a semicolon (;) character. The altitude units may be feet or meters. **The unit must be in TIME mode to enter the accurate position using F56.**

Sample entry: f56 n 38d23'51.3" w 122d42'53.2" 10m<CR>
Equivalent: F56 + 38D23M51.3S + 122D42M53.2S +10M<CR>
Response: OK<CR><LF>

Sample request: F56<CR> (after sending above string)
Response: F56 N 38d23'51.3" W 122d42'53.2" 10m ENTERED<CR><LF>

Sample entry: f56;;40m (with values from example above)
equivalent: F56 ; ; 40M
(no change to latitude or longitude - altitude now 40m)
Response: F56 N 38d23'51.3" W 122d42'53.2" 40m<CR><LF>

NOTE: Altitude must be included in the position entry string - either a value or a (;) must be entered or a syntax error will occur (causing the entered string to be ignored).

3.351 through 3.362 reserved

3.363 Serial Function F60 - Satellites List Request

3.363.1 Use Serial I/O function F60 to request a list of all, current, tracked or bad satellites. To request the list send the string:

F60<SEP><TYPE><CR>

where

F	=	ASCII character F.
60	=	function number.
<SEP>	=	one or more separator characters: either space, comma or tab.
<TYPE>	=	ALL, CURRENT, TRACKED or BAD.
<CR>	=	carriage return character.

The Serial I/O port will respond with a series of strings of the form

F60<SEP>prn NN good enabled tracked current sig level =
+<LEVEL>dB <link freq.> <code> <CR> <LF>

where

NN	=	two-digit satellite number.
<LF>	=	line feed character.
tracked	=	either present or absent.
current	=	either present or absent.
<link freq.>	=	L1 or L2
<code>	=	CA or P or Y

Sample request: F60 ALL<CR>
Response:

F60 prn 14 good enabled tracked current	sig level	=	+42 dB L1 CA<cr><lf>
F60 prn 15 good enabled tracked current	sig level	=	+41 dB L1 CA<cr><lf>
F60 prn 18 good enabled tracked current	sig level	=	+39 dB L1 CA<cr><lf>
F60 prn 19 good enabled	sig level	=	+0 dB<cr><lf>
F60 prn 11 good enabled	sig level	=	+0 dB<cr><lf>
F60 prn 2 good enabled	sig level	=	+0 dB<cr><lf>
F60 prn 16 good enabled	sig level	=	+0 dB<cr><lf>
F60 prn 6 good enabled	sig level	=	+0 dB<cr><lf>
F60 prn 13 good enabled	sig level	=	+0 dB<cr><lf>
F60 prn 12 good enabled	sig level	=	+0 dB<cr><lf>
F60 prn 20 good enabled	sig level	=	+0 dB<cr><lf>
F60 prn 3 good enabled	sig level	=	+0 dB<cr><lf>
F60 prn 17 good enabled	sig level	=	+0 dB<cr><lf>
F60 prn 23 good enabled	sig level	=	+0 dB<cr><lf>
F60 prn 21 good enabled tracked	sig level	=	+27 dB L1 CA<cr><lf>

Keyed receivers will use Y code.

3.364 through 3.371 reserved

3.372 Serial Function F65 - Satellite Select

3.372.1 Use Serial I/O function F65 to select specific satellites for the receiver to track or deselect satellites, i.e. instruct the Mark V to ignore certain satellites. Send the string of the form:

F65<SEP><REQUEST>[<SEP>NN]<CR>

or

F65<SEP><REQUEST>ALL<CR>

where

F	=	ASCII character F.
65	=	function number.
<REQUEST>	=	either SELECT or DESELECT
<SEP>	=	one or more separator characters: either space, comma or tab.
NN	=	two-digit satellite number.
ALL	=	ASCII character string ALL.
[]	=	encloses a phrase that is repeated as often as necessary.
<CR>	=	carriage return character.

The Serial I/O port will respond with an OK.

Sample entry: F65 SELECT 02 18 13<CR>
Response: OK<CR><LT>

Sample entry: F65<TAB> SELECT ALL<CR>
Response: OK<CR><LF>
Sample entry: F65 DESELECT 01 08<CR>
Response: OK<CR><LF>

To determine which satellites are enabled (selected) and being tracked use Serial I/O function F60. Only those satellite numbers appearing on the Satellite List as displayed using F60 may be selected or deselected. Use of any other satellite number will result in the error message "ERROR 04 EXCLUSIVE USE".

NOTE: The time and frequency receiver requires 24 hours after turn on to complete the satellite list.

3.373 Serial Function F66 - Daylight Savings Enable

3.373.1 Use Serial I/O function F66 to enable or disable or set the entry or exit times for DST. The initial out-of-the-box default is "Off". The default upon subsequent power-ups will be the selection in use just prior to the previous power-down.
To request the present status of the daylight savings enable, send F66<CR> to the serial port. The port will respond with the ASCII character string:

F66<SEP><STATE><LT>

where

F	=	ASCII character F.
66	=	function number
<SEP>	=	one or more separator characters: either space, comma or tab.
<STATE>	=	Off or Manual.
<LT>	=	line terminator, either a carriage return and line feed for output strings or a carriage return only for input strings.

If the DST function is in Manual, the port will respond with the longer string described below.

Sample request: F66<CR>
Response: F66 OFF<CR><LF>

To alter the state of the daylight savings enable send a character string with the format above to the serial port.

