



Operation Manual



TSC 4400 / TSC 4400-3 GPS Time & Frequency Standard

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1 Introduction

The TSC 4400 is a state-of-the-art time and frequency reference. It utilizes an internal atomic (rubidium: Rb) clock in conjunction with GPS measurements to provide outputs that are characterized by the short-term stability of the atomic clock and the long-term stability of GPS. Additionally, it provides the user with the capability to enhance the frequency stability and holdover performance of the unit by using an external cesium (Cs) clock as the reference. This provides a scalable architecture that allows users to fulfill a wide range of current and future requirements with a single unit.

PPS accuracy and frequency stability of the TSC 4400 is enhanced by using a dual-frequency (L1/L2) GPS receiver. The dual-frequency receiver applies corrections to the GPS timing signals that remove a significant portion of the errors due to ionospheric delay. The measurements can also be made available to users for the purpose of modeling the total electron content (TEC) of the ionosphere. For those users not requiring the additional accuracy there is also a single-frequency (L1 only) version of the TSC 4400 available at a reduced cost.

As a precision time and frequency standard the TSC 4400 is suitable for a variety of applications including 24/7 operations. In applications where reliability is a must the TSC 4400 provides a fully redundant timing system in 2U (3.5 inches) of vertical rack space. The TSC 4400 is supported by a rack-mount shelf that holds two units in a side-by-side configuration. This allows each unit to be serviced individually while the operational unit remains online.

2 Ordering Information

TSC Part #	GPS Engine	Description
TSC 4400	Dual Frequency	GPS Time & Frequency Standard
TSC 4400-1	Dual Frequency	TSC 4400 with a rack-mount shelf
TSC 4400-2	Dual Frequency	Two TSC 4400 units with a rack-mount shelf (Ideal for redundant applications)
TSC 4400-3	Single Frequency	GPS Time & Frequency Standard
TSC 4400-4	Single Frequency	TSC 4400-3 with a rack-mount shelf
TSC 4400-5	Single Frequency	Two TSC 4400-3 units with a rack-mount shelf (Ideal for redundant applications)

Table 2-1. TSC part numbers for the GPS Time and Frequency Standard.

Notes:

1. Antenna cables sold separately.
2. All units include the antenna, network time protocol (NTP), SNMP monitoring, RS232 control, Ethernet control, data logging capability, and external reference capability.
3. Contact Timing Solutions Corporation (www.timing.com) for current pricing and availability.

3 Getting Started

The TSC 4400 provides a number of features which may require additional setup but this section is intended to provide a guideline for basic setup. After the completion of this section, the TSC 4400 will produce timing outputs to the coarse calibration accuracies specified in Appendix A.

3.1 *Installing the Hardware*

The TSC 4400 is designed to be quickly and easily integrated with other system components. Just a few steps are required in setting up the TSC 4400 so that it will begin producing timing outputs. The most critical step in getting started with the TSC 4400 is to make sure the antenna voltage is set correctly. The TSC 4400 is capable of providing antenna power but this may cause damage to an antenna if the wrong voltage is selected. As a result, the TSC 4400 is shipped from the factory in a configuration that does not provide power to the GPS antenna. If this is not the desired configuration then refer to section 5.6 in setting the antenna voltage correctly.

Once the correct antenna voltage is being provided by the TSC 4400, the unit can be installed in the system. Typically, the unit is mounted in a standard 19" equipment rack (refer to section 5.1) but the unit may also be operated from a bench top. The choice of installation locations should be made while keeping in mind that access to a suitable antenna location will be necessary. Please refer to section 5.7 before installing the TSC 4400 as this can seriously impact the installation location.

3.2 *IP Addressing*

The TSC 4400 runs DHCP by default and will therefore automatically be assigned an IP address if it is connected to a network with a DHCP server. To configure the TSC 4400 for a static IP address, the system file "/etc/rc.conf.local" must be edited.

The CONSOLE port (section 6.2) on the rear panel allows users to access the file system and set the unit to a static IP address. Connection to the CONSOLE port can be made using any terminal program (e.g., HyperTerm, TeraTerm) from the serial port of a computer. Once connectivity is established, a login prompt should appear. Log into the system (username: tsc, password: tsc) and execute the following commands:

```
su (password:tsc)
mount -uw /
vi /etc/rc.conf.local
```

Edit the configuration file and save it once the IP addresses have been uncommented and set accordingly. Figure 3-1 highlights the changes that must be made to configure the TSC 4400 for a static IP address. Once the changes are made, the file can be saved and

```
# XXX rc.conf.local, static for now.
#
# $TSC: Release/lim/extra-files/etc/rc.conf.local,v 1.3
2003/10/22 22:40:06 marc Exp $
#

# Important only because it shows up in the user prompt.
hostname=TSC-4400

# Enable/disable local startup scripts.
local_startup=/usr/tsc/rc.d # path to product startup
scripts

# Example static IP configuration - modify and uncomment
ifconfig_rl0="inet 10.1.2.3 netmask 255.255.255.0"
defaultrouter="10.1.2.255"

###tsc_serial_enable="YES" # lock ttyd0 to clocal mode
```

Figure 3-1. Configuring the TSC 4400 for a static IP address.

the system rebooted. You can then access the file system by telnet (section 6.3) using the newly configured IP address.

3.3 Calibrating the TSC 4400

Utilizing the TSC 4400 as a precise time recovery system requires a complete calibration of the TSC 4400 and distribution system. Cables and distribution equipment external to the TSC 4400 affect the calibration of the overall system and will result in an offset from UTC(USNO). This section assumes the on-time-point (OTP) of the system is the rear panel outputs on the TSC 4400. This is typically not the case and users should refer to section 3.4 for information on changing the OTP of the system.

For applications requiring the utmost level of accuracy, the TSC 4400 should be calibrated at Timing Solutions Corporation (TSC). This process involves installing the user's antenna and antenna cable at TSC and comparing the PPS outputs to a system which has a known offset to UTC(USNO). Once the calibration is complete, the ANTENNA_DELAY value is entered into the startup configuration file (section 7.1) and the unit is delivered to the user. The PPS outputs will be accurate to the precise calibration levels specified in Appendix A as long as the user installs the antenna on a surveyed location. If a surveyed antenna location is not available, the TSC 4400 can be used to survey the location (section 5.8).

A coarse calibration of the TSC 4400 is accomplished by accounting for the individual system delays and combining them to determine the overall delay of the system. This method is generally less accurate because the individual delays in the system are estimated and may not be entirely accurate. Equation 3-1 gives the general formula for performing a coarse calibration of the TSC 4400.

$$TSC4400_Delay(sec\ onds) = \frac{Length_of_Antenna_Cable(meters)}{Signal_Velocity(meters/sec\ ond)} - 48.5E-9 \text{ Eq. 3-1}$$

The *Signal_Velocity* refers to the velocity of the GPS signal as it travels through the antenna cable. This information can be obtained from the manufacturer of the cable. It is typically specified as a percentage of the speed of light and it is up to the user to calculate the actual *Signal_Velocity*. Calculation of the *Signal_Velocity* is shown in Equation 3-2. It is calculated using the speed of light and the *Velocity_of_Propagation* given by the cable manufacturer. If the *Velocity_of_Propagation* is not available or the accuracy of the PPS signal is not important to the application then 0.85 may be used as a typical value.

$$Signal_Velocity(meters/sec\ ond) = 299792458 * Velocity_of_Propagation \text{ Eq. 3-2}$$

Once the *TSC4400_Delay* has been calculated, it must be entered into the ANTENNA_DELAY parameter of the startup configuration file (section 7.1). The change will take effect the next time the system is restarted and the OTP of the system will be the rear panel of the TSC 4400. The TSC 4400 outputs will now be accurate to the coarse calibration accuracy specified in Appendix A.

3.4 Selecting an On-Time-Point (OTP)

The OTP of a system is defined as the point at which the timing signals coincide with UTC(USNO). Typical systems use distribution amplifiers and cabling to distribute timing signals from a single source to multiple users. This distribution network will delay the timing signals and affect their accuracy. For this reason it is important to select an appropriate OTP so that the desired timing signals are accurate when they reach the user.

Section 3.3 calibrates the TSC 4400 assuming that the OTP of the system is the rear panel of the TSC 4400. This is not generally a convenient location for the OTP of

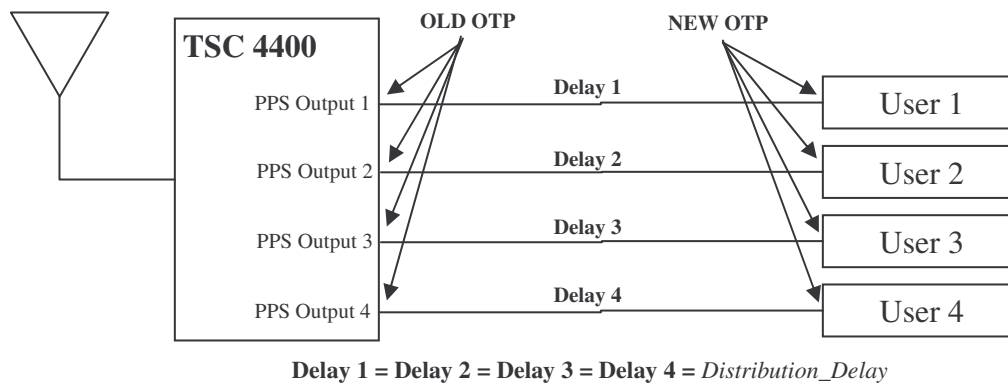


Figure 3-2. Diagram of a typical timing system.

the system because there will be a delay associated with the distribution of the signals to

the user. Figure 3-2 illustrates how to move the OTP of the system from the rear panel of the TSC 4400 to the user inputs. In moving the OTP of the system it is imperative that the distribution delays from the TSC 4400 to each of the users is equal. This will ensure that all users receive accurate timing signals.

Once the delay of the distribution network is known the OTP of the system can be shifted from the output of the TSC 4400 to the input of user equipment. Equation 3-3 is used to calculate the ANTENNA_DELAY parameter that should be entered into the startup configuration file (section 7.1). The *Distribution_Delay* is the measured delay of the timing distribution network as shown in Figure 3-2. The *TSC4400_Delay* is the delay calculated in Equation 3-1 or the calibrated delay given by Timing Solutions Corporation.

$$\text{ANTENNA_DELAY} = \text{TSC4400_Delay(seconds)} - \text{Distribution_Delay(seconds)}$$

Eq. 3-3

4 Theory of Operation

Two distinct tasks are performed by the TSC 4400: collection of GPS measurement data and the generation of timing signals. The two tasks are entirely separate except for the fact that they must share CPU time and data from the GPS receiver. Because the generation of timing signals requires that events (e.g., clock steering) occur at very specific times, operational precedence is always given to timing tasks. As a result, any operations concerning the collection and storage of GPS data are postponed until all timing operations have been completed.

4.1 Generation of Timing Signals

A rubidium standard serves as the frequency reference for the TSC 4400. The frequency of the Rb is continuously adjusted by varying the magnetic fields within the clock itself. The frequency adjustments made to the clock allow it to be aligned with UTC(USNO) which is the source of GPS time. In doing this, the TSC 4400 exhibits the short-term characteristics of the Rb while exhibiting the long-term characteristics of GPS.

The 10 MHz output provided by the Rb clock serves as the timebase for the TSC 4400. All timing signals (e.g., 1 PPS, IRIG-B, 10 MHz) are derived from this reference and thus exhibit the same frequency characteristics. The 10 MHz signal provided by the Rb is distributed directly to the user via rear panel connectors but additional copies of the

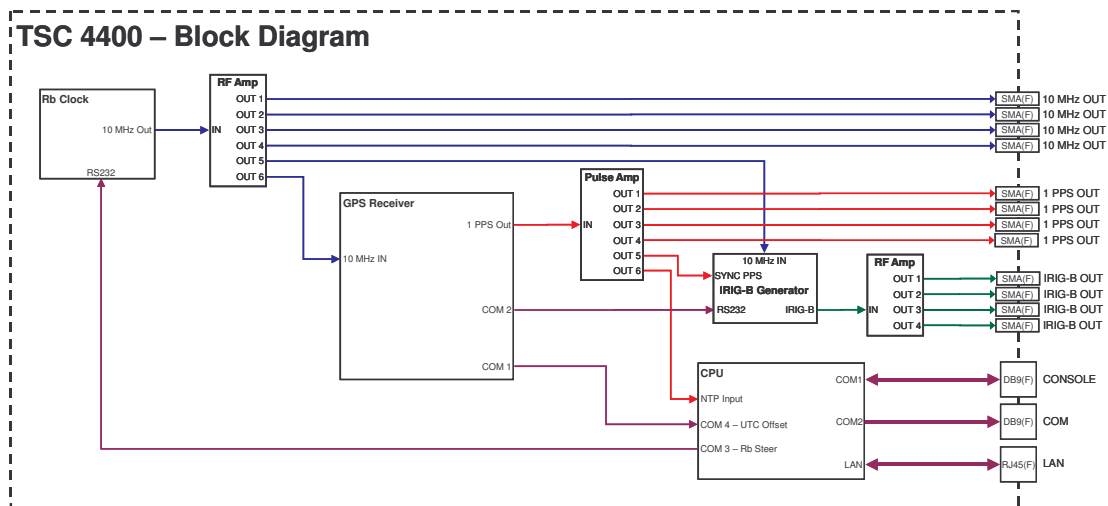


Figure 4-1. Block diagram showing the generation of timing signals within the TSC 4400.

signal are used by the GPS receiver and the IRIG generator to generate 1 PPS and IRIG-B signals respectively.

