



Electronic & Programming Systems

TSMC 400

Time
Synchronised
Measurement
&
Control Unit
User Manual

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List of Abbreviations

In this document, the following abbreviations are used:

Abbreviation	Description
WAMS	Wide Area Monitoring System
WAMPAC	Wide Area Monitoring, Protection and Control
PMU	Phasor Measurement Unit
PDC	Phasor Data Concentrator
DHCP	Dynamic Host Configuration Protocol)
GPS	Global Positioning System
IRIG	Inter-range instrumentation group timecodes
PTP	Precision Time Protocol
IED	Intelligent electronic Device
FCDA	Functional Constraint Data Attribute
GOOSE	Generic Object-Oriented Substation Events

Safety instructions

Safety symbols and messages

Read these instructions carefully and look at the device to become familiar with it before its installation, operation, service or maintenance. The following special messages may appear throughout this document or on a device to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.



Risk of electrical shock

The risk of electrical shock symbol indicates the presence of an electrical hazard, which could result in electrical shock and personal injury if the instructions are not followed.



Safety alert

The safety alert symbol indicates the presence of a hazard, which could result in personal injury. Obey all safety messages that follow this symbol to avoid possible injury or death.

Safety messages



WARNING indicates a potentially hazardous situation, which, if not avoided, can result in death or serious injury.



CAUTION indicates a potentially hazardous situation, which, if not avoided, can result in minor or moderate injury.

Important notes

Restricted liability

Electrical equipment should be serviced and maintained only by qualified personnel. No responsibility is assumed by ELPROS for any consequences arising out of the use of this manual. This document is not intended as an instruction manual for untrained persons.

Device operation

The user is responsible for checking that the rated characteristics of the device are suitable for its application. The user is responsible for reading and following the device's operating and installation instructions before attempting to commission or maintain it. Failure to follow these instructions can affect device operation and constitute a hazard for people and property.

Protective earthing

The user is responsible for compliance with all the existing international and national electrical codes concerning protective earthing of any device.

Description

This document describes the guidelines of the installation and connection of the Time Synchronized Measurement and Control unit (TSMC) series 400.

Reasonable effort was made to verify that all contents were accurate as of the time of publication. Check out our official website (<http://elpros.si>) for any revisions or updates made since the original date of publication.

The ELPROS Time Synchronized Measurement & Control unit (TSMC) is a multifunctional metering and control electronic device. TSMC device can be used for measuring synchrophasor data (currents, voltages, symmetrical components and frequency information), waveform voltage and current data and digital statuses from power systems. High sampling data rate enables following fast dynamical phenomena on all voltage levels.

ELPROS TSMC unit is optimal solution for different types of the implementation on all levels of the power system from generation, transmission to the distribution also in combination with modern trends as renewable sources, battery storages, charging station and digital substations.

Integration with higher level monitoring and control systems WAMS/WAMPAC (Wide Area Monitoring System / Wide Area Monitoring Protection and Control) as ELPROS WAProtector™ system offers complete technical platform for complex solutions on regional and wide area level.

1 Introduction

The TSMC 400 Web user interface described in this document refers to signal and module names of the physical device. The reference picture of TSCM 400 panel and connector overview is given in Figure 1.

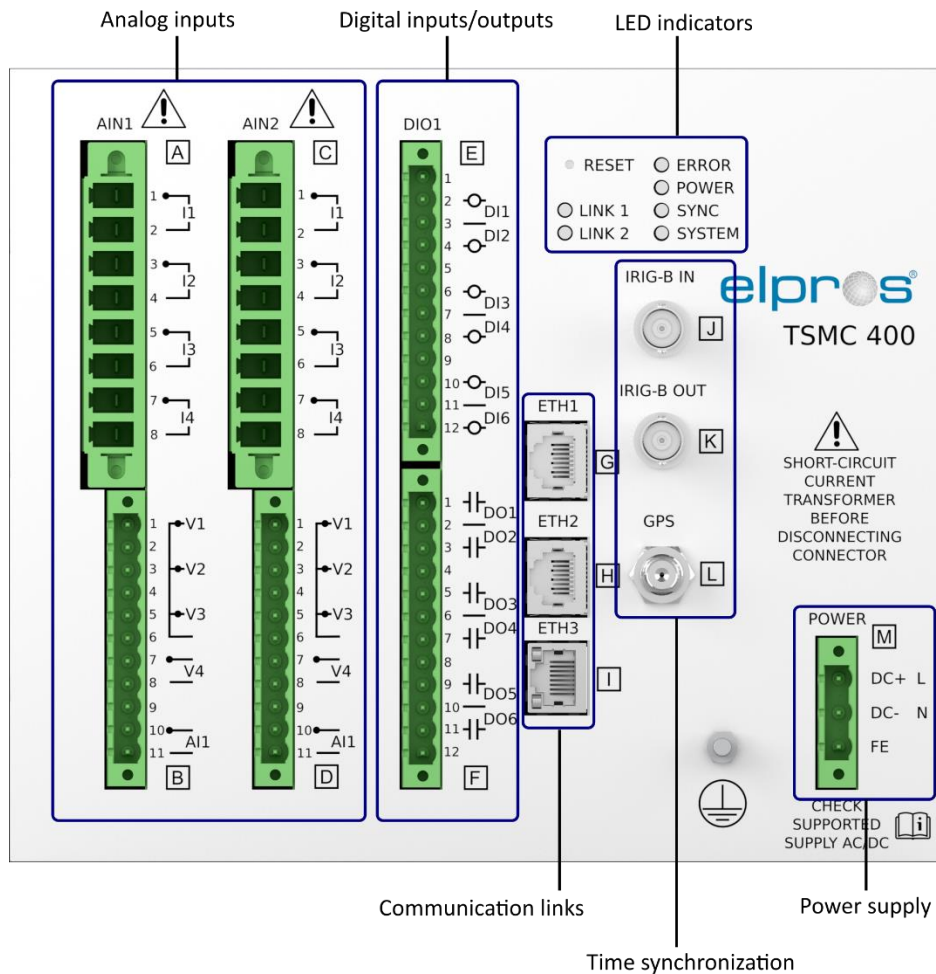


Figure 1: TSCM 400 connectors

2 Web interface overview

Please read this chapter to get an overview and interaction details of the Web interface.

The Web interface is accessible through the Main Ethernet (ETH1, ETH2) ports or the Service (ETH3). The Service Ethernet port has a static preconfigured IP address that cannot be changed:

- Address: 192.168.255.10
- Network mask: 255.255.255.0

The network configuration of the Main Ethernet ports can be changed using the Web interface.

The Web interface is accessed through an internet browser.

1. Connect your PC via an Ethernet cable to the TSMC400 Service (ETH3) port.
2. Configure your PCs Ethernet port:
 - Network address 192.168.255.x, x can be any valid address number except 10.
 - Network mask 255.255.255.0
3. Using an internet browser navigate to the Web interfaces by entering the service port IP address in the navigation bar.

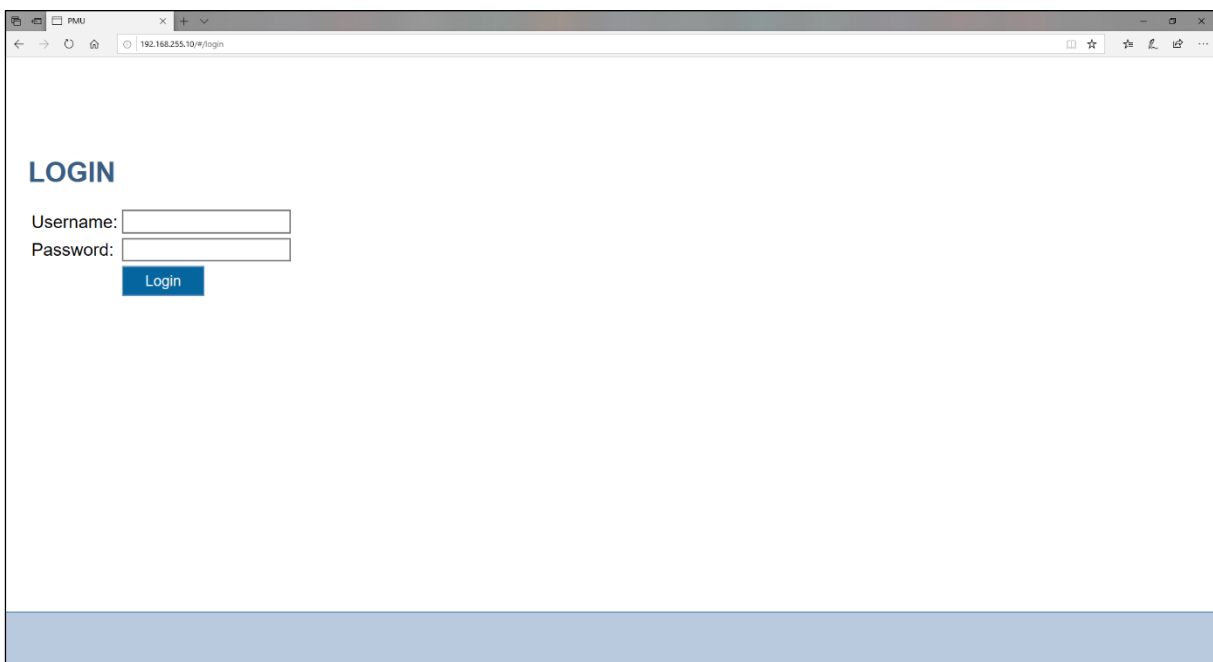


Figure 2: Internet browser navigation to Web interface

2.1 User account and login

There are three available user accounts with different privileges:

User Account	Allowed actions		
	View device status	Change configuration	Perform firmware update
Admin	x	x	x
Config	x	x	
Monitor	x		

Default password for all user accounts is “pass”. It is highly encouraged to change the default password for all three user accounts.

Clicking on the "Username" field will open a drop-down menu where available usernames can be selected from the list.

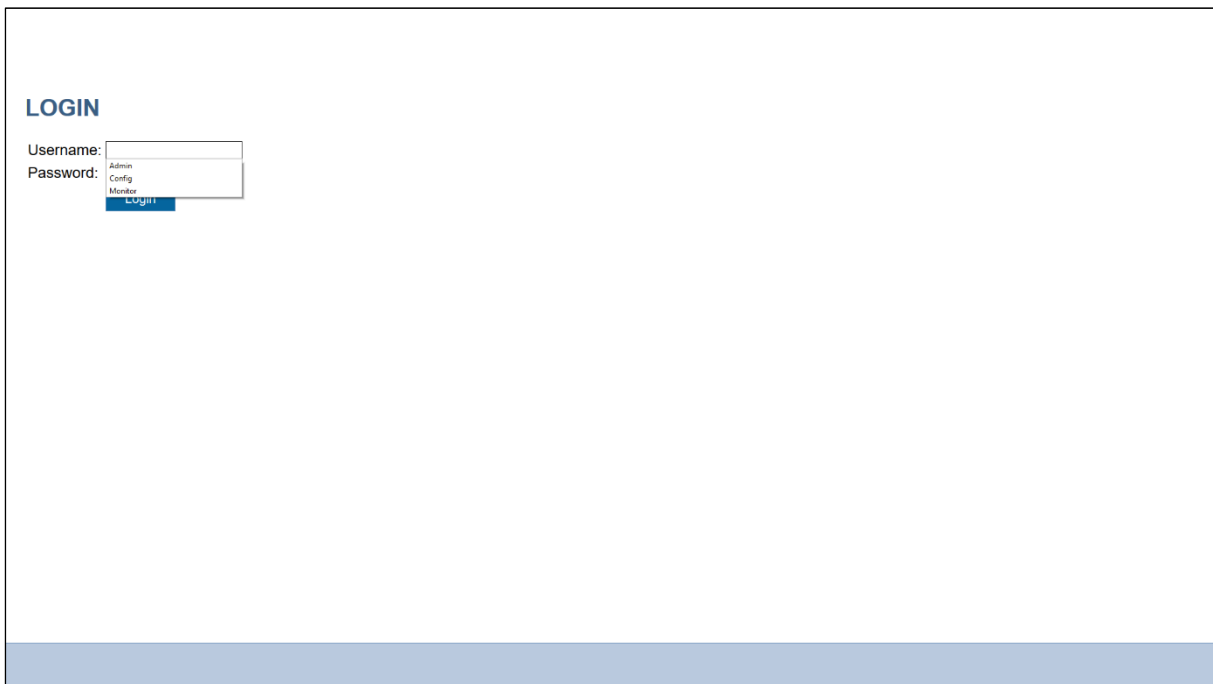


Figure 3: Login screen

2.2 Web interface layout

After login the Web interface is displayed as shown in Figure 4. It contains the following elements:

- Side menu, where different sections of the status and configuration pages can be accessed.
- Status bar, displaying a summary of a device operation status. The physical LED indicators from the devices front panel are mirrored here:
 - **Device:** Type of the device.
 - **Version:** Hardware and software version of the device.
 - **Name:** A name which is user configurable (*System->Device info* menu).

- **Location:** Location of the device which is user configurable (*System->Device info* menu).
- **User:** Current logged in user.
- **Time:** Current time and date (ISO 8601).
- **Power Indicator:**
 - **Green:** Internal power bus and external power supply are at acceptable levels.
 - **Grey:** Internal power bus or external power supply level is too low.
- **Error Indicator:**
 - **Grey:** No error.
 - **Red:** A non-recoverable error occurred.
- **Sync indicator:**
 - **Grey:** No external synchronization source detected.
 - **Green blinking:** External synchronization source available, but not synchronised yet.
 - **Solid green:** Device synchronized to external source.
- **System indicator:**
 - **Green:** 1 per second blink: Device running.
- Device status page displaying current CPU load, device time synchronization, measurement state (running means that measurements are available for sending by IEEE C37.118 protocol) and Current network configuration.

If a user wants to change the user role or logout, click-on the “Logout” button on lower right corner.