Sample entry: F66<TAB>Off<CR>
Response: OK<CR><LF>

To place the DST function in Manual and set the DST entry and exit times send a continuous string of the form:

F66 MANUAL <IN HOUR><SEP><IN WEEK><SEP><IN DAY><SEP>
<IN MONTH><OUT HOUR><SEP><OUT WEEK><SEP><OUT DAY>
<SEP><OUT MONTH><LT>

where

<IN HOUR>	=	time to enter DST in 24-hour format.
<SEP>	=	one or more separator characters, either space comma or tab characters. For output strings this will be a single space character.
<IN WEEK>	=	which week to enter DST, 1, 2, 3, 4 or 0 (for last).
<IN DAY>	=	day of week to enter DST, 1 through 7 where Sunday is 1.
<IN MONTH>	=	month to enter DST, 1 through 12 where 1 is January.
<OUT HOUR>=		hour to exit DST, in 24 hour format.
<OUT WEEK>=		which week to exit DST, 1, 2, 3, 4 or 0 (for last).
<OUT DAY>	=	day in to exit DST, 1 through 7 where Sunday is 1.
<OUT MONTH>	=	month to exit DST, 1 through 12 where 1 is January
<LT>	=	line terminator, a carriage return and line feed for output strings, only a carriage return for input strings.

If desired, any item may be replaced with a semicolon, which will leave its value unchanged. If any of the items in an input string are invalid, an error message will be returned.

Sample Request: F66<CR>
Response: F66 MANUAL 02 1 1 04 02 0 1 10
Meaning: Manual settings are in effect. The entry time is 02 a.m. on the first Sunday of April and the exit time is 02 a.m. on the last Sunday in October.

Sample Entry: F66 MANUAL ; 0 ; ; ; ; ; ;<CR>
Response: OK<CR><LF>
Meaning: DST will now be entered on the last week of the month. All other parameters remain unchanged.

Sample Entry: F66 MANUAL 4 2 2 3 13 4 6 11<CR>
Response: OK<CR><LF>
Meaning: DST will now be entered 04 a.m. on the 2nd Monday in March and exit DST at 01 p.m. on the 4th Friday in November.

3.374 Serial Function F68 - Set Current Year

The GPS week number sent from the satellites has only 10 bits of precision, so that after 1024 weeks from January 6, 1980 (GPS week 0) it rolls back to 0. To correctly calculate calendar dates after this roll point, the software keeps track of the current year so that it can construct an absolute, non-rolling week number since January 6, 1980.

This software release knows that it is already at least 1996, and it will properly handle dates for the next 17 years. In addition, as the clock advances to each new year, the current year is saved and used in the calendar calculations from that point on, so that calculations beyond 2012 are also handled properly. No user intervention is required as long as the clock runs locked to GPS at least once in 5 years to allow the year to be updated.

If after 2012, the current year saved in non-volatile memory is lost, or the clock is not locked to GPS within 5 years of the last year save in non-volatile memory for Function 68, then Function 68 can be used to manually enter the current year. Years prior to 1996 are not accepted, and entering a future year may cause incorrect calendar date calculations.

To request the Function 68 current year setting, send the string:

Sample request: F68<CR>
Response: F68 1996<CR><LF>

To set the current year, send a string with the following format:

Sample entry: F68 1997<CR>
Response: OK<CR><LF>

3.375 Serial Function F69 - Select Local / Standard / GPS / UTC Time

3.375.1 Use Serial I/O function F69 to request or set the time display format. To determine the format send F69<CR> to the Serial I/O port. The port will respond with the following character string:

F69<SEP><HH><LT>

Sample request:		F69<CR>
Response:		F69 STANDARD <CR><LF>
	or	F69 LOCAL <CR><LF>
	or	F69 UTC <CR><LF>
	or	F69 GPS <CR><LF>

To set the Time Type

F69<SEP><TT><LT>

where

F	=	ASCII character F.
69	=	function number.
<SEP>	=	one or more separator characters: either space, comma or tab.
<TT>	=	Time Type. Either STANDARD, LOCAL, GPS or UTC.
<LT>	=	line terminator, either a carriage return and line feed for output strings or a carriage return only for input strings.

Sample request:	F69 STANDARD<CR>
Response:	OK<CR><LF>

Sample request:	F69 UTC<CR>
Response:	OK<CR><LF>

3.375.2 The time types are:

GPS:	The time determined by primary atomic frequency standards. This type of time does not include leap seconds. Therefore, it differs from UTC time.
UTC:	Universal Time Coordinated. This time is related to the local solar mean time at Greenwich Meridian. This time is adjusted once in a while to compensate for the earth's rotational variations.
STANDARD:	This time equals UTC plus the local time zone offset.
LOCAL:	This time equals STANDARD plus Daylight Saving Time offset, when required.

3.375.3 Standard and Local times require the proper setting of the time zone offset with F01 (Set Time Zone). In addition, Local time requires that F66 Daylight Savings Time be properly set, if applicable. The 12/24 hour mode (F02) is applied to all the above time types (GPS, UTC etc.).

3.375.4 When in UTC, STANDARD, or LOCAL time mode, the Mark V 1PPS output is corrected by the GPS-UTC A0 and A1 subsecond correction parameters.

3.376 Serial Function F71 - Oscillator Status Request

3.376.1 Use Serial I/O function F71 to request the internal or external (when operating in External Oscillator enabled mode, see function 07) oscillator's phase, frequency offset, drift rate and DAC value. The phase is the instantaneous error in seconds between the oscillator and the control loop zero servo point. The frequency offset is computed using an averaging time that is equal to the effective averaging time of the oscillator controller. The oscillator drift rate is computed using a 24 hour average and is the daily drift rate of the oscillator. The oscillator DAC value is a signed 16 bit integer that controls the DAC output voltage. It ranges from 32767 to -32768. Send the string F71<CR> to the Serial I/O port and it will respond with the continuous string

F71<SP>phase=<SIGN><MULT>E<SIGN><EXP><SP>s<SP><SP>
offset=<SIGN><MULT>E<SIGN><EXP><SP><SP>
drift=<SIGN><MULT>E<SIGN><EXP>/DAY<SP><SP>
DAC=<SIGN><INT><CR><LF>

where

F	=	ASCII character F.
71	=	function number.
<SP>	=	ASCII space character.
<MULT>	=	multiplier, 4 digits with decimal point.
E	=	ASCII character E for exponent.
s	=	ASCII character s for seconds abbreviation
<SIGN>	=	- for negative or <SP> for positive.
<EXP>	=	2 digit exponent.
/DAY	=	ASCII characters, units of drift rate
<INT>	=	integer, 5 digits
<CR>	=	carriage return.
<LF>	=	line feed.