The GPS receiver locks its internal reference to the 10 MHz signal provided by the frequency reference. A 1 PPS signal is then generated by the receiver which has a fixed phase relationship to the frequency reference. Measurements of this PPS are made

to determine its offset to UTC(USNO) and this information is passed to the CPU via a serial port. These measurements are used in generating a timescale that estimates the clock offset from UTC(USNO). Commands are then sent by the CPU to the Rb clock to adjust the magnetic fields within the clock such that the PPS generated is coincident to UTC(USNO).

The PPS signal from the GPS receiver is used in aligning both the IRIG-B signal and the CPU clock to UTC(USNO). At startup the PPS is used to align the IRIG-B signal with the correct 10 MHz clock cycle. From that point on the IRIG-B signal is kept on-time by using the 10 MHz signal as its reference. The PPS generates an interrupt on the parallel port of the CPU which serves as an indicator of the top-of-second. This is used by the CPU along with messages received from the GPS receiver to set the CPU time to UTC(USNO). In doing this, the CPU can serve as a stratum-1 network time protocol (NTP) server and provide time to other computers and systems on the network.

4.2 Log Collection

GPS measurement data is available to users in a variety of log formats. The TSC 4400 uses a Novatel OEM4-G2 (dual-frequency and WAAS capable) as its GPS receiver and thus any logs generated by the receiver are available to users. For a complete description of logs and their formats refer to volume 2 of the OEM4 manual found at <http://www.novatel.com/Downloads/docupdates.html>. The only restrictions made by the TSC 4400 are that all logs must be in ASCII format and that the total number of requested logs does not exceed the limits specified in Appendix A.

Logs on the TSC 4400 are handled in two ways. They are either stored in volatile memory (/var/ftp/lim) for retrieval by FTP or they are output to the serial port in real-time. Logs stored in volatile memory are referred to as data logs and may be compressed to increase the capacity of the storage area. A total of 16 MB is dedicated to the storage of data logs and as storage capacity is approached older logs will be deleted to make room for newer logs. Real-time logs are logs requested by the user for output to the COM port on the rear panel of the TSC 4400. They are provided to the user in a timely manner but are not stored on the system.

All logs must be requested at startup through the use of configuration files. Data logs are specified in the novalog configuration file (section 7.3) and real-time logs are specified in the real-time configuration file (section 7.4). Data logs are always generated by the TSC 4400 but the COM port must be configured at startup in order to receive real-time logs. Also note that real-time log output is not available when the TSC 4400 is utilizing an external frequency reference because both operations use the COM port on the rear panel.

4.3 Startup Sequence

A very specific sequence exists for starting each of the internal devices within the TSC 4400. This sequence exists to ensure that the unit generates the appropriate timing outputs and that they are all in sync with each other. Startup time of the TSC 4400 varies from 5 to 45 minutes depending upon how long the unit has been powered off but the timing outputs are always generated in the same sequence: 10 MHz, 1 PPS, NTP, IRIG-B.

The 10 MHz frequency reference is generated either by the internal Rb oscillator or an external source. In either case the TSC 4400 waits for the frequency reference to indicate that it has warmed up and is providing a stable signal. The internal Rb is generally warm and operational within 10 minutes but external references may take longer. Once the frequency reference is operational, the front panel indicator “REF LOCK” will illuminate. This indicates that the frequency reference is the TSC 4400 is locked to the frequency reference and the startup operations will continue.

Once the frequency is locked, the GPS receiver is restarted using the 10 MHz signal as its reference. The receiver will begin generating the 1 PPS outputs but they will not be aligned to UTC(USNO). A search algorithm is used by the GPS receiver which attempts to acquire and track the signal received from GPS satellites. This process usually takes 5 to 10 minutes but may take as long as 30 minutes depending upon how long the TSC 4400 has been powered off. After four satellites are being tracked by the GPS receiver, the PPS output is adjusted so that it is aligned with UTC(USNO). The “TRACKING GPS” light on the front panel will also illuminate to indicate to the user that the system is currently tracking the GPS signal.

Serving as a stratum-1 network time protocol (NTP) server requires that the CPU clock within the TSC 4400 be aligned with UTC(USNO). The process of locking the CPU clock to UTC(USNO) requires setting the system time to UTC(USNO) and using the PPS received from the GPS receiver to continuously steer the CPU clock. If the unit has been powered off for a long period of time the CPU time may be multiple seconds off. In these cases, a coarse adjustment of system time is performed and then the startup sequence is restarted. This process should only happen once and only in cases where the system has been powered off.

The IRIG-B generator uses 10 MHz, 1 PPS, and system time in generating the IRIG signal. As a result, it is the final step in the startup procedure. The IRIG-B generator uses the 10 MHz as its frequency reference and the PPS to indicate the start of the second. These two signals serve as the time base for the IRIG-B signal. System time is sent by the CPU to the IRIG-B generator to indicate what time is associated with the received PPS signal. This information is then used in modulating a 1 kHz sine wave to produce the IRIG-B timecode.

5 Hardware Interface

The hardware design of the TSC 4400 allows it to be easily integrated into a variety of more complex systems. As a timing source, it requires only a GPS antenna as input and provides a number of timing outputs that can be distributed to users. All timing outputs are located on the rear panel to eliminate the need for bringing numerous cables to the front of the rack. The front panel provides a simple LED interface to allow quick and easy evaluation of the system's state.



Figure 5-1. Two TSC 4400 units mounted side by side and a single TSC 4400 unit mounted on the shelf.

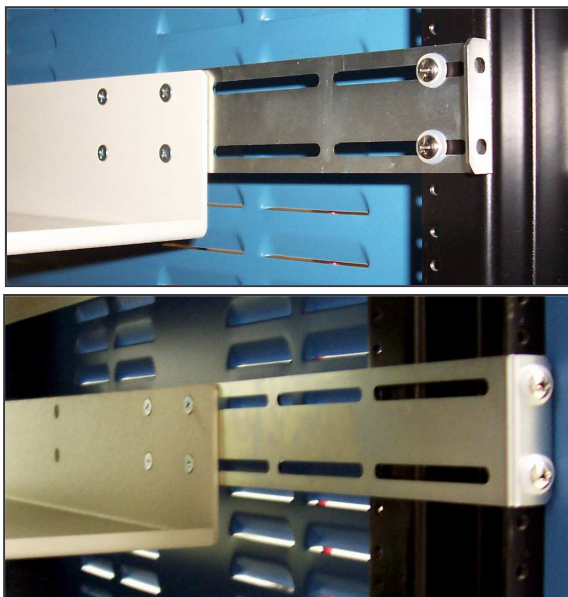


Figure 5-2. Side rails shown mounted to side brackets and to rear brackets.

5.1 Mounting the TSC 4400

The TSC 4400 is optimal for applications requiring a fully redundant timing source. Each unit occupies only one-half of the rack width in a standard 19 inch equipment rack. This allows two units to be placed side-by-side in a rack while using only 2U (3.5 inches) of vertical height. A specialized shelf accompanies the TSC 4400 which supports the unit. The shelf is split in half such that either unit can be removed without disrupting operation of the other unit. This facilitates the maintenance of one unit while the redundant unit continues to provide timing signals.

The supporting shelf is designed to fit most 19 inch equipment racks. It is

mounted to the front of the rack using four screws as indicated by the white arrows in Figure 5-1. It has adjustable side rails that allow the shelf to be adjusted to a wide range of rack depths between 22 and 30 inches. Figure 5-2 also shows the various positions that the side rails may be mounted in. This allows the shelf to be mounted in racks that use either side mount brackets or rear mount brackets.

5.2 Rear Panel

All hardware interfaces are located on the rear panel of the TSC 4400. The system provides three types of timing signals: 1 PPS, 10 MHz, and IRIG-B123. Four SMA(F) connectors are provided for each signal type. These outputs can be used to directly feed other instruments or feed a distribution system that further amplifies the timing signals and provides any number of user outputs. The on-time-point (OTP) of the system is typically at the output of the SMA connectors but it can be adjusted to be any point in an integrated system by accounting for distribution delays and adjusting the ANTENNA_DELAY parameter in the startup configuration file (refer to section 7.1).

The TSC 4400 also accepts a tunable 10 MHz input (e.g., HP5071A). This allows users with more stringent timing requirements to use an external cesium standard as opposed to the internal rubidium standard. This improves the timing performance of the system without requiring a change to any interfaces for users of the timing signals.



Figure 5-3. Rear panel of the TSC 4400.

The only input required for operation of the TSC 4400 as a timing source is the GPS antenna. This is the source of time for the unit and the TSC 4400 will not start up without it. Once satellites have been acquired the unit will continue to output timing signals even when the GPS antenna is removed. However, the accuracy of these outputs will degrade over time.

Two DB9(F) connectors provide serial (RS232) connections to the TSC 4400. Both connectors are DCE terminals and will thus connect to a computer using a straight-through cable (as opposed to a null-modem). The CONSOLE port provides the

user with access to the file system (refer to section 0). This may be necessary for setting up the system initially but is not generally required for continuous operations. The COM port is used either for providing real-time output of GPS logs or for communication with an external frequency reference.

Connection to a local area network (LAN) is supported by the TSC 4400. This allows users to access the unit remotely and also provides error monitoring capabilities. In addition, the TSC 4400 can serve as the source of network time for other systems on the network if using network time protocol (NTP).

5.3 Front Panel

LED indicators are located on the front panel to provide quick identification of the basic system status. More detailed status information can be retrieved via SNMP (refer to section 6.2). The two most significant indicators are the POWER and ALARM lights. They indicate whether the unit is on and whether any major faults have been encountered by the system. The TSC 4400 makes all reasonable attempts to resolve any error conditions automatically. If the ALARM condition is resolved then the light will go out (i.e., ALARM only indicates current error conditions).

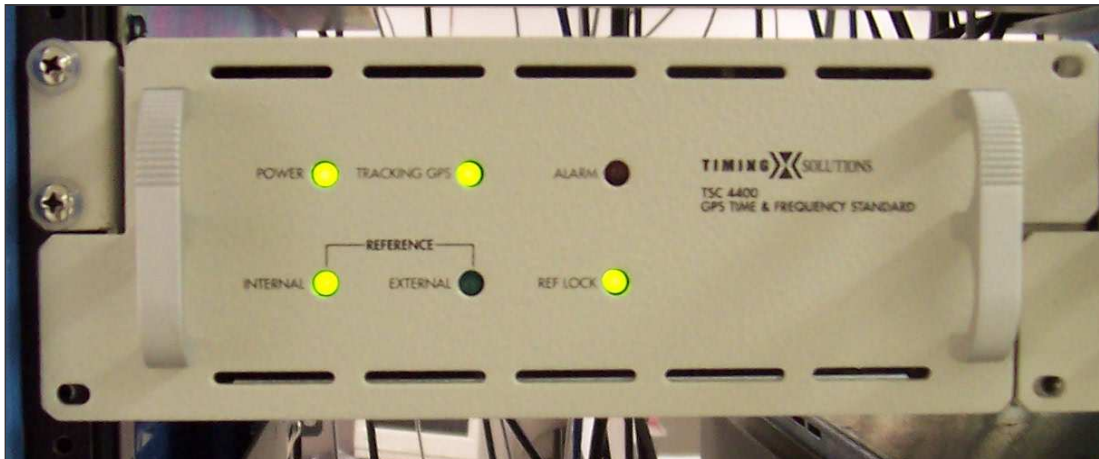


Figure 5-4. Front panel of the TSC 4400.

The REFERENCE lights on the TSC 4400 indicate the frequency reference being used by the system. INTERNAL indicates that the internal rubidium is serving as the reference and EXTERNAL indicates that the 10 MHz reference is being provided externally through the “10 MHz IN” connector on the rear panel. Common errors when using an external frequency reference include not providing the 10 MHz reference signal and not connecting the COM port to the external reference. Both of these conditions will generate an error condition which lights the ALARM indicator.

