TM2000B / TM2500C

v0.6.4

PTP and NTP Time Server
GPS Time Sourced

Installation and Operation Manual

TIME MACHINES

Table of Contents

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TIME MACHINES

1 Introduction

The Time Machines PTP Network Time Server is a simple to use GPS sourced time server that will supply accurate time for all computers and time keeping devices on the network. By placing a time server on the local network, PTP and NTP time packets are provided without requiring systems to go to the Internet to get a Stratum 1 time synchronization. The system uses an active GPS antenna to maintain the current time as broadcast by United States GPS satellites. With this device installed on your local network, there is no longer the worry that if the Internet connection goes down, time synchronization is lost across the network. In addition, the TM2X00 includes a high precision internal clock based on an OCXO (Oven controller oscillator) that allows the unit to serve accurate time beyond loss of the GPS antenna signal.

The TM2500C differs from the TM2000B in that is has a pair of SMB outputs to allow for 1PPS and a synchronized 10MHz reference signal to be output from the device.

The unit is small and can be placed anywhere within the network layout. The built in high sensitivity GPS receiver is able to lock multiple satellites from within many buildings or from a window location, removing the requirement that outdoor antennas be installed.

Setup and use of this time server is straightforward. Simply connect both the included power supply and the GPS antenna to the base unit and then connect the base unit to the local network. Go to a computer on the network and browse to the device at its default address to enter the software setup within the control box. Set parameters to match your network and the system will start to send out time packets to any device on the system that asks for an update from it. Two servers can be setup to provide redundancy and more capacity.

When paired with TimeMachines digital Power Over Ethernet (PoE) or WiFi clocks, synchronized time is assured no matter the state of your network, or the state of the internet time server the clocks are pointed to. Accuracy is also improved because the network delay of the internet is highly variable, while the local LAN connection is likely sub-millisecond delay.

TimeMachine GPS based time servers are suited to any application where coordination of events at multiple locations is required. Without coordinated network time, searching for problems across multiple system logs becomes much more difficult. Education, industrial facilities, military installations, public safety command rooms, government, broadcasting, and hospitals are all candidates for synchronized time systems.

2 Installation

2.1 Location

To receive GPS signals the Time Server's antenna must be located in a location where it can “see” the sky. The GPS module itself is highly sensitive and able to “see” the GPS satellite signals from within many RF transparent structures. Multi-Story or metal structures will likely block the GPS signals such that the antenna must be located elsewhere. In these cases, the GPS antenna may be located in a window. Best function, with quickest lock time, is achieved with a roof mounted outdoor antenna with an unobstructed 360 degree view of the sky. The Time Server box can be located anywhere on the network. All that is required is power and a wired network connection.

2.2 Connections

2.2.1 Antenna

The GPS antenna is connected through the circular female SMA connector on the rear of the Time Server. By default, the GPS antenna connection provides 5.0V to power the LNA in the GPS antenna. This is correct for the supplied GPS patch antenna with the magnetic base. This voltage can be changed with a jumper on the inside of the Time Server. The Time Server has to be opened up and a jumper moved.

Jumper J8 - A: 3.3V B: 5.0V (default)

The only time this jumper would changed would be to allow use of a different antenna that requires +3.3V max for the LNA in the antenna.

2.2.2 Power

A +12V power supply is supplied with the unit. Connect to your local power outlet and the barrel connector to the rear of the Time Server. The time server will begin trying to find the GPS satellites. On power-up, synchronization to the GPS satellites will take several minutes and depends heavily on the signal strength and number of GPS satellites in view of the antenna. No battery backup of position is provided to allow for a warm start so the Time Server is always starting from scratch in determining its location to achieve GPS lock.

2.2.3 Network

Connect the 10/100 RJ45 port on the back of the Time Server to a network connection. Verify that the network settings are correct for your system. See the configuration section of this manual for more information on doing this.

2.2.4 Serial

The serial port is connected by a USB-Mini type connector and will enumerate as a COM port on most modern operating systems. It is an output only port use for some basic status information. No configuration of operating system access is possible through this port. It is setup as 115200,n81.

2.2.5 PPS (2500C Only)

The PPS output is a 3.3V TTL output driven by the DPLL hardware and derived from the 1PPS output of the GPS receiver. It is a 50% duty cycle output where the positive rising edge denotes the second boundary. The GPS receiver 1PPS output is specified at +/20 nano-seconds. Best results are achieved with an outdoor antenna with a full 360 degree view of the sky. Degraded signal quality will degrade the precision of this output.

2.2.6 10MHz (2500C Only)

The 10MHz output is a 3.3V TTL signal driven by the DPLL hardware and derived from the frequency corrected internal OCXO. It is synchronized to the 1PPS such that it will have a positive rising edge that corresponds to the rising edge of the 1PPS signal.

2.2.7 Front Panel Indications

The front panel of the Time Server is very basic in its appearance. Three LEDs show the current status of the unit. The "POW" LED indicates that the unit is receiving power through its wall power supply. To serve time, an accurate GPS lock is required beyond just location information.

The GPS lock process proceeds through several steps and can be followed by watching the two front Yellow LEDs, LOCK and SEC. Initially, when no lock is present, the Yellow LEDs will be OFF. When a 2D lock is achieved, the LOCK LED will begin to BLINK. This is the first stage of GPS lock process. When the LOCK LED goes to a solid ON state, the GPS now has a 3D lock. The last stage of the GPS lock is the timing lock. This signifies that the GPS has the most accurate time base available for use in serving time. To achieve the greatest PTP accuracy, this is required. Once the timing lock has occurred, the SEC LED will begin to blink once per second.

It is also possible for the LOCK LED to turn off, or blink, after a GPS timing lock has occurred and the SEC LED continues to blink. This signifies that the TM2X00 has an accurate internal time and is serving time, but is trying to re-establish the GPS lock because it was lost for some reason.

