

USER'S GUIDE

TIME SYNC HUB MODEL: TSH-100 / TSH-200



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SAFETY PRECAUTIONS

Important safety precautions must be followed before attempting to install, service, or maintain electrical equipment. Carefully read and follow the safety precautions outlined below.

NOTE: *Electrical equipment should be serviced by qualified personnel. No responsibility is assumed by Trystar, Inc. for any consequences arising out of the use of this material. This document is not intended as an instruction manual for untrained persons.*

DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

- Only qualified workers should install this equipment. Such work should be performed only after reading this entire set of instructions.
- NEVER work alone.
- Before performing visual inspections, tests, or maintenance on this equipment, disconnect all sources of electric power. Assume that all circuits are live until they have been completely de-energized, tested, and tagged. Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of backfeeding.
- Apply appropriate personal protective equipment (PPE) and follow safe electrical practices. For example, in the USA, see NFPA 70E.
- Turn off all power supplying the equipment in which the device is to be installed before installing and wiring the device.
- Always use a properly rated voltage sensing device to confirm that power is off.
- Beware of potential hazards, wear personal protective equipment, and carefully inspect the work area for tools and objects that may have been left inside the equipment.
- The successful operation of this equipment depends upon proper handling, installation, and operation. Neglecting fundamental installation requirements may lead to personal injury as well as damage to electrical equipment or other property.

Failure to follow these instructions can result in death or serious injury.

NOTICE: FCC (Federal Communications Commission)

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment.

This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. The user is cautioned that any changes or modifications not expressly approved by Trystar, LLC. may void the user's authority to operate the equipment.

The Class A digital apparatus complies with CISPR 11, Class A, Group 1 (EN 55011) and Canadian ICES-003. (EN 61326-1)
L'appareil numérique de classe A est conforme aux normes CISPR 11, classe A, groupe 1 (EN 55011) et à la norme Canadienne ICES-003. (EN 61326-1).

Open source software components

This Trystar, LLC. device is provided with certain open source software components (collectively, "OSS") developed by third parties. Refer to the section on "Included Software Licenses". (Section 10 of this document)

Product Overview (TSH-100 / TSH-200)

1—INTRODUCTION

Time Sync Hub (TSH-100 / TSH-200): The Trystar® Time Sync Hub provides precise time synchronization to Sequence of Events Recorders (SER) and other intelligent devices within power distribution systems, control systems, across a campus and enterprise wide to enable data analytics for critical applications.

The TSH-100 utilizes Ethernet network-based time protocols IEEE-1588 Precision Time Protocol (PTP) or Network Time Protocol (NTP) to provide a highly accurate date/time reference for a system solution.

The TSH-200 adds a Global Navigation Satellite System (GNSS) receiver using the Global Positioning System (GPS). The TSH-200 also adds support for IRIG-B and DCF77 time synchronization inputs via 5 Vdc input or RS-485.

Both the TSH-100 and TSH-200 provide time synchronization outputs over an Ethernet network using PTP and NTP. They also provide time synchronization outputs in the form of IRIG-B, DCF77, 1per10 (pulse per ten seconds) and PPS (pulse per second) on 5 Vdc and 24 Vdc outputs (time protocol selectable per output) and IRIG-B, DCF77 or Arbiter ASCII with Quality over RS-485.

Time synchronization (PTP). PTP or Precision Time Protocol is an Ethernet protocol for time synchronization over an existing data network. PTP is an industry standard protocol defined by IEEE 1588-2019, 2008. The Time Sync Hub supports the Default profile and can be configured as a PTP grandmaster, backup or redundant PTP master, or a PTP slave device, synchronized to a PTP grandmaster.

Time synchronization (NTP). The Time Sync Hub supports NTP (Network Time Protocol, RFC 5905, version 4) over the Ethernet network. The Time Sync Hub can be configured as a NTP client, receiving time synchronization messages, or as a NTP server, providing time synchronization messages to other devices.

Time synchronization (IRIG-B). IRIG-B (Inter-Range Instrumentation Group) time code is a standard format for transferring timing information between devices developed by the U.S. military in 1956 and standardized in 1960. IRIG-B has a bit rate of 100 Hz and is typically distributed at 5 Vdc. The Time Sync Hub supports unmodulated DCLS (DC level shift pulse width coded) IRIG-B input (TSH-200) and outputs to ensure device clocks throughout a system are time synchronized. The Time Sync Hub can provide IRIG-B outputs at 5 Vdc, 24 Vdc and over RS-485.

Time synchronization (DCF77). DCF77 is a German time synchronization standard controlled by the PTB (Physikalisch-Technische Bundesanstalt). DCF77 is a BCD (Binary Coded Decimal) protocol consisting of one (1) pulse per second over sixty (60) seconds to define the date and time. The Time Sync Hub supports DCF77 input (TSH-200) and outputs to ensure device clocks throughout a system are time synchronized. The Time Sync Hub can provide DCF77 outputs at 5 Vdc, 24 Vdc and over RS-485.

Product Overview (cont.)

Time synchronization (1per10, PPS). In addition to standard time synchronization protocols like IRIG-B and DCF77, the Time Sync Hub can provide outputs of 1per10 (one pulse per ten seconds) and PPS (one pulse per second) as required by some specialized equipment. The Time Sync Hub can output these signals at 5 Vdc and 24 Vdc.

Time synchronization (ASCII). The ASCII time synchronization output is defined by Arbiter Systems and is referred to as ASCII+QUAL (Quality). This time output is a serial communications protocol operating at 9600 bps (bits per second) consisting of an on-time mark (OTM) once per second followed by an ASCII representation of the date/time and time quality. An example of the message is:

<soh>ddd:hh:mm:ssQ where: soh = Hex 01 (start bit = OTM) and Q = time quality (space = locked, ? = unknown)

Time-sync master. One Time Sync Hub can serve as a time-sync master to other devices via PTP or an RS-485 subnet. RS-485 serial protocol is either IRIG-B or DCF77 (per the input time source) or ASCII (selectable). When PTP or NTP is the time source, a Time Sync Hub can output IRIG-B, DCF77, PPS or 1per10.

Settings stored in non-volatile memory. Configuration is accomplished using a standard web browser without need for additional software. All settings are stored in non-volatile memory.

Benefits Time Sync Hub

Simple setup

Using a web browser with no proprietary software. Embedded web server hosts user-friendly web pages for setup and monitoring.

No maintenance required

User settings and system log data are stored in non-volatile flash memory and available via RESTful API.

Easy system integration

Integrate with multiple systems via Ethernet using RESTful API, SNMP (Single Network Management Protocol) and secure web interface.

Flexible time synchronization choices

GNSS (GPS), PTP, NTP, IRIG-B, DCF77, 1per10, PPS, and ASCII (RS-485).

Regulatory approvals to global standards

UL-Listed (UL/IEC 61010), CSA 22.2, CE, RoHS-compliant.

Key Features Time Sync Hub

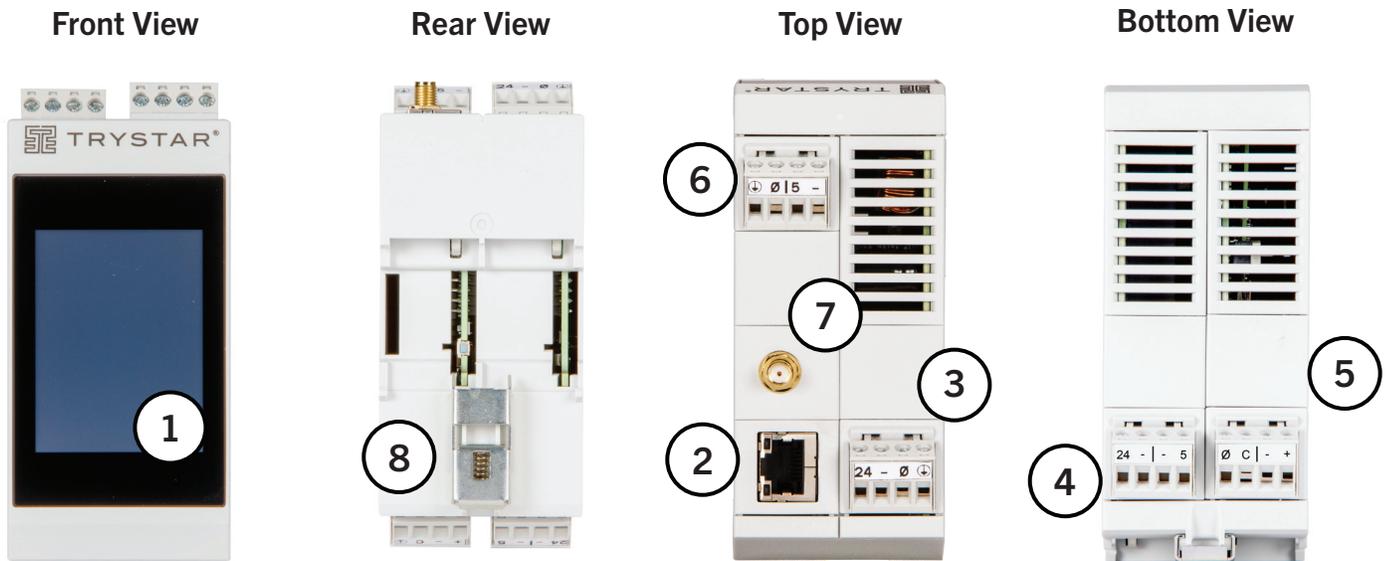


Table 1-1—Key Features

Feature	Description
① Touchscreen Display	Color resistive touchscreen display (2.4" TFT, 320x240 pixels) for local access to status, events and setup parameters. User configurable brightness and screen saver.
② Ethernet	RJ-45 Shielded Twisted Pair network interface, with indicator LEDs for speed (10 or 100 Mbps) and link/activity. The TSH auto-detects Ethernet wiring polarity and network speed.
③ Control Power	Dual control power options of 24 Vdc (20 VA) and PoE (Power over Ethernet, Type 2).
④ 24V / 5V Output	Time synchronization outputs at 24 Vdc and 5 Vdc. Supported protocols include IRIG-B, DCF77, 1per10 and PPS.
⑤ RS-485	Time synchronization output or input. Supported output protocols include ASCII (Arbiter + Qual), IRIG-B, DCF77. Supported input protocols include IRIG-B and DCF77.
⑥ 5V Input (TSH-200)	Time synchronization input at 5 Vdc. Supported protocols include IRIG-B and DCF77.
⑦ GPS (TSH-200)	SMA coax connection for GPS antenna (50 ohms). Device provides 3.3 V to power an active antenna.
⑧ Mounting (DIN)	Standard 35mm DIN Rail.