Health and status of the frequency reference is indicated by the REF LOCK light. If the unit has been off for some time it may take up to ten minutes before the internal rubidium has warmed up and is generating a stable 10 MHz reference. During this period the REF LOCK light will be off. Once the source of the frequency reference is stable the

light should remain on continuously. If a fault is detected in the 10 MHz reference, the REF LOCK light will go out and the ALARM light will be lit. This usually indicates that the frequency reference is failing but can also be the result of human error (e.g., disconnecting the 10 MHz IN connector when the unit is controlling an external reference). In any case, the system will require a complete restart after the error is resolved.

The TRACKING GPS light indicates whether the unit is collecting enough GPS satellites to calculate a position solution. If the light is lit then the GPS data is being used in steering the frequency reference. If it is not lit then the reference is being steered to the unit's best estimate of UTC(USNO). This light should remain on during normal operation but may have occasional outages. These outages do not significantly degrade the timing performance of the system unless they occur for extended periods of time. If this light remains off for more than six hours then the ALARM light will illuminate to indicate a possible error.

5.4 Opening the TSC 4400

There are two situations in which the user is required to open the TSC 4400: to set the antenna voltage and to upgrade the software. Setting the antenna voltage is generally only required during the initial setup. Upgrading software is also a rare occurrence but may be necessary if any issues arise with the installed software that make

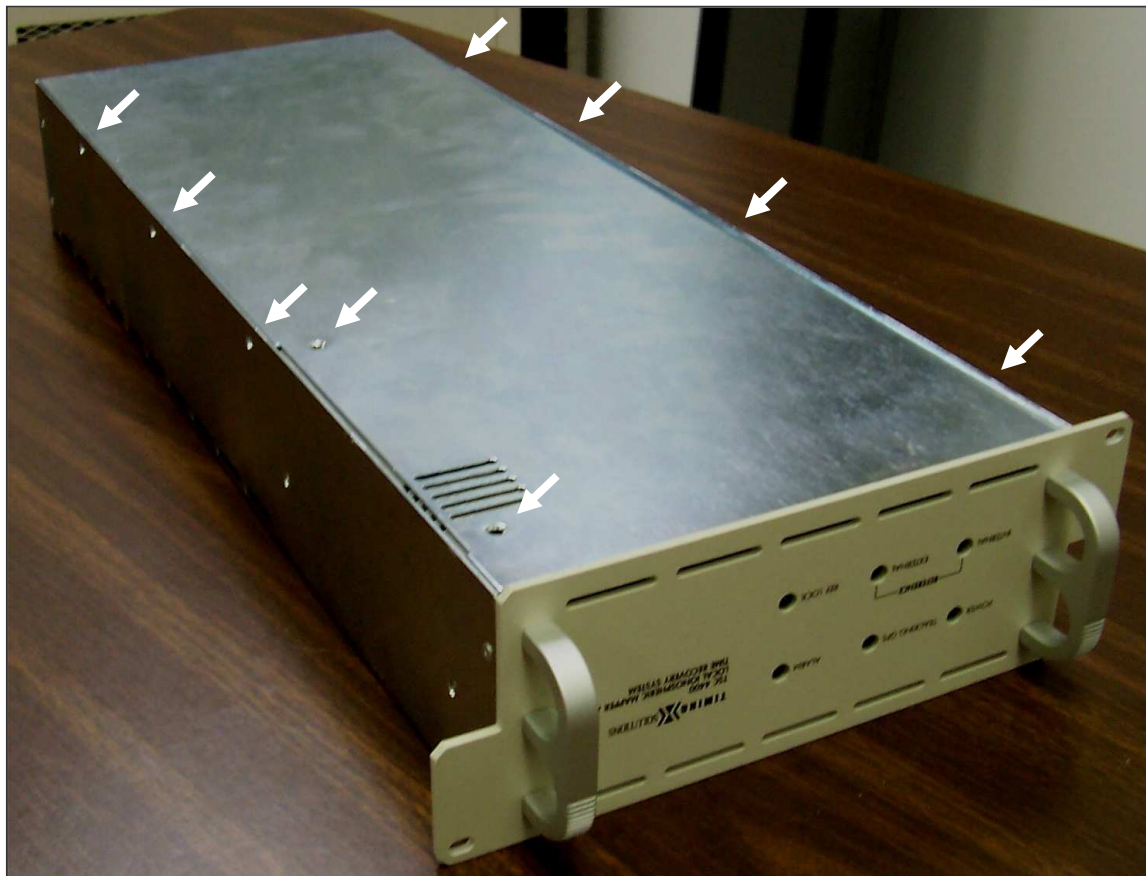


Figure 5-5. Removing the bottom cover of the TSC 4400.

it unsuitable or undesirable to continue its use. Also, most software upgrades can be performed remotely across the LAN connection which makes it unnecessary to open the unit.

Opening the TSC 4400 requires removing the bottom cover. To do this turn the unit upside down as shown in Figure 5-5. The arrows indicate the location of the screws that must be removed. There are two on the bottom and seven along the sides. Once the screws are removed the cover can be lifted off of the chassis.

5.5 Upgrading Software / Declassifying the System

Some users may require that the TSC 4400 be declassified before shipping the system to a new location. Doing this involves removing all non-volatile memory from the unit. Refer to section 5.4 for instructions on opening the TSC 4400. Once the unit is opened, simply remove the flash disk from the single board computer located within the chassis. Figure 5-6 shows the disk before and after removal. The removed flash disk must be destroyed per the user’s standard security procedures. A new flash disk may be obtained from Timing Solutions Corporation.

Upgrading the software requires removing the currently installed flash disk and installing a new one which has the updated software. Simply remove the current flash disk as shown in Figure 5-6 and replace it with the new flash provided by Timing Solutions Corporation.

5.6 Setting the Antenna Voltage

A Novatel GPS-702 antenna is provided with the TSC 4400. As with most modern GPS antennas, it is powered by DC biasing the signal cable. It is imperative that the correct voltage is applied to the antenna because damage may result from an over-voltage condition. The GPS-702 accepts voltage levels from 5-18 VDC but other antennas may utilize a different voltage so it is best to verify the voltage required for the antenna being used.

Three different voltage modes on the TSC 4400 allow it to be quickly integrated with most systems. The antenna voltage is user configurable through the placement of a pin jumper on the appropriate pins within the TSC 4400. Jumper placement determines whether the system provides no power, +5 VDC, or +12 VDC to the GPS antenna. To access the pins which set the antenna voltage it is first necessary to remove the bottom

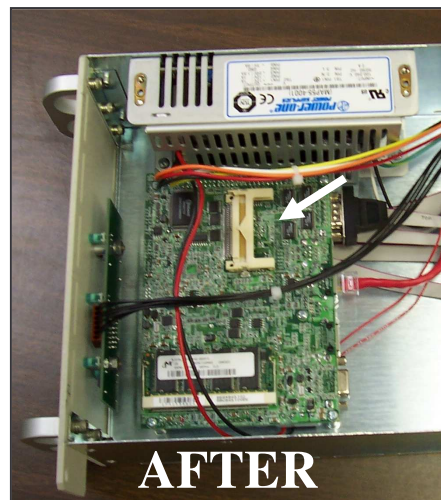


Figure 5-6. Removing the “Flash” disk from the TSC 4400.

cover of the TSC 4400 (refer to section 5.4). Once the cover has been removed the voltage pins can be found on the interface board at the rear of the TSC 4400. **DO NOT REMOVE ANY OF THE COMPUTER BOARDS OR EQUIPMENT WITHIN THE TSC 4400.** The 3-pin header that controls the antenna voltage is labeled “ANTENNA POWER” as shown in Figure 5-7. Labels also indicate which two pins are to be jumpered for the desired antenna voltage. Leaving the pins un-jumpered supplies no voltage to the antenna.

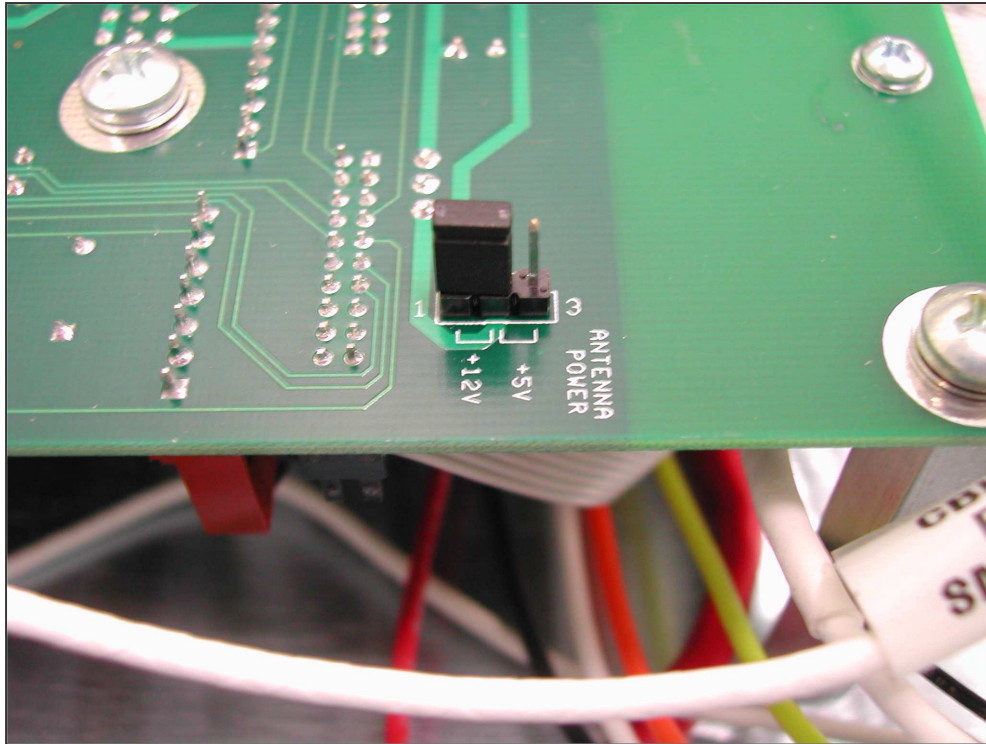


Figure 5-7. Pin jumper shown in the correct position to supply +12 VDC to the antenna.

The default setting from the factory is for no jumper to be present which thus provides no voltage to the antenna. If this is the desired configuration it is not necessary to open the TSC 4400 chassis. The antenna voltage setting can also be verified using a voltmeter. To verify the antenna voltage, apply the probes to the ANTENNA connector on the rear panel. The center conductor should be at a higher potential than the TSC 4400 chassis. This voltage reading indicates the voltage being provided to the antenna. If no voltage is present then the antenna is not being powered by the TSC 4400.

5.7 Antenna Installation

The primary consideration in choosing an antenna location should be sky coverage. Sky coverage is the amount of unobstructed sky that is viewed by the antenna and poor antenna placement can severely limit the amount of sky coverage. To maximize sky coverage the antenna should be placed above the height of the building as much as possible. It should also not be placed near other features that can obstruct its view of the

sky (e.g., buildings, trees, satellite dish). Figure 5-8 illustrates the effect antenna placement has on sky coverage. There are often multiple obstructions that must be contended with and complete sky coverage may not be a possibility. In those instances, personal judgement must be used in determining the best antenna location.

The antenna included with the TSC 4400 has a mounting screw on the bottom. The screw allows the antenna to be easily and securely mounted on a 5/8" coarsely threaded rod. Threaded rods are available at most hardware stores and will need to be mounted securely to the side of a building or other stationary object. Once the rod is secured it will provide a stable mount for the antenna.

Once a suitable antenna location has been identified, it is necessary to ensure that the GPS signal that reaches the TSC 4400 is of suitable quality. The TSC 4400 requires a minimum of 15 dB gain from the combination of the antenna and cable loss. The antenna included with the TSC 4400 has 27 dB so the total cable losses in the system must not exceed 12 dB at 1.5 GHz.

If the location of the antenna dictates that a longer cable must be used then a line amplifier will need to be inserted into the signal path. A line amplifier is a device used to amplify the GPS signal to overcome the losses resulting from longer cable runs. In selecting a line amplifier it is necessary to make sure that it provides an adequate amount of gain and that it operates from 1200 MHz to 1600 MHz.