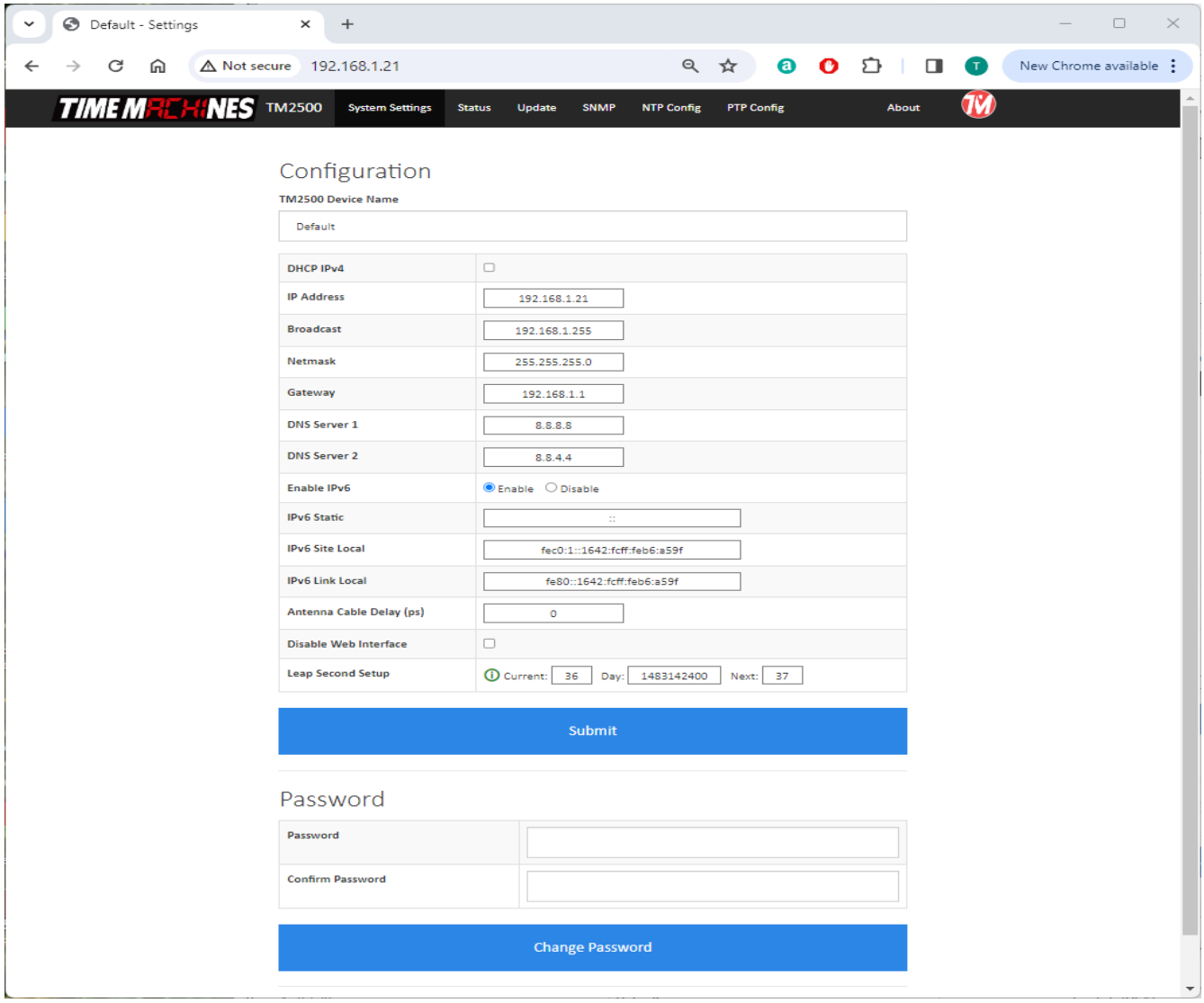
3 Configuration

3.1 Web Page – Default username/password is "admin/tmachine"

3.2 Default IP address is 192.168.1.20

All Time Server parameters are accessed on the configuration web page. The page can be accessed by pointing any web browser at the IP address of the Time Server. The initial IP address is 192.168.1.20 from the factory.

3.3 Settings Page



3.3.1 TM2X00 Name

This is a generic entry that has no effect on the TM2X00 operation other than to allow the user to enter a name for the device to help recognize it when parameter updates are required.

3.3.2 IP Address

The IP address of the unit set to by entering a standard IPv4 dotted quad in this field. 192.168.1.20 or 10.10.0.96 are examples of acceptable formats for this field. Clicking the Submit button will set the entered IP parameters.

3.3.3 Broadcast

The Broadcast entry is used to control the propagation of network broadcast packets on the network and to what level they will propagate from the device. This is frequently opposite of the Netmask

setting. This is used by the PTP functions to advertise the presence of the server. Clicking the Submit button will set the entered IP parameters. **THIS IS NOT the address to point NTP and PTP clients at, they should given the IP Address.**

3.3.4 Netmask

The Netmask entry determines what addresses are on the local network and what addresses are reached through the Gateway. Typical Netmasks are 255.255.0.0 or 255.255.255.0. Consult the network administrator for more information on how this entry should be set. Clicking the Submit button will set the entered IP parameters.

3.3.5 Gateway

The Gateway IP address is used when a destination address is determine to not be on the local network. Consult the network administrator for this setting. Clicking the Submit button will set the entered IP parameters.

3.3.6 DNS1 and DNS2

Enter the IP addresses for the DNS servers on your network.

3.3.7 Enable IPv6

Setting this option to Enable will turn on support for IPv6 in the device. This includes SNMP, NTP, Web, and PTP. Currently, the TimeMachines Locator protocol is not setup to support IPv6.

3.3.8 IPv6 Static

This entry is user editable and can be set to any valid IPv6 address global unicast address. Routing and communication on the local network are assumed. This is not user editable.

3.3.9 IPv6 Site Local

The Site Local address is the equivalent to a private address in IPv4. It is technically a deprecated feature, but is typically provided by a router on the local network and starts with FEC0.

3.3.10 IPv6 Link Local

The Link Local address is derived from the MAC address of the device. This address is not forwarded by routes but does allow computers on the same network link to communicate via IPv6.

3.3.11 Antenna Cable Delay (TM2500 only)

This entry is to compensate for cable delay introduced by the antenna cable. The value is in pico seconds. The Delay, in pico-seconds, through a cable is D=(L*C*1000)/V. Where:

- L is the cable length in feet
- C is a constant based on the speed of light, adjusted for feet: 1.016
- V is the velocity of propagation for a a specific cable. The cable datasheet is the source for this. The LMR-195/RG-58 sold by TimeMachines has a value of 0.77.

When multiplied out, the delay for the TimeMachines sold cable is 1319 pico-seconds per foot.

Determine the total length of cable between the TM2500 SMA jack and the antenna, multiply it by 1319 and enter that value in this field. This is only important for phase alignment of the 1PPS and 10MHz outputs and has little effect on the NTP/PTP accuracy due to the jitter of a typical packet network.

3.3.12 Disable Web Interface

This is a security option. Once the device is configured and operating as expected, it is possible to check this box, save the setting, and then reboot that device. From that point forward, the web server is disabled. To recover from this mode, the device must be reset to factory parameters by holding the front button for about 5 seconds. The IP address will be reset and the web page will be active again. This allows for a physical security measure to be used to protect settings of the device.

3.3.13 Leap Second Setup

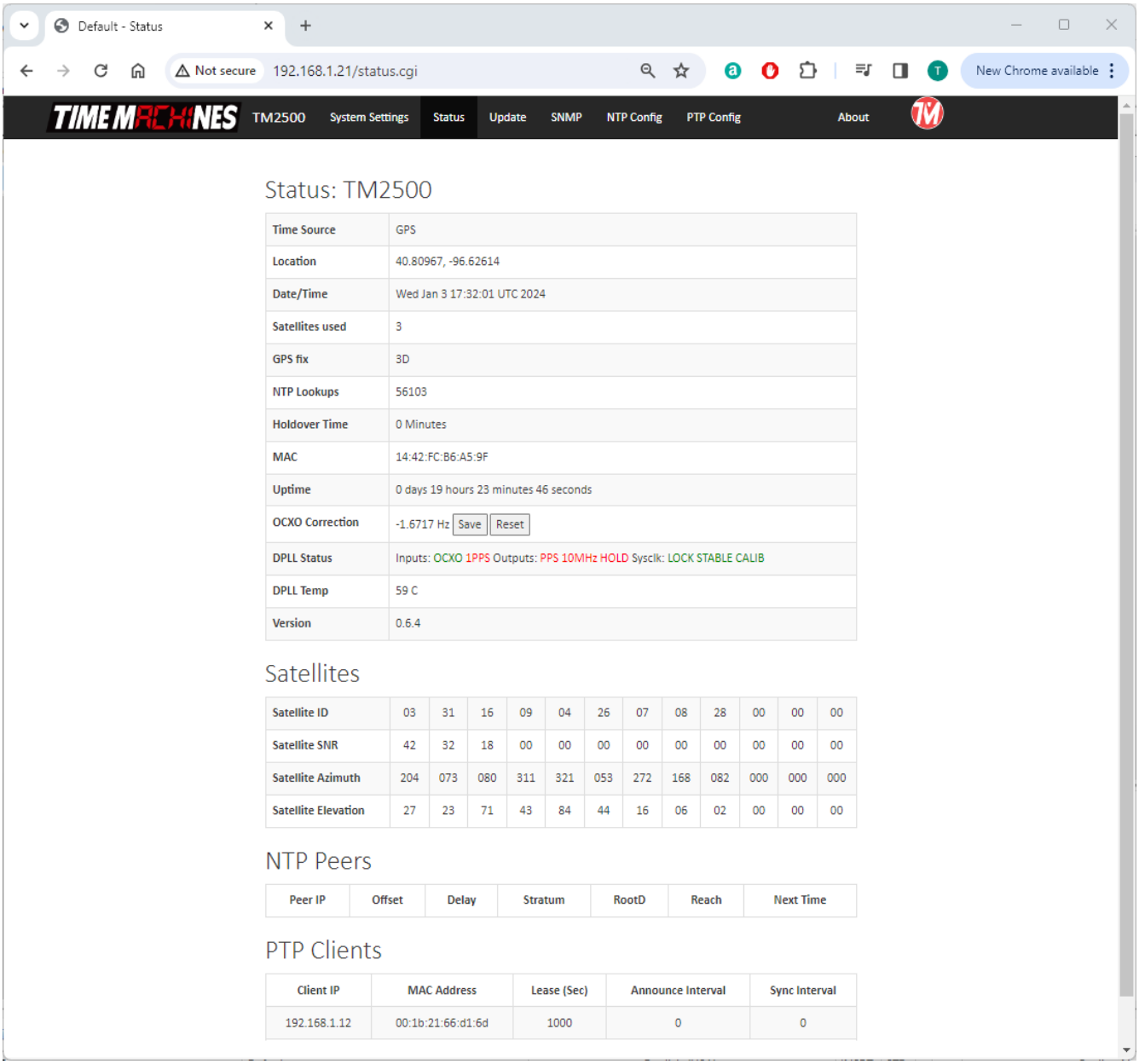
There are three fields that control the leap second reporting of the TM2X000 devices for both NTP and PTP time services. As of the writing of this document, the last leap second was on December 31st, 2016 at midnight (1483142400 seconds after Unix epoch date of January 1, 1970). It went from 36 leap seconds, separating atomic time from UTC, to 37 seconds. These are the default settings for the device. These should NOT be changed until another leap second is announced. When that occurs, the Current setting will be changed to 37, the Day adjusted to midnight of the day it will occur (always June 30th, or December 31st), and the Next setting will be updated as well to the new number of leap seconds. There is some thought that the next leap second may be negative due to the earths rotation slowing. Both positive and negative leap seconds are supported through this interface. NTP will report the entire day of the leap second whether it is a positive or negative second change, and PTP will do the same for last 12 hours of the day. Both will adjust appropriately for the lost or additional second at midnight.