2—INSTALLATION

The Time Sync Hub is designed to be mounted inside on a standard DIN rail in the orientation shown below (control power and Ethernet connection UP). When choosing a mounting location, consider the following:

- Allow for easy access to the device.
- Allow space for all wiring to be neatly routed to and from the device.
- Allow sufficient ventilation (top and bottom) space to stay within the operating temperature limits of the device (see Specifications).

Typical locations for mounting the Time Sync Hub include:

- Power equipment low voltage cell or compartment.
- Office or raised floor environment.
- Auxiliary control cabinet or panel.

The Time Sync Hub is mounted on a standard (35 mm) top-hat style DIN rail by hanging the device on the top edge of the DIN rail and rotating it downward until the device latches on the bottom edge of the rail.

NOTE: The DIN rail should be bonded to Earth ground.

To uninstall, insert a flat blade screwdriver between the two connectors on the bottom of the unit to engage the DIN rail latch. Apply firm pressure to disengage the clip from the rail, rotating the unit upward.

3—WIRING

Wiring connections for the Time Sync Hub include an Ethernet network interface RJ-45 connector (STP), control power, time synchronization outputs (5V, 24V, RS-485), and time synchronization inputs (5V, GPS antenna).

Removable plug-in, screw terminal connectors are provided to simplify making connections. Pay careful attention to the signal markings on each connector.

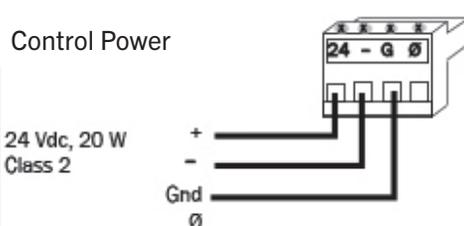


Figure 3-1. Control Power

Control Power

The Time Sync Hub requires a control power source with nominal voltage of 24 Vdc from a Class 2 power supply. A #18 AWG (minimum) cable, such as Belden 8760, is recommended.

Additionally, the Time Sync Hub can be powered through the Ethernet connection using a Type 2 PoE (Power over Ethernet) source.

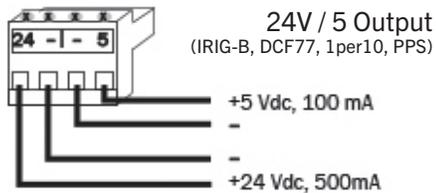


Figure 3-2. Time Outputs

Time Synchronization Outputs

The Time Sync Hub can provide time synchronization outputs on its 5V and 24V outputs concurrently. The user can select the same or different time protocols per output. Available time protocols include: IRIG-B, DCF77, 1per10 and PPS. A #18 AWG (minimum) cable, such as Belden 8760, is recommended for output connections.

Recommended cable lengths are shown in the table below (Table 3-1). Max number of devices is dependent on the impedance of each device’s input.

Table 3-1—Recommended Cable Lengths

Output Voltage	Max. Total Load Allowed	Max. Cable Length	Typical Protocol
5V	100mA	300’ @ 100mA	IRIG-B
24V	500mA	1,000’ @ 100mA 700’ @ 200mA 470’ @ 300mA 350’ @ 400mA 280’ @ 500mA	DCF77 1 per 10

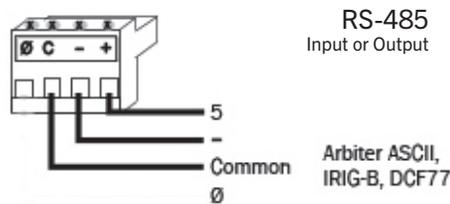


Figure 3-3. RS-485 Input/Output

RS-485 Serial Interface

The Time Sync Hub’s RS-485 serial interface can function as either a time synchronization input or output. Typically, functioning as an output, supported time protocols include IRIG-B, DCF77 and ASCII. The ASCII output is a time synchronization protocol defined by Arbitr Systems called “ASCII + QUAL.”

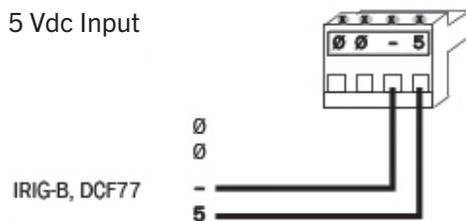


Figure 3-4. 5Vdc Input

Time Synchronization Inputs

The Time Sync Hub (TSH-200) can receive time synchronization input on its 5 V input. Supported time input protocols include: IRIG-B and DCF77.

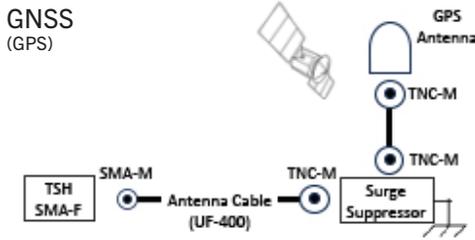


Figure 3-5. GNSS (GPS)

GNSS (Global Navigation Satellite System)

The Time Sync Hub model TSH-200 accepts time synchronization input from a GNSS antenna (50 ohm, 3.3 V, active) using the GPS (Global Positioning System). UF-400 series coax cable is recommended for connecting the antenna to the Time Sync Hub. A surge suppressor should be installed inline as close to the building entry point as possible and bonded to an Earth ground.

Table 3-2—Recommended Equipment

Equipment	Trystar P/N (recommended)	Alternates
Antenna	GPS-A	L-Com HG-GPGLTIM32 Trimble 101155-20
Surge Suppressor	GPS-SS	CITEL P8AX09-T/FF Times LP-GPX-05-TFF
Antenna Cable (50ft.)	GPS-AC50	L-Com 400 Ultra Flex Series, MM
Antenna Cable (100ft.)	GPS-AC100	L-Com 400 Ultra Flex Series, MM
Antenna Cable (250ft.)	GPS-AC250	L-Com 400 Ultra Flex Series, MM

A #18 AWG (minimum) cable, such as Belden 8760, is recommended for input connections.

4—LOCAL TOUCHSCREEN DISPLAY

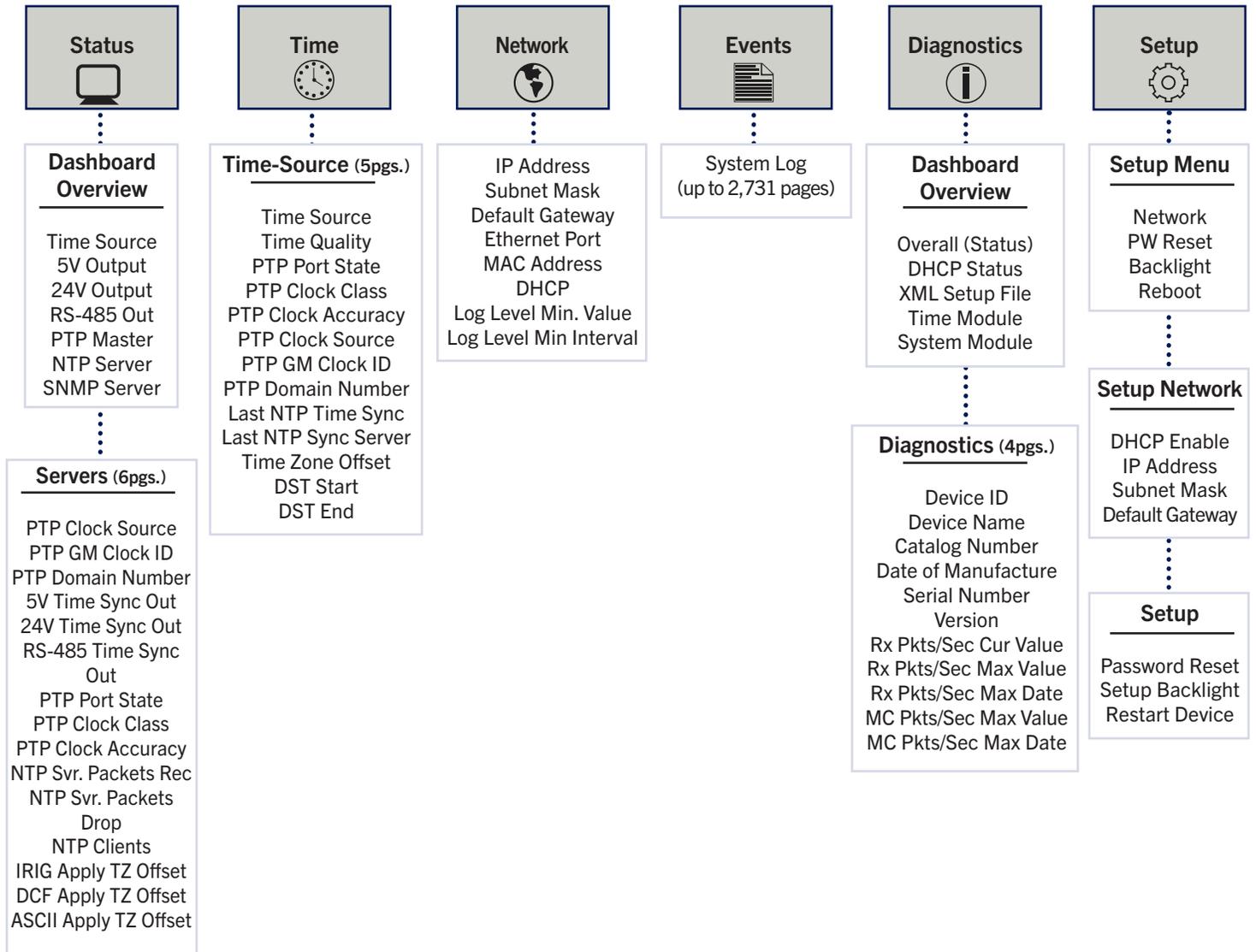
The Trystar Time Sync Hub features a 2.4” color (TFT) touchscreen display to provide local access to status, events and setup parameters.