The amount of gain required from a line amplifier can be calculated by knowing the total loss of the antenna cables being used. The signal loss due to a cable varies depending upon the frequency of the signal. For the purposes of GPS antennas the cable loss should be calculated at 1500 MHz. The manufacturer of the cable being used should be able to provide an estimate of the cable loss at 1500 MHz. Once the cable loss is

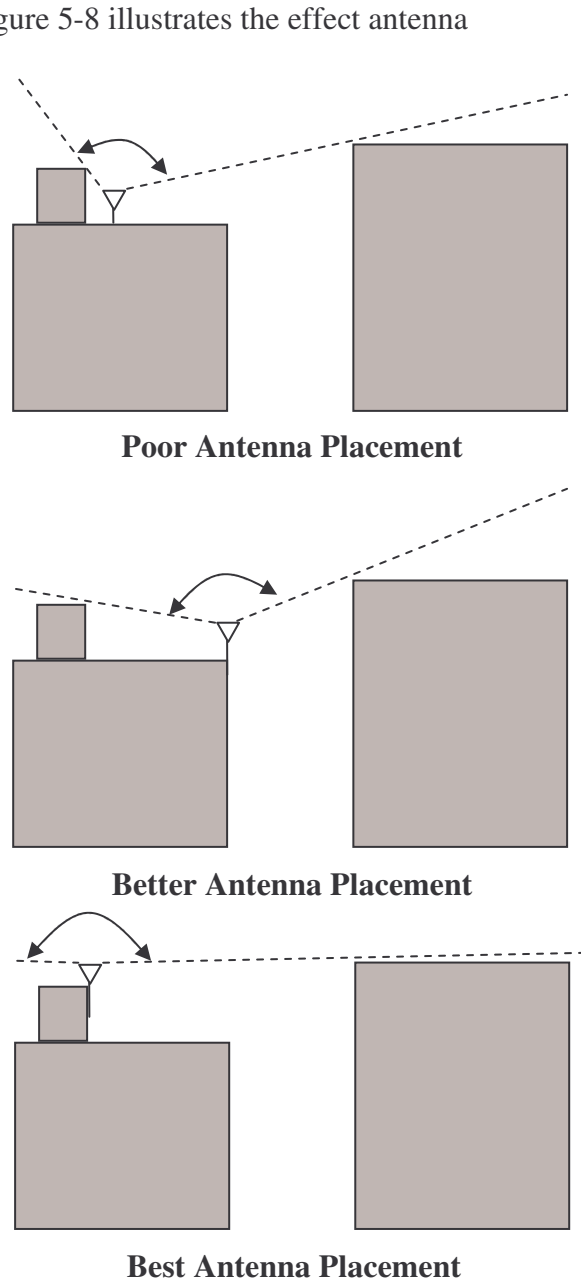


Figure 5-8. Effect of antenna placement on sky coverage.

known it can be inserted into Equation 5-1 to calculate the required gain of the line amplifier:

$$MIN_Gain(dB) = \frac{Cable_Loss(dB/100ft) * Cable_Length(ft)}{100} - 12 \quad \text{Eq. 5-1.}$$

The *MIN_Gain* value in Equation 5-1 serves as the minimum gain required from the line amplifier being used. It is possible to use amplifiers with a slightly higher gain than the minimum value but it will not improve the performance of the system. Using amplifiers with significantly higher gain values can also cause degradation of the GPS signal because it overdrives the input of the GPS receiver.

Placement of the line amplifier is also a concern in a properly designed system. Placing the amplifier too far from the antenna may cause unexpected degradation in the GPS signal. The best place for the amplifier is typically half way between the antenna and TSC 4400. This allows the line amplifier to benefit from any surge protection that may be installed near the antenna but is still close enough to the antenna so as not to

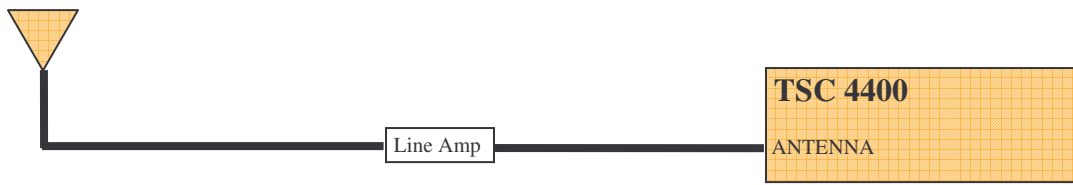


Figure 5-9. Typical configuration for longer cable runs.

degrade the signal significantly. Figure 5-9 shows the block diagram of a typical installation that requires a longer antenna cable. Another consideration when installing the line amplifier is how it will receive power. Some amplifiers are powered using a DC bias on the antenna cable and others are power from AC adapters directly. Please contact Timing Solutions if you require assistance in selecting the right amplifier for your application.

Outdoor Antenna Grounding

If an outside antenna is connected to the TSC 4400, be sure the antenna is grounded so as to provide some protection against voltage surges and built-up static charges. Article 810 of the National Electrical Code, ANSI/NFPA 70 provides information with regard to proper grounding of the mast and supporting structure, grounding of the lead-in wire to an antenna discharge unit, size of grounding connectors, location of antenna discharge unit, connection to grounding electrodes, and requirements for the grounding electrode.

Power Lines

An outside antenna system should not be located in the vicinity of overhead power lines or other electric light or power circuits, or where it can fall into such power

lines or circuits. When installing an outside antenna system, extreme care should be taken to keep from touching such power lines or circuits as contact with them might be fatal.

5.8 *Surveying the Antenna Location*

In using the TSC 4400 as a precise time recovery system it is necessary to accurately know the location of the antenna (< 1 meter). Many users may have existing antenna positions that have been surveyed and thus one of these locations may be used to mount the antenna for the TSC 4400. In cases where an antenna survey has not been performed it is necessary to either have a survey done or use the self-surveying feature of the TSC 4400 to determine the location of the antenna.

The self-surveying feature of the TSC 4400 provides a simple and accurate way of obtaining the antenna location. When the ANTENNA_POSITION parameter in the startup configuration file is set to AUTO, the TSC 4400 will generate a RINEX observation file that can be used in determining an accurate antenna location. Refer to section 7.1 for more information on the antenna positioning modes available in the TSC 4400.

6 Software Interface

Software interfaces on the TSC 4400 are limited in their ability to provide users with real-time control. Adjusting system parameters during operation of the TSC 4400 can seriously impact the timing performance of the unit and is therefore limited by the software. Once properly installed, the TSC 4400 serves as a stand-alone device which requires little to no interaction. Remote error monitoring capabilities are provided as a means to ensure that the unit is powered and operating properly.

6.1 Operating System

The TSC 4400 operates a TSC modified version of FreeBSD. FreeBSD is a Berkeley derivative of the UNIX operating system and largely equivalent to other UNIX operating systems. However, due to the limited storage capacity (64 MB) of the system, a number of standard UNIX commands may not be present (e.g., man, script).

6.2 Console

Access to the TSC 4400 operating system is available through the console port located on the back of the unit. The TSC 4400 is a DCE device utilizing the RS232 communication protocol. Settings for the port are: 9600 baud, 8 data bits, 1 stop bit, no parity, and no flow control. It is sometimes necessary to access the system via the console because the IP address of the TSC 4400 is not known. As with telnet, users should be extremely cautious when modifying system files so as not to disable TSC 4400 operation.

6.3 Telnet

Access to the TSC 4400 file system is available via telnet. Telnet access is completely equivalent to accessing the TSC 4400 via the CONSOLE (section 6.2) except that it can be done remotely because it uses the LAN connection. Another advantage of accessing the TSC 4400 via telnet is that multiple telnet sessions may be active at once. Thus, a user may log in multiple times and multiple users may be logged in simultaneously.

Accessing the file system is not required for normal operations and great care must be taken when using telnet because altering system files can disable operation of the TSC 4400. It is recommended that only users with UNIX experience and sufficient knowledge of the system be allowed to access the file system. Telnet access is sometimes convenient because it allows a user to directly modify configuration files (section 7). The login and password for telnet access is “gps”.

6.4 Simple Network Management Protocol (SNMP)

The TSC 4400 utilizes SNMP to provide remote monitoring of system status. SNMP is a protocol used by devices to share system information with a SNMP server responsible for monitoring the status of multiple devices. When polled by the SNMP server the TSC 4400 retrieves the desired system information and provides it to the server.

SNMP utilizes a sequence of numbers (similar to an IP address) to distinguish various devices from one another. Each device has a unique ID based upon its classification. All products manufactured by Timing Solutions Corporation (TSC) have the prefix “1.3.6.1.4.1.6914” which identifies it as a TSC product. Additional fields are appended to this prefix to identify the product and the field being monitored. Table 6-1 summarizes¹ the Management Information Base (MIB) provided by the TSC 4400.

MIB Prefix: 1.3.6.1.4.1.6914

Appended Field ID	Field Name	Data Type	Values
10	tsc4400	Object Group	[systemStatus, logManager, gpsReceiver, frequencyReference, timescale, irigB, ntp]
10.1	systemStatus	Object Group	[sysError, errorType, trackingGps, lastTracking, lastFlywheel, loggingData, version, systime, initialized]
10.1.1.0	sysError	Display String	Message
10.1.2.0	errorType	Display String	NON-CRITICAL / CRITICAL / FATAL
10.1.3.0	trackingGps	Display String	TRUE / FALSE
10.1.4.0	lastTracking	Display String	UTC
10.1.5.0	lastFlywheel	Display String	UTC
10.1.6.0	loggingData	Display String	TRUE / FALSE
10.1.7.0	version	Display String	Revision Number
10.1.8.0	systime	Display String	UTC
10.1.9.0	initialized	Display String	YES after initialization
10.2	logManager	Object Group	[logError, lastLogTime, lastLog, currentLogTime, currentLog]
10.2.1.0	logError	Display String	Message
10.2.2.0	lastLogTime	Display String	UTC
10.2.3.0	lastLog	Display String	Filename
10.2.4.0	currentLogTime	Display String	UTC
10.2.5.0	currentLog	Display String	Filename
10.3	gpsReceiver	Object Group	[gpsError, gpsLocked, last-lock-utc, positioning-mode, antennaLat, antennaLong, antennaAlt, model, serial, hwVersion, swVersion, measType]
10.3.1.0	gpsError	Display String	Message

¹ A more complete description of the MIB can be found in appendix C.

Appended Field ID	Field Name	Data Type	Values
10.3.2.0	gpsLocked	Display String	TRUE / FALSE
10.3.3.0	gpsLastLock	Display String	UTC
10.3.4.0	positioningMode	Display String	MANUAL / AUTO / FIXED / DYNAMIC
10.3.5.0	antennaLat	Display String	N dd:mm:ss.ssss
10.3.6.0	antennaLong	Display String	E dd:mm:ss.ssss
10.3.7.0	antennaAlt	Display String	Ellipsoidal Height in meters
10.3.8.0	model	Display String	Model # of GPS receiver
10.3.9.0	serial	Display String	Serial # of GPS receiver
10.3.10.0	hwVersion	Display String	HW version of GPS receiver
10.3.11.0	swVersion	Display String	SW version of GPS receiver
10.3.12.0	measType	Display String	Single / Dual frequency measurements being received
10.4	frequencyReference	Object Group	[refError, refLocked, refLastLock]
10.4.1.0	referrer	Display String	Message
10.4.2.0	refLocked	Display String	TRUE / FALSE
10.4.3.0	refLastLock	Display String	UTC
10.5	timescale	Object Group	[tsError, utcInit, currentState, utcStateBegin]
10.5.1.0	tsError	Display String	Message
10.5.2.0	currentState	Display String	Message
10.5.3.0	utcInit	Display String	UTC
10.5.4.0	utcStateBegin	Display String	UTC
10.5.5.0	utcOffset	Display String	UTC offset measured by GPS receiver
10.6	irigB	Object Group	[irigError, valid, upcomingLeapSecond]
10.6.1.0	irigError	Display String	Message
10.6.2.0	valid	Display String	YES / [EMPTY]
10.6.3.0	upcomingLeapSecond	Display String	+1 / -1 / 0
10.7	ntp	Object Group	[ntpError, refClockLocked, acceptRatio]
10.7.1.0	ntpError	Display String	Message
10.7.2.0	refClockLocked	Display String	TRUE / FALSE
10.7.3.0	acceptRatio	Display String	% of accepted measurements

Table 6-1. Management Information Base for the TSC 4400.

6.5 File Transfer Protocol (FTP)

Two levels of access are granted via file transfer protocol (ftp). Guest users (username: ftp) are provided read/write access to the ionospheric logs and privileged

users (username: gps, password: gps) are granted read/write access to the configuration files. Privileged users require read/write access to maintain the configuration files used by the TSC 4400. However, caution should be exercised when uploading files because improper file location or format can cause the TSC 4400 to cease operation.

In addition to the FTP server capabilities of the TSC 4400, it has the ability to autonomously FTP the log files (section 7.3) to another computer on the network. This allows log files to be pushed to a server as they are created. This is often a preferred method of operation because logs on the TSC 4400 are stored in volatile memory so they are erased in the case of power failures.

Configuration of the autonomous FTP push capability is configured using parameters in the file “/etc/rc.conf.local”. All parameters of the format “tsc_push_*” are used in determining the characteristics of the push operation. It is important to note that the system must be rebooted before changes to the parameters will take affect.