3.3.14 Password

The Password of the unit can be changed in this field. The existing password is not displayed for security purposes. Enter the new password and click the “Change Password” button to update. The TM2X00 will then prompt for the new password to be entered to continue access to the web pages.

*** Default Username/Password is “admin”/“tmachine”.**

3.4 Status Page



The status page is an information only page. It shows the various pieces of information about the current working state of the device.

3.4.1 Time Source

This field displays the current source of time. It can be GPS, Peer Time Server, or Manually set.

3.4.2 Location

Location shows the latitude and longitude of the device itself based on the GPS receiver. Paste this set of coordinates into Google Maps to see your location.

3.4.3 Date/Time

The Date/Time entry shows the current UTC date and time of the device. This is not updated realtime. Refreshing the page will update this time. Note that it is the clients responsibility to adjust for timezone and daylight savings adjustments.

3.4.4 Satellites Used

This shows the current number of satellites that are in view and locked by the GPS receiver.

3.4.5 GPS Fix

This displays the level of the current GPS lock.

No GPS Fix – Check cable connections. If connected correctly, likely the antenna needs a better view of the sky. Obstructions, building materials, window tinting can all cause possible signal issues.

2D - GPS satellites found.

3D – Required for serving time.

3.4.6 NTP Lookups

This field updates on a page reload and shows how many NTP time requests have been requested from client devices.

3.4.7 Holdover Time

When the GPS lock is lost and time is being served by the internal OCXO, this will show the amount of time in minutes that the holdover state has been active.

3.4.8 MAC

This is an information only field and displays the MAC address of the Time Server.

3.4.9 Uptime

Time elapsed since last boot up.

3.4.10 OCXO Correction

This field shows the frequency correction being applied to correct the OCXO back on to its root frequency. This value can be saved or reset from this web page. The purpose of saving this value, after the device has run for a period of a couple hours with 3D lock, is to give a more accurate starting point for the correction algorithm to begin on power up. If for some reason the value seems wrong or not working, a Reset is allowed that will, after a reboot, start the algorithm from default and restart the correction process.

If using the TM2X00B for manual NTP time generation, having the device on the GPS for a period of time to determine the correction, then saving it, will dramatically improve drift of the TM2X00B when operated without GPS reception. The Reset button resets the OCXO to its starting point to restart the convergence process. Once locked again, the setting can be Saved.

3.4.11 DPLL Status (TM2500C Only)

This line on the Status web page give a quick view of the Inputs, Outputs, and Clock quality of the Digital PLL (DPLL) in the TM2500C. The items will be colored either Red or Green. Red meaning the input or output is not locked and stable, Green meaning the input or output is locked to the clock.

- Sysclk status information is information about the internal operation of the DPLL. These typically go green almost immediately upon startup of the device and short of some hardware failure, will be green any time they are checked by the Status page reload.
- Inputs to the chip are the OCXO, which will be stable to the DPLL essentially from the startup of the device. The 1PPS however, will stay Red until some time after the GPS locks to the satellites in view. At least a 2D lock is required before the 1PPS input will go to Green.
- Outputs, which are dependent on both the OCXO and 1PPS inputs will stay red until both inputs are stable. Once these outputs turn green on the Status page, their respective output signals will be present on the SMB connectors. The DPLL does require a little bit of time after 2D lock to converge and start outputting signals.

3.4.12 DPLL Temp (TM2500C Only)

This is the temperature of the Digital PLL chip on the TM2500C circuit board. It has an operation range of -40C to +85C.

3.4.13 Version

Displays current software version running on device.

3.4.14 Satellites

This table shows the current list of locked satellites, their signal strengths (SNR), as well as their current location over the planet. Refreshing the web page updates the table to their current values.

3.4.15 NTP Peers

If time is being updated from a Peer time server, then this table shows the current list of Peer servers that are being checked to maintain the time in the TM2X00. Several Fields are displayed for each time server.

- Peer IP – The Peer IP address is the first field displayed.
- Offset – This is the offset of the peer time servers' time when compared to the internal clock of the TM2X00.
- Delay – The round trip delay to the peer time server
- Stratum – This field shows the stratum level being reported by the peer time server
- RootD – This is the root delay value of the peer time server. This is the time servers reported delay from its location to the root of the NTP time setup. A stratum 1 server is considered to be at the root of an NTP setup/design.
- Reach – This is a bit field that shows the result of the last 8 lookup attempts of the peer time server. A value of 0xff signifies that the last 8 attempts have been answered by the time server.

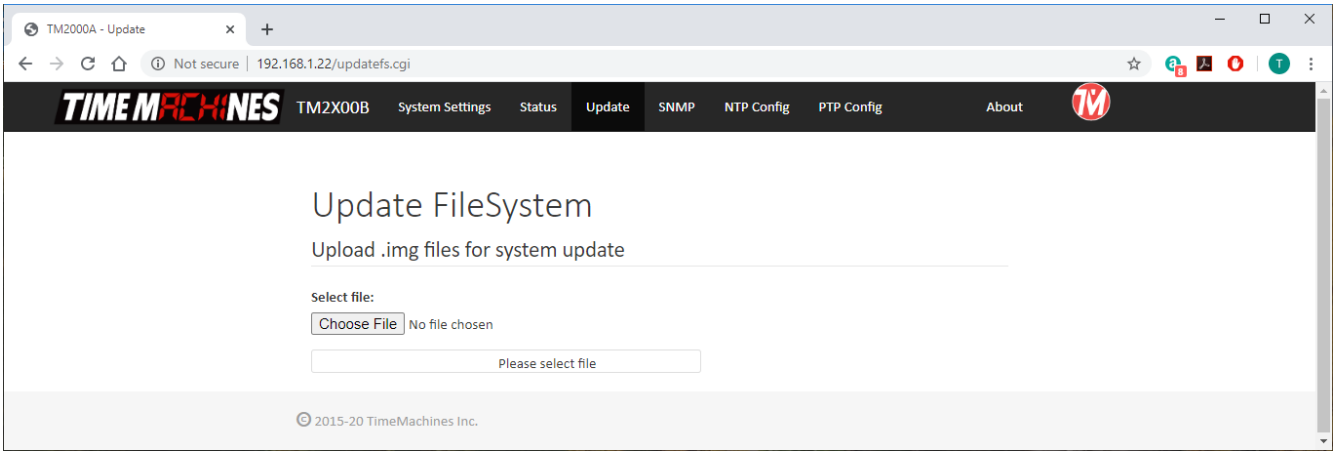
A successful lookup causes a 1 to be shifted in to the LSB of the byte and all other bits to be shifted 1 bit to the left. A non 0xff value signifies that either the server has just started or that some lookup requests are not getting answered.

- Next Time – This is the time that the next request for time from the peer time server will occur. The NTP client of the TM2X00 will start out with a check every 30 seconds or so and then expand out if time is tracking well to a couple of minutes. The TM2X00 doesn't allow the time sync to extend beyond a few minutes to maintain accurate internal time.