Sample request: F71<CR>
Response:
F71 phase=-5.678E-09 s offset=-1.986E-07 drift= 6.013E-08/DAY
DAC=-24567<CR><LF>

3.377 reserved

3.378 Serial Function F72 - Fault Status

3.378.1 This function displays the current status of faults in the Mark V sub-systems. Currently, the status of the antenna, the PLL synthesizer lock status and the GPS lock status are the only such faults being monitored. The faults indicated here contribute to the state of the summary alarm open collector output and should be checked via F72 whenever an alarm output is detected.
Send the string F72<CR> and the serial I/O port will respond:

F72<SEP>Antenna: <ANT STATUS> PLL: <PLL STATUS>
GPS: <GPS STATUS><CR><LF>

where

F	=	ASCII character F
72	=	function number
<SEP>	=	one or more separator characters: either space, comma or tab
<ANT STATUS>	=	OK, OPEN or SHORT
<PLL STATUS>	=	OK, UNLOCKED
<GPS STATUS>	=	LOCKED, UNLOCKED
<CR>	=	ASCII carriage return character
<LF>	=	ASCII line feed character

3.379 Serial Function F73 - Request / Set Alarm Status / Control

3.379.1 This function allows the user to control which conditions will signal an alarm or fault through the 87-6XX GPS-XL sub-assembly open collector output at P46B pin 1, or through relay contacts on 86-336 or 86-379 option boards. The user can also monitor the status of the individual indicators that contribute to the summary alarm outputs.

3.379.2 The fault status flags can be read by the following command, regardless of whether the faults are enabled or not:

F73<CR>

which returns:

F73<SP>S12345678<SP>M12345678<SP>m12345678<CR><LF>

where

F	=	ASCII character F	
7	=	ASCII character 7	
3	=	ASCII character 3	
<SP>	=	ASCII space character	
S	=	'S'	Status delimiter
1	=	'L'	Satellite Lock OK
		'U'	Unlock Spec Reached
2	=	'A'	Position Accurate, Full Accuracy and Stability When Locked
		'B'	Position Approximate, Slightly Degraded Accuracy and Stability When Locked
		'C'	Position Unknown, Highly Degraded Accuracy and Stability, Not Locked
		'D'	Position and Time Unknown, Not Locked

3	=	'A'	Auto Mode
		'T'	Time Mode
		'S'	Survey Mode
		'D'	Differential Mode
4	=	'0'	Number of Current Satellites used in solutions thru '6'
5	=	'-'	Currently not used
6	=	'-'	Currently not used
7	=	'-'	Currently not used
8	=	'-'	Currently not used
M	=	'M'	Major Alarm delimiter
1	=	'-'	System PLL OK
		'P'	System PLL Unlock
2	=	'-'	PLL Synthesizer OK
		'P'	PLL Synthesizer Unlocked
3	=	'-'	Antenna OK
		'O'	Antenna Open
		'S'	Antenna Short
4	=	'-'	Receiver OK
		'R'	Receiver Fault
5	=	'-'	Non-Volatile RAM Data OK
		'N'	Non-Volatile RAM Data Fault
6	=	'-'	The minor alarm, 'Time Error Threshold Reached', has not persisted for Timeout seconds.
		'U'	The minor alarm, 'Time Error Threshold Reached', has persisted for Timeout seconds.
7	=	'-'	Currently not used
8	=	'-'	Currently not used
m	=	'm'	Minor Alarm delimiter
1	=	'-'	Time Error Threshold Not Reached
		'U'	Time Error Threshold Reached
2	=	'-'	Tracking OK
		'T'	Not Tracking Satellites
3	=	'-'	Oscillator Tuning Voltage OK
		'X'	Oscillator Tuning Voltage Requires Adjustment
4	=	'-'	Non-Volatile RAM Battery Voltage OK
		'B'	Non-Volatile RAM Battery Voltage Low
5	=	'-'	Unit has locked at least once.
		'A'	Initial Acquisition Mode, unit has not yet locked since power on.
6	=	'-'	Currently not used
7	=	'-'	Currently not used
8	=	'-'	Currently not used
<CR>	=		ASCII carriage return character
<LF>	=		ASCII line feed character

3.379.3 The user can query or control which faults affect the alarm output by the following commands. When setting the mask, the letter 'E' enables the fault, the letter 'D' disables it, and a '-' leaves it unchanged.

Sending

F73<SP>MASK<CR>

returns:

F73<SP>MASK<SP>M12345678<SP>m12345678<CR><LF>

Sending

F73<SP>MASK<SP>M12345678<SP>m12345678<CR>

sets the alarm mask where the mask characters are:

M	=	'M'	Major Alarm delimiter
1	=	'E'	PLL Synthesizer Alarm Enabled
		'D'	PLL Synthesizer Alarm Disabled
2	=	'E'	Antenna Alarm Enabled
		'D'	Antenna Alarm Disabled
3	=	'E'	Receiver Alarm Enabled
		'D'	Receiver Alarm Disabled
4	=	'E'	Non-Volatile RAM Data Alarm Enabled
		'D'	Non-Volatile RAM Data Alarm Disabled
5	=	'E'	The minor alarm, 'Time Error Threshold Reached', has persisted for Timeout seconds, Alarm Enabled
		'D'	The minor alarm, 'Time Error Threshold Reached', has persisted for Timeout seconds, Alarm Disabled
6	=	'-'	Currently not used
7	=	'-'	Currently not used
8	=	'-'	Currently not used
m	=	'm'	Minor Alarm delimiter
1	=	'E'	Time Error Threshold Reached Alarm Enabled
		'D'	Time Error Threshold Reached Alarm Disabled
2	=	'E'	Tracking Alarm Enabled
		'D'	Tracking Alarm Disabled
3	=	'E'	Oscillator Tuning Voltage Alarm Enabled
		'D'	Oscillator Tuning Voltage Alarm Disabled
4	=	'E'	Non-Volatile RAM Battery Voltage Alarm Enabled
		'D'	Non-Volatile RAM Battery Voltage Disabled
5	=	'E'	Initial Acquisition Mode Alarm Enabled
		'D'	Initial Acquisition Mode Alarm Disabled
6	=	'-'	Currently not used
7	=	'-'	Currently not used
8	=	'-'	Currently not used

The command returns:

OK<CR><LF>

if successful.