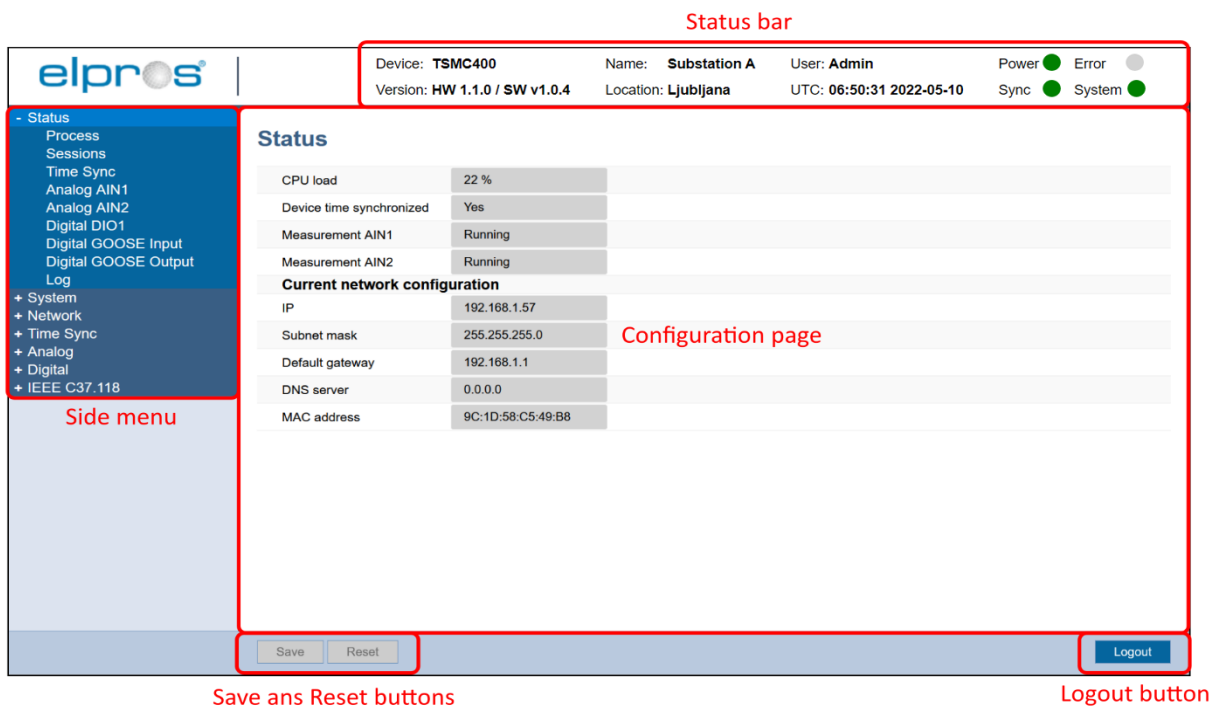


Figure 4: Web interface layout

2.3 Applying configuration

When changing configuration on any page the changed field is marked with bold text and different colour. See an example in Figure 5 where “IP” field was changed.

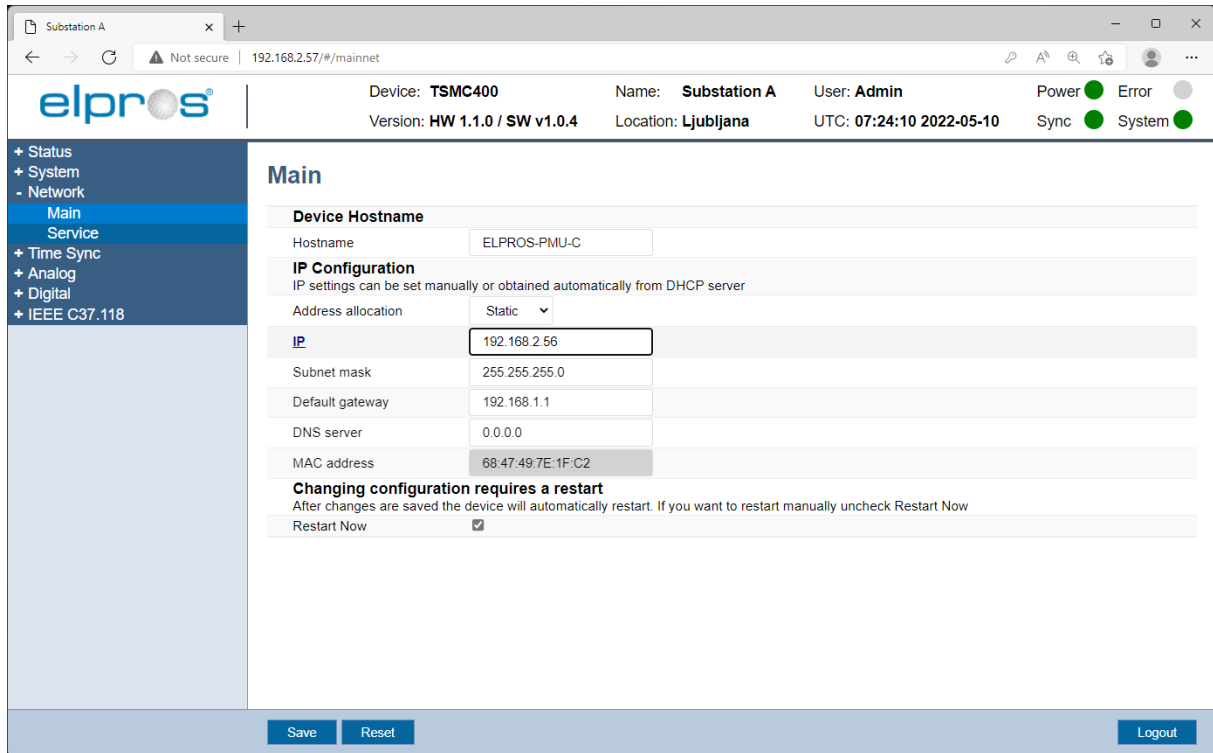


Figure 5: Changing settings

To apply the configuration setting click-on the “Save” button. To revert the changes, click-on “Reset” button.

Pop-up window warning is displayed if the configuration page is switched and there are unapplied changes on the current page as shown in Figure 6.

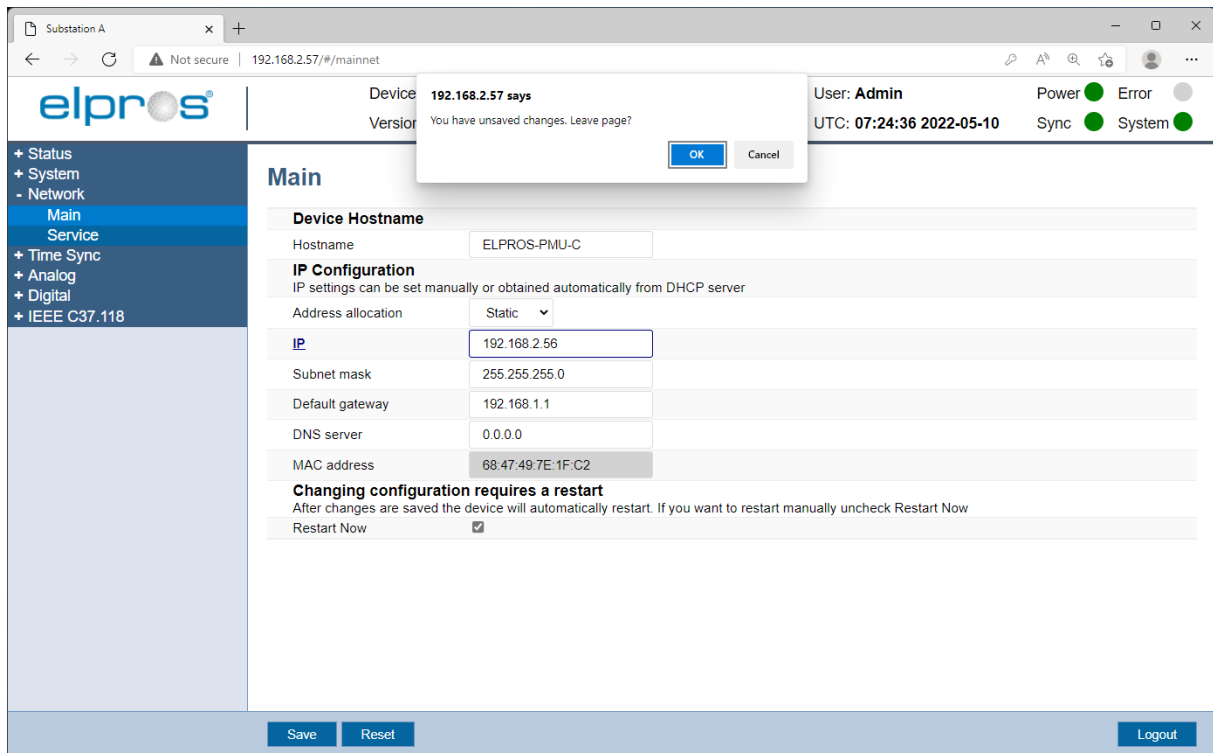


Figure 6: Unsaved changes warning

3 Device configuration

Device can be configured using the configuration pages selected in the side menu.



When the device configuration is finished the device should be restarted.

3.1 Communication interface configuration

Select the "Network" from the side menu for configuration of Network settings.

Configuration of the network settings requires Admin or Config user profile.

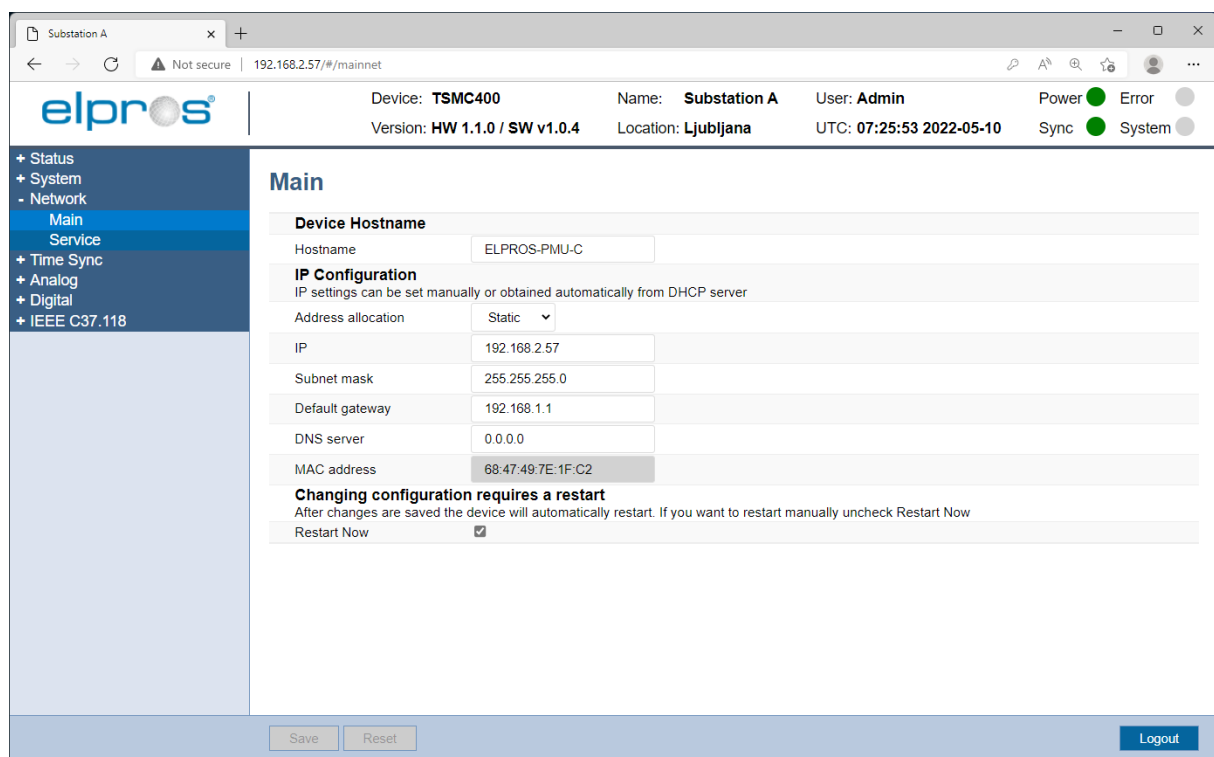


Figure 7: Main communication interface configuration

3.1.1 Main communication interface (ETH1, ETH2) configuration

Main communication network interface of the device can be configured on the *Network->Main* page:


- **Hostname:** Device hostname reported to DHCP (Dynamic Host Configuration Protocol) server if Address Allocation is set to DHCP.
- **Address Allocation:** Type of address allocation:
 - **DHCP:** IP address, default gateway and DNS server allocated by a network DHCP server. Settings received from DHCP Server are displayed in the settings fields and cannot be changed.
 - **Static:** IP address, default gateway and DNS server set manually.
- **IP:** Device static IP.
- **Subnet Mask:** Network subnet mask.
- **Default Gateway:** Network gateway IP.

- **DNS Server:** DNS server IP.
- **MAC address:** network adapter hardware address.

The IP, Subnet Mask, Default Gateway and DNS Server can be entered in decimal dot notation: aaa.bbb.ccc.ddd.

The IP, Subnet Mask, Default Gateway and DNS Server are displayed in decimal dot 10 notation.

If Address Allocation is selected as DHCP, fields: IP, Subnet Mask, Default Gateway and DNS Server display the settings received from the DHCP server.



CAUTION: When configuring an IP address make sure that it is a different subnet then the service port subnet (see 3.1.2). If the subnets are the same the service port will not function.

After the configuration is applied a device restart is required for the configuration to take effect. If the "Restart Now" checkbox is checked after saving the configuration, the device will restart automatically.

The default IP configuration is:

- **IP:** 192.168.1.50
- **Subnet Mask:** 255.255.255.0

3.1.2 Service communication interface ETH3

Information related to the service port can be viewed on *Network->Service* page, see Figure 8. The service port configuration is fixed and cannot be changed. The IP configuration is:

- **IP:** 192.168.255.10
- **Subnet Mask:** 255.255.255.0

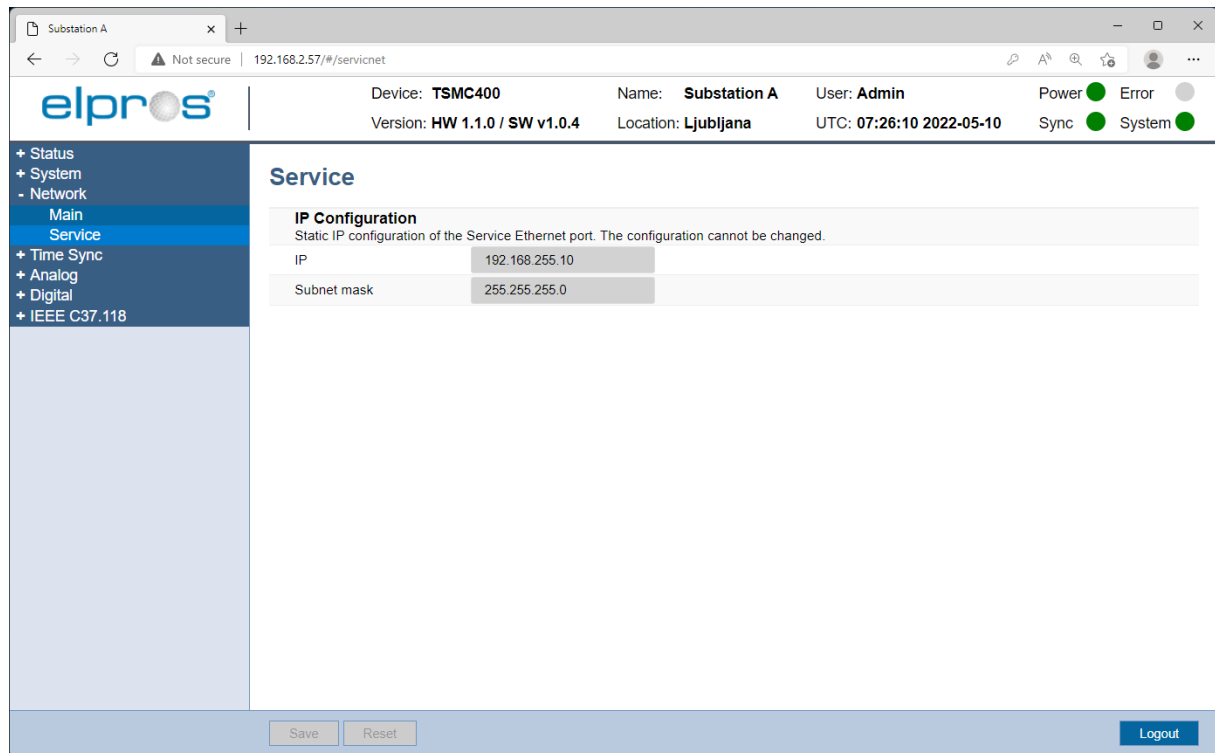


Figure 8: Service Ethernet port configuration

3.2 System configuration

Admin and Config users have access to the System settings. Only the Admin user has access to the Firmware, Configuration and Passwords sub-menu.