3.4.16 PTP Clients

This area is used to show the current PTP clients that have successfully logged into the device for unicast PTP. This will display entries only if the TM2X00 is in Unicast PTP mode. In multicast mode, the TM2X00 does NOT keep track of all clients getting time from it. The client's IP address, MAC address, lease time, and update rates (1/2^value) for Announce and Sync packets is displayed. The zero values for Announce and Sync Intervals show a 1 packet per second rate.

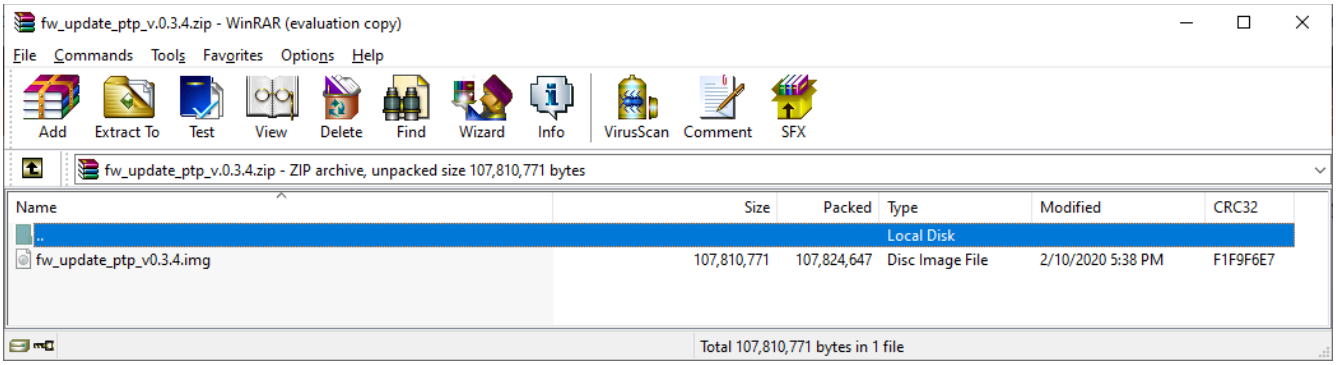
3.5 Update Page



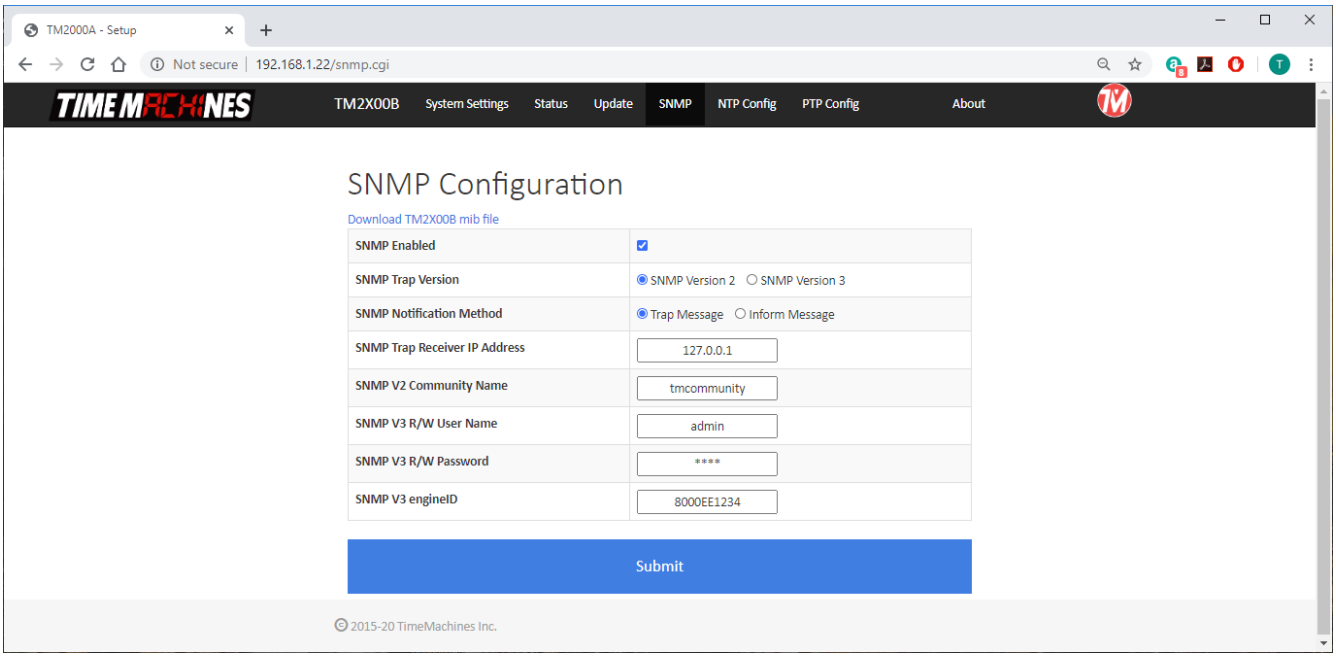
The update page is used to update firmware of the unit. The firmware updates will be archived and available for download from the timemachinescorp.com website. Save the file to the local computers drives. Most likely the file will need to be unzipped. The file type that is used for the update is a .img file. Browse to it using the Choose File button on the Update Page. Once the file is found the update can begin. This process takes 10 to 15 minutes and power should not be removed during the process or the device may be unrecoverable. There are periods of time where there may be little or no indication of the update process occurring, so its important to give it plenty of time. Once completed, the unit will reset and resume operation. Login to the device with a web browser to confirm the version update.

3.5.1 Update Notes:

Some unzip software, Apple MAC computers being one, will extract the files further than they should be. The .IMG file that is contained in the downloaded .ZIP file is actually a file system archive itself, however extraction beyond the .IMG file should not be done as the TM2X000B will do the extraction during the update. The picture below shows the unzip of the downloaded file contents which is all that should be extracted and uploaded for the update.



3.6 SNMP Setup



3.6.1 MIB File-Download TMI-COMMON-SHI.txt

At the top of the page, is the option to download the MIB file for the TM2X00. This is useful in many monitoring systems. It will download to the browsers default download directory.

There are currently 4 supported trap notifications: GPS Lock change alarm, PeerSync Lost alarm, HoldOver expired alarm, and Stratum Change alarm. 14 different web page values are also made available through the SNMPGet system.

3.6.2 Enable

This will enable the SNMP application to startup after bootup.

3.6.3 SNMP Trap Version

This sets the version to SNMPv2 or SNMPv3. It affects format of the trap/inform messages in the next option. If set to V2, then the trap/inform message will only identify itself with the community name with no other security features. The V3 mode supports a username/password combination to be used where the password is hashed with MD5. Full encryption of the SNMP packet is not supported.

3.6.4 Notification Method

This sets the notification method to either Trap or Inform. A Trap messages is an un-acknowledged status packet, while the Inform message is acknowledged by the receiver. The Inform message creates a higher reliability that the receiver received the packet and can act on it. The Trap method is also widely used. Version 2 of these messages is a simpler format and setup, but without the username/password authentication. Version 3 will require the username and password to be setup on the SNMP web page, as well as using the Engine ID setting to synchronize the encryption when using Trap messages.

Trap/Inform messages are status checked one time per minute.

3.6.5 Trap Receiver IP Address

Enter the IP Address of the device being used to receive the trap/inform packets

3.6.6 SNMP V2 Community Name

The SNMP community name is used as a simple authentication for Version 2 SNMP packets.

3.6.7 SNMP V3 R/W User Name

Enter the desired SNMPv3 username.