3.379.4 The time error threshold at which the time error fault is activated can be queried or set by the following command. Sending

F73<SP>THRESHOLD<CR>

returns:

F73<SP>THRESHOLD<SP><nanoseconds><SP>ns<CR><LF>

where <nanoseconds> is the time error threshold in nsec.

Sending

F73<SP>THRESHOLD<SP><nanoseconds><CR>

sets the time error threshold and returns:

OK<CR><LF>

if successful.

3.379.5 The timeout after which a time error fault becomes a timeout fault can be queried or set by the following command.

F73<SP>TIMEOUT<CR>

which returns:

F73<SP>TIMEOUT<SP><seconds><SP>s<CR><LF>

where <seconds> is the timeout in seconds, between 0 and 86400.

Sending

F73<SP>TIMEOUT<SP><seconds><CR>

sets the timeout and returns:

OK<CR><LF>

if successful.

3.379.6 If a checksum error is detected while recalling settings from non-volatile RAM, an NVRAM data fault is indicated. This same fault is active if an attempt was made to recall non-volatile RAM settings and default settings were created since no settings were found. This can occur the first time the clock is started up, when some option boards are installed, or if the non-volatile RAM battery is low or jumper JP1 is removed. In all these cases, an NVRAM fault is indicated since the operator should check the non-volatile settings to verify that they are correct.

After the operator has confirmed that all settings are correct, the following command can be used to cancel the error, so that future errors can be caught.

F73<SP>CLEAR<SP>NVRAM<SP>FAULT<CR>

clears the fault and returns:

OK<CR><LF>

3.379.7 In all implementations using the 87-6XX GPS-XL core, the open collector alarm output at P46B pin 1 has the following states:

Off	Power off
Off	Error, major or minor enabled alarm fault.
On	Normal, no major or minor enabled alarm faults.

If the processor on the 87-6XX GPS-XL sub-assembly were to fail, resulting in a failure to trigger the watchdog timer, the watchdog timer would reset the processor and attempt to restart the system. During the processor reset, and the alarm output transistor open collector would be off, indicating a fault. If the processor were unable to recover and resume triggering the watchdog timer, a succession of watchdog timer timeouts followed by resets would result. At the same time, the open collector alarm output transistor might either be off, or might toggle between off and on following the repeated resets, indicating an alarm condition.

3.380 Serial Function F79 - Warm Start / Clear Almanac

3.380.1 This function can be used to issue a reset command (warm start) to the Trimble Force 22 GPS module or to clear stored almanac data retained in battery-backed RAM.

Send the string F79<CR> and the Mark V will respond by initiating a warm start. This command does not clear stored almanac and ephemeris data.

Sample:	F79<CR>
Response:	OK<CR><LF>

Send the string F79 clear almanac <CR> and the Mark V will respond by clearing almanacs in battery backed RAM.

Sample:	F79 clear almanac <CR>
Response:	OK <CR><LF>

Cryptokeys held in the Force 22 SAASM are not affected by either a warm start or by clearing almanacs.

3.381 through 3.383 are reserved.

3.384 Serial Function 92 - P(Y) Functions

Serial I/O Function 92 displays P(Y) receiver cryptokey status, allows zeroizing cryptokeys, Displays mission duration status, allows setting mission duration, allows setting anti-spoof mode, and allows performing a P(Y) receiver SAASM self-test.

To request cryptokey status, send the following string:

Sample request: F92 KEYS<CR>
Response: F92 KEYS: valid<CR><LF>

This indicates that keys have been loaded, and that they have been found to be valid based on GPS data.

Possible responses from this request are:

F92 KEYS: SAASM Error
F92 KEYS: No Key
F92 KEYS: loaded
F92 KEYS: valid
F92 KEYS: insufficient
F92 KEYS: valid nnn hours
F92 KEYS: unknown
F92 KEYS: NAV Data Needed Soon

To zeroize cryptokeys, send this string:

Sample request: F92 ZEROIZE<CR>
Response: F92 KEYS ZEROIZED<CR><LF>

Possible responses from this request are:

F92 ZEROIZE FAILURE
F92 KEYS ZEROIZED

To request the mission duration status, send this string:

Sample request: F92 MD<CR>
Response: F92 MD: 46 hours set<CR><LF>

Possible responses from this request are:

F92 MD: nnn hours set
F92 MD: nnn hours set; need keys
F92 MD: nnn hours default
F92 MD: nnn hours default; need keys
F92 MD: not set
F92 MD: unknown

To set the mission duration, send this string:

Sample request: F92 MD: 100<CR>
Response: OK<CR><LF>

Possible responses from this request are:

OK
F92 MD Error: Rejected, no keys
F92 MD Error: SAASM error
F92 MD Error: Previously set
F92 MD Error: Zeroize & retry
F92 MD Error: Waiting for time
F92 MD Error: Invalid date

To request the current anti-spoof mode, send this string:

Sample request: F92 AS<CR>
Response: F92 AS: ON<CR><LF>

Possible responses from this request are:

F92 AS: OFF
F92 AS: ON MIXED
F92 AS: ON

In the "ON MIXED" anti-spoof mode setting, the receiver prefers to use Y code, but will use P code if needed to do fixes. Since virtually all current satellites are sending Y code and not P code, when the Mark V is keyed, anti-spoofing should be set to "ON".