User Configuration

```
tsc_push_host=           # remote IP address or host name
tsc_push_user=          # remote ftp user name
tsc_push_password=      # remove ftp password
```

The TSC 4400 uses the FTP user information to transfer files to the specified system. The parameter “tsc_push_host” specifies the IP address of the system to which the log files will be transferred. The login information used by the TSC 4400 is determined by the “tsc_push_user” and “tsc_push_password” parameters. If these parameters do not contain a valid login name and password for the remote system then the file transfer will fail and the log files will remain in volatile memory on the TSC 4400.

File Location

```
tsc_push_datadir=/var/ftp/lim      # where to look locally for files to push
tsc_push_remotedir=~${tsc_push_user} # remote directory
tsc_push_fileext=.dat             # add an extension to the file before transfer?
```

Files are transferred from the “tsc_push_datadir” directory to the “tsc_push_remotedir” directory on the remote system. The “tsc_push_user” must have the appropriate permission on the remote system to access the “tsc_push_remotedir” directory. If the specified user does not have the appropriate level of access then the file transfer will fail. The “tsc_push_fileext” parameter causes the TSC 4400 to append the specified extension to the files before transferring them to the remote system. This allows multiple units to push data to the same server while preserving information about the source of the data.

Operation Parameters

```
tsc_push_enable=NO           # control whether rc.d script runs pushdata
tsc_push_pollsleep=20        # how often (sec) to poll for files in datadir
tsc_push_dieerr=NO           # die if we detect a push error?
tsc_push_errsleep=120        # how much (sec) to wait if we get a push error
tsc_push_purgestart=NO       # remove existing file in datadir on startup?
```

Log files are transferred to the remote system according to the operation parameters. When the “tsc_push_enable” parameter is set to “YES” the log files are automatically transferred to the remote system. When set to “NO” the log files remain on the TSC 4400 and are available for others to FTP to the system and retrieve the files.

The maximum frequency at which log files are transferred is determined by the “tsc_push_pollsleep” and “tsc_push_errsleep” parameters. The “tsc_push_pollsleep” parameter specifies the interval in seconds at which the “tsc_push_datadir” directory is checked for valid log files. When a valid log file is found in “tsc_push_datadir” then an attempt is made to transfer the file to the remote system. If that attempt fails then the TSC 4400 will wait for the number of seconds specified by the “tsc_push_errsleep” parameter and then try again. This is useful in scenarios where network connectivity is intermittent because the TSC 4400 will periodically attempt to transfer the file until network connectivity is restored.

The “tsc_push_dierr” and “tsc_push_purgestart” parameters are used in determining how the TSC 4400 behaves when errors are encountered. If “tsc_push_dierr” is set to yes then the TSC 4400 stops attempting to transfer files once an error is encountered. Accumulated files are deleted at startup when the “tsc_push_purgestart” parameter is set to yes.

6.6 Network Time Protocol (NTP)

Network Time Protocol (NTP) is provided for the dissemination of time to other devices on the network. The NTP structure classifies devices based upon levels referred to as stratum. Stratum-1 indicates a device that is determining time based upon its internal hardware. All higher order stratum receive their time from a device which is in the stratum immediately below them. Thus, a stratum-2 device receives time from a stratum-1 device and a stratum-5 device receives time from a stratum-4 device. The TSC 4400 is a stratum-1 device.

6.7 Diagnostic Port (1136)

The TSC 4400 provides an IP port to aid in diagnosing system errors. Each of the subsystems within the TSC 4400 provides diagnostic output that can aid in identifying system errors. It is typically not necessary for users to access the diagnostic port because all system errors are reported via SNMP but advanced users may find the diagnostic port useful during initial setup of a TSC 4400 because it outputs information about the startup sequence.

Diagnostic messages are only displayed on the diagnostic port. If access to these messages is desired then the output of the diagnostic port must be saved to a file. It is recommended that diagnostic messages be saved only to remote systems and not locally on the TSC 4400. Storing files locally may cause the file system to exceed its storage capacity and the TSC 4400 will no longer operate. Viewing the diagnostic messages locally may be done by typing “telnet localhost 1136” from the CONSOLE (section 6.2) or a telnet session (section 6.3).

6.8 Command Port (1137)

System commands can be issued to the TSC 4400 via the command port. These commands provide a limited set of operations to be used for remote control of the system. Typically, a remote monitoring station may record an error via SNMP that indicates user intervention is required. The remote monitoring station would then be able to access the command port via the Ethernet and issue the commands required for recovering from the error. The following list provides a short description of each command.

gpscmd

Syntax: gpscmd <gps command string>
Function: Send a command to the GPS receiver. It is not recommended that this command be used unless the user understands the full impact the command will have on the system. An improper command may cause the TSC 4400 to enter a fatal error state and require the system to be rebooted in order to recover. The GPS command string should be entered without any quotation marks.

help

Syntax: help <command>
Function: Display information about system commands and their syntax. Typing only “help” lists all the available commands and is useful as a quick reference.

logdisable

Syntax: logdisable <subsystem>
Function: Disable logging of subsystem messages to the diagnostic port. This command is the inverse of the “logenable” command in that it prevents status messages from the various subsystems from being output to the diagnostic port.

logenable

Syntax: logenable <subsystem>
Function: Enable logging of subsystem messages to the diagnostic port. The TSC 4400 is comprised of multiple subsystems that are responsible for controlling various aspects of system operation. If logs from a subsystem are enabled then all status messages concerning its operation will be output to the diagnostic port. Valid subsystems are: lim, gps, timescale, clock, and logmgr. Sending the “logenable all” commands enables logging on all the subsystems.

prompt

Syntax: prompt <on | off>
Function: Turn the prompt for the command port either on or off. The prompt may not be desirable for users who automate interaction

with the TSC 4400 through the command port. Using this command allows the prompt to be disabled.

rbadjust

Syntax: rbadjust
Function: Make a coarse adjustment to the frequency of the internal frequency reference. The frequency of the Rb will change over time and will eventually require a coarse adjustment to its internal parameters to keep it sufficiently close to 10 MHz. The TSC 4400 will generate the alarm “Rubidium requires coarse tuning adjustment” when the Rb needs to be retuned. This alarm may appear briefly at startup as a result of adjustments being made to the timing outputs of the TSC 4400. If the alarm persists for more than two hours then it is necessary to manually issue the “rbadjust” command. This command will cause the system to be restarted and will result in a disruption of the timing outputs.

Note: The need for a coarse adjustment of frequency does not necessarily indicate that the timing outputs are out of tolerance. Thus, operation may continue until a convenient time is found to make the adjustment.

resetirig

Syntax: resetirig
Function: Reset the IRIG-B outputs on the TSC 4400. This command may be used to force the TSC 4400 to reset its IRIG-B outputs. It should never be necessary to issue this command as an invalid IRIG-B signal indicates a serious error.

show

Syntax: show
Function: Display the current value of system variables. Monitoring system variables is not necessary for normal operations but is sometimes useful in troubleshooting. The system variables can give insight into whether the system is functioning properly.

shutdown

Syntax: shutdown
Function: Attempt to shutdown the TSC 4400. This is the best way to shutdown the software on the TSC 4400 because it allows the system to store any remaining logs and halt all software processes gracefully. To keep the software from automatically restarting it is necessary to create the file “/var/tmp/lim.dontrun”. This can be

done by typing “touch /var/tmp/lim.dontrun” from either the CONSOLE (section 6.2) or via TELNET (section 6.3).

quit

Syntax: quit
Function: Exit the command port interface.

7 Configuration Files

Configuration files are used in configuring the TSC 4400 for a variety of applications. A total of five configuration files exist and they are located in the “/mod/site/” directory. The configuration files may be uploaded or downloaded via ftp (section 6.5) by anyone using the “gps” username. Access to configuration files is not granted to the “ftp” user for security reasons. Modifying configuration files may create a condition in which the TSC 4400 will no longer operate and thus access is not granted to low-level users.

Once the configuration of the TSC 4400 is set it will operate in that configuration until it is restarted. Configuration files are loaded only at startup and thus changing configuration files after the system is operational will have no effect on the system. In order to force configuration changes to take effect the system must be restarted. This may cause a disruption in the timing outputs so it is recommended that users of the timing signals be notified before restarting the system. Restarting the system can be accomplished by sending the “shutdown” command to the command port (section 6.8). Once the system has successfully halted it will automatically restart.

7.1 Startup Configuration

The startup configuration file is the first configuration file loaded and is used in configuring the TSC 4400 for basic system operations. The startup configuration file (/mod/site/startup.cfg) is generally specific to each installation because it contains information about the antenna location. It is recommended that a backup copy of the configuration file be saved before making changes because corrupting the file may cause the system to enter a fatal error mode the next time the system is restarted.

The TSC 4400 allows users to maintain configuration files remotely if desired. On startup the unit will access the “/mnt/lim/startup.cfg” file to determine how to configure the system. If that file does not exist then the TSC 4400 will access the “/mod/site/startup.cfg” file. The “/mnt/lim/” directory is designed specifically for mounting a network server or other computer to the TSC 4400 file system. Doing this allows all configuration files to be stored remotely and not on the unit itself. The general process for mounting a remote computer to the TSC 4400 file system is to access the TSC 4400 file system as the root user and type:

```
mount_nfs <IP Address>:<path> /mnt/lim
```

The <IP Address> should be the IP address of the remote computer that is to be mounted to the TSC 4400 file system. The <path> should be the directory in which the configuration files are located on the remote system.

WARNING: It is not recommended that users modify the “/etc/fstab” file to automatically mount a remote file system to the TSC 4400. Users will be unable to access the TSC 4400 if the remote file system is not present at startup.

The remainder of this section analyzes each portion of the startup configuration file and explains the various ways to configure the TSC 4400.

Positioning Modes

# Positioning Mode	
ANTENNA_POSITION = AUTO	# MANUAL/AUTO
AUTO_POS_PERIOD = 12	# Length of time to use in # auto-positioning (Hours).
# Antenna Location	
DATUM = WGS84	# WGS84/NAD83
LATITUDE = 40:01:9.89122	# Degrees North
LONGITUDE = -105:14:20.74648	# Degrees East
ALTITUDE = 1592.729	# Ellipsoidal Height in meters

The TSC 4400 includes both MANUAL and AUTO modes for determining the antenna location. The AUTO mode is recommended when the antenna location has not been surveyed. When AUTO is selected the TSC 4400 will automatically determine the location of its antenna. It does this by averaging its calculated position solutions over a period specified by the AUTO_POS_PERIOD parameter. The factory default for the AUTO_POS_PERIOD is 12 hours but it is recommended that this auto positioning period not be less than four hours. Once the AUTO_POS_PERIOD expires the TSC 4400 will enter the FIXED position mode. In this mode the unit fixes its antenna location to the position determined during the AUTO positioning period and continues to operate. Fixing the antenna position reduces the noise of the GPS measurements and increases the frequency stability of the timing outputs.

In addition to automatically determining its antenna location, the TSC 4400 generates a RINEX (Receiver INdependent EXchange) format observation file. This file format is a standard used by the GPS community and provides all the necessary GPS measurements for determining the antenna location. The file can be retrieved from the system by using ftp (login: ftp, password: ftp) to log in and retrieve the file. Once logged in the file will be in the “rinex” subdirectory and will have a “[yy]o” extension where [yy] represents the last two digits of the current year. Many online processing centers are available (e.g., <http://www.ngs.noaa.gov/OPUS>, <http://sopac.ucsd.edu/cgi-bin/SCOUT.cgi>) and will process the observation file free of charge. Doing this improves the position estimate of the antenna and is recommended for precise time recovery.

If the location of the antenna is known then the MANUAL mode may be used. This mode uses the information provided by the DATUM, LATITUDE, LONGITUDE, and ALTITUDE parameters to fix the antenna position at startup. This bypasses the auto positioning period and does not generate a RINEX observation file. This mode of operation is recommended if the antenna position is known.

Antenna Configuration

# Antenna configuration parameters.	
ANTENNA_DELAY = 0E-9	# Seconds
MASK_ANGLE = 10	# Degrees

Antenna configuration parameters allow TSC 4400 operation to be customized based upon the installation. ANTENNA_DELAY allows users to adjust the on-time-point (OTP) of the TSC 4400 to be any point in the system. The OTP of a system refers to the point at which the difference between the timing signals and the time they represent is zero. Typical installations use cables to transmit timing signals and these cables add additional delays to the system that must be compensated for. To select the OTP of a system users should add the delay of the antenna cable going to the TSC 4400 and subtract the delay of cables after the TSC 4400. The net sum of these two numbers provides the ANTENNA_DELAY parameter.