For system configuration options navigate to *System* menu:

- Nominal frequency
- Device info
- Configuration (Factory setting)
- Passwords
- Restart
- Firmware

3.2.1 Nominal frequency

The configuration of the power system frequency can be configured on the *System->Nominal frequency* page. Options are:

- 50 Hz,
- 60 Hz.

After the configuration of this setting the restart of a device is required for the configuration to be in effect. If the "Restart Now" checkbox is left checked, after saving the configuration the device will restart automatically.

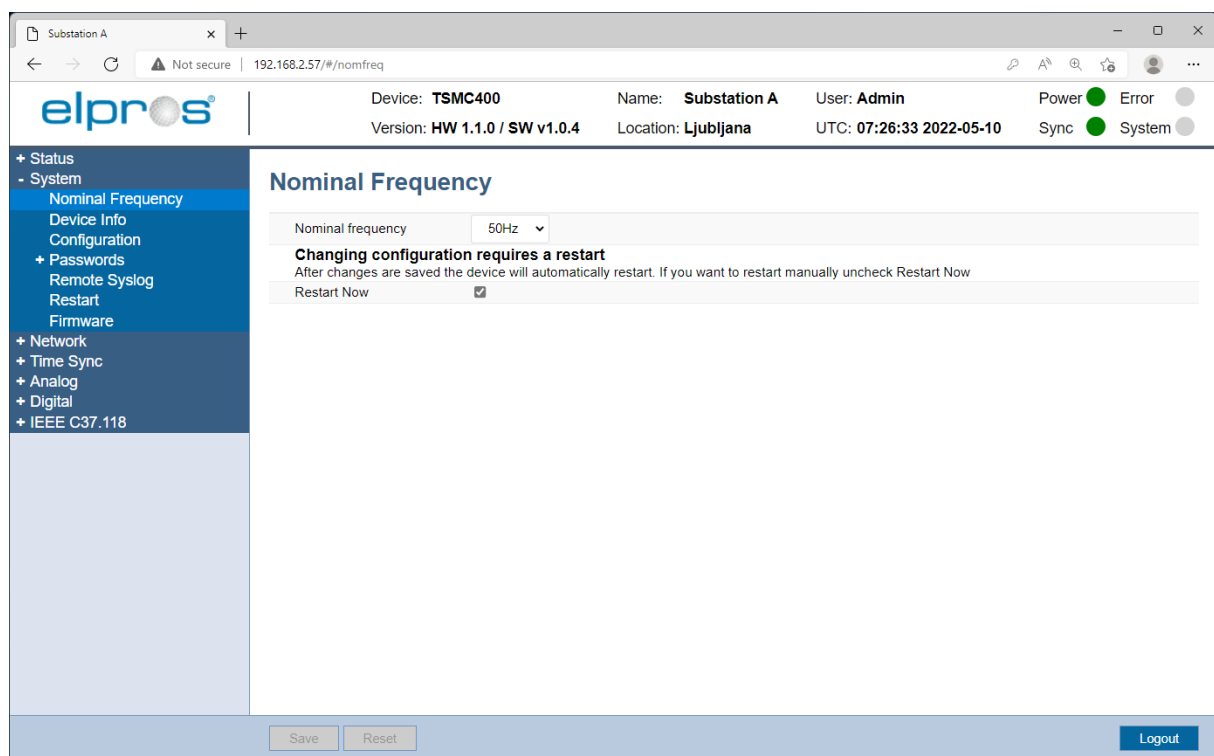


Figure 9: Nominal grid frequency configuration

3.2.2 Device info

The basic device information can be entered on the *System->Device info* page, see Figure 10. This page contains description provided for user's convenience. The names entered here are displayed in the status bar under Name and Location and in C37.118 Header frame:

- **Device Name:** Displayed in status bar under Name

- **Device Location:** Displayed in status bar under Location

The “Read only” section displays the hardware version and the serial number.

The “GPS location” section contains:

- **Device Lat:** Location latitude
- **Device Lon:** Location longitude
- **Device Altitude:** Location altitude

These are device location parameters are used in C37.118 CFG-3 frame. Parameters can be configured manually or can be obtained with GPS receiver data automatically by selecting “Set to GPS location” checkbox if GPS module is assembled with device. Read-only fields “GPS Lat”, “GPS Lon”, “GPS Altitude” show current GPS receiver location.

Device Info	
User Configurable	
Device name	Substation A
Device location	Ljubljana
GPS location	
Device Lat	46.07799
Device Lon	14.50123
Device Altitude	380.07500
Set to GPS location	<input type="checkbox"/>
GPS Lat	46.0779949
GPS Lon	14.5012314
GPS Altitude	380.1
Read only	
Hardware version	1.1.0
Serial number	1002210645

Figure 10: Device information

3.2.3 Configuration

Device configuration can be returned to its factory state on the *System->Configuration* page, see Figure 11. Passwords and network configuration will be preserved.

After checking the "Factory configuration" checkbox and clicking-on the "Save" button another conformation check box will be displayed, see Figure 12. To finish reset to factory configuration the conformation checkbox needs to be checked and the "Save" button clicked-on. After this the device will restore factory configuration and perform a restart.

To return all configuration including passwords and network configuration to its factory settings the physical "RESET" button (see Figure 1) on the device shall be used:

1. Press the RESET button on the device and hold it pressed, the device will reset.
2. Hold the RESET button at least for 10 seconds or until the SYSTEM LED indicator starts blinking.
3. The device was reset to the factory configuration and perform a restart.



CAUTION: This will revert all configuration including the network interface to its factory configuration. The device can become remotely inaccessible when this action is performed.

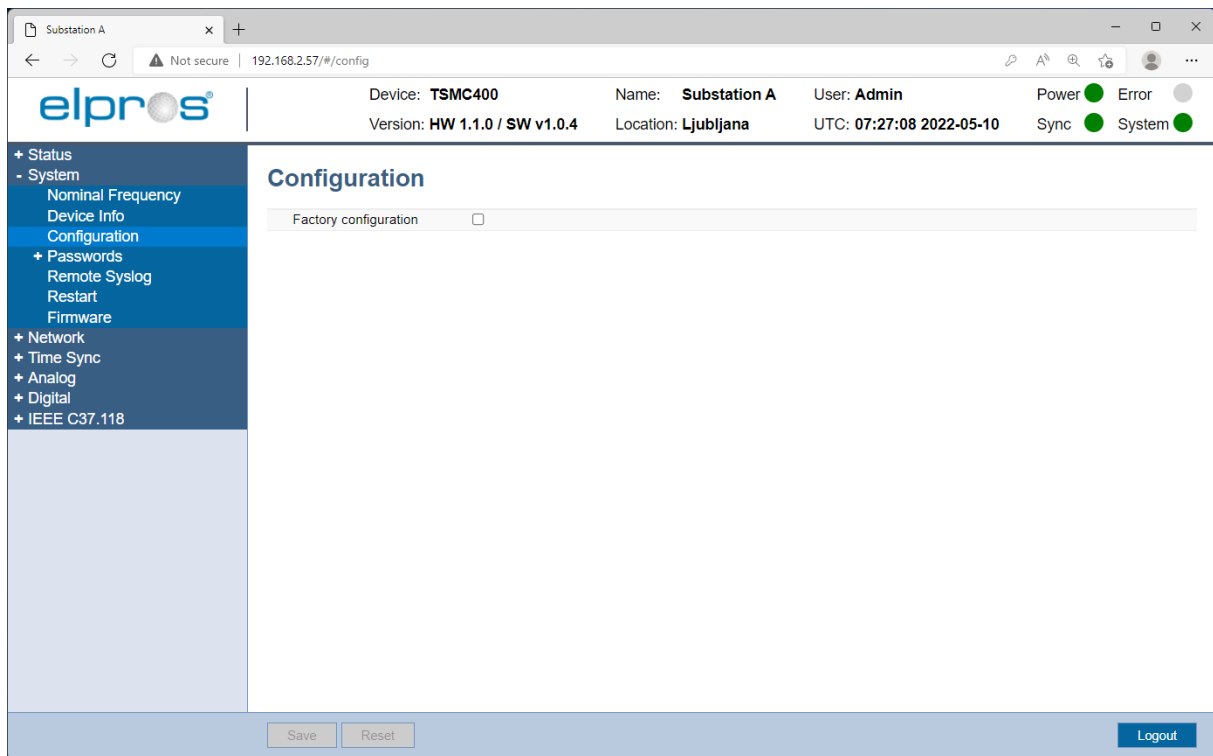


Figure 11: Configuration reset to factory configuration

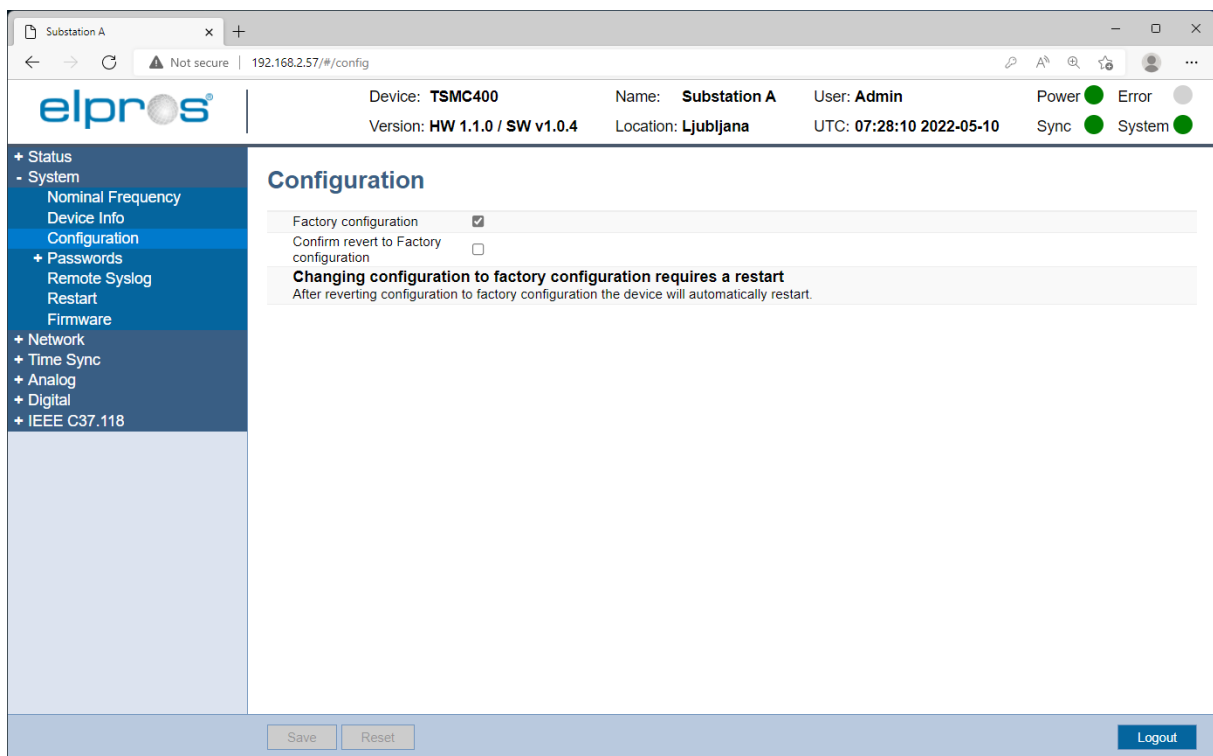


Figure 12: Confirm revert to factory configuration.

3.2.4 Passwords

User passwords can be changed on the *System->Passwords* page, see Figure 13:

- Admin password
- Config password
- Monitor password

Passwords can only be changed by the Admin user.

3.2.4.1 Admin password

To change the Admin user password, navigate to *System->Passwords->Admin password* page, see Figure 13:

1. Enter current Admin password.
2. Enter new Admin password.
3. Repeat Admin user password.
4. Click-on the save button.
5. You will be automatically logged out.

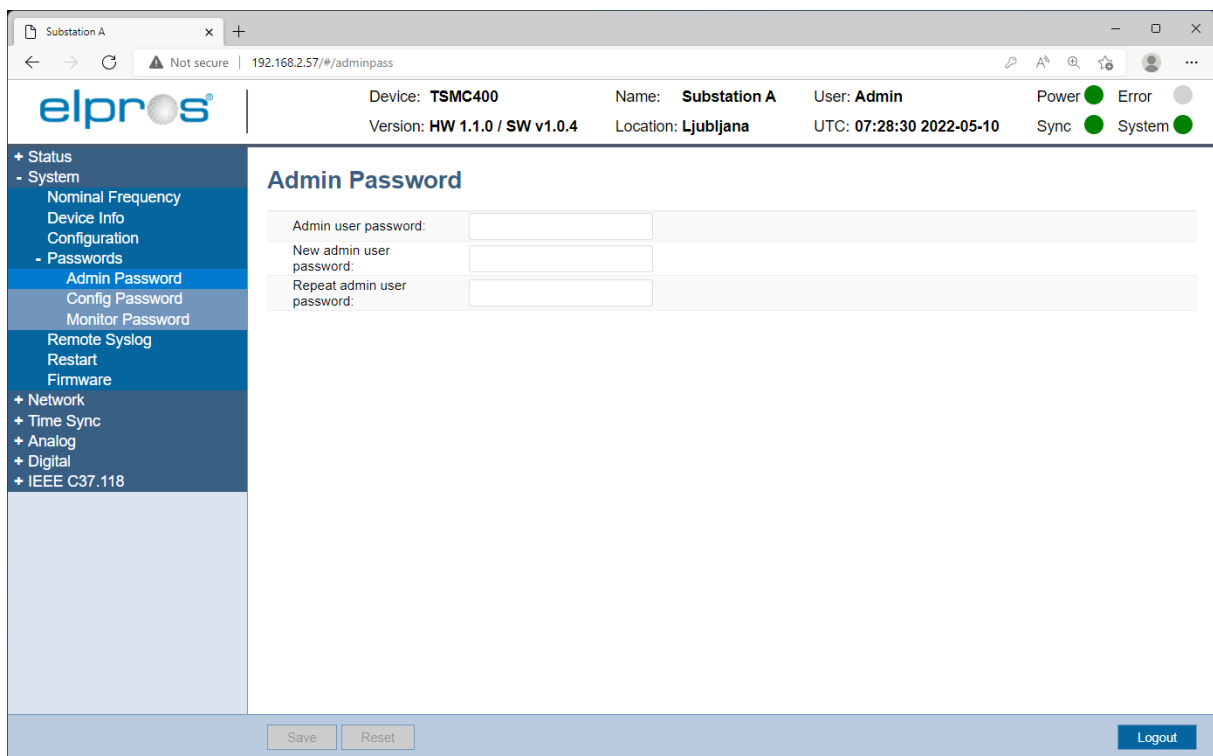


Figure 13: Admin password change page

3.2.4.2 Config password

To change the Config user password, navigate to *System->Passwords->Config password* page, see Figure 14:

1. Enter current Admin password.
2. Enter new Config password.
3. Repeat Config user password.
4. Click-on the save button.