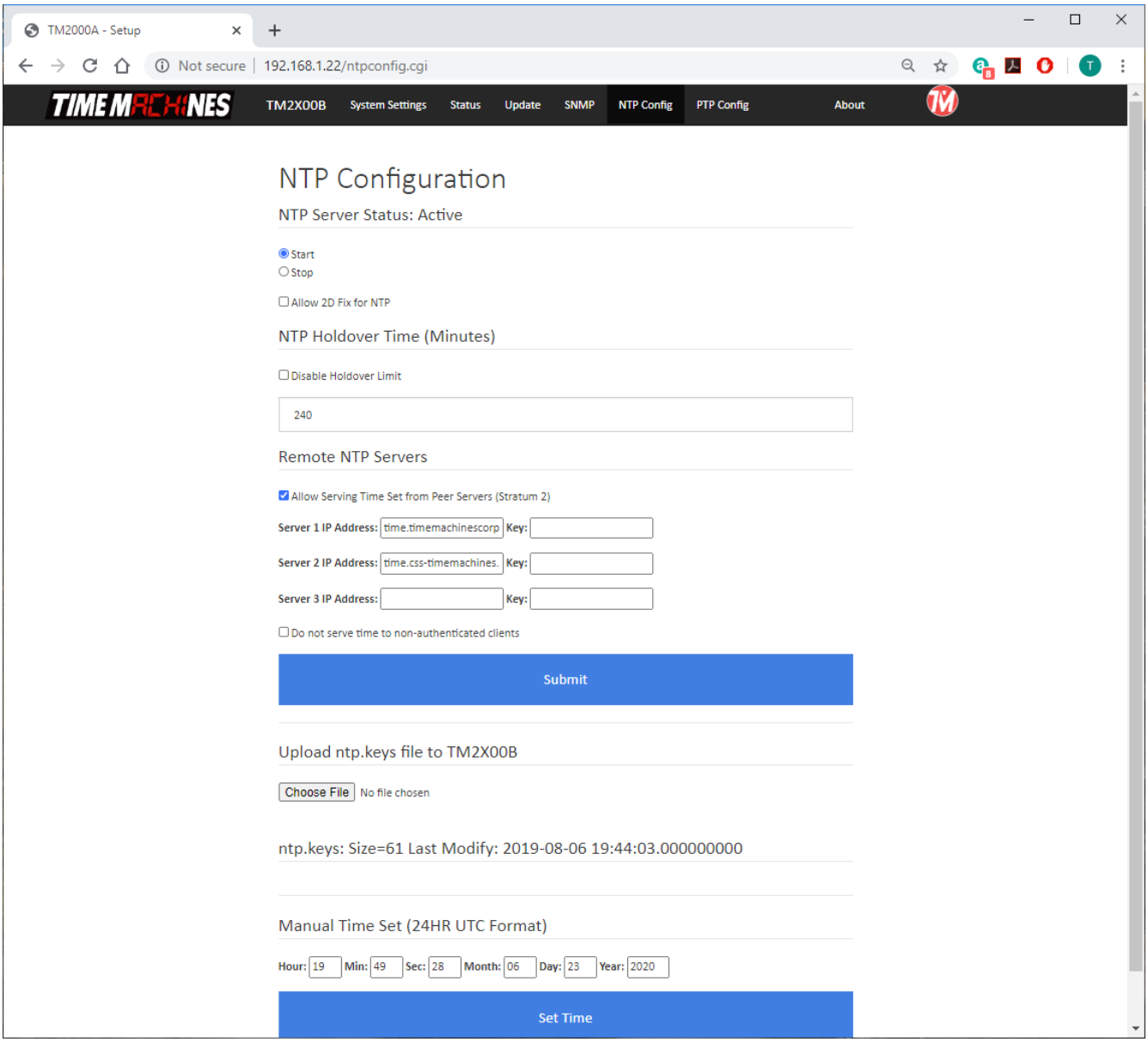
3.6.8 SNMP V3 R/W Password

Enter the SNMPv3 password associated with the username.

3.6.9 SNMP V3 Engine ID

When using SNMPv3 Trap messages, the engine ID needs to match between the trap receiver and the TM2X00 as the sender. This entry specifically allows setting of the SNMP engineID. This is handled in this way because the bulk of the file system for the TM2X00 is not R/W and parameters that are updated by the SNMP daemon are stored in RAM and lost on a power cycle/reboot. A reboot may be required when setting up Trap messages. Inform messages are a simpler implementation and may be simpler to setup for V3 SNMP.

3.7 NTP Settings Page



The NTP Settings page is used to control the function of the NTP client and server options of the TM2X00.

3.7.1 Start / Stop NTP Server

The NTP daemon can be started and stopped from this page. By default, NTP support is enabled once 3D lock is achieved. Click the desired option and then click the Submit button. Once a time source is available, GPS, Peer, or Manually Set, the TM2X00 will enable the NTP server service and NTP requests will be allowed.

3.7.2 Allow 2D Fix for NTP

This checkbox will allow the TM2X00 to start serving time once a 2D lock is achieved by the GPS receiver. It is generally better to get a 3D lock as timing accuracy is improved and more stable. The GPS module maker doesn't guarantee accuracy until a 3D lock is achieved, but this option exists if needed. If the TM2X00 is capable of getting a 3D lock, then this option should generally be un-checked.

3.7.3 Disable Holdover Limit

When checked, this option allows the holdover limit of the device to extend forever. The TM2X00 requires a GPS lock to initially set its time, but by checking this option, it can then be run without a GPS lock. The time WILL drift off of standard at a rate that is dependent on the accuracy of the OCXO of the device, but this option is included for cases where exact accuracy isn't required, just synchronization of devices withing a closed system. Drift has been measured as high as 0.1 seconds per week. ***This setting also governs the holdover behavior of the PTP modes.***

3.7.4 NTP Holdover Time (Minutes)

This setting is used to set how long holdover is allowed GPS lock is lost. The device will change to Stratum 16 when the set holdover time is expired and GPS lock is not achieved.

3.7.5 Remote NTP Servers Enable

Enabling this option, and setting a list of remote NTP servers will allow the TM2X00 to get its time from another NTP server using the NTP protocol. When operating in this mode, the TM2X00 can begin serving time shortly after it has booted up because it doesn't have to wait for the GPS to lock. It will also allow the TM2X00 to operate without a GPS at all if desired. If at some point after boot up, GPS lock is obtained, then the GPS becomes the time source and Peer NTP lookups are stopped. Once the TM2X00 has obtained a lock, if it is lost it will not return to the Peer NTP servers for time maintenance, even after the holdover period has expired.

3.7.6 Remote NTP Servers List

The NTP Servers list allows setting of up to three different time sources. The TM2X00 runs a version of the Linux NTP daemon that will select the “best” source for setting its time, but will also keep tabs on all of the time sources. If authentication is being used, a key values, 1-65535 can be entered into the key field on the same line as the server.

3.7.7 Serve Time Only With Authentication

Checking this option will set the server into an authenticated client only mode. Normally, if a ntp.keys file has been uploaded, and the client sends authentication credentials, the TM2X00 will check and respond with authentication. If a client does not send an NTP request with authentication information, then the TM2X00 will respond with a non-authenticated packet. However, if this mode is selected, the TM2X00 will only respond to clients that have valid authentication included in the NTP request.

3.7.8 Authentication-Upload Key List

Starting is version 0.3.4, the NTP server of the TM2X00 supports authentication. Both MD5 and SHA1 are supported. While these are not considered cryptographically secure in this modern age of

computing, subsequent standards for NTP authentication remain in flux and these are the most common requirements. They maintain the compatibility required of most NTP clients requiring authentication.

A standard ntp.keys file can be uploaded through this page. Simply choose the file to upload from your local computer and allow the upload to complete. This is a one way transaction, there is no way to pull the ntp.keys file from the TM2X00 back to the local browser.

The allowed formats for the key file are as follows (this is the default key file in the device):

```
#
#ntp.keys file
#
#Two types of keys supported, MD5 and SHA1
#Line Format:  Key # <space> Key Type <space> Key
#Key# is a positive integer number greater than 0
#Key Type is either (M)D5 or SHA(1)
#Key:  For MD5 is a character string 1-32 character ASCII String, or for SHA a 40
character hex string
1 M tmachine
3 SHA1 D5C9F80F7B1220D9710049AE41FB5BB5B18D148E
```

A matching copy of the ntp.keys file will need to be entered on the client device, or remote server if the Peer Time Server mode is being used.

If setting up a NTPD implementation, the ntp.conf file on the server will need to include directives to load the key file and authorize them. There are many tutorials on the Internet that discuss setting up authentication on the NTPD implementation. The minimum extra commands that get added to the ntp.conf file are: **keys**, **trustedkey**, and the updates to the individual server lines. Other clients supporting authentication will have other instructions to follow.