Adjustment of the MASK_ANGLE parameter may be necessary for installations with severe multi-path problems. The MASK_ANGLE of the antenna refers to the elevation angle above the horizon at which all satellites above it are tracked. It may be possible to track satellites below the MASK_ANGLE but the data is intentionally omitted because it is unreliable. Installations with severe multi-path problems may find that they get better timing performance out of the TSC 4400 when using a higher MASK_ANGLE.

Frequency References

```
# Frequency reference
REFERENCE = INTERNAL                # INTERNAL/EXTERNAL
EXTERNAL_REF = NONE                 # NONE/HP5071A
```

The TSC 4400 utilizes an INTERNAL rubidium (Rb) clock as its frequency reference. Using the Rb frequency reference allows the unit to provide better timing outputs than could be provided by using GPS alone. In addition to using the internal Rb of the TSC 4400 as a frequency reference, users may decide to provide an EXTERNAL frequency reference to the TSC 4400. The external frequency reference is then steered by the TSC 4400 via RS232 through the COM connector (section 5.2) on the rear of the unit. Only the HP5071A is currently supported but users should contact Timing Solutions Corporation about the possibility of utilizing other clocks.

COM Configuration

```
# COM port configuration
COM_MODE = CLOCK                    # REALTIME/CLOCK
```

The COM connector on the rear of the TSC 4400 is configurable as either a REALTIME output device or as serial communication with an external CLOCK. The CLOCK configuration is required for steering external frequency references. It provides the means by which the TSC 4400 controls the external reference. The REALTIME mode allows users to receive GPS data in real-time over the serial port. When REALTIME is selected the TSC 4400 will configure the port per the settings described in the real-time configuration file (section 7.4).

Configuration File Location

```
# Configuration files
NOVALOG_CFG = /mod/lim/novalog.nml    # Specifies ionospheric logs
```



```

REALTIME_CFG = /mod/lim/realtime.nml           # to be output.
                                                # Specifies logs to output to
TIMESCALE_CFG = /mod/lim/internalRb.cfg        # the COM port.
                                                # Contains clock specific
ERROR_LOG = /dev/null                          # KAS2 filter information.
                                                # Does nothing but is required.

```

The location of configuration files other than the startup configuration file must be specified. This allows multiple configuration files to co-exist on the TSC 4400. The behavior of the TSC 4400 can then be modified by specifying the configuration file to be used. Note that these paths must be changed if using a remote system to store the configuration files. Details about the specific configuration files can be found in later sections.

Log Compression

```

# Ionospheric log file handling.
COMPRESS_LOGS = TRUE                          # Specifies ionospheric logs should
                                                # be compressed with gzip.

```

Ionospheric logs are those logs specified in the noalog configuration file (section 7.3). Twelve megabytes of space is allocated to the storage of these logs. The oldest logs are deleted to make space for newer logs when the allocated storage space has been filled. To maximize the allocated storage space, the TSC 4400 allows users to COMPRESS_LOGS if desired. When enabled, the TSC 4400 compresses logs using the gzip format.

WAAS Configuration

```

# WAAS Configuration.
WAAS_SEARCH_MODE = TABLE                     # AUTO / TABLE
WAAS_TABLE_FILE = /mod/lim/waasprn.tbl       # Table specifying WAAS Config

```

The TSC 4400 is capable of tracking satellites used in Wide Area Augmentation Systems (WAAS). These satellites broadcast GPS signals with information that is useful in improving the accuracy of GPS. Two modes are available for determining which WAAS satellites to track: AUTO and TABLE. AUTO search mode allows the TSC 4400 to search for and track any WAAS satellites that it can find. TABLE mode forces the TSC 4400 to select the two nearest WAAS satellites based upon longitude of the satellites listed in WAAS_TABLE_FILE and attempt to track those. The TSC 4400 can only track two WAAS satellites at a time.

7.2 Timescale Configuration

The timescale configuration file specifies control loop parameters used in tracking GPS. Modifying the timescale configuration file can significantly impact the timing performance of the TSC 4400. Thus, it is not recommended that changes be made to this file without first contacting Timing.Solutions Corporation. The location of the timescale configuration parameter is specified by the TIMESCALE_CFG parameter in the startup

configuration file (section 7.1). Two timescale files are included by default on the TSC 4400: “/mod/site/internalRb.cfg” and “/mod/site/HP5071.cfg”. The “/mod/site/internalRb.cfg” file is to be used when the unit is using its internal frequency reference and the “/mod/site/HP5071.cfg” file is to be used when steering an external HP5071A cesium frequency reference.

7.3 Noalog Configuration

The noalog configuration file defines which GPS logs are to be stored by the TSC 4400. The location of the noalog configuration file is defined by the NOVALOG_CFG parameter in the startup configuration file. This feature allows multiple configuration files to reside on the system. Behavior of the TSC 4400 can then be quickly modified by changing the NOVALOG_CFG parameter to specify the desired configuration file.

Log Rotation Interval

```
# Rotate ionospheric log files every 15 minutes.  
LOGDATA = 15
```

Log files are broken into time intervals specified by the LOGDATA parameter. The filename of each log contains a timestamp that indicates the start time of the log. Once the LOGDATA interval has expired, the file is closed and available for ftp download (section 6.5). A new file is then started and given a new file name according to the time the file was created. If the logs in the storage directory exceed the available space then the oldest logs will be deleted to ensure that there is room for newer logs.

Log Archiving

```
# Maximum number of log files to be retained.  
# Note: -1 = keep as many log files as disk space allows.  
LOGFILES = -1
```

The number of logs archived by the TSC 4400 is specified using the LOGFILES parameter. Logs are stored in volatile memory so all logs are lost if power is cycled. During operation the TSC 4400 continues archiving until the total number of logs is equal to the LOGFILES parameter. Once that condition is reached the oldest logs are deleted and the newer logs retained so that the total number of logs will always equal the LOGFILES parameter. Setting LOGFILES to “-1” causes the system to store as many log files as the volatile memory will allow (16 MB).

Carrier Smoothing

```
# Carrier Smoothing Parameter  
CARRIER_SMOOTHING = 60
```

CARRIER_SMOOTHING defines the time in seconds over which the GPS carrier signal is smoothed. For dual frequency receivers, this value is applied to both L1 and L2 frequencies. The CARRIER_SMOOTHING parameter may be set to any integer value between 5 and 2000 seconds. Shorter smoothing results in noisier GPS data.

Data Logging

```
# List of log commands, the output of which will be placed in the
# ionospheric log files.
COMMAND = "log ionutca  onchanged "           // log IONO & UTC data
COMMAND = "log rawalma  onchanged "           // log alamanc on startup
COMMAND = "log rangea  ontime 60 "            // L1/L2 obs @ 60 seconds
COMMAND = "log ionutca  ontime 7200"          // log IONO & UTC data every 2 hours
COMMAND = "log rawephema onchanged "          // log broadcast ephemerides
COMMAND = "log waas9a  onchanged "            // log WAAS data
```

The COMMAND parameter is used in requesting GPS data logs from the TSC 4400. All logs specified in the Novatel OEM4-G2 manual (<http://www.novatel.com/Downloads/docupdates.html>) are supported in their ASCII format. The primary restriction is that the total number of logs requested in the novalog configuration file and the real-time configuration file must not exceed the maximum number of logs specified in Appendix A. Also, only ASCII format log commands and NMEA messages are supported. All other commands are disregarded by the TSC 4400. Logs are available for ftp download (login: ftp, password: ftp) from the “/var/ftp/lim/” directory.

7.4 Real-Time Configuration

The real-time configuration file specifies the characteristics of the COM port on the rear of the TSC 4400. This configuration file is only loaded when the mode of the COM port has been set to REALTIME in the startup configuration file (section 7.1). When the port is configured as REALTIME it will output serial data from the GPS receiver in a real-time manner. The location of the real-time configuration file is defined by the REALTIME_CFG parameter within the startup configuration file.

Baud Rate

```
BAUD = 19200
```

The baud rate of the COM port is specified using the BAUD command. The baud rate is settable to the following data rates: 110, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, or 115200. Regardless of the baud rate selected, the COM port will always use 8 data bits, no parity, 1 stop bit, and no flow control.

Data Logging

```
COMMAND = "log GPGGARTK ontime 1"
COMMAND = "log GPGSV ontime 10"
```

Real-time data logs are requested from the TSC 4400 using the COMMAND parameter. This parameter is identical to the COMMAND parameter used in the novalog configuration file. The commands must be in the Novatel format but only ASCII log commands and NMEA messages are supported. All other commands are disregarded. In addition, the total number of logs requested by the real-time configuration file and the

noalog configuration file must not exceed the maximum number of logs specified in Appendix A.

7.5 WAAS Configuration

# Name	PRN	Longitude(Deg E)	Doppler	Window
AORE	120	-15.5	0	50
AORW	122	-54	0	50
POR	134	178	0	50
IOR	131	64	0	50
IORW	126	25	0	50

The WAAS configuration file defines which WAAS satellites to search for based upon the longitude of the TSC 4400. The location of the WAAS configuration table is defined by the WAAS_TABLE_CFG parameter in the startup configuration file. Note that this table is only used when the WAAS_SEARCH_MODE parameter is set to TABLE. The TSC 4400 is only capable of tracking two WAAS satellites at a time so it will track the two closest WAAS satellites. If a specific satellite is to be tracked and it is not one of the two closest satellites then entries from the table may be removed so that only the desired satellites are left.

8 Logging Data in Real-time

Certain applications require that GPS data be retrieved in a timely manner. For this purpose, the COM port on the rear of the TSC 4400 may be configured to provide real-time data output. Which logs are output will be specific to the application but users may request any of the ASCII logs specified in the user manual for the Novatel OEM4-G2 receiver (<http://www.novatel.com/Downloads/docupdates.html>). The only limitation is that the total number of logs requested must not exceed the number specified in Appendix A.

The following instructions walk through the setup for generating real-time data output.

1. Connect the COM port on the rear of the TSC 4400 to the device logging the serial data using a DB9(M)-DB9(F) serial cable.
2. Modify the startup configuration file (section 7.1) to generate real-time output data.
 - a. Set COM_MODE to REALTIME.
3. Modify the realtime configuration file (section 7.4).
 - a. Set BAUD to the desired baud rate
 - b. Set COMMAND to the logs that you wish to output. Note that multiple instances of COMMAND are supported so multiple logs may be requested.
4. Restart the system. Send the “shutdown” command to the command port (section 6.8).

9 Steering an External Reference

The TSC 4400 is capable of significant performance enhancements when using an external frequency reference. Using an external reference allows the unit to take advantage of the increased frequency stability of higher performance clocks such as a Cesium reference without having to buy a whole new system. This allows users to meet their current timing requirements without limiting their capability to meet more stringent timing requirements in the future.

External references are controlled using the COM port on the rear panel of the TSC 4400. As a result, it is not possible to use an external frequency reference when logging real-time data. The following instructions provide the necessary steps for configuring the TSC 4400 to use an external reference.

1. Connect the COM output to the serial interface of the external reference using a DB9(M)-DB9(F) serial cable.
2. Connect the 10 MHz output of the frequency reference to the 10 MHz IN connector on the back of the TSC 4400.
3. Modify the startup configuration file (section 7.1) to use an external reference.
 - a. Set COM_MODE to CLOCK.
 - b. Set REFERENCE to EXTERNAL.
 - c. Set EXTERNAL_REF to identify the type of clock being used. Currently only the HP5071A is supported.

- d. Set TIMESCALE_CFG to “/mod/site/HP5071.cfg”.
 - i. Please contact Timing Solutions Corporation when using external references other than the HP5071A.
- 4. Restart the system. Send the “shutdown” command to the command port (section 6.8).

10 Maintenance

The recommended maintenance schedule for the TSC 4400 is outlined in Table 10-1. Although this schedule is sufficient for most applications, it may be necessary to increase the number of scheduled maintenance events for extremely dusty or dirty environments. Contact Timing Solutions Corporation if there are questions about the scheduled maintenance cycle.

A minimal amount of maintenance is required for the TSC 4400. It is designed to operate continuously over long periods of time with little to no interaction. The primary factor in maintaining a working unit is to verify that it remains dust free. Dust and particles may enter the unit through vent holes and accumulate inside. Although this is typically not a major concern, it may be a significant concern in installations with a high dust content. The following maintenance schedule is applicable.

Interval	Maintenance Required
Monthly	(none)
Yearly	1. Internal inspection. 2. Antenna inspection.

Table 10-1. Maintenance schedule for TSC 4400.

Internal Inspection

The internal inspection of the TSC 4400 is necessary to ensure that all components are relatively free of dust and particles that may cause electronic components to fail. The following instructions outline the required steps in performing an internal inspection of the TSC 4400.