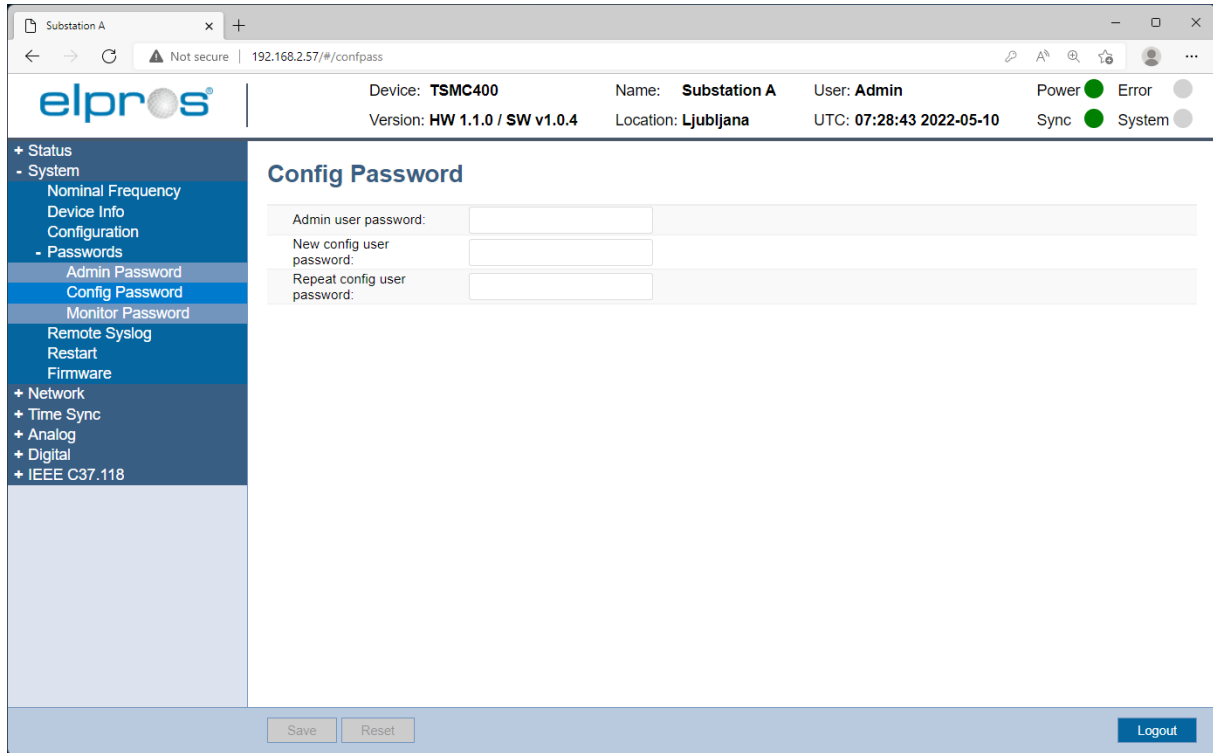


Figure 14: Config password change page

3.2.4.3 Monitor password

To change the Monitor user password, navigate to *System->Passwords->Monitor password* page, see Figure 15:

1. Admin password: Enter current Admin password.
2. New Monitor password: Enter new Monitor password.
3. Repeat Monitor user password: Repeat Monitor user password.
4. Click-on the save button.

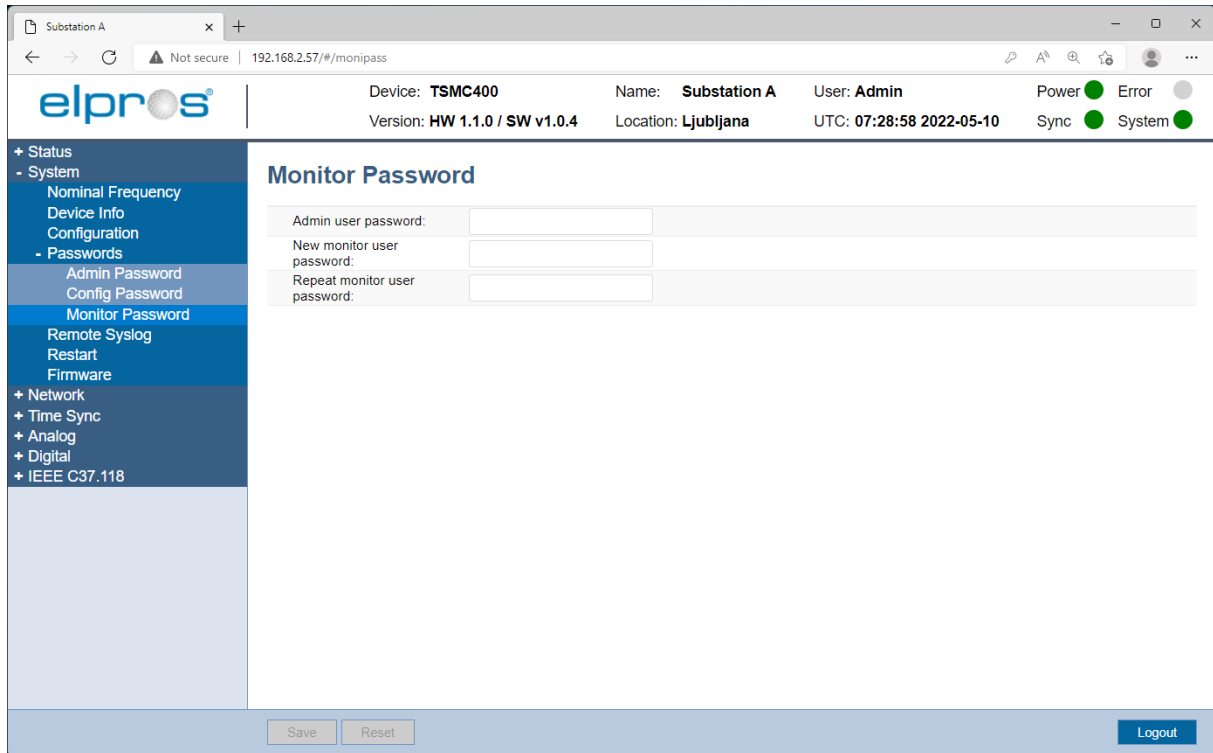


Figure 15: Monitor password change page

3.2.5 Remote Syslog

The device supports sending of System log (Syslog) messages to remote Syslog server according to RFC 5424 Syslog protocol. Syslog messages are sent to server on port 514 with transport layer protocol UDP. The purpose of Syslog is to monitor:

- Changes in device configuration
- Device restart
- User login
- Time synchronisation

Systems logs can be observed on the device in “status-> Log” (see chapter 4.9).

Configuration parameters are:

- **Enable remote Syslog sending:** Enables sending log messages to Syslog server on configured IP.
- **Syslog server IP:** Remote Syslog server IP.

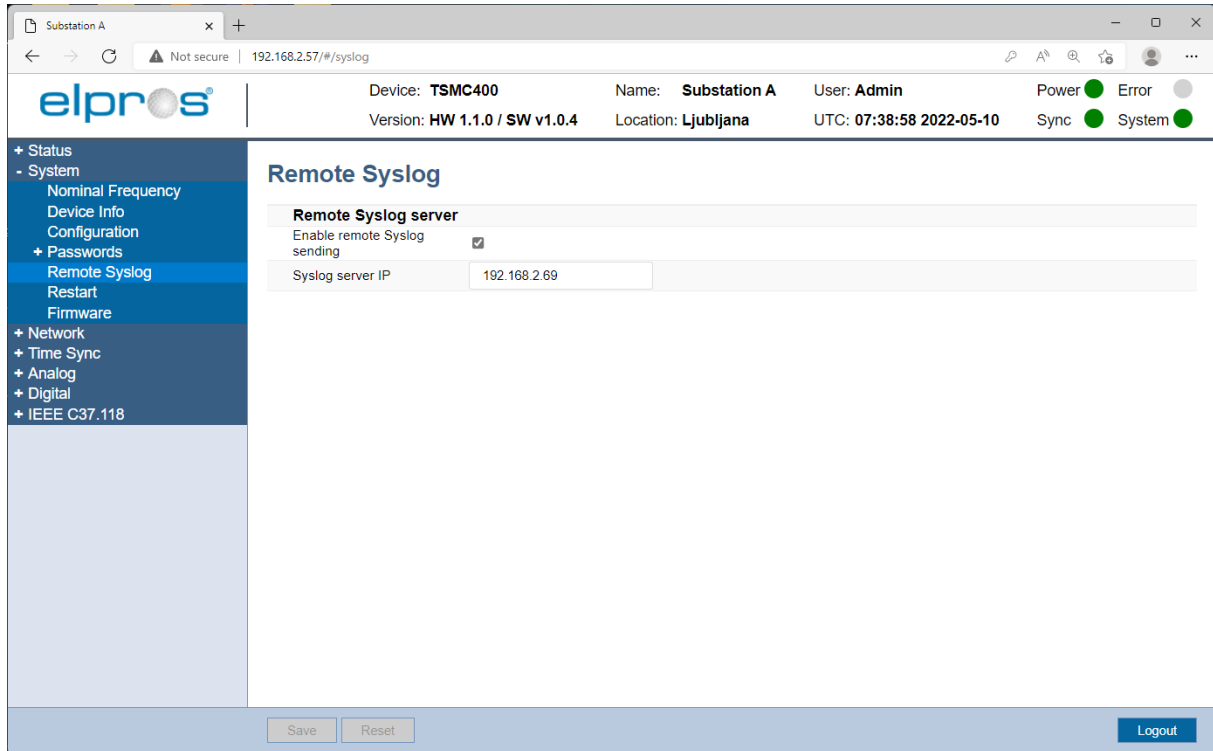


Figure 16: Remote Syslog server configuration

3.2.6 Restart

A device restart can be performed with a command on the *System->Restart* page, see Figure 17.

To restart the device:

1. Mark the Restart box.
2. Click-on the save button.

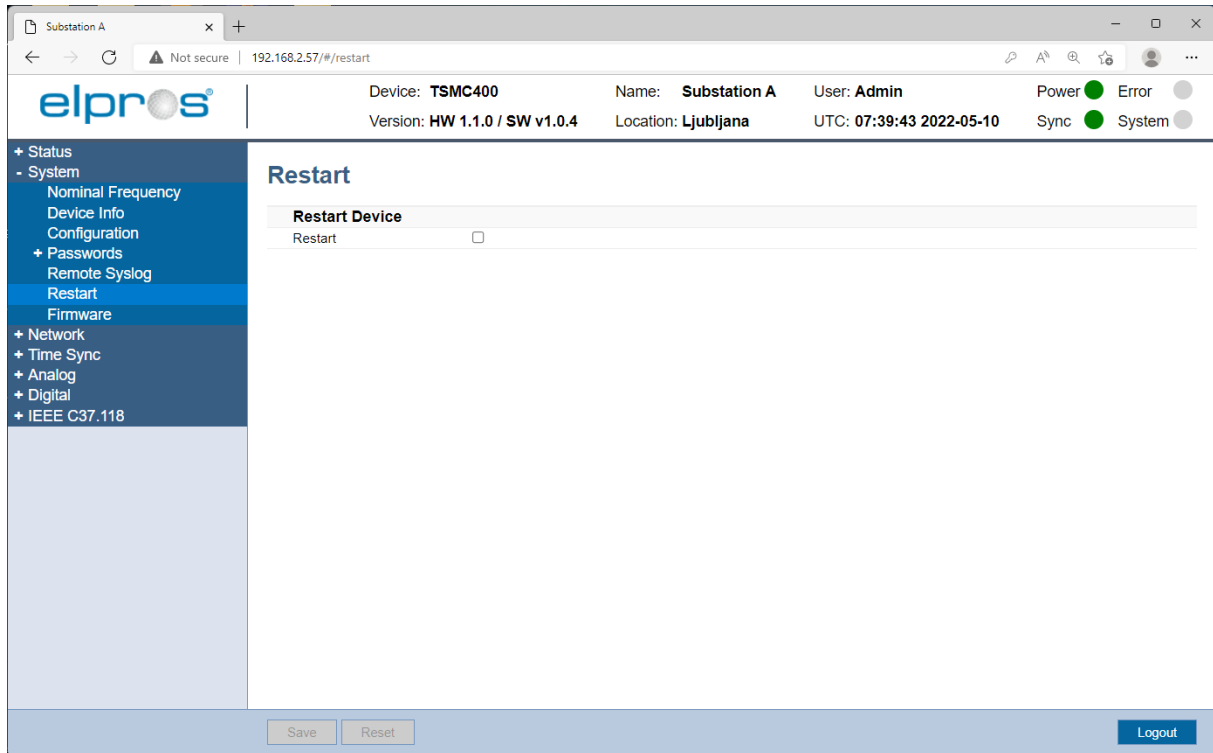


Figure 17: Device restart page

3.3 Firmware update

This section describes the process of updating TSMC400 firmware to a newer version.

Firmware sub-menu is accessible only to Admin user.



CAUTION: Be advised that to complete the update procedure the device will restart at the last action of the procedure.

Follow the next steps to upload new firmware and to complete the installation:

When new firmware version is available ELPROS support will contact you by email with available link for download.

1. Download the firmware version.
2. From the Web user interface, use the navigation menu on the left to access the firmware update section (*System->Firmware*), see Figure 18. This page also includes the information about the current firmware version.

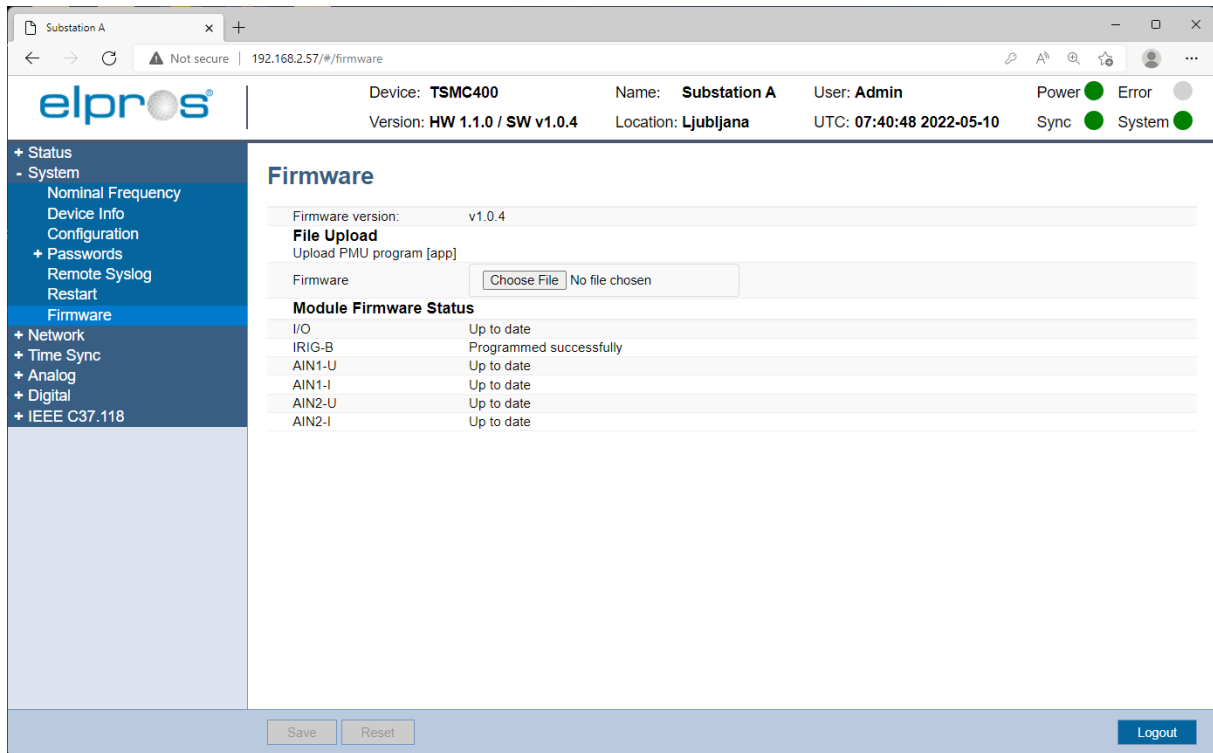


Figure 18: Firmware update page

3. Before updating the firmware, make sure that both the PC and TSCM 400 are correctly connected to the power supply and that there is no risk of disconnection during the process.
4. Click-on the “Browse” button in the “Firmware” section and navigate to your local folder where the downloaded firmware version is stored (TSMC400 firmware filename is “app” without file name extension), see Figure 19.