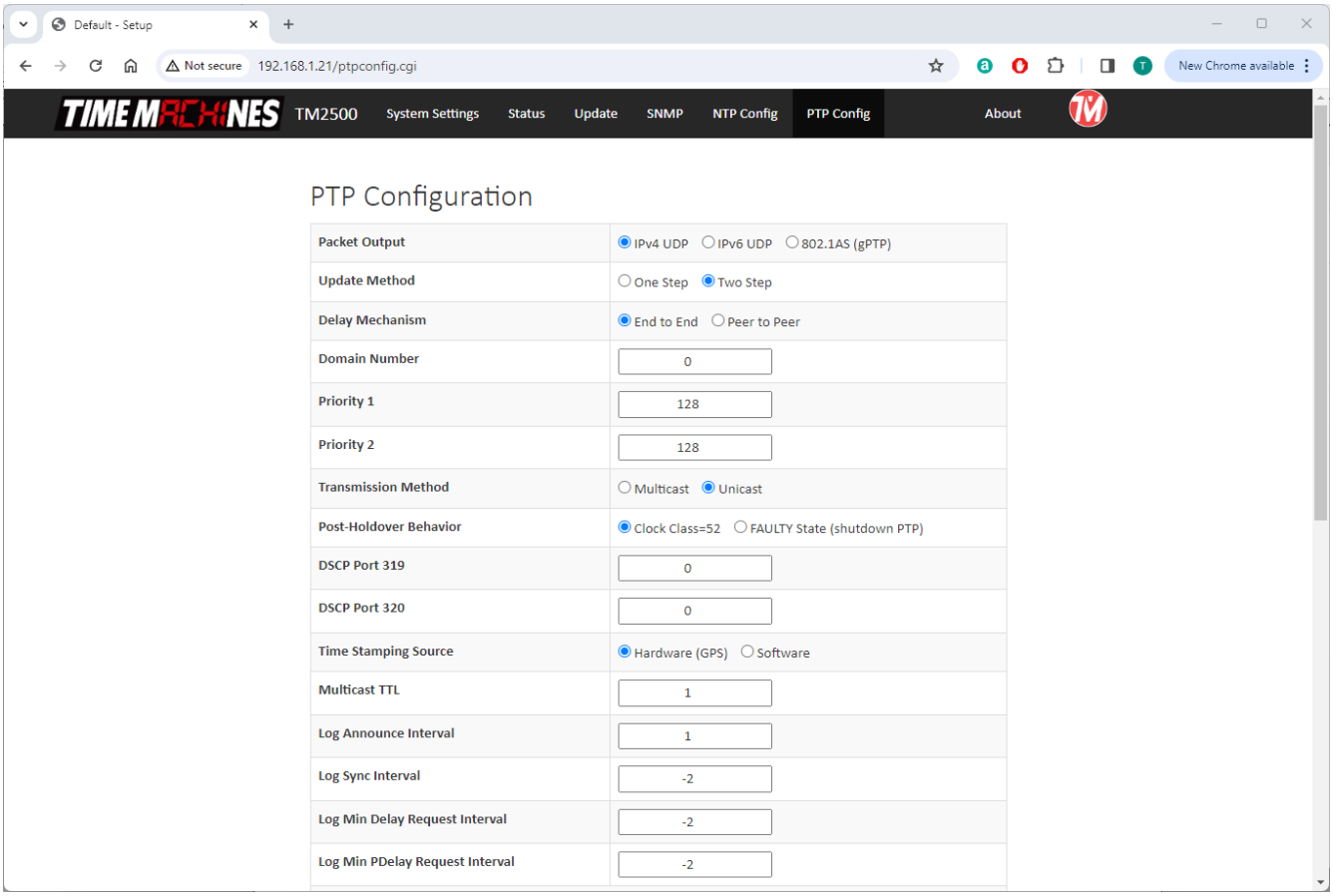
3.7.9 Set TM2X00 time manually

This set of fields allows the TM2X00 to have its time set manually from the web page. Entering the UTC time of day, 24 hour mode, and clicking the Set Time button below the fields will set the time of the TM2X00 accordingly and enable the NTP server software to responds to requests from clients. Holdover settings have no effect when the time has been set manually. If at any point GPS or Peer NTP settings start getting time, then the manual mode will be ended.

3.7.10 Serving PTP Without GPS

As of version 0.6.4, with PTP set to Software Time Stamping, the TM2000/2500 will serve PTP based on a manual or NTP peer time setting.

3.8 PTP Settings Page



3.8.1 PTP Holdover

PTP holdover duration is governed by the setting on the NTP Settings page.

3.8.2 Packet Output

Packet output types supported, starting in version 0.6.4 include both IPv4, Layer 2, and IPv6 Ethernet packets. Only one of these modes can be active at a time on the device.

3.8.3 PTP Update Method One/Two Step

This setting controls the Sync/Delay packet generation mode of the TM2X00. Default normal operation is to use 1 Step. In this mode, a single Sync packet is generated at the requested/setup rate and HW time stamping is applied to the packet just before it goes onto the Ethernet wire. In the two step mode, two Sync packets are generated also with hardware time stamping, with the second packet containing the launch time of the first packet to allow the receiver to determine the accuracy.

3.8.4 Delay Mechanism

Selection of End to End or Peer to Peer delay determination is supported. End to End is typically used when network routers are not PTP aware. Peer to Peer is the standard for 802.1AS

3.8.5 Domain Number

Use this entry to set the Domain number to be included in the PTP packets. The domain number is a method to allow multiple PTP servers on the same network, but to separate their traffic between client devices.

3.8.6 Priority 1 & Priority 2

Allows setting the Priority 1 value in the packets

3.8.7 PTP Transmission Method

The PTP transmission method can be set to either Multicast or Unicast. When in Multicast mode is set, the device will start generating Announce and Sync packets shortly after saving the parameters or GPS 3D lock is achieved. In the Unicast mode, it is required that the client connect to the time server and request PTP packets. Unicast mode supports 3-5 clients typically depending on the packet request rates. Multicast, supports more clients.

3.8.8 PTP Post-Holdover Behavior

There are two options here: Update Clock Class to 52 which in the PTP protocol means: "A clock of clock Class 52 shall not be a slave to another clock in the domain." If set to Faulty, it will report as Faulty and should not be synced to by a client. **Holdover time limits for the TM2X00 are set in the NTP settings page.**

3.8.9 DSCP Port 319 and 320 Settings

This allows the DSCP/Diffserve/TOS value to be set. This is the value for first bye of the IP header. Valid values are 0-63 decimal. Announce packets are sent to port 320, Sync and Delay messages are sent to port 319. Consult your network documentation for the setting of these values.

3.8.10 Time Stamping Source (PTP without GPS)

This setting would usually be set to hardware and hardware is by far the preference. It has 10X less jitter for timing. However, if PTP sync is desired and GPS is NOT available, then setting this to Software mode will allow PTP to operate if time is sourced manually or through NTP Peers.

3.8.11 Multicast Configuration – TTL

This sets the Multicast UDP Time to Live value. It will default to 1 which would support only a single router hop. Increasing this value allows a PTP packet to propagate further on a network.

3.8.12 Multicast Configuration – Log Announce Interval

Set the Announce Message interval. The rate of sync packets is 2^(-value). The default setting of 1, sets the interval at 2^(-1) = 0.5 packets per second, or every 2 seconds. A value of 0, generates a packet 1 time per second, etc.