To set the anti-spoof mode to "OFF", send this string:

Sample request: F92 AS: OFF<CR>
Response: OK<CR><LF>

To set the anti-spoof mode to "ON", send this string:

Sample request: F92 AS: ON<CR>
Response: OK<CR><LF>

To request the built-in self test of the Force 22 SAASM, send:

Sample request: F92 BST<CR>
Response: F92 BST: valid keys<CR><LF>

Possible responses from this request are:

F92 BST: SAASM failed
F92 BST: no keys

F92 BST: keys loaded
F92 BST: valid keys
F92 BST: unknown
F92 BST: timeout

3.385 through 3.387 are reserved.

3.388 Serial I/O Messages

3.388.1 The Serial I/O port will respond with the message "ERROR 01 VALUE OUT OF RANGE" if the input string was in the correct format but contained a value, probably numeric, that was out of the range of acceptable values. Refer to the paragraphs explaining the function in use for the correct range of values.

Sample entry: F01 13:00<CR>
Response: ERROR 01 VALUE OUT OF RANGE<CR><LF>

3.388.2 The Serial I/O port will respond with the message "ERROR 02 SYNTAX" if it receives a string in an incorrect format. Refer to "GENERAL INPUT AND OUTPUT FORMAT" in this section.

Sample entry: F03 LOCAD<CR>
Response: ERROR 02 SYNTAX<CR><LF>

3.388.3 The Serial I/O port will respond with the message "ERROR 03 BAD/MISSING FIELD" if the input string lacks a required field. Refer to the paragraph in this section explaining the function in use.

Sample entry: F14 1E<CR>
Response: ERROR 03 BAD/MISSING FIELD<CR><LF>

3.388.4 The Serial I/O port will respond with the message "ERROR 04 EXCLUSIVE USE" if another port has exclusive use and if the string sent is a request to enter data. Refer to "Serial I/O FUNCTION F15 - EXCLUSIVE USE ENABLE" in this section for an explanation of the exclusive use function.

Sample entry: F53 AUTO<CR>
Response: ERROR 04 EXCLUSIVE USE<CR><LF>

3.388.5 The Serial I/O port will respond with the message "ERROR 05 NO SUCH FUNCTION" if the function number requested is not implemented.

Sample entry: F40<CR>
Response: ERROR 05 NO SUCH FUNCTION<CR><LF>

3.389 to 3.393 reserved

3.394 INPUTS AND OUTPUTS

3.395 External Oscillator Input (Option)

3.395.1 A rear-panel mounted BNC connector provides External Oscillator input capability. When the Mark V and External Oscillator are properly configured using GPS-XL module 87-6XX jumpers JP3, JP4, JP5 and JP6 (Refer to Sheet 2 of configuration Dwg. 87-6XX) and keypad or Serial I/O Functions 07 and 14, and the External Oscillator Control DAC output is connected to the electronic frequency control input of the External Oscillator, the External Oscillator will be disciplined to the GPS derived frequency of UTC. The input frequency for this input must be 10 MHz. The signal may be TTL levels or a sine wave with an amplitude of 1.0 to 5.0 volts peak to peak. The input impedance is selectable at 1K or 50 ohms via jumper JP10 on GPS-XL module 87-6XX.

3.395.2 **CAUTION:** If the external oscillator is selected "ON" via Function 07 and **if no input is present** on the External Oscillator Input connector, the operation of the unit will be unpredictable. The jumper settings **MUST** match the mode set by Function 07.

3.396 through 3.397 reserved

3.398 External 1PPS Time Interval / Event Time Time Tag Input (Option)

3.398.1 A rear-panel mounted BNC connector will accept an externally applied 1PPS or Event input signal for measurement against the GPS derived UTC time. The signal should have a minimum pulse width of 100 nS. It must have a TTL low level and its high level must be in the range from a TTL high level to 10 VDC. The input impedance is selectable at 1K or 50 ohms via GPS-XL module 87-6XX jumper JP7. The rising edge of the pulse is measured with respect to the Mark V UTC time to 30 nS. Refer to "SERIAL I/O FUNCTION F28 - TIME INTERVAL/EVENT TIMING" for details concerning the use of this input.

3.399 reserved

3.400 External Frequency Measurement Input (Option)

3.400.1 A rear-panel mounted BNC connector will accept an externally applied signal for measurement with respect to the Mark V disciplined frequency. The resolution of the measurements is 6×10^{-11} at 1 second averaging. The input frequency for this input may be 1, 5, or 10 MHz and the signal may be TTL levels or a sine wave with an amplitude of 1.0 to 5.0 volts peak to peak. The input impedance is selectable at 1K or 50 ohms via GPS-XL module 87-6XX jumper JP9. Refer to "SERIAL I/O FUNCTION - EXTERNAL FREQUENCY MEASUREMENT" for details concerning the use of this input.

3.401 reserved

3.402 1 PPS Output (Standard)

3.402.1 A time-stable ACMOS levels 50 ohm 1 PPS output is provided on a rear-panel mounted BNC connector. The rising edge of this pulse coincides with the start of the UTC second. The pulse width is 20 us. If no satellites are being tracked, the 1 PPS pulse will be as stable as the internal (or external if so configured) oscillator of the Mark V. The 1PPS output is capable of driving a 50 ohm load. This output is valid whenever the Mark V has an accurate position and is tracking at least one satellite.

3.403 reserved

3.404 1, 5, or 10MHz (TTL) Output (Option)

3.404.1 Time-stable ACMOS levels 50 ohm 1, 5 or 10MHz outputs are provided on a rear-panel mounted BNC connector. The duty cycles of the output waveforms are 50%. The rising edges of these signals coincide with the rising edge of the 1PPS output to within 100 nS.