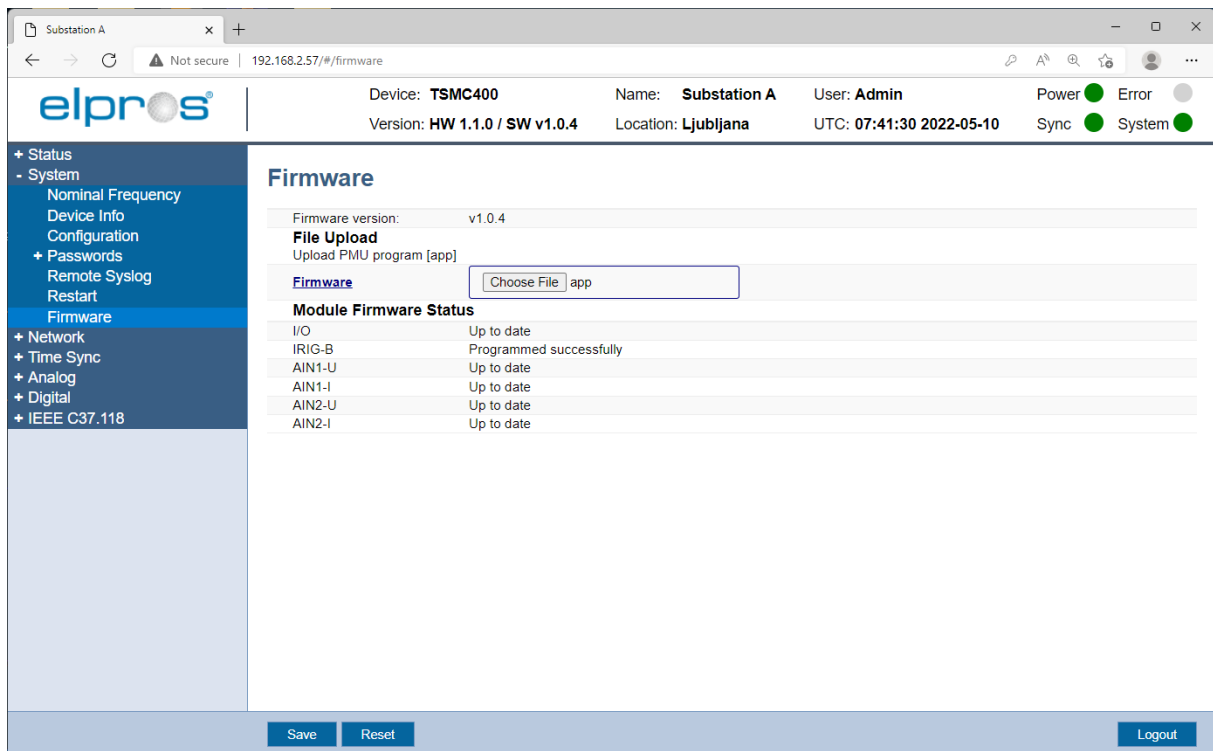


Figure 19: Select firmware to upload

- Click-on the "Save" button to upload the selected firmware.

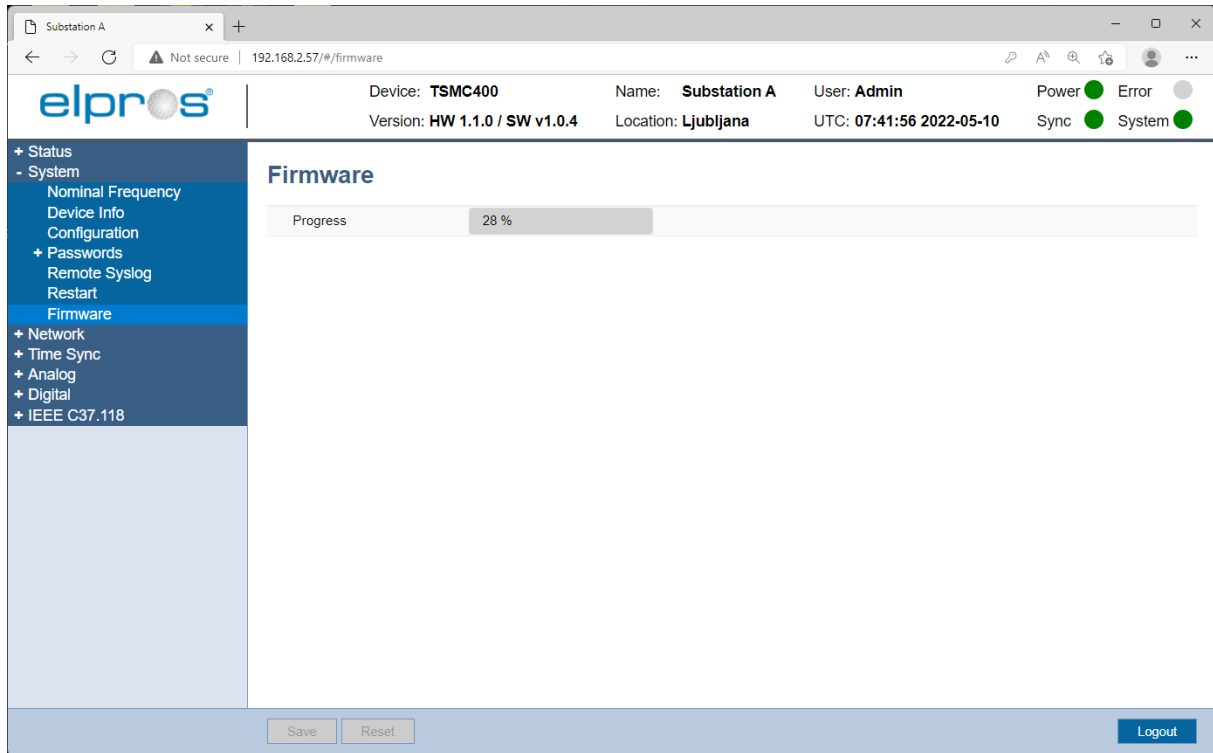
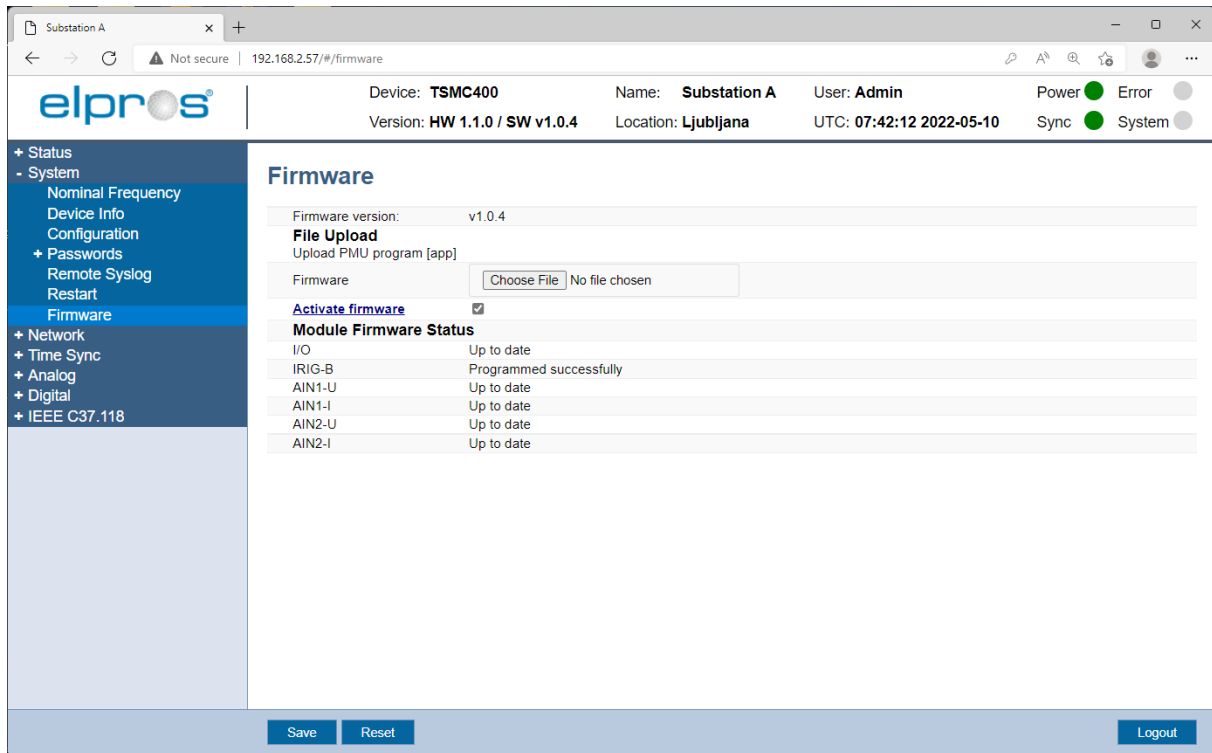


Figure 20: Firmware being uploaded

- When the upload completes an "Activate Firmware" check box will appear as shown in Figure 21. To complete the update procedure, check the "Activate Firmware" check box and click "Save". The device will restart with the new firmware.
- After the restart the device will check all the internal module firmware. If a module needs firmware update this will be done automatically. The status of the module firmware can be checked in the "Module Firmware status" section of the page.



Substation A

Device: **TSMC400** Name: **Substation A** User: **Admin** Power Error
 Version: **HW 1.1.0 / SW v1.0.4** Location: **Ljubljana** UTC: **07:42:12 2022-05-10** Sync System

Firmware

Firmware version: v1.0.4

File Upload
 Upload PMU program [app]

Firmware No file chosen

Activate firmware

Module Firmware Status

I/O	Up to date
IRIG-B	Programmed successfully
AIN1-U	Up to date
AIN1-I	Up to date
AIN2-U	Up to date
AIN2-I	Up to date

Save Reset Logout

Figure 21: Activate the uploaded firmware

3.4 Time synchronization configuration

This section describes the configuration of the time synchronization sources.

When multiple time synchronization sources are connected to the TSMC 400 one can be used as the "Main" time source and the others as "Back-up".

This means that if the "Main" time source becomes unavailable the "Back-up" time sources will be selected. The source selection priority is as follows; higher number is higher priority:

1. Main clock source
2. Back-up clock source 1
3. Back-up clock source 2

The "Main" and "Back-up" clock sources can be configured on the *Time Sync* page, see Figure 22.

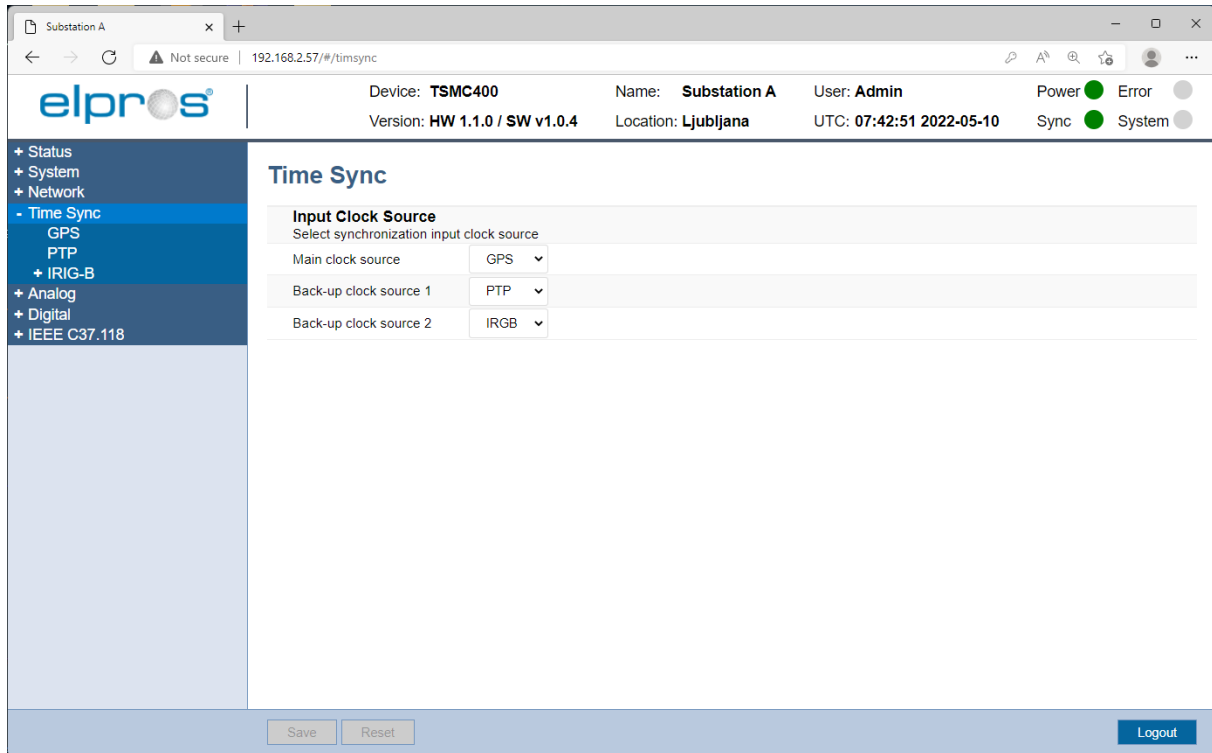


Figure 22: Time synchronization source configuration

The clock source options are:

- **Main clock source:** Options: GPS, IRIG-B, PTP.
- **Back-up clock source 1:** Options: GPS, IRIG-B, PTP.
- **Back-up clock source 2:** Options: GPS, IRIG-B, PTP.

All clock sources ("Main", "Back-up 1" and "Back-up 2") can be configured to the same interface. This will cause the device to only use that clock source i.e., GPS regardless of other available clock sources.

GPS status page (see Figure 23) and PTP status page (see Figure 24) contain additional information and the status. These pages are informative nature and they don't require any configuration.