3.8.13 Multicast Configuration – Log Sync Interval

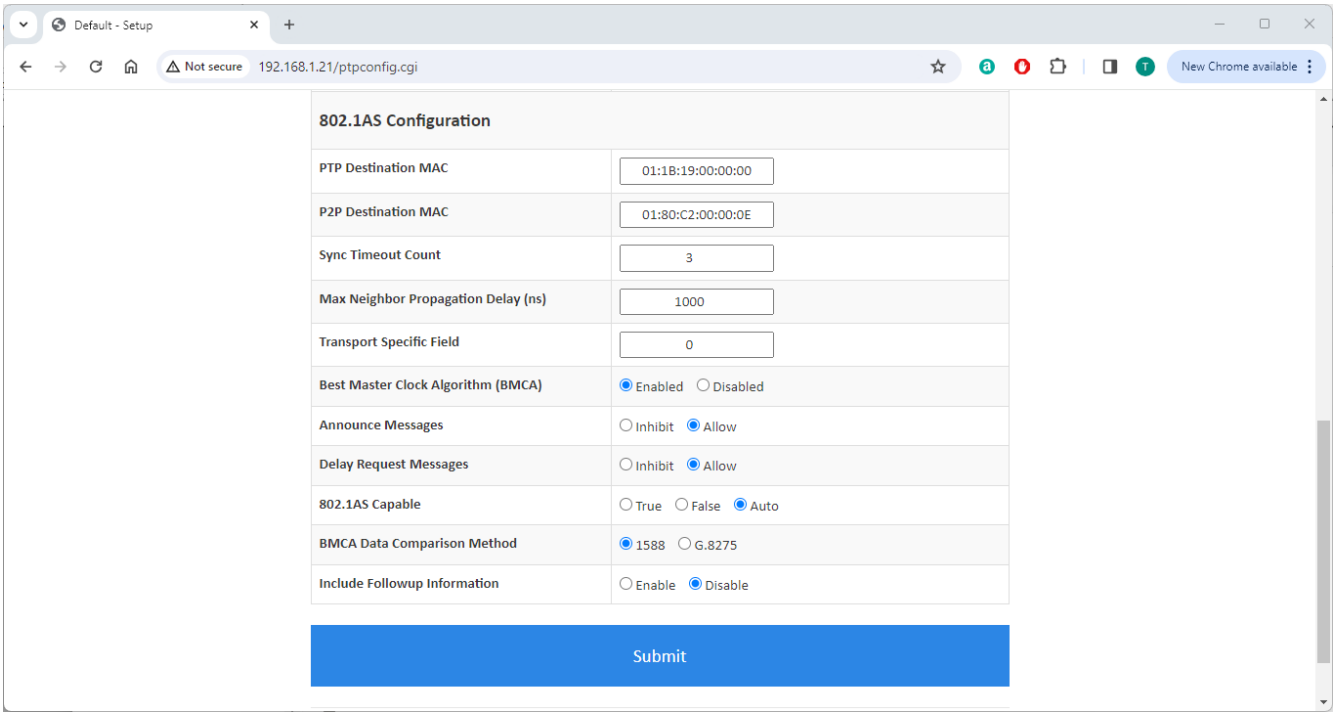
Sets the requested Sync Message interval. The rate of sync packets is 2^(-value). The default of -7, therefore makes the default rate 2^-(-7) = 128 packets per second.

3.8.14 Multicast Configuration – Log Min Delay Request Interval

The minimum permitted mean time interval between Delay_Req messages. A shorter interval makes the TM2X00 react faster to the changes in the path delay. It's specified as a power of two in seconds. Generally, this setting doesn't need adjustment on the TM2X00.

3.8.15 Multicast Configuration – Log min Peer Delay Request Interval

The minimum permitted mean time interval between Pdelay_Req messages. It's specified as a power of two in seconds. Generally, this setting doesn't need adjustment on the TM2X00.



3.8.16 802.1AS Configuration – PTP Destination MAC

This is the MAC address that 802.1AS PTP messages will be sent. Default: 01:1B:19:00:00:00

3.8.17 802.1AS Configuration – P2P Destination MAC

This is the MAC address that 802.1AS Peer to Peer Delay messages are sent. Default: 01:80:C2:00:00:0E

3.8.18 802.1AS Configuration – Sync Timeout Count

This sets the number of sync/follow-up messages that can be missed before the Best Master Clock election code is started. Setting this option to 0, disables it.

3.8.19 802.1AS Configuration – Max Neighbor Propagation Delay (ns)

This is the upper limit for peer delay measurements, in nano-seconds, before the port is marked as not being 802.1AS capable.

3.8.20 802.1AS Configuration – Transport Specific Field

The transport specific field, it should range from 0 to 255. It generally has to match the client setting.

3.8.21 Best Master Clock Algorithm (BMCA)

This enables/disable the BMCA algorithm. In automotive mode for example, BMCA is typically disabled as the master is known and startup should occur as quickly as possible.

3.8.22 Announce Messages Inhibit

This disables the timer for Announce messages and stops the generation of the Announce Messages. Announce Messages are typically inhibited in Automotive Profile, otherwise enabled.

3.8.23 Delay Request Messages Inhibit

This disables and stops the generation of the Delay Request Messages. Delay Request Messages are typically inhibited in Automotive Profile, otherwise enabled.

3.8.24 802.1AS Capable

There are three options: false, true, and auto. When set to true, the PTP server skips functional checks to unset 802.1AS mode. In auto, 802.1AS is set to false initially, but once checks are completed, it can be set to true. In false, 802.1AS will not be configured.

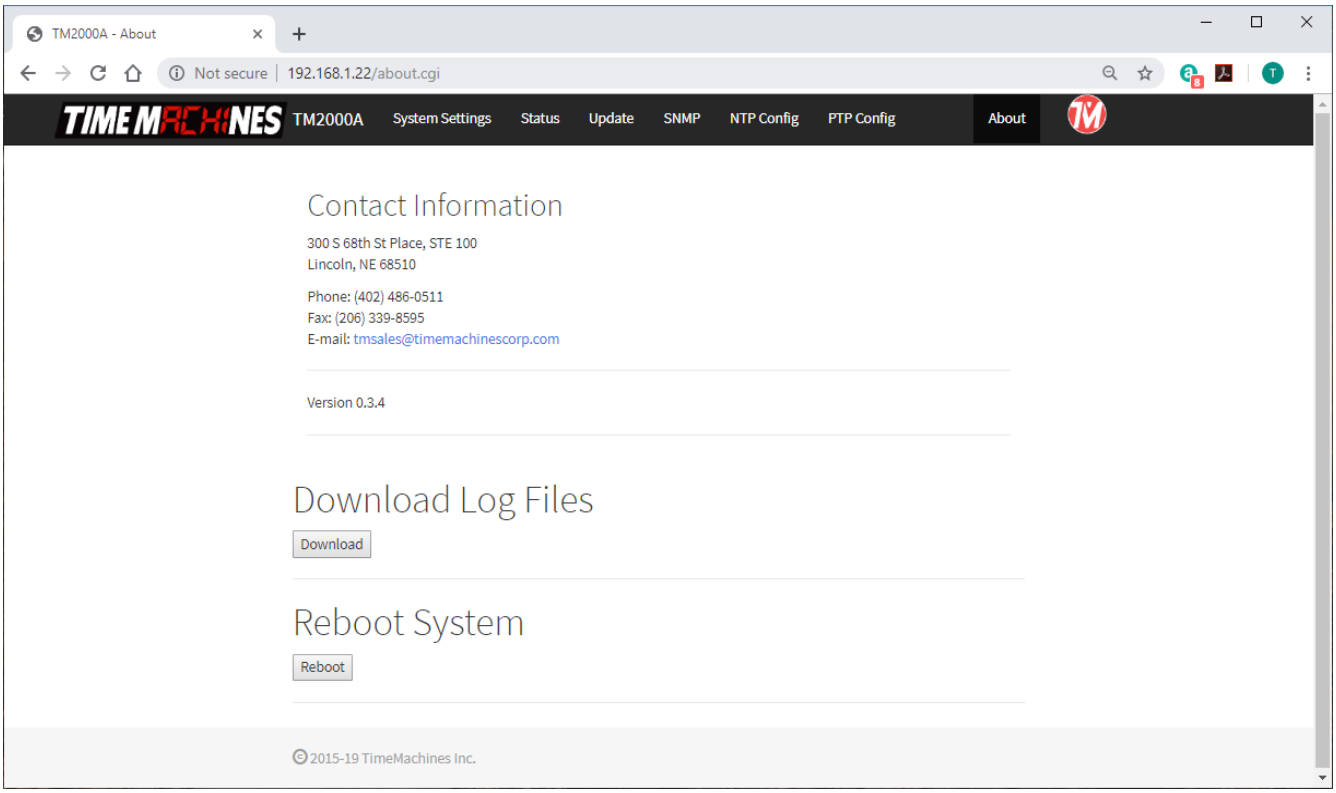
3.8.25 BMCA Data Comparison Method

Typically the 1588 mode is used. The exception is when running G.8275.X modes when this should be set to G.8275.