The Time Sync Hub’s display provides information to allow the user to verify proper operation, including current date/time, time quality and time zone offset(s). In addition, communication parameters (DHCP, IP address, subnet mask, default gateway) can be configured or modified through the display interface.

Table 4-1—Icon Legend

Display Menu Icon Legend			
	Home		Page Navigation
	Status		Events
	Time		Diagnosis
	Network		Setup

Display Menu Structure



Display Home



Display - Home

The Time Sync Hub touchscreen display home screen shows the present date and time of the device. The color of the date and time indicates the synchronization status and time quality of the device.

Green: Time synchronization signal being received and GOOD time quality

Yellow: Time quality is FAIR

Orange: Time quality is POOR

Red: Time synchronization signal not being received, or Manual time set



Figure 4-1. Home Screen

Display Status



Display - Status

The Status screen provides a dashboard of the Time Sync Hub’s status as well as detailed information of the configuration time inputs and outputs (servers).



Figure 4-2. Display Status

Display Events



Display - Events

The Time Sync Hub provides a System Log or security audit log. This log includes information about user log-in, failed log-in, updates, configuration changes, device resets, extreme network activity, time synchronization lock and loss, and other information important for device management.

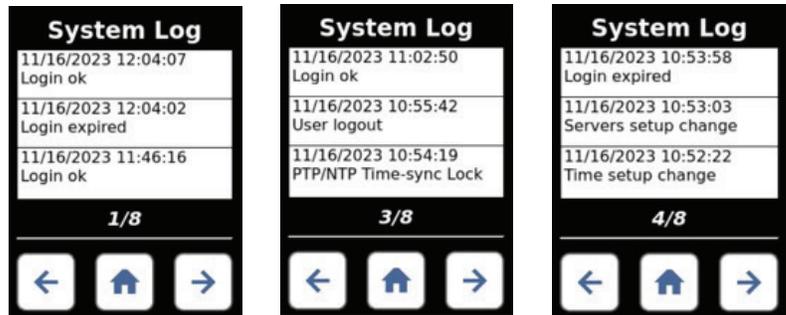


Figure 4-3. Display Events

Display Diagnostics



Display Diagnostics

The Diagnostics screens provide detailed information about the Time Sync Hub device. The first screen is a dashboard of key systems followed by information on the device.

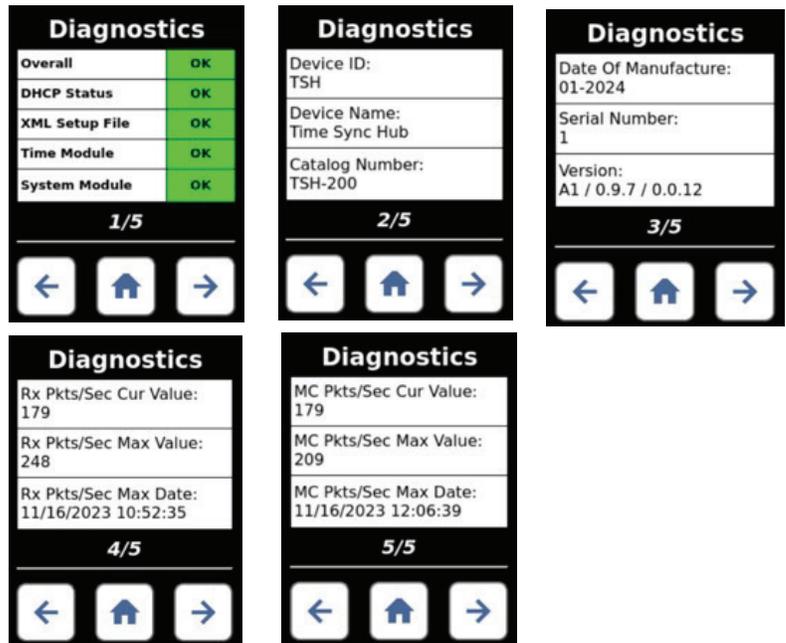


Figure 4-4. Display Diagnostics

Display Setup



Display – Setup

The Setup screen allow the user to perform initial device configuration (network settings) and other useful tasks including configuring the device’s backlight, reset the device and recover a lost password.

The Setup screen includes four (4) options: Network, Password Reset, Backlight and Reboot. (see fig. 4-5)

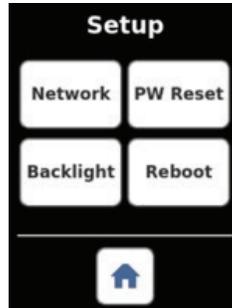


Figure 4-5. Display Setup

To configure the Network parameters of the Time Sync Hub, select the Network button. From this interface you can configure network parameters including enabling/disabling DHCP or setting a static IP address. A user-friendly keypad is provided to configure the IP address, subnet mask and default gateway.

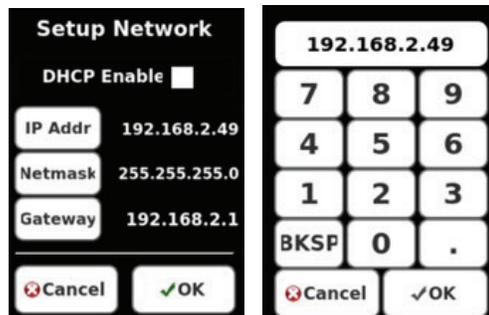


Figure 4-6. Network Setup

Password Reset

Setup – Password Reset (PW Reset)

The PW Reset option allows a user to temporarily reset the device’s password to the default value (admin) for a period of 5 minutes. If the password is not changed, the previous password is restored. This procedure requires the user to have physical access to the device to select the option and the ability to connect to the device’s web interface Setup > Admin page to set a new password. (see fig. 4-7)

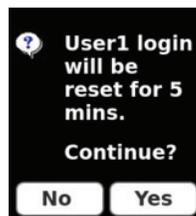


Figure 4-7. Network Setup

Setup - Backlight

Setup - Backlight

The Backlight option allow a user to configure the display’s backlight ON intensity, idle intensity and timeout. (see *fig. 4-8*)



Figure 4-8. Setup Backlight

Setup - Reset

Setup – Reset

The Reset option allows a user the ability to initiate a reboot of the Time Sync Hub.

NOTE: Communications with the device will be lost until the reboot is complete.

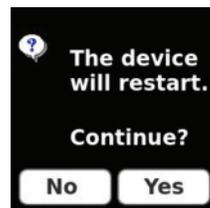


Figure 4-9. Reset

5—INITIAL SETUP

The initial setup of the Time Sync Hub consists of configuring network parameters to enable access to the device's web interface. Initial setup can be configured using the device's local touchscreen display or by directly connecting a PC (Personal Computer) to the device's Ethernet port.

Initial Setup via Touchscreen Display

The Time Sync Hub features a color touchscreen display that supports initial configuration of Ethernet Network communication parameters.

- To configure Ethernet or confirm settings, select the "Setup" icon followed by the "Network" button.
- To Enable DHCP (default), select the "DHCP Enable" check box.
- To configure a static IP address, deselect the "DHCP Enable" check box, then select the "IP Addr", "Netmask" and "Gateway" buttons and enter the appropriate values provided by your network administrator.
- Select the "OK" button to save settings.

You can now access the Time Sync Hub over your Ethernet network to complete setup.

Initial Setup via Webpage (direct connection)

The Time Sync Hub has a default static IP address allowing a PC to be directly connected to the device for configuration. To configure network parameters enabling the Time Sync Hub to be accessible on an existing Ethernet work, do the following:

1. Disable Wi-Fi on your PC.
2. Connect the Time Sync Hub to your PC using a standard Ethernet patch cable.
3. Your PC should default to an IP address compatible with the Time Sync Hub's default address. If there is an issue making a connection to the device, set your PC's static IP address to 169.254.0.11.
4. Apply power to the Time Sync Hub.
5. Open a standard web browser (Edge, Chrome and Firefox are recommended).
6. Type the default IP address 169.254.0.10 into your web browser.
7. Enter the default username (admin) and password (admin) and click "Login" to access the home page. NOTE: Both the username and password are case sensitive. *If this is the first login to this device, you will be prompted to change the password. Once the password has been changed, the device's home page will be accessible.*
8. Click the Setup tab to change the network settings to those provided by your network administrator and click "Update" to save.
9. Disconnect the Ethernet patch cable and connect the Time Sync Hub to your local area network. Continue to the next section for additional setup.
10. Restore your PC to its previous network settings. (e.g. Enable Wi-Fi, "Obtain IP address automatically.")

6—WEB SERVER INTERFACE

The Time Sync Hub’s web interface can be accessed using either a direct connection (PC to Time Sync Hub) or over an existing Ethernet network. The device’s web interface provides device Status and Diagnostics, a System Log, and the ability to configure the device. Default username (admin) and password (admin).

Status

The Status menu provides read-only information about the Time Sync Hub and its configuration.