3.405 reserved

3.406 1 kPPS (TTL) Output (Option)

3.406.1 A time-stable ACMOS levels 50 ohm 1 kPPS output is provided on a rear-panel mounted BNC connector. The duty cycle of this signal is 50%. The rising edge coincides with the rising edge of the 1PPS output.

3.407 reserved

3.408 IRIG-B Outputs

3.408.1 IRIG-B outputs, either the Amplitude Modulated 1kHz carrier (STANDARD) and/or the HCMOS DC Level Shift Modulation (OPTION) are provided on rear-panel mounted BNC connector(s). The primary purpose of the IRIG-B time code outputs are to drive slave displays manufactured by TrueTime. Refer to SECTION VIII for a full description of this code. When using this code for other than driving the TrueTime Models RD-B, RMD-B, SF-DC or 560 Distribution Amplifier, it should be noted that four bits in the "control functions" portion of the IRIG-B code encode the TIME QUALITY INDICATORS. These are fully described in SECTION VIII.

The DC level shift modulation output (OPTION) is HCMOS levels into 100 ohms or will drive up to 15 LSTTL loads.

The modulated 1 kHz sine wave is capable of driving a 600 ohm load. The high level of the code is 2.5 +/-0.25 volts peak-to-peak and the low level is .75 +/-0.1 volts peak-to-peak into 600 ohms. The open circuit levels are twice those into 600 ohms, i.e. the source impedance is 600 ohms.

3.409 reserved

3.410 Slow Code Output (Option))

3.410.1 This output option is provided on a rear-panel mounted BNC connector. This output provides one pulse per minute, primarily for placing timing marks on drum recorders. Each pulse edge is aligned to within a few nanoseconds of the time and frequency receiver's 1 PPS output pulse, with the rising edge at the start of the minute.

The initial out-of-the-box default values are:

Once per minute	=	2 seconds
Once per hour	=	4 seconds
Once per day	=	6 seconds

Refer to keypad or Serial I/O Function F17 for detailed information on "SLOW CODE SETUP".

The output is HCTTL levels and will drive up to 100 ohms or will drive up to 15 LSTTL loads.

3.411 reserved

3.412 Precision 60 PPS Output (Option)

3.412.1 This output option is provided on a rear-panel mounted BNC connector. It is intended to be a frequency source for driving a synchronous motor through a power amplifier. This would allow a drum recorder to be kept synchronized to the correct time, independent of local power line frequency variations. The output is a quasi square wave with an unusual duty cycle. It is 50% over a period of 50 ms, or 3 cycles.

The cycle timings are:

cycle #1 high 9 ms, low 8 ms
cycle #2 high 8 ms, low 9 ms
cycle #3 high 8 ms, low 8 ms

The output is HCTTL levels and will drive up to 100 ohms or will drive up to 15 LSTTL loads.

3.413 reserved

3.414 Precision Programmable Pulse Output (Option)

3.414.1 This output option is provided on a rear-panel mounted BNC connector. It allows generation of a precisely synchronized trigger pulse at an arbitrary time and with

arbitrary pulse width in integer multiples of 1 ms. The rising edge of the trigger output may be programmed to occur with 1 ms resolution and will be within 150 ns of the UTC millisecond. Refer to "SERIAL I/O FUNCTION F26 - PROGRAMMABLE PULSE OUTPUT" for details of the programming of this output pulse.

3.415 reserved

3.416 External Oscillator Control DAC Output (Option)

3.416.1 This output option is provided on a rear-panel mounted BNC connector and allows disciplining of an external oscillator directly via 16 bit DAC control. GPS-XL module 87-6XX jumper JP5 selects the output voltage range as either -5 to +5 VDC or 0 to +10 VDC. The output impedance is 100 ohms. Refer to Configuration Dwg. 87-6XX for details of connections and jumper settings. Refer to keypad or Serial I/O functions F07 and F14 for configuration of the Mark V operation to support this output.

Appendix A: Time Code Formats

The following time code descriptions, tables, and diagrams are excerpts from the Range Commanders Council's IRIG Serial Time Code Formats, IRIG Standard 200-98, available on the Web at http://jcs.mil/RCC/manuals/200/.

TABLE 1. TYPICAL MODULATED CARRIER SIGNAL

					MARK INTERVAL NUMBER OF CYCLES			
FORMAT	SIGNAL NO.	TIME FRAME RATE	CARRIER FREQUENCY F	SIGNAL BIT RATE ER	RATIO F/ER	CODE "0" & INDEX	CODE "1"	POSITION IDENTIFIER & REF.
B	B120, 122, 123	1 per sec.	1 kHz	100 pps	10:1	2	5	8

Control Functions (Time Quality)

All [IRIG] time code formats reserve a set of bits known as control functions (CF) for the encoding of various control, identification, or other special purpose functions. The control bits may be programmed in any predetermined coding system. A binary 1 bit has a duration equal to 0.5 of the index count interval, and a binary (0) has a duration equal to 0.2 of the index count interval. Control function bits follow position identifier P_5 or P_6 beginning at index count 50 or 60 with one control function bit per index count, excepting each tenth bit which is a position identifier. [IRIG-A and IRIG-B have 27 control bits available.]

Control functions are presently intended for intrarange use but not for interrange applications; therefore, no standard coding system exists. The inclusion of control functions into a time code format as well as the coding system employed is an individual user defined option.

IRIG-B

General Description

4.2 Time Code Format B

4.2.1 The 74-bit time code contains 30 bits of BCD time-of-year information in days, hours, minutes, and seconds; 17 bits of SB seconds-of-day; and 27 bits for control functions.

4.2.2 The BCD code (seconds sub-word) begins at index count 1 (LSB first) with binary coded bits occurring between position identifier bits P_0 and P_5: 7 for seconds, 7 for minutes, 6 for hours, and 10 for days, to complete the BCD word. An index marker occurs between the decimal digits in each sub-word to provide separation for visual resolution. The BCD time code recycles yearly.