3.8.26 Include Followup Information

When enabled, this appends additional 802.1AS data to the 2nd Sync packet required in Automotive Profile.

3.9 About Page



The About Page shows contact information and software version of the device as well a couple of diagnostic buttons.

3.9.1 Download Log Files

Clicking the Download button will cause the TM2X00 to create a binary format log file and initiate an HTTP download. The binary log can be used by TimeMachines as an aid in troubleshooting.

3.9.2 Reboot System

Clicking the Reboot button will cause the TM2X00 to do a software based reset. This is a full kernel reset of the unit and takes 20-30 seconds to complete.

4 Setting Up PTP without GPS

Starting in version 0.6.4 of the firmware, it became possible to provide PTP timing information without a GPS lock. The major steps to do that are:

1) Provide a time to the device
   - Manually set the time from the NTP setup page, OR
   - Use NTP Peers to set the device time. This will be much more accurate and having 2 or 3 sources for NTP time is preferred.
   - Ideally the device has been run with GPS for several days and the OCXO correction saved on the Status Web page. This will significantly improve drift performance of the device. While this doesn't help with accuracy of the device compared to atomic time, it does help maintain consistency over a period of time.
2) Set the PTP Time Stamping Source to “Software” on the PTP setup webpage. This enables PTP to operate without the hardware having been setup by GPS.

From this point, PTP should operate normally with significantly degraded accuracy compared to GPS, but for a local system without GPS, it does allow PTP to operate without GPS.

5 Using TimeMachines TM2000/2500 with LinuxPTP

See the Applications section of the website for multiple configuration examples with LinuxPTP.

6 Troubleshooting

6.1 GPS Lock

Getting GPS lock on the Time Server is required for it to function. Most GPS lock issues come down to issues with Antenna location, or cabling. If there are problems getting GPS lock (I.e.the Lock LED doesn't turn on and the 1 PPS LED doesn't flash each second) trying moving the antenna outside and see if that resolves the issue. If it does, try a window and see if lock is maintained. If that works, move the antenna back to its original location and see if lock is lost. This will help determine where lock can be received and where it cannot. If no lock is achieved outdoors, then something is either wrong with the cabling or the Time Server itself. Contact TimeMachines for help.

6.2 Resetting to Factory Defaults

Front Panel Button - Push and hold the front panel button with a small object for 5 seconds. This will cause the TM2X00 to reset to factory default settings.

The front panel button, accessible with a paperclip or other small object, accessible from the front panel of the TM2X00 is used to reset the units software settings to factory original. This is useful when a password is forgotten or the IP address cannot be determined. To do this, insert a paperclip or ball point pen end through the hole in the front of the unit until you feel the button depress. Hold this button down for a few seconds and release the button by extracting the paperclip/pen. It should now have the factory default password and IP address information.

6.3 Contacting TimeMachines for Support

The first thing that should typically be sent with any email request for support is a screen shot of the Status Page from the TM2000/2500. Please provide as much information as possible when requeting support. If you are calling, please have the device in front of you along with a computer that is connected to it. Tech support will generally ask questions that are best answered with hands on the equipment.

7 Locator Data Query

Starting in version 0.3.3, the Locator service employed by TimeMachines clock products is also included in the TM2X00. This makes it easier to manage and monitor a time system on a local network using the TM-Manger software. See the TM-Manager documentation for more information on this feature.

Locator Data Format

The Locator Data Service is a simple UDP/IP protocol that can be used by other network applications to extract status and location information from the TM1000A.

Requesting information from the TM2X00 is done by sending a 3 byte message to the TM2X00, using UDP/IP, to port 7372. The three bytes, in hexadecimal, are: 0xA1 0x04 0xB2 The TM2X00 will also respond to a broadcast to the same port.

The response packet is 80 bytes and will be formatted as follows:

Bytes	Description
0	TM2X00 response value = 0x05
1 to 4	client IP address
5 to 10	MAC address
11 and 12	firmware version Major:Minor
13	Lock status 0=No Lock, 1=2D Lock, or 2=3D Lock
14 to 17	NTP Sync count, 32 bits, MSB to LSB
18 to 20	Current Time, H:M:S, UTC
21 to 45	Location of unit 25 bytes, Latitude, Longitude, null terminated
46 to 80	Name of Time Server, null terminated

TM-Manager uses this protocol to find a monitor TM2X00's on the network. A Wireshark capture of that software can be used to see an example of the data transfer. TM-Manager support of the TM2X00 started in version 1.04.

8 Specifications

8.1 Time Server Features and Specifications

- Receive time information from GPS satellites anywhere on the surface of the earth
- RFC1119/1305 NTP Protocol to serve time (Network Time Protocol)
- RFC1769/2030/4330 SNTP Protocol (Simple Network Time Protocol)
- IEEE 1588:2008 Version 2 PTP protocol
  - Telecom Profiles: G.8265.1, G.8275.1, and G.8275.2
  - 802.1AS
  - End to End and Peer to Peer Delay options
  - Postive and Negative Leap second support for NTP and PTP
- Server Time Level: Stratum 1
- NTP Server Time Precision: better than 1mS + network jitter.
- PTP Server Time Precision: better than 3uS + network jitter.
- All networked computing platforms support time synchronization either natively or with add on drivers including: Windows, Macintosh, and Linux. Many other devices can access the device as well including VoIP phones and digital clocks.
- 10M/100M adaptive network interface
- Unit is capable of serving 750+ NTP synchronizations per second. That provides support for over 600,000+ devices updating every 15 minutes on the network.
- Active Patch GPS antenna included. Magnetic base.
- Compliant with FCC Part 15B, and CE marked for radiated emissions and is a lead free product.
- Power Requirements:
  - TM2000B: 5W at startup and 2.5W continuous at 12V DC
  - TM2500C: 7W at startup and 5W continuous at 12V DC
- Environmental Requirements: Commercial temperature range, 0-70C, 95% humidity non-condensing. Altitude -304m to 18,000m.
- Networking: Static or DHCP IPv4 addressing. Standard browser interface for setup.
- Indications: Power, GPS Signal Lock, and 1PPS indications
- Rear Connections:
  - Power 8-16VDC, Connector: 5.5mm outside diameter, 2.5mm inside, center positive
  - Cat5 Ethernet 10/100 Ethernet

  - Serial (status information only, 115200,n81), mini-USB enumerates as Com port
  - GPS antenna via SMA connection. Supports +3.3V and 5V active GPS antennas with internal jumper setting. TM2500C has BNC output connection.
- Serial port outputs data every two seconds, including the following items:
  - IP, Time, GPS fix, Time known, ptpClockClass, ptpClockAccuracy, ntpStratum.
- Mechanical Dimensions: 5 in. x 4.2 in. x 1.3in.

8.2 GPS Module Specifications

- Based on MediaTek MT3339 Chipset
- 33 tracking/ 66 acquisition-channel GPS receiver
- Sensitivity: -165dBm
- High accuracy 1-PPS, ±20ns jitter
- GPS Time Precision: +/- 10ns RMS jitter.
- Antenna Connection: 1575.42MHz (L1 Band)
- TTFF (Time To First Fix)
  - Cold start @-125dBm typically 33 seconds
  - Re-acquisition (<10s obstruction) typically 1 second

8.3 Antenna Specifications

- Active patch antenna with magnetic base.
- Size: 1.57 in. x 1.89 in. x 0.51 in thick, 43 grams.
- Amplifier: LNA +28dB Noise: 1.5dB VSWR: 2.0 Voltage: 2.7-6.0V.
- Cable: RG174, 5m length, SMA male.
- Environmental: -40 to +85C
- Waterproof to Ipx6

8.4 TM2500C OCXO Timing Information / Specifications

- 1 PPS / 10MHz output is 3.3V TTL signal
- Standard SMB connections
- 1PPS signal is +/20 nS
- 10MHz Synchronized signal. Correlation between signals +/- 20nS. Highest correlation occurs with outdoor antenna with 360 degree view of sky.
- Best stability of the OCXO and 10Mhz reference in holdover is achieved:
  - 8 hours of operation required if TM2X00B off for 24 hours

- 24 hours of operation required if TM2X00B off for 1 week
- 48 hours of operation required if TM2X00B off for 1 month
- Stable temperature conditions

(Specifications are subject to change without notice)