Status > Overview

Overview provides a summary dashboard of the Time Sync Hub’s status for each time input source and each time output along with a time quality indication. (see *fig. 6-1*)

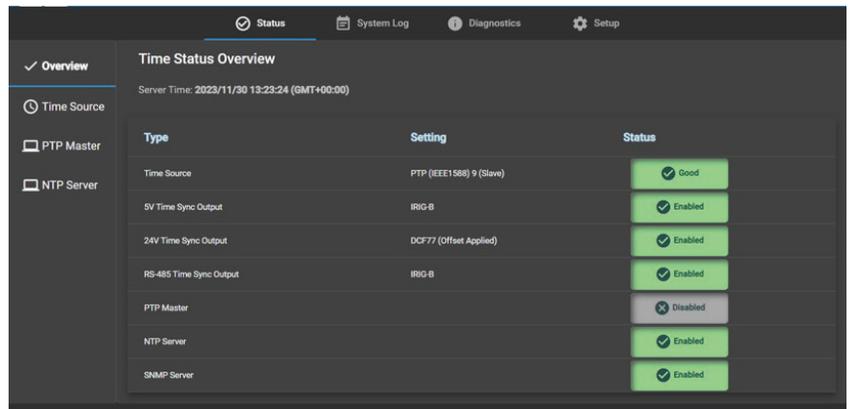


Figure 6-1. Time Status Overview Page

Status > Time Source

Time Source identifies the time signal being received. Options include: PTP, NTP, GPS, IRIG-B and DCF77.

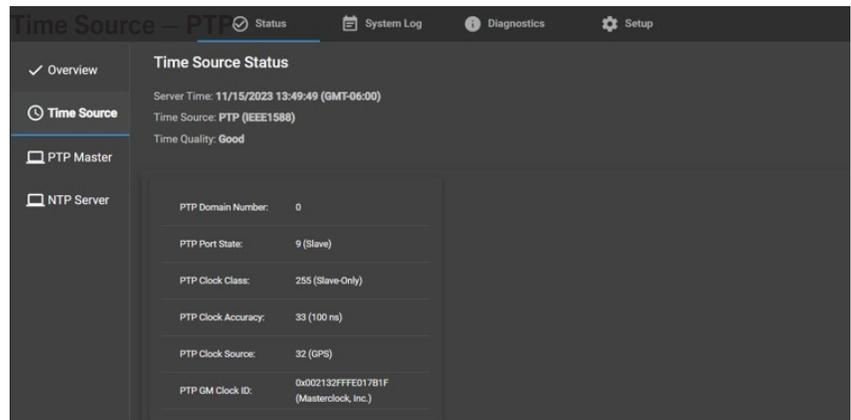


Figure 6-2. Time Source, PTP

Time Source –NTP

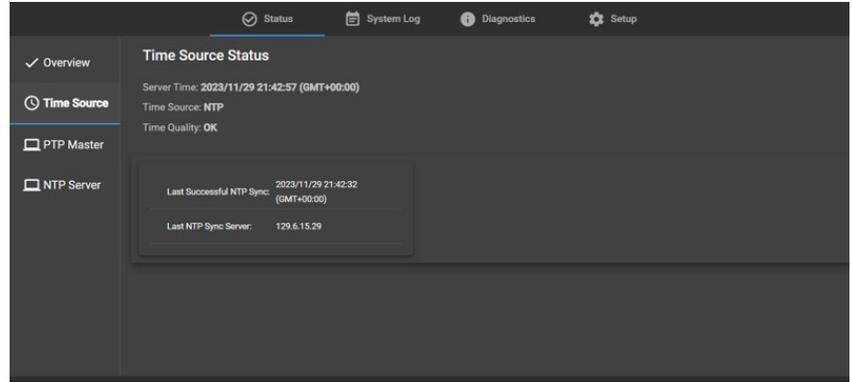


Figure 6-3. Time Source, NTP

Time Source – GPS

The GPS time source status includes the location of the Time Sync Hub, number of satellites visible to the antenna, number of satellites being used, a graph of signal strength and a plot of satellite locations relative to the antenna. (see fig. 6-4)



Figure 6-4. Time Source, GPS

Status > PTP Master

PTP Master provides information on the Time Sync Hub’s PTP Master configuration and its status, Enabled or Disabled. (see fig. 6-5)

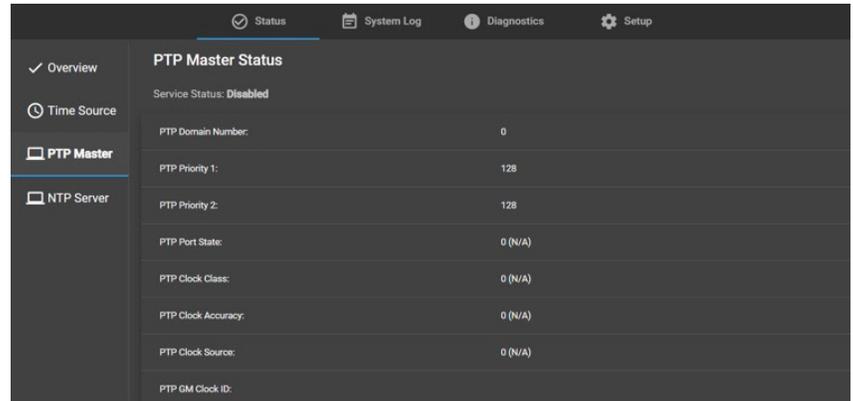


Figure 6-5. Status, PTP Master

Status > NTP Server

NTP Server provides information on the Time Sync Hub’s NTP Server configuration and its status (Enabled or Disabled) and a list of connected NTP clients. (see fig. 6-6)

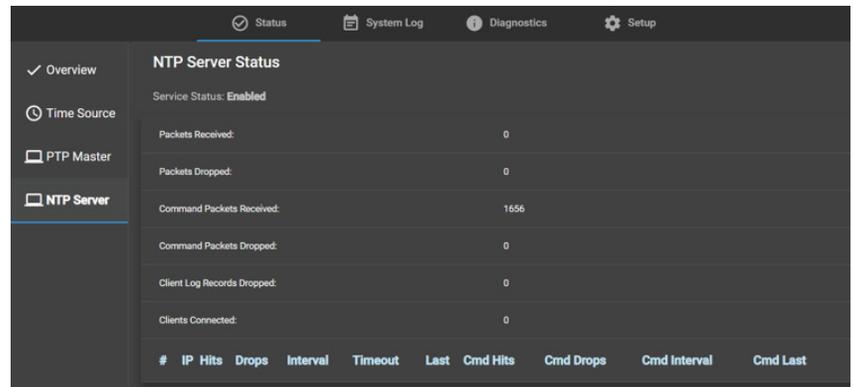
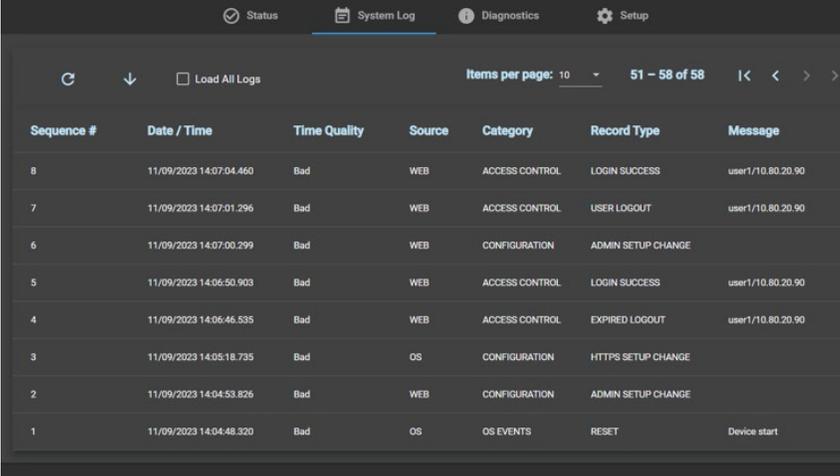


Figure 6-6. Status, NTP Server

System Log

The Time Sync Hub's System Log or Security Audit Log provides a history of the device and users. This log can be downloaded by selecting the down arrow (↓) at the top left of the page.

Each log entry includes a Sequence number, Date/time, Time quality, Source, Category, Record Type and Message. (see *fig. 6-7*)



Sequence #	Date / Time	Time Quality	Source	Category	Record Type	Message
8	11/09/2023 14:07:04.460	Bad	WEB	ACCESS CONTROL	LOGIN SUCCESS	user1/10.80.20.90
7	11/09/2023 14:07:01.296	Bad	WEB	ACCESS CONTROL	USER LOGOUT	user1/10.80.20.90
6	11/09/2023 14:07:00.299	Bad	WEB	CONFIGURATION	ADMIN SETUP CHANGE	
5	11/09/2023 14:06:50.903	Bad	WEB	ACCESS CONTROL	LOGIN SUCCESS	user1/10.80.20.90
4	11/09/2023 14:06:46.535	Bad	WEB	ACCESS CONTROL	EXPIRED LOGOUT	user1/10.80.20.90
3	11/09/2023 14:05:18.735	Bad	OS	CONFIGURATION	HTTPS SETUP CHANGE	
2	11/09/2023 14:04:53.826	Bad	WEB	CONFIGURATION	ADMIN SETUP CHANGE	
1	11/09/2023 14:04:48.320	Bad	OS	OS EVENTS	RESET	Device start

Figure 6-7. System Log

The **Sequence #** (number) is a sequential value to define the order of events regardless of the date/time setting of the device.

Date/time and **Time Quality** document the time of the event and the accuracy of the time stamp recorded.

Source identifies the originator of the event. Options include:

- Web page.
- Display.
- RESTful API.
- Reset button.
- Operating system.
- Time source.
- SNMP.

The System Log **Category** and **Type** include:

- Access control.
 - Log-in – successful, unsuccessful.
 - Account lockout (after 5 failed attempts, all accounts are locked for 5-minutes).
- Request errors.
 - Malformed messages.
 - Invalid message or command .
 - Network Stats (i.e. high network traffic detected).