1. Remove the bottom of the TSC 4400 per section 5.4.
2. Visually inspect the various components and make sure that an excessive amount of dust is not present. Excessive dust can be removed by using compressed air to clean the electrical components of any accumulated dust.
3. Re-install the bottom cover of the TSC 4400.

Antenna Inspection

Antennas and antenna cables are a common source of failure because they are exposed to environmental elements. The following process outlines the steps required in performing an inspection of the antenna and antenna cable.

1. Follow the antenna cable from the rear of the TSC 4400 to the antenna. Look for any severe bends in the cable or damage to the shielding of the cable.

2. Remove any severe bends that were found in the cable and replace cables that have damaged shielding.
3. Examine the portion of the cable that is exposed to the elements. Look for signs of excessive weathering such as a deterioration of the outermost insulator. Replace any cables or antennas that appear severely weathered.
4. Clean any buildup of dirt or other contaminants from the surface of the antenna. These contaminants may cause a degradation in the strength of the GPS signal.
5. Verify that the antenna is still securely mounted. An insecurely mounted antenna can cause injury or death when it falls.

Appendix A. Technical Specification

TSC 4400, Dual Frequency (L1/L2) Unit

- Environmental -	
Power	100 – 240 VAC 47 – 63 Hz 85 Watts Maximum
Operating Temperature	0° - 50° C, 95% Humidity, non-condensing
Storage Temperature	-20° - 70°, 95% Humidity, non-condensing
- Physical -	
Size (TSC 4400)	19" W x 22" D x 3.5" H (482.6 x 431.8 x 88.9 mm)
Weight (TSC 4400)	12 pounds (5.5 kg)
Weight (Mounting Shelf)	17 pounds (7.7 kg)
- 10 MHz Input -	
Quantity	1
Connector	SMA(F)
Input Power	-20 dBm – 10 dBm
Input Impedance	50 ohms \pm 10%
- PPS Outputs -	
Quantity	4
Connector	SMA(F)
Level (50 ohm load)	3.0 V \pm 10%
Output Impedance	50 ohms \pm 10%
Pulse Width	1 ms \pm 10%
Risetime (20%-80%)	< 3 ns
Jitter	< 1 ns rms pulse-to-pulse < 1 ns rms pulse-to-10 MHz
Skew	\pm 1 ns

<p>UTC(USNO) Offset (w/ GPS)</p> <ul style="list-style-type: none"> - Precise Calibration - Coarse Calibration <p>Holdover Accuracy (w/o GPS)</p> <ul style="list-style-type: none"> - Using Internal Reference - Using External Reference 	<p>15 ns RMS</p> <p>100 ns RMS</p> <p>@ 6 hours: 50 ns @ 12 hours: 100 ns @ 24 hours: 300 ns</p> <p>Dependent upon stability of frequency reference being supplied and time constant used in steering.</p>
<p>- 10 MHz Outputs -</p> <p>Quantity</p> <p>Connector</p> <p>Output Power</p> <ul style="list-style-type: none"> - Using Internal Reference (50 Ohm load) - Using External Reference <p>Output Impedance</p> <p>Phase Noise (SSB)</p> <ul style="list-style-type: none"> - Using Internal Reference - Using External Reference <p>Allan Variance (with GPS)</p> <ul style="list-style-type: none"> - Using Internal Reference 	<p>4</p> <p>SMA(F)</p> <p>13 dBm ± 1 dB $1.25\text{ V} \leq V_{pp} \leq 1.60\text{ V}$</p> <p>Power(10 MHz IN)</p> <p>50 ohms ± 5 ohms</p> <p>@ 1 Hz: -95 dBc/Hz @ 10 Hz: -130 dBc/Hz @ 100 Hz: -140 dBc/Hz @ 1 kHz: -150 dBc/Hz @ 10 kHz: -155 dBc/Hz @ 100 kHz: -155 dBc/Hz</p> <p>Refer to specification for frequency reference being used as input.</p> <p>@ 10⁰ s: < 3 x 10⁻¹¹ @ 10¹ s: < 8 x 10⁻¹² @ 10² s: < 2 x 10⁻¹² @ 10³ s: < 8 x 10⁻¹³ @ 10⁴ s: < 7 x 10⁻¹³ @ 10⁵ s: < 1 x 10⁻¹³</p>

- Using External Reference	Dependent upon stability of frequency reference provided and time constant used in steering.
- IRIG B Outputs -	
Quantity	2
Connector	SMA(F)
Timecode	IRIG-B123
Carrier Frequency	1 kHz
Level (into 50 Ohms)	$2.6\text{ V} \leq V_{pp} \leq 3.3\text{ V}$
Output Impedance	50 ohms \pm 10%
Modulation Index	3:1
Output in absence of timecode	1 kHz @ 1 V _{pp} (10 dBm)
UTC(USNO) Offset (w/ GPS)	< 5 μ s
- DC IRIG B Outputs -	
Quantity	2
Connector	SMA(F)
Timecode	IRIG-B003
Level (into 50 Ohms)	$2.8\text{ V} \leq V_{pp} \leq 3.5\text{ V}$
Output Impedance	50 ohms \pm 10%
UTC(USNO) Offset (w/ GPS)	< 5 μ s
- Ethernet Interface -	
Quantity	1
Connector	RJ-45
Protocol	IEEE 802.11
Speed	10/100 Base-T
Network Time Protocol (NTP)	
- Stratum	Level 0/Level 1
- UTC(USNO) Offset	100 ms
File Transfer Protocol (FTP)	

- Guest User	ftp
- Guest Password	ftp
- Privileged User	gps
- Privileged Password	gps
Status Monitoring	Simple Network Management Protocol (SNMP) See Appendix B for MIB specification.
Command Port	1137
Diagnostic Port	1136
Real-time Logging Port	1135
- Data Logs -	
Output Format	ASCII
Maximum Log Storage	16 MBytes
Max Number of Requested Logs	7
Min Log Interval	1 minute
Max Log Interval	24 hours
- COM -	
Connector	DB9(F)
Function	Reconfigurable between real-time output or control of external reference.
Real-time Log Format	ASCII
- CONSOLE -	
Connector	DB9(F)
Function	File system access using a standard terminal
Baud Rate	9600 bps
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	Off
- ANTENNA -	

Connector	TNC(F)
Impedance	50 ohms
Output Voltage	Selectable: 5V, 12V, or GND
Input Frequency	L1 (1575 MHz) L2 (1272 MHz)
Antenna Cable	Cable loss should not exceed 10 dB

Appendix B. Technical Specification

TSC 4400-3, Single Frequency (L1) Unit

- Environmental -	
Power	100 – 240 VAC 47 – 63 Hz 85 Watts Maximum
Operating Temperature	0° - 50° C, 95% Humidity, non-condensing
Storage Temperature	-20° - 70°, 95% Humidity, non-condensing
- Physical -	
Size (TSC 4400)	19" W x 22" D x 3.5" H (482.6 x 431.8 x 88.9 mm)
Weight (TSC 4400)	12 pounds (5.5 kg)
Weight (Mounting Shelf)	17 pounds (7.7 kg)
- 10 MHz Input -	
Quantity	1
Connector	SMA(F)
Input Power	-20 dBm – 10 dBm
Input Impedance	50 ohms \pm 10%
- PPS Outputs -	
Quantity	4
Connector	SMA(F)
Level (50 ohm load)	3.0 V \pm 10%
Output Impedance	50 ohms \pm 10%
Pulse Width	1 ms \pm 10%
Risetime (20%-80%)	< 3 ns
Jitter	< 1 ns rms pulse-to-pulse < 1 ns rms pulse-to-10 MHz
Skew	\pm 1 ns

<p>UTC(USNO) Offset (w/ GPS)</p> <ul style="list-style-type: none"> - Precise Calibration - Coarse Calibration <p>Holdover Accuracy (w/o GPS)</p> <ul style="list-style-type: none"> - Using Internal Reference - Using External Reference 	<p>25 ns RMS</p> <p>100 ns RMS</p> <p>@ 6 hours: 50 ns @ 12 hours: 100 ns @ 24 hours: 300 ns</p> <p>Dependent upon stability of frequency reference being supplied and time constant used in steering.</p>
<p>- 10 MHz Outputs -</p> <p>Quantity</p> <p>Connector</p> <p>Output Power</p> <ul style="list-style-type: none"> - Using Internal Reference (50 Ohm load) - Using External Reference <p>Output Impedance</p> <p>Phase Noise (SSB)</p> <ul style="list-style-type: none"> - Using Internal Reference - Using External Reference <p>Allan Variance (with GPS)</p> <ul style="list-style-type: none"> - Using Internal Reference 	<p>4</p> <p>SMA(F)</p> <p>13 dBm ± 1 dB $1.25\text{ V} \leq V_{pp} \leq 1.60\text{ V}$</p> <p>Power(10 MHz IN)</p> <p>50 ohms ± 5 ohms</p> <p>@ 1 Hz: -95 dBc/Hz @ 10 Hz: -130 dBc/Hz @ 100 Hz: -140 dBc/Hz @ 1 kHz: -150 dBc/Hz @ 10 kHz: -155 dBc/Hz @ 100 kHz: -155 dBc/Hz</p> <p>Refer to specification for frequency reference being used as input.</p> <p>@ 10⁰ s: < 3 x 10⁻¹¹ @ 10¹ s: < 8 x 10⁻¹² @ 10² s: < 2 x 10⁻¹² @ 10³ s: < 4 x 10⁻¹² @ 10⁴ s: < 4 x 10⁻¹² @ 10⁵ s: < 4 x 10⁻¹³</p>

- Using External Reference	Dependent upon stability of frequency reference provided and time constant used in steering.
- IRIG B Outputs -	
Quantity	2
Connector	SMA(F)
Timecode	IRIG-B123
Carrier Frequency	1 kHz
Level (into 50 Ohms)	$2.6\text{ V} \leq V_{pp} \leq 3.3\text{ V}$
Output Impedance	50 ohms \pm 10%
Modulation Index	3:1
Output in absence of timecode	1 kHz @ 1 V _{pp} (10 dBm)
UTC(USNO) Offset (w/ GPS)	< 5 μ s
- DC IRIG B Outputs -	
Quantity	2
Connector	SMA(F)
Timecode	IRIG-B003
Level (into 50 Ohms)	$2.8\text{ V} \leq V_{pp} \leq 3.5\text{ V}$
Output Impedance	50 ohms \pm 10%
UTC(USNO) Offset (w/ GPS)	< 5 μ s
- Ethernet Interface -	
Quantity	1
Connector	RJ-45
Protocol	IEEE 802.11
Speed	10/100 Base-T
Network Time Protocol (NTP)	
- Stratum	Level 0/Level 1
- UTC(USNO) Offset	100 ms
File Transfer Protocol (FTP)	

- Guest User	ftp
- Guest Password	ftp
- Privileged User	gps
- Privileged Password	gps
Status Monitoring	Simple Network Management Protocol (SNMP) See Appendix B for MIB specification.
Command Port	1137
Diagnostic Port	1136
Real-time Logging Port	1135
- Data Logs -	
Output Format	ASCII
Maximum Log Storage	16 MBytes
Max Number of Requested Logs	7
Min Log Interval	1 minute
Max Log Interval	24 hours
- COM -	
Connector	DB9(F)
Function	Reconfigurable between real-time output or control of external reference.
Real-time Log Format	ASCII
- CONSOLE -	
Connector	DB9(F)
Function	File system access using a standard terminal
Baud Rate	9600 bps
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	Off
- ANTENNA -	

Connector	TNC(F)
Impedance	50 ohms
Output Voltage	Selectable: 5V, 12V, or GND
Input Frequency	L1 (1575 MHz)
Antenna Cable	Cable loss should not exceed 10 dB

Appendix C. TSC 4400 – Management Information Base

```

-----
-- Copyright (c) 2003 - Timing Solutions Corporation.
-- All Rights Reserved.
--
-- $TSC: devel/mibs/TSC4400-MIB.mib,v 1.1.2.4 2005/10/18 16:10:57 mPhillips Exp $
--
-- 1.3.6.1.4.1.6914 or
-- iso.org.dod.internet.private.enterprise.timing.
-- 1. 3. 6. 1. 4. 1. 6914.
--
-----

```

TSC4400-MIB DEFINITIONS ::= BEGIN

IMPORTS

```

    enterprises, MODULE-IDENTITY, OBJECT-TYPE, Integer32, IpAddress
        FROM SNMPv2-SMI
    DisplayString
        FROM SNMPv2-TC
    OBJECT-GROUP
        FROM SNMPv2-CONF;

```

timingMib MODULE-IDENTITY

LAST-UPDATED "200510140000Z" -- Oct. 14 2005

ORGANIZATION "Timing Solutions Corporation"

CONTACT-INFO "mPhillips@timing.com"

DESCRIPTION "Timing Solutions TSC4400 SMI SNMP framework"