4.2.3 The SBS word begins at index count 80 and is between position identifiers P_8 and P_0 with a position identifier bit (P_9) between the 9th and 10th binary SBS coded bits. The SBS time code recycles each 24 hour period.

4.2.4 The control bits occur between position identifiers P_5 and P_8, with a position identifier every 10 bits.

The frame rate is 1.0 second with resolutions of 10 ms (dc level shift) and 1 ms (modulated 1 kHz carrier)."

Detailed Description

5.2 Format B, Signal B000

The beginning of each 1.0 second time frame is identified by two consecutive 8.0 ms bits, P_0 and P_r. The leading edge of P_r is the on-time reference point for the succeeding time code words. Position identifiers, P_0 and P_1 through P_9, (8 ms duration) occur every 10th bit and 10 ms before the leading edge of each succeeding 10 pps "on-time" bit (see figure 5).

5.2.2 The two time code words and the control functions presented during the time frame are pulse width coded. The binary zero and the index markers have a duration of 2.0 ms, and a binary one has a duration of 5.0 ms. The 100 pps leading edge is the on-time reference point for all bits.

5.2.3 The BCD time-of-year code word consists of 30 bits beginning at index count one. The sub-word bits occur between position identifiers P_0 and P_5: 7 for seconds, 7 for minutes, 6 for hours, and 10 for days to complete the BCD time code word. An index marker occurs between the decimal digits in each sub-word to provide separation for visual resolution. The LSB occurs first. The code recycles yearly. Each bit position is identified in table 3.

5.2.4 Twenty-seven control functions occur between position identifiers P_5 and P_8. Any control function bit or combination of bits can be programmed to read a binary one or zero during any specified number of time frames. Each control bit position is identified in table 3.

5.2.5 The SB seconds-of-day code word occurs between position identifiers P_8 and P_0. Seventeen bits give time-of-day in seconds with the LSB occurring first. A position identifier occurs between the 9th and 10th binary coded bit. The code recycles each 24-hour period. Each bit position is identified as shown in table 3.

5.2.6

Pulse Rates	Pulse Duration
Bit rate: 100 pps Position identifier: 10 pps Reference mark: 1 pps	Index marker: 2 ms Binary zero or uncoded bit: 2 ms Binary one or coded bit: 5 ms Position identifiers: 8 ms Reference bit: 8 ms

Resolution	Mark-To-Space Ratio
10 ms dc level 1 ms modulated 1 kHz carrier	Nominal value of 10:3 Range of 3:1 to 6:1

TABLE 3. FORMAT B, SIGNAL B000

BCD TIME-OF-YEAR CODE (30 DIGITS)

SECONDS SUB-WORD			MINUTES SUB-WORD			HOURS SUB-WORD			DAYS SUB-WORD					
BCD Code Digit No.	Sub-word Digit Wt SECONDS	BIT Time (Note 1)	BCD Code Digit No.	Sub-word Digit Wt MINUTES	BIT Time	BCD Code Digit No.	Sub-word Digit Wt HOURS	BIT Time	BCD Code Digit No.	Sub-word Digit Wt DAYS	BIT Time	BCD Code Digit No.	Sub-word Digit Wt DAYS	BIT Time
Reference BIT		P_r	8	1	P_r + 100 ms	15	1	P_r + 200 ms	21	1	P_r + 300 ms	29	100	P_r + 400 ms
1	1	P_r + 10 ms	9	2	P_r + 110 ms	16	2	P_r + 210 ms	22	2	P_r + 310 ms	30	200	P_r + 410 ms
2	2	P_r + 20 ms	10	4	P_r + 120 ms	17	4	P_r + 220 ms	23	4	P_r + 320 ms	Index BIT		P_r + 420 ms
3	4	P_r + 30 ms	11	8	P_r + 130 ms	18	8	P_r + 230 ms	24	8	P_r + 330 ms	Index BIT		P_r + 430 ms
4	8	P_r + 40 ms	Index BIT		P_r + 140 ms	Index BIT		P_r + 240 ms	Index BIT		P_r + 340 ms	Index BIT		P_r + 440 ms
Index BIT		P_r + 50 ms	12	10	P_r + 150 ms	19	10	P_r + 250 ms	25	10	P_r + 350 ms	Index BIT		P_r + 450 ms
5	10	P_r + 60 ms	13	20	P_r + 160 ms	20	20	P_r + 260 ms	26	20	P_r + 360 ms	Index BIT		P_r + 460 ms
6	20	P_r + 70 ms	14	40	P_r + 170 ms	Index BIT		P_r + 270 ms	27	40	P_r + 370 ms	Index BIT		P_r + 470 ms
7	40	P_r + 80 ms	Index BIT		P_r + 180 ms	Index BIT		P_r + 280 ms	28	80	P_r + 380 ms	Index BIT		P_r + 480 ms
Position Ident. (P_1)		P_r + 90 ms	Position Ident. (P_2)		P_r + 190 ms	Position Ident. (P_3)		P_r + 290 ms	Position Ident. (P_4)		P_r + 390 ms	Position Ident. (P_5)		P_r + 490 ms

CONTROL FUNCTIONS (27 BITS)

Control Function BIT	BIT Time	Control Function BIT	BIT Time	Control Function BIT	BIT Time
1	P_r + 500 ms	10	P_r + 600 ms	19	P_r + 700 ms
2	P_r + 510 ms	11	P_r + 610 ms	20	P_r + 710 ms
3	P_r + 520 ms	12	P_r + 620 ms	21	P_r + 720 ms
4	P_r + 530 ms	13	P_r + 630 ms	22	P_r + 730 ms
5	P_r + 540 ms	14	P_r + 640 ms	23	P_r + 740 ms
6	P_r + 550 ms	15	P_r + 650 ms	24	P_r + 750 ms
7	P_r + 560 ms	16	P_r + 660 ms	25	P_r + 760 ms
8	P_r + 570 ms	17	P_r + 670 ms	26	P_r + 770 ms
9	P_r + 580 ms	18	P_r + 680 ms	27	P_r + 780 ms
Position Ident. (P_6)	P_r + 590 ms	Position Ident. (P_7)	P_r + 690 ms	Position Ident. (P_8)	P_r + 790 ms