When GPS is the Main clock source it may take up to 13 minutes for the device to synchronize its time from restart or cold start. This is because the GPS receiver may need to receive a new almanac from the satellite constellation if it detects that the stored almanac is not valid anymore. It takes 12.5 minutes for the satellite constellation to transmit the full almanac. Almanac consists of satellite constellation data, status and information to relate GPS derived time to Coordinated Universal Time (UTC).

3.4.1 GPS status

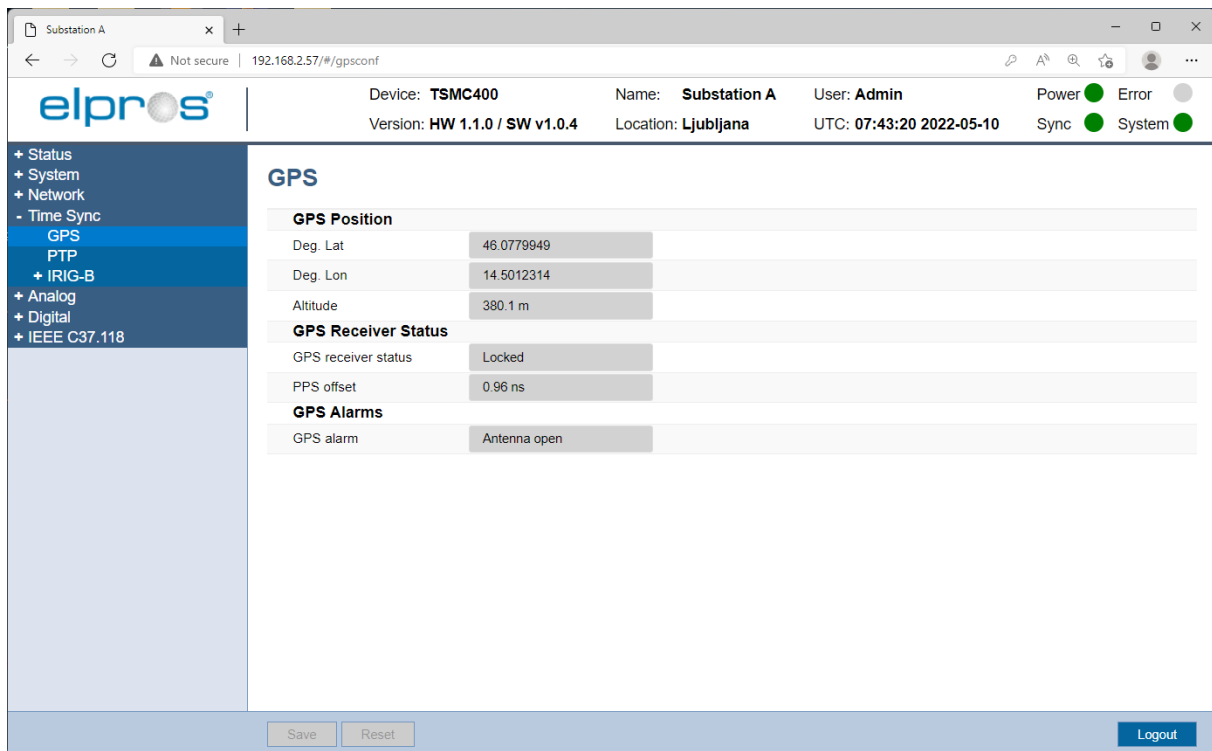
A detailed GPS status can be accessed from *Time Sync->GPS* page, see Figure 23.

Information related to the GPS position:

- **Deg. Lat:** Latitude measured by the GPS receiver.
- **Deg. Lon:** Longitude measured by the GPS receiver.
- **Altitude:** Altitude measured by the GPS receiver.

Information related to the GPS receiver status: Status of the GPS receiver:

- **Locked:** GPS receiver is locked.
- **Do not have GPS time:** GPS receiver is not locked, does not have current time.
- **PDOP (Position Dilution Of Precision) is too high:** Seen satellites are not spread over the sky, GPS receiver cannot get a lock. Antenna may be partially blocked.
- **No usable satellites:** GPS receiver can see some satellites but cannot use them to get a lock.
- **Only 1 usable sat:** GPS receiver can see only 1 usable satellite.
- **Only 2 usable sat:** GPS receiver can see only 2 usable satellites.
- **Only 3 usable sat:** GPS receiver can see only 3 usable satellites.
- **TRAIM (Timing Receiver Autonomous Integrity Monitoring) rejected the fix:** GPS receiver fix rejected due to incorrect information provided by the satellites.



The screenshot shows the elpros web interface for Substation A. The header displays device information: Device: TSMC400, Name: Substation A, User: Admin, Version: HW 1.1.0 / SW v1.0.4, Location: Ljubljana, and UTC: 07:43:20 2022-05-10. The left navigation menu includes Status, System, Network, Time Sync, GPS (selected), PTP, IRIG-B, Analog, Digital, and IEEE C37.118. The main content area is titled 'GPS' and contains three sections: GPS Position, GPS Receiver Status, and GPS Alarms.

GPS Position	
Deg. Lat	46.0779949
Deg. Lon	14.5012314
Altitude	380.1 m

GPS Receiver Status	
GPS receiver status	Locked
PPS offset	0.96 ns

GPS Alarms	
GPS alarm	Antenna open

At the bottom of the interface, there are 'Save', 'Reset', and 'Logout' buttons.

Figure 23: Detailed GPS status

GPS receiver alarms:

- **Antenna Open:** An open circuit detected on the GPS antenna port. Check GPS antenna connection, check GPS antenna. If multiple PMUs use the same antenna over a splitter this alarm may be displayed. In this case if the GPS receiver is locked the alarm can be safely ignored.
- **Antenna Short:** A short circuit detected on the GPS antenna port. Check GPS antenna connection, check GPS antenna.
- **Not tracking satellites:** Currently not tracking any satellites. This alarm is displayed during device start-up and will be cleared when the first satellite is found. If the alarm is not cleared after 1 minute from device start-up check for antenna alarms.
- **Position is questionable:** A position is saved but is not valid. GPS needs to acquire a lock for this alarm to disappear.
- **Almanac not complete:** Current GPS almanac not valid. GPS need to acquire new almanac to determine correct time. This may take up to 12 minutes.

3.4.2 PTP

A detailed PTP status can be viewed on *Time Sync->PTP* page, see Figure 24.

- **PTP status:** Specifies if the PTP Signal is present or not.
- **Peer delay on ETH1:** Specifies peer delay of PTP packet measured on port ETH1 in ns.
- **Peer delay on ETH2:** Specifies peer delay of PTP packet measured on port ETH2 in ns.
- **Clock Drift:** Specifies PTP module clock drift in ns.
- **Current offset:** Specifies current clock offset of the PTP module in ns.
- **Master clock connected on port:** Specifies on which port a (ETH1, ETH2) a PTP master clock is connected.
- **BMCA:** Displays Best Master Clock Algorithm result i.e., the selected master clock.
- **Selected master clock:** Currently selected master clock.
- **Master Clock List:** Displays all detected master clocks.

The screenshot shows the elpros web interface for 'Substation A'. The browser address bar shows '192.168.2.57/#/ptpconf'. The header displays device information: Device: TSMC400, Name: Substation A, User: Factory, Version: HW 1.1.0 / SW v1.0.4, Location: Ljubljana, UTC: 12:12:48 2022-05-10. Status indicators for Power, Error, Sync, and System are all green. The left navigation menu includes Status, System, Network, Time Sync, GPS, PTP (selected), IRIG-B, Analog, Digital, and IEEE C37.118. The main content area is titled 'PTP' and contains the following data:

PTP	
PTP status	Signal not present
Peer delay on ETH1	0 ns
Peer delay on ETH2	0 ns
Clock Drift	10000 ns
Current offset	0 ns
Master clock connected on port	ETH1
Number of Sync Missed	0
BMCA	
Selected master clock	00:17:47:70:0B:E8
Master Clock List	
-	00:17:47:70:0B:E8

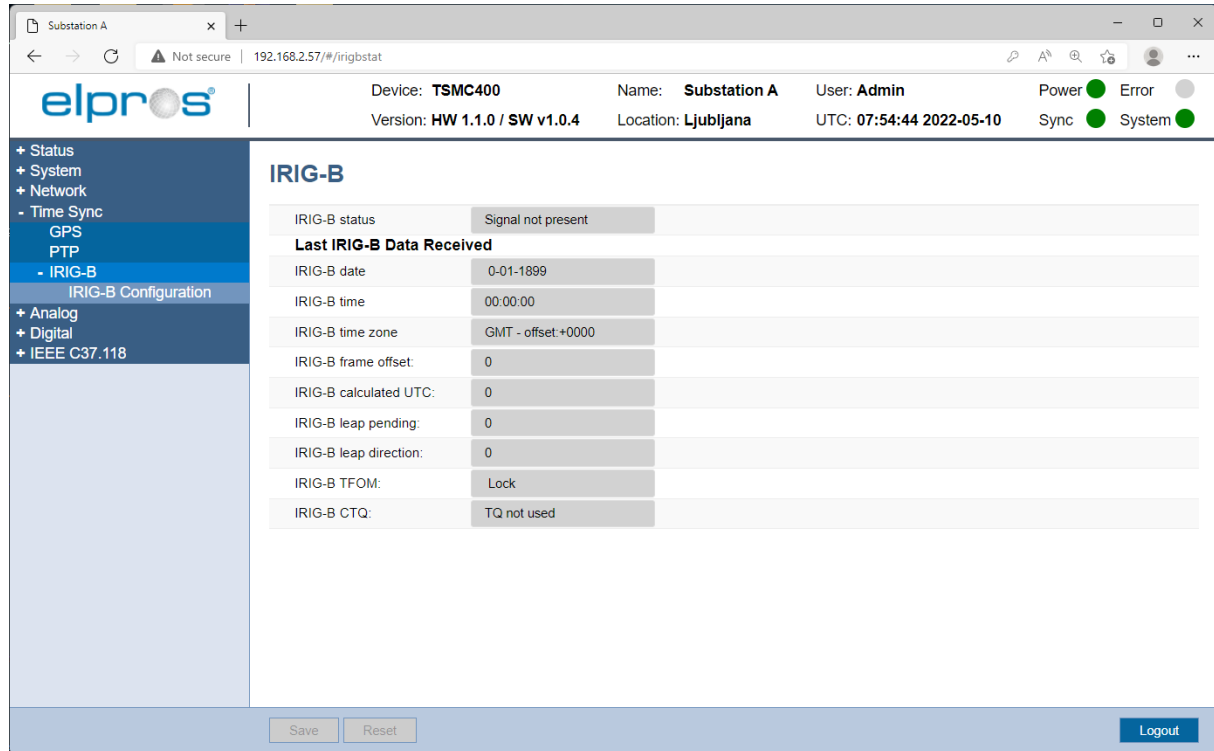
At the bottom of the interface, there are 'Save', 'Reset', and 'Logout' buttons.

Figure 24: PTP status

3.4.3 IRIG-B

A detailed IRIG-B status can be viewed on *Time Sync->IRIG-B* page, see Figure 25.

- **IRIG-B status:** Specifies if IRIG-B Signal is present or not.
- **Last IRIG-B Data Received:** Displays data from the last received IRIG-B frame.



The screenshot shows the elpros web interface for Substation A. The top navigation bar includes the elpros logo and system information: Device: TSMC400, Name: Substation A, User: Admin, Version: HW 1.1.0 / SW v1.0.4, Location: Ljubljana, and UTC: 07:54:44 2022-05-10. The left sidebar shows a menu with options like Status, System, Network, Time Sync, GPS, PTP, IRIG-B, and IRIG-B Configuration. The main content area is titled 'IRIG-B' and displays the following data:

IRIG-B status	Signal not present
Last IRIG-B Data Received	
IRIG-B date	0-01-1899
IRIG-B time	00:00:00
IRIG-B time zone	GMT - offset:+0000
IRIG-B frame offset:	0
IRIG-B calculated UTC:	0
IRIG-B leap pending:	0
IRIG-B leap direction:	0
IRIG-B TFOM:	Lock
IRIG-B CTQ:	TQ not used

At the bottom of the page, there are 'Save' and 'Reset' buttons on the left, and a 'Logout' button on the right.

Figure 25: IRIG-B status

IRIG-B can be configured on the *Time Sync->IRIG-B->IRIG-B Configuration*, see Figure 26:

- **Input frame type:** Select the IRIG-B input frame type:
 - **BASIC:** Standard IRIG-B frame.
 - **IEEE1344:** IRIG-B frame in accordance with IEEE 1344.
 - **C37.118 EXTENSION:** IRIG-B frame with IEEE C37.118 extension.
 - **PPS:** Pulse per second is received, without IRIG-B data.
- **Output frame type:** Select the IRIG-B output frame type:
 - **DISABLE OUTPUT:** Disables the device IRIG-B output.
 - **BASIC:** Standard IRIG-B frame.
 - **IEEE1344:** IRIG-B frame in accordance with IEEE 1344.
 - **C37.118 EXTENSION:** IRIG-B frame with IEEE C37.118 extension.
 - **PPS:** Pulse per second is generated, without IRIG-B data.
- **IRIG-B cable correction:** Enter the estimated cable delay in nano seconds from the source to the device. The delay is internally compensated.

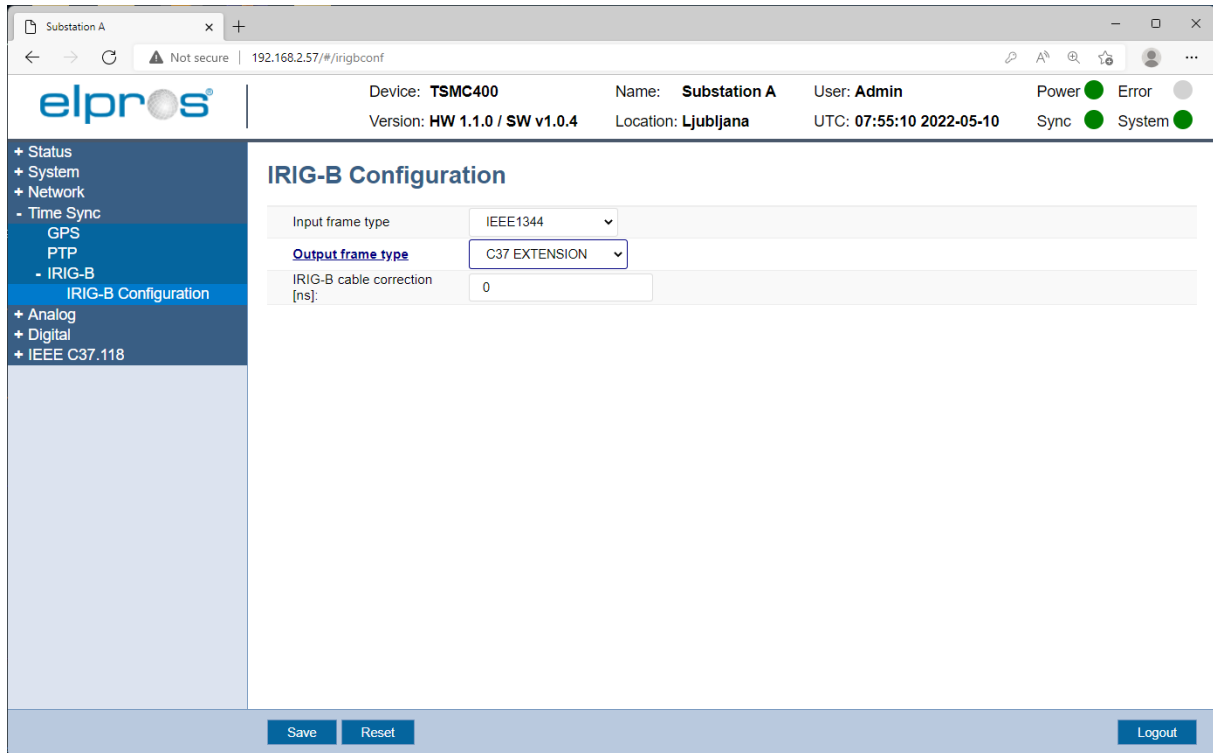


Figure 26: IRIG-B Configuration

3.5 Analog module configuration

	WARNING: A change of Analog Modul configuration may disable communication over IEEE C37.118 protocol! Review PMU IEEE C37.118 configuration after changing Analog Modul configuration.
--	---

	WARNING: A change of Analog Modul configuration requires a device restart!
--	---

TSCM 400 can support up to two analog modules that can be configured based on different types of inputs, see Figure 1.