- Component/device events.
 - Reboot.
 - Update.
 - Security certificate expiration .
 - 24 Vdc loss.
 - 24 Vdc restored.
 - Power fail.
 - Power on.
- Operating system events.
- Configuration change.
 - Changes to device setup:
 - Communications.
 - Time.
 - Administration.
- System log events.
 - Log flooding attempt with user ID.

The System Log **Message** is a text string of up to 48 characters describing the result or identifying the originator of the event (e.g. User ID, IP address).

Diagnostics

The Diagnostics page can be used to verify device data such as device name, catalog number (model), date of manufacture, serial number, hardware and firmware versions, and available memory. (see *fig. 6-8*)

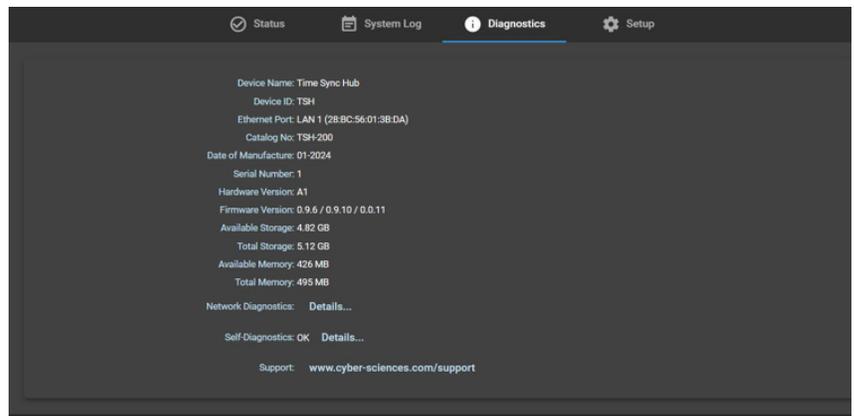
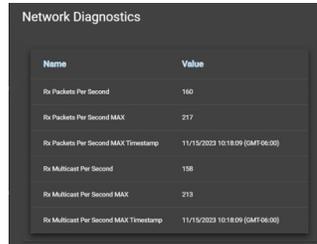


Figure 6-8. Diagnostics

Additional diagnostic information is available on the Ethernet network by clicking on “Details” links. (see fig. 6-9)



Name	Value
Rx Packets Per Second	160
Rx Packets Per Second MAX	217
Rx Packets Per Second MAX Timestamp	11/15/2023 10:18:09 (GMT 06:00)
Rx Multicast Per Second	158
Rx Multicast Per Second MAX	213
Rx Multicast Per Second MAX Timestamp	11/15/2023 10:18:09 (GMT 06:00)

Figure 6-9. Details Link

Setup

Configuration (setup) of the Time Sync Hub can be accomplished over an Ethernet network using a standard web browser. No special software is required. At the log-in screen, enter the username (default = admin) and password (default = admin). The Status > Overview screen will appear. Click on the Setup tab to be configure the device.

Setup > Network

The Time Sync Hub features a standard Ethernet interface (10/100Base-Tx) for connection to a local area network (LAN). The device auto-detects wiring polarity and network speed (10 or 100 Mbps). To configure communication parameters, click “Network” under the Setup tab. (see fig. 6-10)

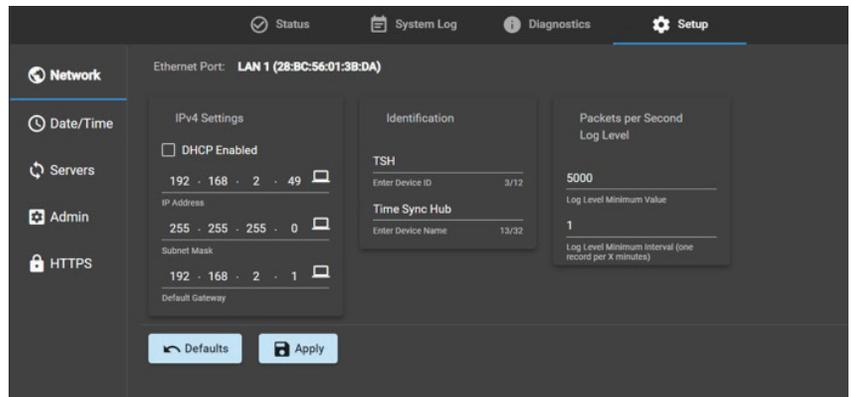


Figure 6-10. Network Screen

Table 6-1—Network Options

Option	Description	Available Values	Default
Ethernet Port	MAC address assigned at the factory	hh-hh-hh-hh-hh-hh	Read-only
DHCP Enabled	When Enabled, the device automatically obtains an IP address from a DHCP server at startup	Enabled or Disabled	Enabled
IP Address	Network (IP) address of the device	0.0.0.0 to 255.255.255.255	169.254.0.10
Subnet Mask	IP subnet mask of the network segment	0.0.0.0 to 255.255.255.255	255.255.0.0
Default Gateway	IP address of the gateway (router) connecting multiple network segments	0.0.0.0 to 255.255.255.255	0.0.0.0
Device ID	Name of the device used by network devices and application software	UTF-8 text string, 12 characters max *	TSH
Device Name	Descriptive name assigned to the device in device web pages and some application software	UTF-8 text string, 32 characters max *	Time Sync Hub
Packets Per Second Log Level	Threshold to trigger a log entry for the number of Ethernet packets per second the device receives	0 (disabled) – 4,294,967,295	5000
Log Level Interval	Interval for log entries when the number of Ethernet packet threshold has been exceeded	0 (disabled) to 4,294,967,295 minutes	1 minute

Setup > Date/Time

The Time Sync Hub requires a time synchronization input signal as its reference time. Supported time inputs include PTP (IEEE 1588) and NTP. Additionally, the TSH-200 can receive time inputs from GPS, IRIG-B and DCF77.

The Time Sync Hub provides the ability to present information in local time by applying local time and DST (Day Light Savings Time) offsets. Local time will be applied to the device’s display, web interface and System Log. (see fig. 6-11)

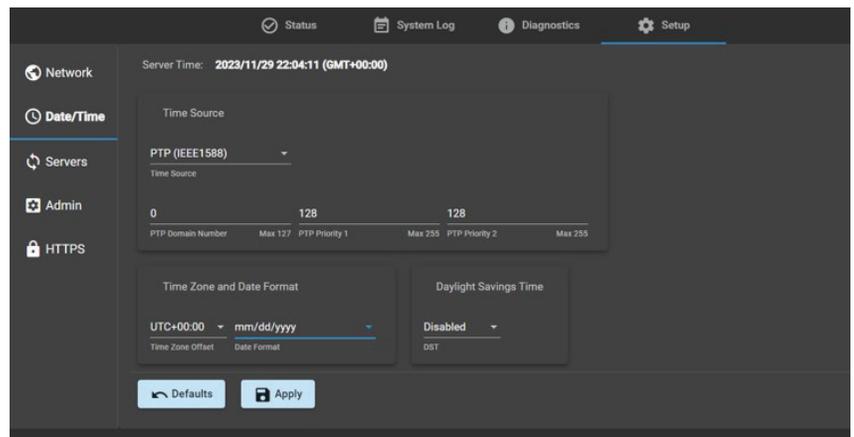


Figure 6-11. Date/time Screen

Table 6-2—Date/time setup

Option	Description	Available values	Default
Time Source	Specifies the time source input for the device.	IRIG-B (unmodulated) DCF77, NTP Manual time set PTP (IEEE 1588), GPS	PTP
Time Zone	Local time offset in hours and minutes from UTC (Coordinated Universal Time).	UTC -12:00 to +13:00	0 (UTC +00:00)
Date Format	User selectable date format	MM-DD-YYYY DD-MM-YYYY YYYY-MM-DD	MM-DD-YYYY
Daylight Savings Time (DST)	Apply DST adjustment (+1 hour) during specified period	Enabled or Disabled	Disabled
DST Start and End	Starting and Ending date/time to apply DST offset.	Month: Jan – Dec Week: 1st – 5th (last) Day: Sun – Sat Time: 00:00 – 23:00	USA defaults

Setup > Servers

The Time Sync Hub has the unique ability to provide time synchronization signals to intelligent devices using multiple outputs. For example, the TSH-200 can receive a time input from a GPS antenna and provide time outputs of IRIG-B (5V), DCF77 (24V), ASCII (RS-485) and function as both a PTP Master and NTP Server concurrently.

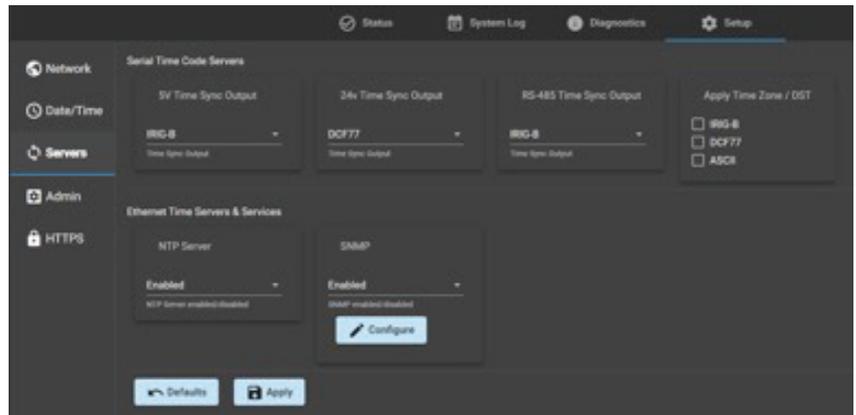


Figure 6-12. Server Screen

Table 6-3—Server Screen

Option	Description	Available values	Default
5V Time Output	Specifies the time protocol to apply to the 5V output	IRIG-B, DCF77, 1per10, PPS	Disabled
24V Time Output	Specifies the protocol to apply to the 24V output	IRIG-B, DCF77, 1per10, PPS	Disabled
RS-485 Time Output	Specifies the protocol to apply to the RS-485 port	IRIG-B, DCF77, ASCII	Disabled
Apply Time Zone / DST	Applies local time and DST offset to the selected output	IRIG-B, DCF77, ASCII	Disabled
PTP Master	Indicates if the Time Sync Hub is to serve as a PTP time master for other devices	Enabled or Disabled	Disabled
NTP Server	Indicates if the Time Sync Hub is to serve as a NTP time master for other devices	Enabled or Disabled	Disabled

SNMP (Simple Network Management Protocol)

SNMP is an application layer protocol enabling the exchange of network management information between devices. The Time Sync Hub supports SNMP version 2 and version 3 (user selectable), over TCP/IP port 161. Device information is available via MIB-2 (according to RFC 1213) and a custom MIB defined below.