STRAIGHT BINARY SECONDS TIME-OF-DAY CODE (17 DIGITS)

SB Code BIT	Sub-word Digit Weight	BIT Time	SB Code BIT	Sub-word Digit Weight	BIT Time
1	2^0 = (1)	P_r + 800 ms	10	2^9 = (512)	P_r + 900 ms
2	2^1 = (2)	P_r + 810 ms	11	2^{10} = (1024)	P_r + 910 ms
3	2^2 = (4)	P_r + 820 ms	12	2^{11} = (2048)	P_r + 920 ms
4	2^3 = (8)	P_r + 830 ms	13	2^{12} = (4096)	P_r + 930 ms
5	2^4 = (16)	P_r + 840 ms	14	2^{13} = (8192)	P_r + 940 ms
6	2^5 = (32)	P_r + 850 ms	15	2^{14}=(16384)	P_r + 950 ms
7	2^6 = (64)	P_r + 860 ms	16	2^{15}=(32768)	P_r + 960 ms
8	2^7 = (128)	P_r + 870 ms	17	2^{16}=(65536)	P_r + 970 ms
9	2^8 = (256)	P_r + 880 ms	Index BIT		P_r + 980 ms
Position Ident. (P_9)		P_r + 890 ms	Position Ident. (P_0)		P_r + 990 ms

Note 1: The BIT Time is the time of the BIT leading edge and refers to the leading edge of Pr

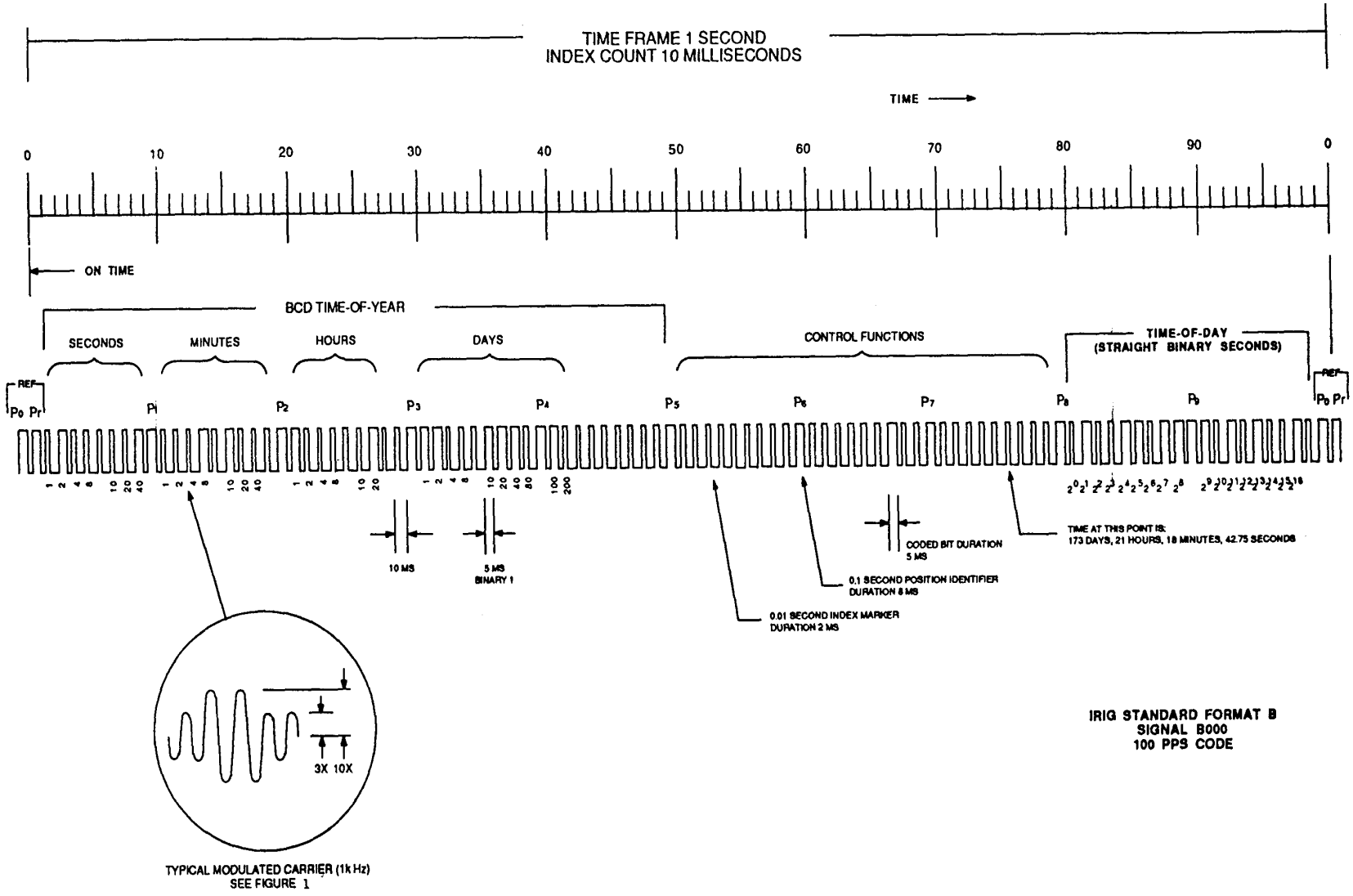

Figure 5. Format B: BCD time-of-year in days, hours, minutes, and seconds; straight binary seconds-of-day plus optional control bits.