Use the side menu to select the “Analog” menu. The available modules will be displayed regarding the analog module configuration. An example for a TSMC 400 device with one analog module is shown in Figure 27.

Analog module configuration parameters:

- **Module Name:** This name is reflected in the IEEE C37.118 configuration and used as station name in IEEE C37.118.2 protocol.
- **Class:** Analog module can be either a M class or P class according to IEEE C37.118.1. The PMU class configured in IEEE C37.118 (see chapter 3.7.1) match the analog module class.

Modules names AIN1 and AIN2 reflect the naming on the device panel, see Figure 1.

AC analogue input currents and voltages enable precise measuring of the electrical values with possibility of monitoring fast dynamical phenomena. Data exchange allows data frames transmission up to 200 phasor frames per second.

DC input enables connection of different additional sensors for time synchronized monitoring of measurements which are important for control systems and analysis. An example of using DC input are sensors for direct measuring of rotation of the generator rotor in power plants.

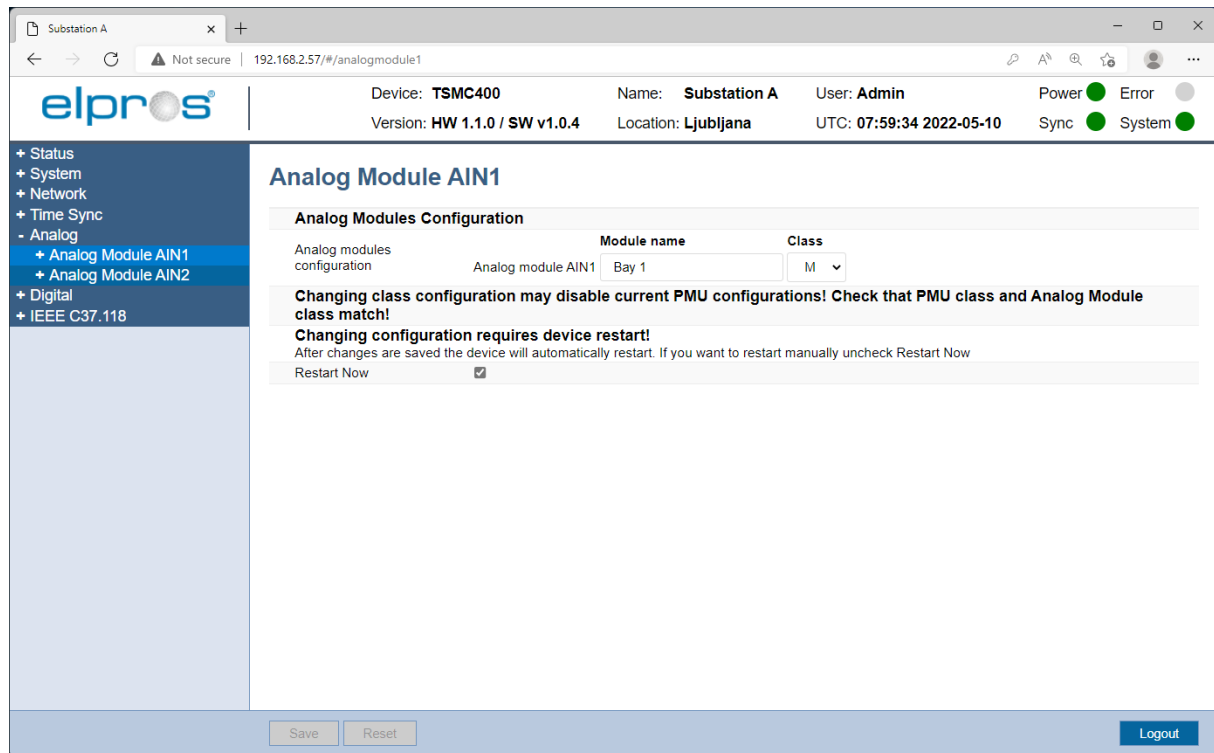


Figure 27: Analog module configuration

3.5.1 Voltage inputs page

WARNING: A change of any configuration on this page requires a device restart!

Each voltage input has three configuration parameters, as shown Figure 28:

- **Nominal Vpp:** nominal phase to phase voltage of VT primary. Used by Dynamic Limiter to calculate thresholds, see 3.5.4.
- **Nominal Vpg:** nominal phase to ground voltage calculated from Vpp.
- **Channel Name:** is a custom name of the voltage channel that is reflected in the IEEE C37.118 protocol.
- **Phase Correction:** is the phase angle error correction of the voltage transformer. The entered value in degrees will be added to the measured phasor angle before reporting over IEEE C37.118.
- **Scale Factor:** is the nominal turn ratio of the voltage transformer. The entered value will be multiplied with the measured phasor magnitude before reporting over IEEE C37.118.

Voltage inputs V1, V2, V3 and V4 reflect the naming on the device panel, see Figure 1.

After the configuration is applied a device restart is required for the configuration to take effect. If the "Restart Now" checkbox is checked after saving the configuration, the device will restart automatically.

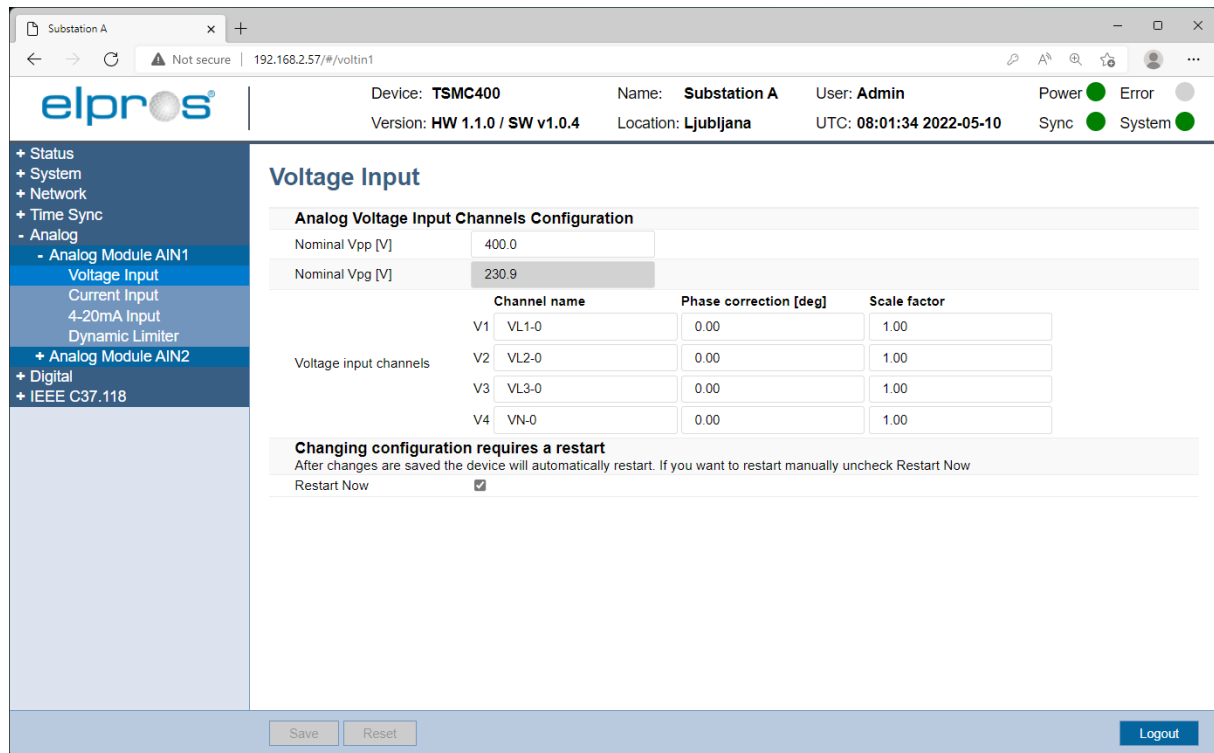


Figure 28: Analog voltage input configuration

3.5.2 Current inputs page

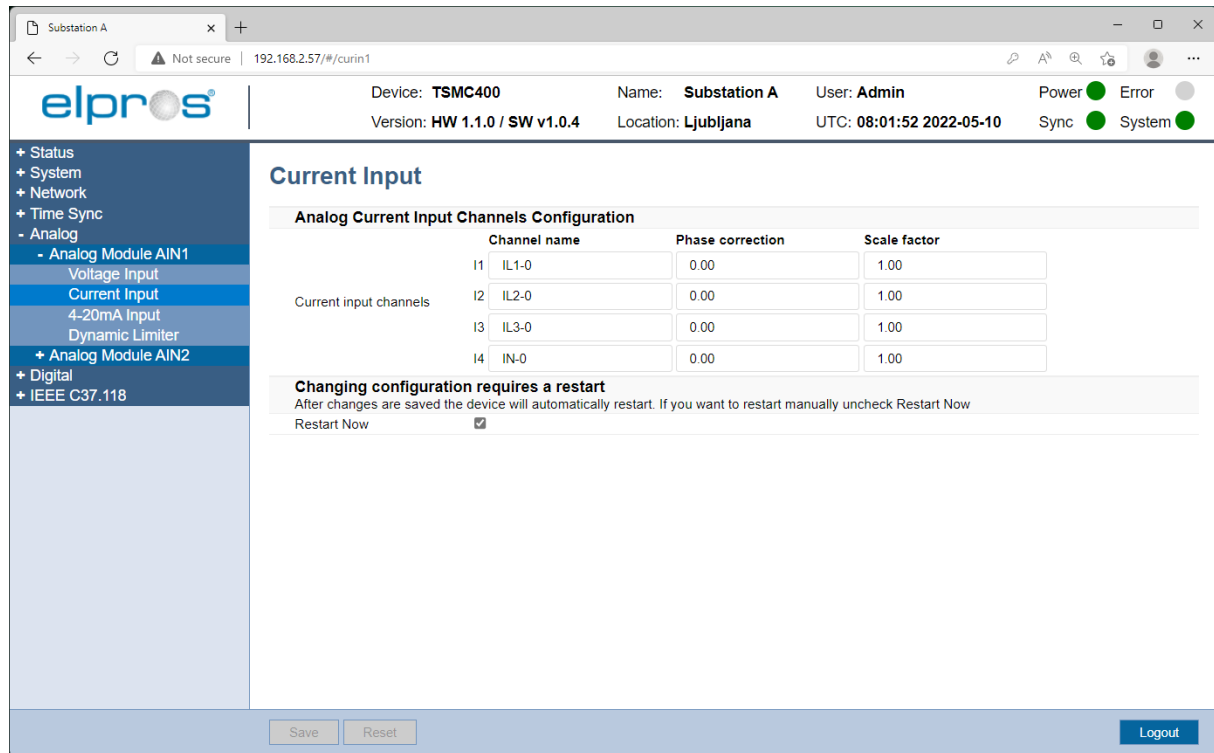
WARNING: A change of any configuration on this page requires a device restart.

Each current input has three configuration parameters, as shown in Figure 29:

- **Channel Name:** is a custom name of the current channel that is reflected in the IEEE C37.118 protocol.
- **Phase Correction:** is the phase angle error correction of the current transformer. The entered value in degrees will be added to the measured phasor angle before reporting over IEEE C37.118.
- **Scale Factor:** is the nominal turn ratio of the current transformer. The entered value will be multiplied with the measured phasor magnitude before reporting over IEEE C37.118.

Current inputs I1, I2, I3 and I4 reflect the naming on the device panel, see Figure 1.

After the configuration is applied a device restart is required for the configuration to take effect. If the "Restart Now" checkbox is checked after saving the configuration, the device will restart automatically.



Substation A

Device: TSMC400 Name: Substation A User: Admin Power Error
 Version: HW 1.1.0 / SW v1.0.4 Location: Ljubljana UTC: 08:01:52 2022-05-10 Sync System

Current Input

Analog Current Input Channels Configuration

	Channel name	Phase correction	Scale factor
I1	IL1-0	0.00	1.00
I2	IL2-0	0.00	1.00
I3	IL3-0	0.00	1.00
I4	IN-0	0.00	1.00

Current input channels

Changing configuration requires a restart
 After changes are saved the device will automatically restart. If you want to restart manually uncheck Restart Now

Restart Now

Save Reset Logout

Figure 29: Analog current input configuration

3.5.3 Current loop 4 - 20 mA input



WARNING: A change of any configuration on this page requires a device restart.

The current loop input has two configuration parameters as shown in Figure 30:

- **Channel Name:** Is a custom name of the current channel that is reflected in the IEEE C37.118 protocol.
- **Scale Factor:** The value entered will be multiplied with the measured value before reporting over IEEE C37.118.

Current loop input AI1 reflect the naming on the device panel, see Figure 1.

After the configuration is applied a device restart is required for the configuration to take effect. If the "Restart Now" checkbox is checked after saving the configuration, the device will restart automatically.