Additionally, the Time Sync Hub can send notifications (Traps) to a NMS (Network Management System) over TCP/IP port 162. Supported events for notification are:

- Change in time quality
- Device configuration change

To utilize SNMP, you will need to upload the Time Sync Hub’s custom MIB file into your NMS. The MIB file is available at www.cyber-sciences.com/downloads. The Time Sync Hub’s MIB includes the following: (see table 6.4)

Table 6-4—SNMP Custom MIB

OID	Example	Description
Catalog Number	TSH-200	TSH-100 or TSH-200
Date of manufacture	1-2024	MM-YYYY
Serial number	1	1-99999
Firmware version	1.0.0	xx. yy. zz.
Device type	200	100 or 200 w/GPS
Device name	Time Sync Hub	-
Device ID	TSH	-
Server Time	1701705626	UNIX epic (seconds since 1/1/1970)
Time Quality	0	0 = Good 1 = Fair 2 = Poor 3 = Bad
Time Source	9	0 = IRIG-B (5V) 1 = IRIG-B (RS-485) 2 = NTP 3 = Manual 4 = DCF77 (5V) 5 = DCF77 (RS-485) 6 = reserved 7 = PTP 8 = reserved 9 = GPS

Table 6-4—SNMP Custom MIB (cont.)

OID	Example	Description
5V output protocol	4	4 = IRIG-B 5 = DCF77 6 = 1per10 11 = PPS
24V output protocol	4	4 = IRIG-B 5 = DCF77 6 = 1per10 11 = PPS
RS-485 output protocol	1	1 = IRIG-B 2 = DCF77 3 = ASCII (Arbiter + quality)
5V output time zone offset applied	1	0 = Disabled 1 = Enabled
24V output time zone offset applied	1	0 = Disabled 1 = Enabled
RS-485 output time zone offset applied	1	0 = Disabled 1 = Enabled
NMEA GPGGA	\$GPGGA,160017.000,3554.0199,N,08622.3171,W,2,9,0.92,200.6,M,-31.5,M,,*6C	Time, position, fix type
NMEA GPGLL	\$GPGLL,3554.0199,N,08622.3171,W,160017.000,A,D*43	Latitude and longitude
NMEA GPGSA	\$GPGSA,A,3,25,10,02,31,32,12,21,26,28,,,,,1.22,0.92,0.79,1*12	Satellites in use
NMEA GPGSV	\$GPGSV,3,1,12,28,81,297,34,31,59,239,15,32,56,055,35,10,38,148,26,0*69	Satellites in view with ID

Additional information on GPS NMEA sentences can be found in Section 7 – GPS Sentences.

SNMP configuration assumes an advanced understanding of SNMP. To assist with the configuration, each parameter is described below.

SNMP Version 2 Configuration

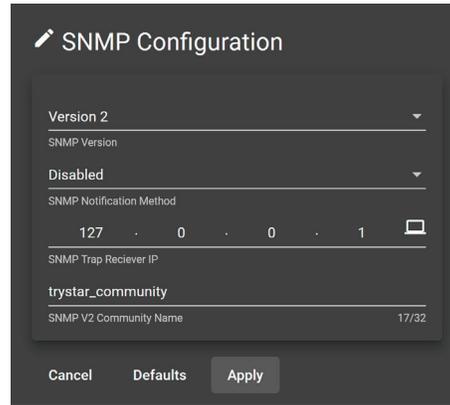


Figure 6-13.
SNMP Configuration

Table 6-5—Setup, SNMP Version 2

Option	Description	Available values	Default
Version	Specifies the version of SNMP to support	Version 2 or 3	2
Notification Method	Enables or disables Traps and selects the type of notification	Disabled, Trap, Inform	Disabled
Trap Receiver IP Name	Specifies the IP address of the SNMP receiver to which notifications will be sent	0.0.0.0 to 255.255.255	127.0.0.1
Community Name	Specifies the read-only community name	V2 – csi_community	-

SNMP Version 3 Configuration

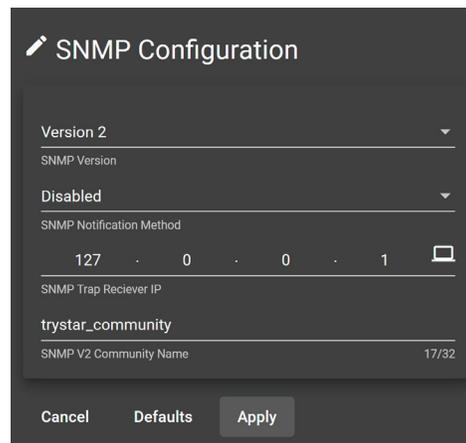


Figure 6-14.
SNMP Configuration

Table 6-6—Setup, SNMP

Option	Description	Available values	Default
Version	Specifies the version of SNMP to support	Version 2 or 3	2
Notification Method	Enables or disables Traps and selects the type of notification	Disabled, Trap, Inform	Disabled
Trap Receiver IP Name	Specifies the IP address of the SNMP receiver to which notifications will be sent	0.0.0.0 to 255.255.255.255	127.0.0.1
User Name	User name for authentication on SNMP receiver	UTF-8 text string 32 characters max (case sensitive) *	admin
Password	Password for authentication on SNMP receiver	UTF-8 text string 32 characters max (case sensitive) *	admin
Receiver Engine ID	SNMP Trap receiver engine ID	Hex (0x) format 40 characters max	Unique to each device
Local Engine ID	Time Sync Hub’s Trap engine ID	Hex (0x) format 40 characters max (read-only)	ID of NMS server
Authentication Protocol	Authentication protocol used by Time Sync Hub	SHA512	SHA512
Privacy Protocol	Privacy protocol used by Time Sync Hub	AES	AES

* Only the following special characters are available: ! @ # \$ % & * () _ - + = { } [] ; . ~ ’

Setup > Admin (Administration)

The Admin setup tab allows the user to define credentials for up to two (2) administrator level user accounts.

Additionally, the Admin tab provides the ability to update device firmware, perform a device reset and download the System Log (security audit log) in a CSV format.

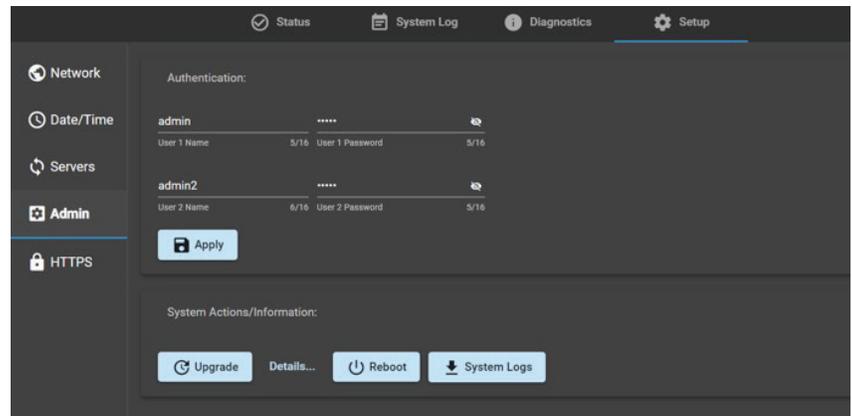


Figure 6-15. Admin Page

Table 6-7—Setup, Admin

Option	Description	Available values	Default
User 1 Name	User account #1 (administrator level)	UTF-8 text string 16 characters max (case sensitive) *	admin
User 1 Password	Password used with User account #1	UTF-8 text string 16 characters max (case sensitive) */**	admin
User 2 Name	User account #2 (administrator level)	UTF-8 text string 16 characters max (case sensitive) *	admin2
User 2 Password	Password used with User account #2	UTF-8 text string 16 characters max (case sensitive) */**	admin
Upgrade	Action button to update the device’s firmware	-	-
Reboot	Action button to restart the device	-	-
System Logs	Action button to download system logs from the device	-	-

* Only the following special characters are available: ! @ # \$ % & * () _ - + = { } [] ; . ~ ' " , & #

** Password must be changed during the first login

Setup > HTTPS

The Time Sync Hub uses HTTPS (port 443) to enhance security for all communications. HTTPS (HyperText Transport Protocol Secure) uses TLS (Transport Layer Security) encryption version 1.3 with AES 256-bit encryption.

The Time Sync Hub is shipped from the factory with a self-signed SSL (Secure Socket Layer) security certificate. This certificate is valid for two (2) years. When the self-signed certificate expires, the Time Sync Hub provides the ability to generate a new self-signed certificate. Larger enterprises with their own or other registered certificates can load these certificates to the device using the Upload feature.