::= { enterprises 6914 }

tsc4400 OBJECT-GROUP

OBJECTS { systemStatus, logManager, gpsReceiver, frequencyReference, timescale, irigB }

STATUS current

DESCRIPTION "base for TSC-4400"

::= { timingMib 10 }

--

-- tsc4400

--

--groups

systemStatus OBJECT-GROUP

OBJECTS { sysError, currentTime, trackingGps, lastTracking, lastFlywheel,
loggingData, version,
 systime, initialized }
STATUS current
DESCRIPTION "Information pertaining to the TSC-4400 system functions"
REFERENCE tsc4400
 ::= { tsc4400 1 }

logManager OBJECT-GROUP
OBJECTS { logError, lastLogTime, lastLog, currentLogTime, currentLog }
STATUS current
DESCRIPTION "Information pertaining to the management of ionospheric logs"
 ::= { tsc4400 2 }

gpsReceiver OBJECT-GROUP
OBJECTS { gpsError, gpsLocked, gpsLastLock, positioningMode, antennaLat,
antennaLong, antennaAlt,
 model, serial, hwVersion, swVersion, measType }
STATUS current
DESCRIPTION "Information pertaining to the gps receiver operation"
 ::= { tsc4400 3 }

frequencyReference OBJECT-GROUP
OBJECTS { refError, refLocked, refLastLock }
STATUS current
DESCRIPTION "Information pertaining to the frequency reference being used"
 ::= { tsc4400 4 }

timescale OBJECT-GROUP
OBJECTS { tsError, currentState, utcInit, utcStateBegin, utcOffset }
STATUS current
DESCRIPTION "Information about the timescale and its current state"
 ::= { tsc4400 5 }

irigB OBJECT-GROUP
OBJECTS { irigError, valid, upcomingLeapSecond }
STATUS current
DESCRIPTION "Information about the generation of IRIGB"
 ::= { tsc4400 6 }

ntp OBJECT-GROUP
OBJECTS { ntpError, refClockLocked, acceptRatio }
STATUS current
DESCRIPTION "Information about the state of the network time protocol server"
 ::= { tsc4400 7 }

```

--
--tsc4400.systemStatus
--
sysError      OBJECT-TYPE
SYNTAX       DisplayString
MAX-ACCESS   read-only
STATUS       current
DESCRIPTION   "Displays any current TSC 4400 error messages. Messages are
high-level system messages and other object groups may contain more detailed
information. Ex. Error message may read 'GPS Receiver Failure' and the gpsReceiver
object group may provide an error message like 'No GPS data for over 6 hours' "
 ::= { systemStatus 1 }

currentTime  OBJECT-TYPE
SYNTAX       DisplayString
MAX-ACCESS   read-only
STATUS       current
DESCRIPTION   "Displays current time of the system. "
 ::= { systemStatus 2 }

trackingGps   OBJECT-TYPE
SYNTAX       DisplayString
MAX-ACCESS   read-only
STATUS       current
DESCRIPTION   "TRUE/FALSE response. Indicates that GPS clock measurements
are being made and the frequency reference is being steered based upon these
measurements."
 ::= { systemStatus 3 }

lastTracking  OBJECT-TYPE
SYNTAX       DisplayString
MAX-ACCESS   read-only
STATUS       current
DESCRIPTION   "UTC of the last time the TSC 4400 began steering the frequency
reference to GPS."
 ::= { systemStatus 4 }

lastFlywheel  OBJECT-TYPE
SYNTAX       DisplayString
MAX-ACCESS   read-only
STATUS       current
DESCRIPTION   "UTC of the last time the TSC 4400 began flywheeling in the
absence of GPS"
 ::= { systemStatus 5 }

loggingData   OBJECT-TYPE

```


SYNTAX DisplayString
 MAX-ACCESS read-only
 STATUS current
 DESCRIPTION "TRUE/FALSE response. Indicates whether ionospheric logs are being generated. This will typically be 'FALSE' during system startup (about 30 min) but should then remain 'TRUE' during TSC 4400 operation."
 ::= { systemStatus 6 }

version OBJECT-TYPE
 SYNTAX DisplayString
 MAX-ACCESS read-only
 STATUS current
 DESCRIPTION "software version"
 ::= { systemStatus 7 }

systemtime OBJECT-TYPE
 SYNTAX DisplayString
 MAX-ACCESS read-only
 STATUS current
 DESCRIPTION "Current system time."
 ::= { systemStatus 8 }

initialized OBJECT-TYPE
 SYNTAX DisplayString
 MAX-ACCESS read-only
 STATUS current
 DESCRIPTION "'YES' if the system has been initialized and is running normally."
 ::= { systemStatus 9 }

 --- tsc4400.logManager

logError OBJECT-TYPE
 SYNTAX DisplayString
 MAX-ACCESS read-only
 STATUS current
 DESCRIPTION "Displays any current errors with the log manager. The log manager is responsible for monitoring ionospheric logs and tracking the size of logs so as not to exceed the allocated memory."
 ::= { logManager 1 }

lastLogTime OBJECT-TYPE
 SYNTAX DisplayString
 MAX-ACCESS read-only
 STATUS current
 DESCRIPTION "UTC of the previous log's start time."

::= { logManager 2 }

lastLogOBJECT-TYPE

SYNTAX DisplayString

MAX-ACCESS read-only

STATUS current

DESCRIPTION "Filename of the previous log."

::= { logManager 3 }

currentLogTime OBJECT-TYPE

SYNTAX DisplayString

MAX-ACCESS read-only

STATUS current

DESCRIPTION "UTC of the current log's start time."

::= { logManager 4 }

currentLog OBJECT-TYPE

SYNTAX DisplayString

MAX-ACCESS read-only

STATUS current

DESCRIPTION "Filename of the current log."

::= { logManager 5 }

--

-- tsc4400.gpsReceiver

--

gpsError OBJECT-TYPE

SYNTAX DisplayString

MAX-ACCESS read-only

STATUS current

DESCRIPTION "Displays any current errors with the gps receiver. The gps receiver is responsible for measuring the local clock offset to GPS and also recording ionospheric measurements."

::= { gpsReceiver 1 }

gpsLocked OBJECT-TYPE

SYNTAX DisplayString

MAX-ACCESS read-only

STATUS current

DESCRIPTION "TRUE/FALSE response. Indicates that GPS satellites are being tracked and measurements appear valid."

::= { gpsReceiver 2 }

gpsLastLock OBJECT-TYPE

SYNTAX DisplayString

MAX-ACCESS read-only

STATUS current
DESCRIPTION "UTC of the last time the GPS receiver was locked to at least four GPS satellites."
 ::= { gpsReceiver 3 }

positioningMode OBJECT-TYPE
SYNTAX DisplayString
MAX-ACCESS read-only
STATUS current
DESCRIPTION "MANUAL/AUTO/FIXED/DYNAMIC responses. Indicates how the TSC 4400 is computing its antenna coordinates."
 ::= { gpsReceiver 4 }

antennaLat OBJECT-TYPE
SYNTAX DisplayString
MAX-ACCESS read-only
STATUS current
DESCRIPTION "Current latitude of the antenna in N “dd:mm:ss.ssss”. The value is only valid when in MANUAL or FIXED positioning mode."
 ::= { gpsReceiver 5 }

antennaLong OBJECT-TYPE
SYNTAX DisplayString
MAX-ACCESS read-only
STATUS current
DESCRIPTION "Current longitude of the antenna in E “dd:mm:ss.ssss”. The value is only valid when in MANUAL or FIXED positioning mode."
 ::= { gpsReceiver 6 }

antennaAlt OBJECT-TYPE
SYNTAX DisplayString
MAX-ACCESS read-only
STATUS current
DESCRIPTION "Current ellipsoidal height of the antenna in meters. This value is only valid when in MANUAL or FIXED positioning mode."
 ::= { gpsReceiver 7 }

model OBJECT-TYPE
SYNTAX DisplayString
MAX-ACCESS read-only
STATUS current
DESCRIPTION "The model name of the GPS receiver."
 ::= { gpsReceiver 8 }

serial OBJECT-TYPE
SYNTAX DisplayString

MAX-ACCESS read-only
STATUS current
DESCRIPTION "The serial number of the GPS receiver."
 ::= { gpsReceiver 9 }

hwVersion OBJECT-TYPE
SYNTAX DisplayString
MAX-ACCESS read-only
STATUS current
DESCRIPTION "The version number of the GPS receiver hardware."
 ::= { gpsReceiver 10 }

swVersion OBJECT-TYPE
SYNTAX DisplayString
MAX-ACCESS read-only
STATUS current
DESCRIPTION "The version number of the GPS receiver software."
 ::= { gpsReceiver 11 }

measType OBJECT-TYPE
SYNTAX DisplayString
MAX-ACCESS read-only
STATUS current
DESCRIPTION "Dual/Single depending on whether the receiver is making dual frequency or single frequency measurements"
 ::= { gpsReceiver 12 }

--

-- tsc4400.frequencyReference

--

refError OBJECT-TYPE
SYNTAX DisplayString
MAX-ACCESS read-only
STATUS current
DESCRIPTION "Displays any current errors for the frequency reference. The frequency reference is an atomic standard (e.g., Rb, Cs) that provides a 10 MHz signal used in generating all other timing signals."
 ::= { frequencyReference 1 }

refLocked OBJECT-TYPE
SYNTAX DisplayString
MAX-ACCESS read-only
STATUS current
DESCRIPTION "TRUE/FALSE response. Indicates the frequency reference has warmed up and is stable. The initial warm-up period typically lasts about 15 minutes depending upon the reference being used."

::= { frequencyReference 2 }

refLastLock OBJECT-TYPE
SYNTAX DisplayString
MAX-ACCESS read-only
STATUS current
DESCRIPTION "UTC of the last time the health and status of the frequency reference was checked."
::= { frequencyReference 3 }

--

-- tsc4400.timescale

--

tsError OBJECT-TYPE
SYNTAX DisplayString
MAX-ACCESS read-only
STATUS current
DESCRIPTION "Displays any current errors with the timescale. The timescale provides an estimate of UTC based upon GPS measurements. The frequency reference is then steered to this estimate of UTC."
::= { timescale 1 }

currentState OBJECT-TYPE
SYNTAX DisplayString
MAX-ACCESS read-only
STATUS current
DESCRIPTION "Displays the current state of the timescale. Typical states are 'Run', 'Flywheel', and 'Initialization'.
::= { timescale 2 }

utcInit OBJECT-TYPE
SYNTAX DisplayString
MAX-ACCESS read-only
STATUS current
DESCRIPTION "UTC that the timescale was initialized."
::= { timescale 3 }

utcStateBegin OBJECT-TYPE
SYNTAX DisplayString
MAX-ACCESS read-only
STATUS current
DESCRIPTION "UTC when the current timescale state was entered."
::= { timescale 4 }

utcOffset OBJECT-TYPE
SYNTAX DisplayString

```

MAX-ACCESS      read-only
STATUS          current
DESCRIPTION     "The UTC offset reported by the GPS receiver."
 ::= { timescale 5 }

--
-- tsc4400.irigB
--
irigError       OBJECT-TYPE
SYNTAX         DisplayString
MAX-ACCESS     read-only
STATUS        current
DESCRIPTION    "Displays any current errors with the irig generator. IRIGB signals
are generated from an ASCII data stream received from the GPS receiver."
 ::= { irigB 1 }

valid          OBJECT-TYPE
SYNTAX        DisplayString
MAX-ACCESS    read-only
STATUS        current
DESCRIPTION   "Yes/No response. Indicates whether the timecode being
generated is valid. The timecode is typically not valid on startup but is valid once the
GPS receiver has locked."
 ::= { irigB 2 }

upcomingLeapSecond OBJECT-TYPE
SYNTAX        DisplayString
MAX-ACCESS    read-only
STATUS        current
DESCRIPTION   "+1/-1/0 response. Indicates whether a leap second will be
implemented during the next 24 hours."
 ::= { irigB 3 }

--
-- tsc4400.ntp
--
ntpError        OBJECT-TYPE
SYNTAX         DisplayString
MAX-ACCESS     read-only
STATUS        current
DESCRIPTION    "Displays any current errors with the network time protocol
server."
 ::= { ntp 1 }

refClockLocked OBJECT-TYPE
SYNTAX        DisplayString

```

MAX-ACCESS read-only
STATUS current
DESCRIPTION "Indicates whether or not the ntp reference clock has locked. This refers to the stratum-1 ntp server locking to the stratum-0 reference clock."
::= { ntp 2 }

acceptRatio OBJECT-TYPE
SYNTAX DisplayString
MAX-ACCESS read-only
STATUS current
DESCRIPTION "A filter is used in removing outliers and this indicates the percentage of the measurements that are being accepted."
::= { ntp 3 }

END