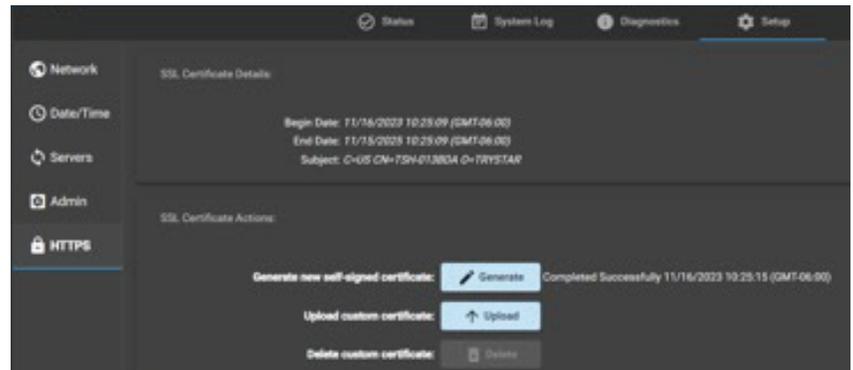


Figure 6-15. HTTPS Configuration

Table 6-8—Setup, HTTPS

Option	Description	Default
SSL Certification Details	-	-
Begin Date	Date the SSL certificate was created	Creation date is based on date of manufacturer
End Date	Expiration date for the SSL certificate	Expiration is 2 years for self-signed certificates
Subject	SSL certificate name	C=US CN=TSH-##### (MAC) O=TRYPSTAR
Generate new self-signed certificate	Action button to Generate a new self-signed certificate	-
Upload custom certificate	Action button to Upload a custom certificate	-
Delete custom certificate	Action button to Delete an existing certificate	-

7—GPS SENTENCES

The National Marine Electronics Association (NMEA) standard 0183 defines the format of Global Positioning System (GPS) information. The Trystar Time Sync Hub provides GPS information sentences GPGGA, GPGLL, GPGSA and GPGSV.

GPGGA sentence

The sentence contains the following fields:

Table 7-1—GPGGA sentence

Name or Field	Example	Description
Message ID	\$GPGGA	GGA protocol header
UTC time	142120.000	hhmmss.sss
Latitude	3554.1048 (35 degrees, 54.1048 minutes)	ddmm.mmmm
N/S Indicator	N	N = North, S = South
Longitude	08622.3219 (86 degrees, 22.3219 minutes)	dddmm.mmmm
E/W indicator	W	E = East or W = West
Position Fix Indicator	2	-
Satellites used	7	Range is 0 to 12
HDOP	1.17	Horizontal Dilution of Precision
MSL Altitude	203.6	Meters
Units	M	Meters
Geoid Separation	-31.5	Meters
Units	M	Meters
Age of diff. corr.	-	Second
Diff. ref. station ID	-	-
Checksum	*69	Hexadecimal value
<CR><LF>	-	End of message termination

NOTE:

An example GPGGA GPS sentence is:
\$GPGGA,142120.000,3554.0148,N,08622.3219,W,2,7,1.17,203.6,M,-31.5,M,,*69

GPGLL sentence

The sentence contains the following fields:

Table 7-2—GPGLL sentence

Name or Field	Example	Description
Message ID	\$GPGLL	GLL protocol header
Latitude	3554.0148	ddmm.mmmm
N/S indicator	N	N =North or S = south
Longitude	08622.3219	dddmm.mmmm
E/W indicator	W	E =East or W = West
UTC time	142120.000	hhmmss.sss
Status	A	A = data valid or V = data not valid
Mode	D	A =Autonomous , D =DGPS, E =DR
Checksum	*69	Hexadecimal value
<CR><LF>	-	End of message termination

NOTE:

An example GPGLL sentence is:
\$GPGLL,3554.0148,N,08622.3219,W,142120.00,A,D*47

GPGSA sentence

The sentence contains the following fields:

Table 7-3—GPGSA sentence

Name or Field	Example	Description
Message ID	\$GPGSA	GSA protocol header
Mode MA	A	M = Manual, forced to operate in 2D or 3D, A = Automatic 2D/3D
Mode 123	3	1 = Fix not available, 2 = 2D fix, 3 = 3D fix
Satellites used 1 -12 (fields 4 – 15)	23, 21, 25, 32, 18, 31, 10, , , , ,	Number of satellite used in solution; null if unused; total of 12 fields GPS = 1 to 32, SBAS = 33 to 64 GLO = 65 to 96
Position dilution of precision (PDOP)	1.47	<1 = Ideal (highest possible confidence level). 1-2 = Excellent. 2-5 = Good (min. appropriate for accuracy). 5-10 = Moderate (recommend a more open view of the sky). 10-20 = Fair (low confidence; indicates a rough estimate of position). >20 = Poor
Horizontal dilution of precision (HDOP)	1.17	Same as PDOP above
Vertical dilution of precision (VDOP)	0.89	Same as PDOP above
System ID	1	GNSS system ID; only output if version is 4.11
Checksum	*15	Hexadecimal value
<CR><LF>	-	End of message termination

NOTE:

An example GPGSA sentence is:
\$GPGSA,A,3,23,21,25,32,18,31,10,,,,,1.47,1.17,0.89,1*15”

GPGSV sentence

These sentences contain the following fields:

Table 7-4—GPGSV sentence

Name or Field	Example	Description
Message ID	\$GPGSV	-
Number of sentences	3	-
Sentence number	1	-
Number of satellites	11	-
Information on first satellite	10, 77, 039, 34	Satellite number, elevation, azimuth, SNR
Satellite number	10	GPS = 1 to 32
Elevation	77	Degrees: 0 to 90 (maximum)
Azimuth	039	Degrees, true: 000 to 359
SNR	34	Signal to Noise Ratio: 00 to 99 dB; null when not tracking
Information on second satellite	32, 62, 307, 30	Satellite number, elevation, azimuth, SNR
Information on third satellite	23, 47, 111, 29	Satellite number, elevation, azimuth, SNR
-	-	-
System ID	0	GNSS system ID; only output if version is 4.11
Checksum	*6B	Hexadecimal value
<CR><LF>		End of message termination

NOTE:

Example GPGSV sentences are:

*\$GPGSV,3,1,11,10,77,039,34,32,62,307,30,23,47,111,29,44,37,225,29,0*6B*
*\$GPGSV,3,2,11,21,24,311,15,25,19,124,18,12,17,086,,02,16,318,,0*63*
*\$GPGSV,3,3,11,24,16,044,,18,10,169,28,31,10,209,40,0*54*

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8—PRODUCT SPECIFICATIONS

Electrical	
Control Power	24 Vdc, + 40/- 20 %, 20 VA (max), Class 2 supply PoE+ (Power over Ethernet), 802.3at-2009, Type 2, 20 W (max)
Ride-through	> 15 seconds (max)
Time Inputs	
Ethernet	10/100Base-TX, RJ-45, STP Protocols: PTP (IEEE 1588-2019), NTP (version 4)
GNSS (GPS)	SMA (female), Bullet Antenna, TNC, 50 ohms, 3.3 V, active
5Vdc Digital Input	5 Vdc, +/-10%, 416-Ohms, 12 mA Protocols: IRIG-B (unmodulated), DCF77
RS-485 Serial	2-wire with common and shield Protocols: IRIG-B, DCF77
Time Outputs	
Ethernet	Protocols: PTP (IEEE-1588 - 2019), NTP (version 4)
5 Vdc Digital Output	5 Vdc, 100 mA (max) Isolation: 1,500 V Protocols: IRIG-B, DCF77, 1per10, PPS
RS-485 Serial	2-wire with common and shield Isolation: 2,500 V Protocols: Arbiter ASCII+QUAL, IRIG-B (unmodulated), DCF77
Clock Accuracy *	< 10 us (PTP, IRIG-B, DCF77) ≤ 100 ns (GNSS)
Clock Holdover *	< 0.5 ms over 24 hr period
Mechanical	
Mounting	Standard 35mm DIN rail (top-hat)
Dimensions	100 mm (H) x 110 mm (D) x 50 mm (W) / 3.93" (H) x 4.33" (D) x 1.96" (W)
Weight	0.36 kg / 0.8 lbs
Environmental	
Operating Temperature	-25 to +70 °C
Storage Temperature	-40 to +80 °C
Humidity Rating	5% to 95% relative humidity (non-condensing) at +40 °C
Altitude Rating	0 to 3000 meters (10,000 feet)
Pollution Degree	Class 2

Regulatory		
	Safety USA	UL listed (NRAQ), CSA C22.2, CE mark (EN/UL 61010-1, EN/UL 61010-2-201)
	Safety Canada	cUL (CSA C22.2, 61010-1, UL 61010-2-201)
	Safety Europe	CE mark (EN 61010-1, EN 61010-2-201)
	Safety International	IEC 61010-2-201:2013
	EMC	EN 61326-1:2020, FCC /ICES-003 – Class A
	Radiated Emmissions	CISPR11, ANSI C63.4-2014 (FCC Part 15 Subpart B, ICES-003 Issue 7)
	Electrostatic Discharge Immunity	EN 61000-4-2:2009
	Radiated Electromagnetic Field Immunity	EN 61000-4-3:2020 + A1:2008 + A2:2010
	Electrical Fast Transient / Burst Immunity	EN 61000-4-4:2004
	Surge Immunity	EN 61000-4-5:2006
	Conducted Radio Frequency Immunity	EN 61000-4-6:2009
	Magnetic Immunity	EN 61000-4-8:2010

9—TROUBLESHOOTING

LCD Error Messages	Possible Cause	Suggested Action(s)
1000	Internal firmware update error	Restart the unit, verify firmware version. Run firmware update. If problem persist, contact customer service
2000	Internal error	Restart the unit; if issue returns contact customer service
6000	Error in initialization	Restart the unit; if issue returns contact customer service
7000	Read error	Restart the unit; if issue returns contact customer service
8000	Write error	Restart the unit; if issue returns contact customer service
65535	All other errors	Restart the unit; if issue returns contact customer service

Error	Possible Cause	Suggested Action(s)
No PTP Time Sync	PTP master clock may need configuration, has lost its time sync, or the PTP master clock is set to a different domain.	<ul style="list-style-type: none"> • Check that the master clock is time synced and set the slave devices to the same domain number. • Ensure the PTP master clock is configured for the Delay Request-Response Default PTP profile. • Confirm managed Ethernet switch(s) are configured to support PTP messaging.
Loss of Time Sync (PTP)	PTP master clock has lost its time sync or has been set to a different domain number.	<ul style="list-style-type: none"> • Confirm the PTP master clock is time sync’ed. • Ensure the PTP master and slave devices have the same domain number.
Loss of Time Sync (NTP)	NTP servers are invalid or unreachable, or the NTP clock has lost its time sync.	<ul style="list-style-type: none"> • Check the “Last Successful NTP Sync” value on the SER’s Time setup web page. A value of ‘---’ indicates the NTP server is unreachable. • Confirm network connectivity to the NTP server. • Ensure the NTP clock is synchronized. • Enter an alternate NTP server IP address. • Restart the SER.
Web Interface Appears Unavailable	<p>Incorrect URL in the address bar.</p> <p>The IP address is unreachable on the network segment, or another device is using the same IP address as the Time Sync Hub.</p>	<ul style="list-style-type: none"> • Verify the device’s IP address by viewing the Network option on the display. • Verify the IP address can be pinged and there is no other device on the network that shares the same IP address. • If another device is using the same IP address, one of the device’s IP addresses must be changed.
5V time input does not work	The proper time input protocol may not be selected.	<ul style="list-style-type: none"> • Confirm the proper time protocol is selected.
Lost / Forgotten User Login Credentials	Personnel change or typing error in entering login credentials.	<ul style="list-style-type: none"> • The Time Sync Hub provides a method for resetting login credentials to factory defaults. Refer to “Section-5”.

Technical Support

If you have questions, we recommend reviewing the Technical Library and FAQs on our website, or contact customer support.

Prior to contacting Trystar (Cyber Sciences) technical support, please be prepared to provide:

- Model number, Serial number, MAC address, Firmware version, Hardware version, Date of manufacturer

This information can be found on the device’s product label, display under “Diagnostics” (“i” icon) or web page.

Providing a detailed description of the issue (screen captures, system log, information from ‘Diagnostics’) can be very helpful.

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TinyXML

Version: 2.6.2

License: Zlib

Copyright: n/a

Link: <https://github.com/csi12345/tinyxml2/blob/master/LICENSE.txt>

JAM STAPL

Version: 2.5

License: Altera

Copyright: Altera Corporation, 101 Innovation Drive, San Jose, CA 95134 and its licensors - Restricted Rights

Link: <https://www.intel.com/content/www/us/en/programmable/support/support-resources/download/licensing/lic-jam.html>

LinuxPTP

Version: 3.1.1

License: GPL v2.0

Copyright: Copyright (C) 1989, 1991 Free Software Foundation, Inc., 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301 USA

Link: <https://github.com/richardcochran/linuxptp/blob/master/COPYING>

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PHP-JWT

Version: 6.4.0

License: BSD-3-Clause

Copyright: Copyright (c) 2011, Neuman Vong

Link: <https://github.com/firebase/php-jwt/blob/main/LICENSE>

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Google Angular

Version: 12.2.18

License: MIT Web developer platform (<https://angular.io/license>)

Copyright: Copyright (c) 2010-2024 Google LLC.

Link: <https://github.com/angular/angular/blob/main/LICENSE>

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Version 2, June 1991

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[This is the first released version of the library GPL. It is numbered 2 because it goes with version 2 of the ordinary GPL.]

Preamble

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For example, if you distribute copies of the library, whether gratis or for a fee, you must give the recipients all the rights that we gave you. You must make sure that they, too, receive or can get the source code. If you link a program with the library, you must provide complete object files to the recipients so that they can relink them with the library, after making changes to the library and recompiling it. And you must show them these terms so they know their rights.

Our method of protecting your rights has two steps: (1) copyright the library, and (2) offer you this license which gives you legal permission to copy, distribute and/or modify the library.

Also, for each distributor's protection, we want to make certain that everyone understands that there is no warranty for this free library. If the library is modified by someone else and passed on, we want its recipients to know that what they have is not the original version, so that any problems introduced by others will not reflect on the original authors' reputations.

Finally, any free program is threatened constantly by software patents. We wish to avoid the danger that companies distributing free software will individually obtain patent licenses, thus in effect transforming the program into proprietary software. To prevent this, we have made it clear that any patent must be licensed for everyone's free use or not licensed at all.

Most GNU software, including some libraries, is covered by the ordinary GNU General Public License, which was designed for utility programs. This license, the GNU Library General Public License, applies to certain designated libraries. This license is quite different from the ordinary one; be sure to read it in full, and don't assume that anything in it is the same as in the ordinary license.

The reason we have a separate public license for some libraries is that they blur the distinction we usually make between modifying or adding to a program and simply using it. Linking a program with a library, without changing the library, is in some sense simply using the library, and is analogous to running a utility program or application program. However, in a textual and legal sense, the linked executable is a combined work, a derivative of the original library, and the ordinary General Public License treats it as such.

Because of this blurred distinction, using the ordinary General Public License for libraries did not effectively promote software sharing, because most developers did not use the libraries. We concluded that weaker conditions might promote sharing better.

However, unrestricted linking of non-free programs would deprive the users of those programs of all benefit from the free status of the libraries themselves. This Library General Public License is intended to permit developers of non-free programs to use free libraries, while preserving your freedom as a user of such programs to change the free libraries that are incorporated in them. (We have not seen how to achieve this as regards changes in header files, but we have achieved it as regards changes in the actual functions of the Library.) The hope is that this will lead to faster development of free libraries.

The precise terms and conditions for copying, distribution and modification follow. Pay close attention to the difference between a “work based on the library” and a “work that uses the library”. The former contains code derived from the library, while the latter only works together with the library.

Note that it is possible for a library to be covered by the ordinary General Public License rather than by this special one.

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A “library” means a collection of software functions and/or data prepared so as to be conveniently linked with application programs (which use some of those functions and data) to form executables.

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“Source code” for a work means the preferred form of the work for making modifications to it. For a library, complete source code means all the source code for all modules it contains, plus any associated interface definition files, plus the scripts used to control compilation and installation of the library.

Activities other than copying, distribution and modification are not covered by this License; they are outside its scope. The act of running a program using the Library is not restricted, and output from such a program is covered only if its contents constitute a work based on the Library (independent of the use of the Library in a tool for writing it). Whether that is true depends on what the Library does and what the program that uses the Library does.

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2. You may modify your copy or copies of the Library or any portion of it, thus forming a work based on the Library, and copy and distribute such modifications or work under the terms of Section 1 above, provided that you also meet all of these conditions:

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- c) You must cause the whole of the work to be licensed at no charge to all third parties under the terms of this License.
- d) If a facility in the modified Library refers to a function or a table of data to be supplied by an application program that uses the facility, other than as an argument passed when the facility is invoked, then you must make a good faith effort to ensure that, in the event an application does not supply such function or table, the facility still operates, and performs whatever part of its purpose remains meaningful.

(For example, a function in a library to compute square roots has a purpose that is entirely well-defined independent of the application. Therefore, Subsection 2d requires that any application-supplied function or table used by this function must be optional: if the application does not supply it, the square root function must still compute square roots.)

These requirements apply to the modified work as a whole. If identifiable sections of that work are not derived from the Library, and can be reasonably considered independent and separate works in themselves, then this License, and its terms, do not apply to those sections when you distribute them as separate works. But when you distribute the same sections as part of a whole which is a work based on the Library, the distribution of the whole must be on the terms of this License, whose permissions for other licensees extend to the entire whole, and thus to each and every part regardless of who wrote it.

Thus, it is not the intent of this section to claim rights or contest your rights to work written entirely by you; rather, the intent is to exercise the right to control the distribution of derivative or collective works based on the Library.

In addition, mere aggregation of another work not based on the Library with the Library (or with a work based on the Library) on a volume of a storage or distribution medium does not bring the other work under the scope of this License.

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Once this change is made in a given copy, it is irreversible for that copy, so the ordinary GNU General Public License applies to all subsequent copies and derivative works made from that copy.

This option is useful when you wish to copy part of the code of the Library into a program that is not a library.

4. You may copy and distribute the Library (or a portion or derivative of it, under Section 2) in object code or executable form under the terms of Sections 1 and 2 above provided that you accompany it with the complete corresponding machine-readable source code, which must be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange.

If distribution of object code is made by offering access to copy from a designated place, then offering equivalent access to copy the source code from the same place satisfies the requirement to distribute the source code, even though third parties are not compelled to copy the source along with the object code.

5. A program that contains no derivative of any portion of the Library, but is designed to work with the Library by being compiled or linked with it, is called a “work that uses the Library”. Such a work, in isolation, is not a derivative work of the Library, and therefore falls outside the scope of this License.

However, linking a “work that uses the Library” with the Library creates an executable that is a derivative of the Library (because it contains portions of the Library), rather than a “work that uses the library”. The executable is therefore covered by this License. Section 6 states terms for distribution of such executables.

When a “work that uses the Library” uses material from a header file that is part of the Library, the object code for the work may be a derivative work of the Library even though the source code is not. Whether this is true is especially significant if the work can be linked without the Library, or if the work is itself a library. The threshold for this to be true is not precisely defined by law.

If such an object file uses only numerical parameters, data structure layouts and accessors, and small macros and small inline functions (ten lines or less in length), then the use of the object file is unrestricted, regardless of whether it is legally a derivative work. (Executables containing this object code plus portions of the Library will still fall under Section 6.)

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You must give prominent notice with each copy of the work that the Library is used in it and that the Library and its use are covered by this License. You must supply a copy of this License. If the work during execution displays copyright notices, you must include the copyright notice for the Library among them, as well as a reference directing the user to the copy of this License. Also, you must do one of these things:

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- b) Accompany the work with a written offer, valid for at least three years, to give the same user the materials specified in sub section 6a, above, for a charge no more than the cost of performing this distribution.
- c) If distribution of the work is made by offering access to copy from a designated place, offer equivalent access to copy the above specified materials from the same place.
- d) Verify that the user has already received a copy of these materials or that you have already sent this user a copy.

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It may happen that this requirement contradicts the license restrictions of other proprietary libraries that do not normally accompany the operating system. Such a contradiction means you cannot use both them and the Library together in an executable that you distribute.

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