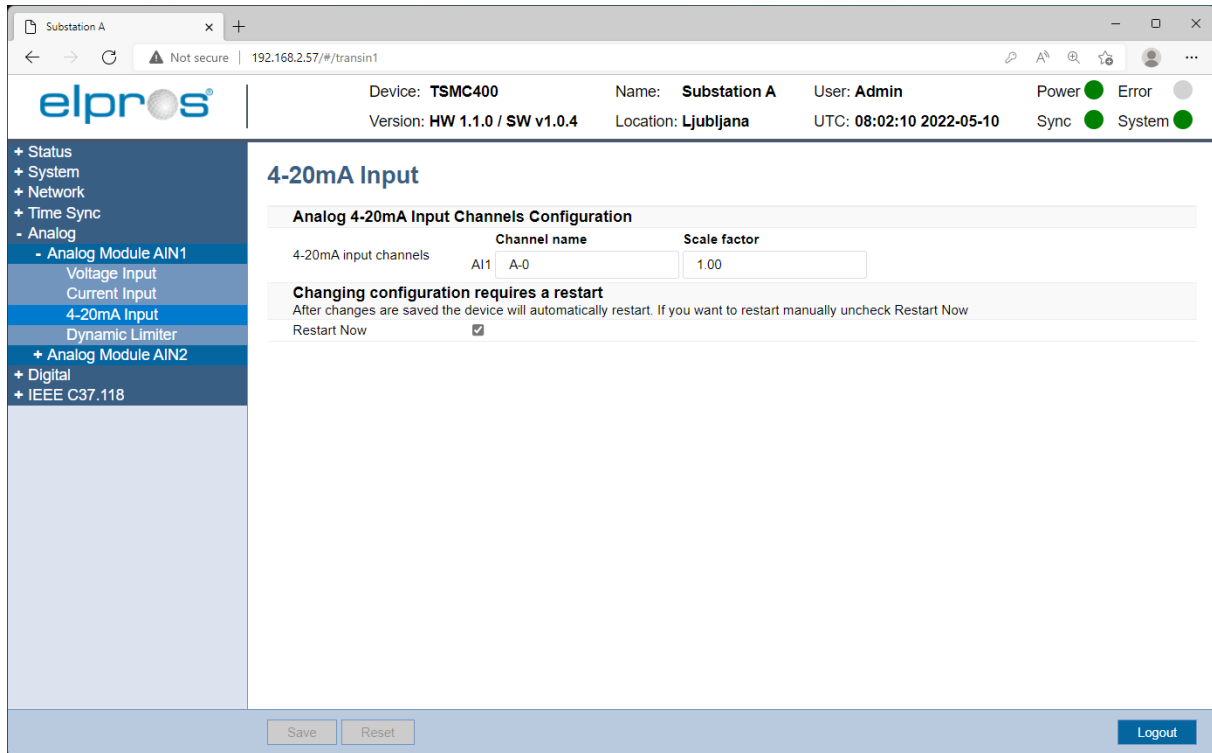


Figure 30: Analog current loop 4 - 20 mA input configuration

3.5.4 Dynamic Limiter

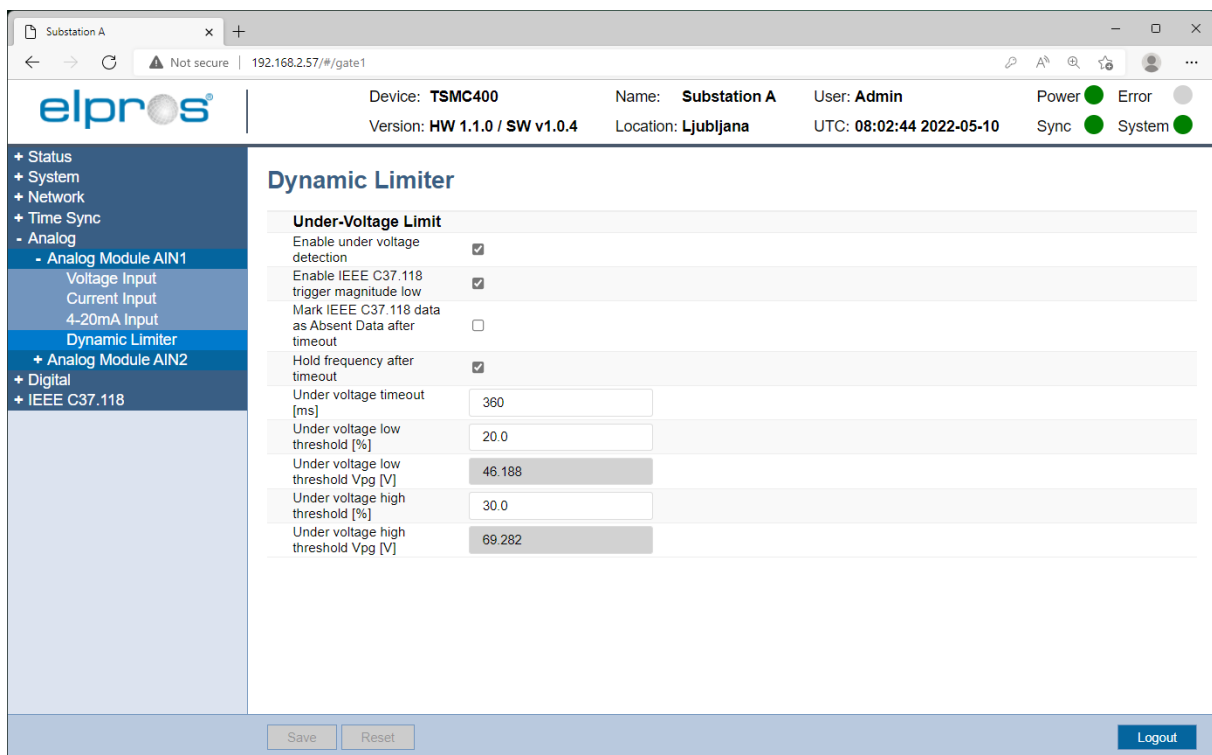
The frequency calculation algorithm dynamically selects a voltage phase based on the results of the calculation. If frequency cannot be calculated on the first phase because of signal distortions or no signal the next phase is used. If the frequency cannot be calculated on any phase status “Absent Data” is reported in C37.118 stream. In the case of bigger transients or disconnected bay/bus the reported frequency can be with higher error.

When dynamic limiter is enabled the best voltage phase for frequency calculation is selected based on estimated signal distortion. In a case of undervoltage condition the reported frequency is locked on the last known good value or at nominal system frequency if a valid good value is not available. Once undervoltage condition is normalised reporting of the calculated frequency resumes. For bay/bus disconnect conditions absent data reporting can be enabled with configuration parameter: “Mark C37.118 data as Absent Data after Under voltage Timeout” where after a “Under voltage Timeout”, measurements are reported as absent in the C37.118 data stream.

The following configuration options are available (see Figure 31):

- **Enable Under Voltage Detection:** Enables undervoltage detector. If disabled, all the following configuration on this page has no effect.
- **Enable C37.118 trigger Magnitude Low:** Enable C37.118 “Magnitude Low” trigger flag when undervoltage condition is detected.
- **Mark C37.118 data as Absent Data after Under voltage Timeout:** Marks measurement data in C37.118 stream as absent, when undervoltage conditions is detected for longer than “Under voltage Timeout”.
- **Hold Frequency after Timeout:** Continues to hold the calculated frequency after the undervoltage timeout expires.

- **Under voltage Timeout:** Is started when phasor magnitude drops below “Under voltage low threshold” and is stopped when phasor magnitude rises above “Under voltage high threshold”.
- **Under voltage low threshold:** Phasor magnitude where under voltage condition is detected and the “Under voltage Timeout” is started. The magnitude is entered in percent of the “Nominal Vpp” voltage configured in 3.5.1.
- **Under voltage low threshold Vpg:** Calculated phase to ground voltage from “Under voltage low threshold” and “Nominal Vpp”, see 3.5.1.
- **Under voltage high threshold:** Phasor magnitude where under voltage condition is cleared and the “Under voltage Timeout” is stopped. The magnitude is entered in percent of the “Nominal Vpp” voltage configured in 3.5.1.
- **Under voltage high threshold Vpg:** Calculated phase to ground voltage from “Under voltage high threshold” and “Nominal Vpp”, see 3.5.1.



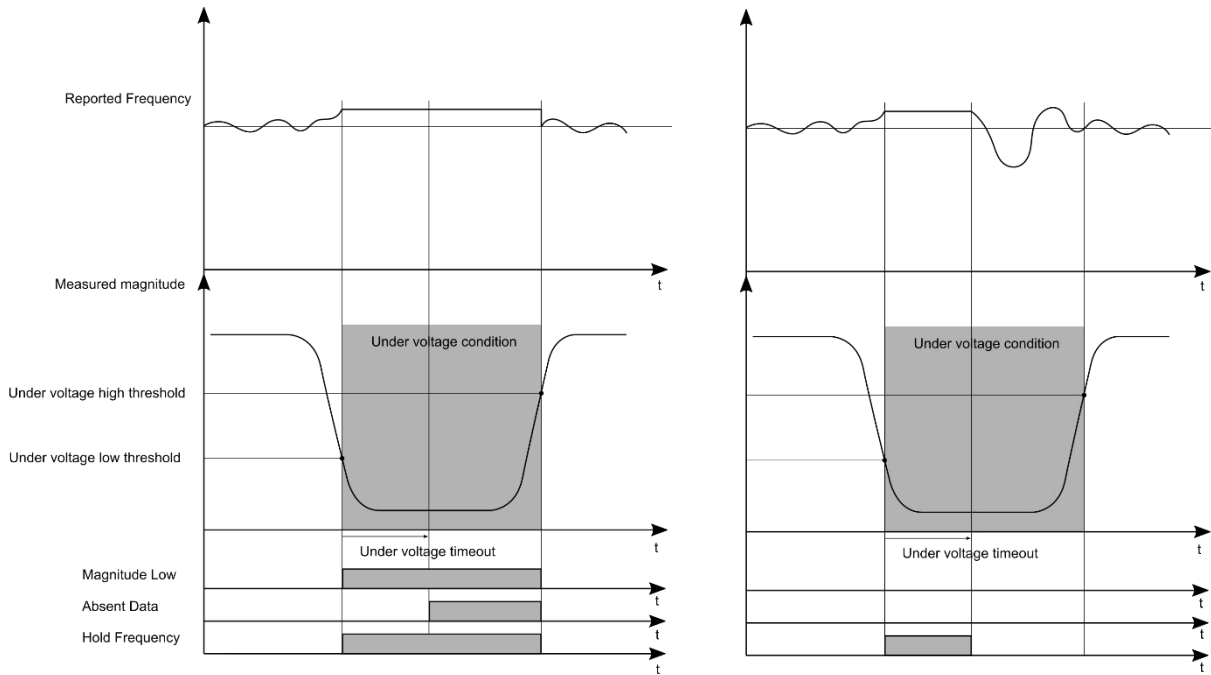
The screenshot shows the elpros web interface for Substation A. The header displays device information: Device: TSMC400, Name: Substation A, User: Admin, Version: HW 1.1.0 / SW v1.0.4, Location: Ljubljana, and UTC: 08:02:44 2022-05-10. The main configuration area is titled "Dynamic Limiter" and includes the following settings:

Under-Voltage Limit	
Enable under voltage detection	<input checked="" type="checkbox"/>
Enable IEEE C37.118 trigger magnitude low	<input checked="" type="checkbox"/>
Mark IEEE C37.118 data as Absent Data after timeout	<input type="checkbox"/>
Hold frequency after timeout	<input checked="" type="checkbox"/>
Under voltage timeout [ms]	<input type="text" value="360"/>
Under voltage low threshold [%]	<input type="text" value="20.0"/>
Under voltage low threshold Vpg [V]	<input type="text" value="46.188"/>
Under voltage high threshold [%]	<input type="text" value="30.0"/>
Under voltage high threshold Vpg [V]	<input type="text" value="69.282"/>

At the bottom of the configuration area, there are "Save" and "Reset" buttons, and a "Logout" button in the bottom right corner.

Figure 31: Dynamic Limiter

Figure 32 presents examples of Dynamic Limiter parameters configuration and their principle of operation.



Dynamic Limiter

Under-voltage Limit	
Enable Under Voltage Detection	<input checked="" type="checkbox"/>
Enable IEEE C37.118 trigger Magnitude Low	<input checked="" type="checkbox"/>
Mark IEEE C37.118 data as Absent Data after Timeout	<input checked="" type="checkbox"/>
Hold Frequency after Timeout	<input checked="" type="checkbox"/>
Under voltage Timeout [ms]	360
Under voltage low threshold [%]	20.0
Under voltage low threshold Vpg [V]	48.4974
Under voltage high threshold [%]	40.0
Under voltage high threshold Vpg [V]	96.9949

Dynamic Limiter

Under-voltage Limit	
Enable Under Voltage Detection	<input checked="" type="checkbox"/>
Enable IEEE C37.118 trigger Magnitude Low	<input type="checkbox"/>
Mark IEEE C37.118 data as Absent Data after Timeout	<input type="checkbox"/>
Hold Frequency after Timeout	<input type="checkbox"/>
Under voltage Timeout [ms]	360
Under voltage low threshold [%]	20.0
Under voltage low threshold Vpg [V]	48.4974
Under voltage high threshold [%]	40.0
Under voltage high threshold Vpg [V]	96.9949

Figure 32: Examples of Dynamic Limiter parameters configuration and their principle of operation

3.6 Digital card configuration

The interface for digital inputs/outputs is divided into four sections:

- Binary inputs
- Binary outputs
- GOOSE inputs
- GOOSE outputs

3.6.1 Digital inputs

Digital inputs are automatically mapped to the first 6 bits of IEEE C37.118 digital word.

Each input can be configured with the following parameters, see Figure 33:

- **Channel name:** is a custom name of digital input that is reflected in the IEEE C37.118 protocol.
- **Debounce time:** Is the minimum time that the input signal must remain in the new state before the new state is reported. The value is in ms from 1 to 255.
- **Invert:** Invert the read state before reporting in IEEE C37.118 data frame.

Figure 33: Binary input configuration

3.6.2 Digital output

Digital outputs enable control actions directly from the TSMC400 device. Such solution is optimal in case of the control actions which require short delays between detection and control reaction. Option is suitable for WAMPAC systems which operate with activation of the RAS/SIPS (Remedial Action Schemes / System Integrity Protection Schemes) scenarios. The outputs can be controlled using a custom command in a C37.118 command frame.

Each output can be configured with the following parameters, see Figure 34:

- **Channel name:** is a custom name of digital output that is reflected in the IEEE C37.118 protocol.
- **Invert:** Invert the received state command before sending command to relay.



WARNING: A change of channel invert flag will toggle the physical relay!

Substation A

Device: TSMC400 Name: Substation A User: Admin Power Error
 Version: HW 1.1.0 / SW v1.0.4 Location: Ljubljana UTC: 08:04:35 2022-05-10 Sync System

DIO1 Output

Digital Binary Output Configuration

Invert
 When enabled the received signal via IEEE C37.118 command frame is inverted before the action is applied to the relay.

Channel name	Invert
DO1 D00	<input type="checkbox"/>
DO2 D01	<input type="checkbox"/>
DO3 D02	<input type="checkbox"/>
DO4 D03	<input type="checkbox"/>
DO5 D04	<input type="checkbox"/>
DO6 D05	<input type="checkbox"/>

Save Reset Logout

Figure 34: Binary output configuration

3.6.3 GOOSE input

The device can subscribe to up to 16 different GOOSE publishers. Up to 16 dataset members in total can be mapped to the fourth digital word of IEEE C37.118 data frame. The third digital word is used to indicate if the corresponding GOOSE inputs status indicated in the fourth digital word is valid.

General properties for all subscribers:

- **Min supervision time:** Minimum initial timeout in seconds for indicating invalid status of GOOSE inputs due to no incoming GOOSE messages.

To subscribe to a GOOSE publisher the following procedure must be followed:

1. Load a SCL file and map dataset members to GOOSE inputs, see 3.6.3.1.
2. Select the control block to be configured in “GOOSE Control Block select” drop down menu and click “Select”, see Figure 35.
3. Mapped dataset members are displayed. Customize “C37 Name” fields if needed. These names are used as bit names in IEEE C37.118.2 frames, see Figure 37. The same names with prefix “V” are used in the third word to indicate valid status, see section 3.7.3.
4. Tick the “Enable” box on the right side of the GOOSE control block and click “Save” to enable the subscriber.

To unsubscribe from a GOOSE publisher or change the mapping of the dataset the following procedure must be performed:

1. Tick the “Delete” box next to the subscriber configuration that is to be unsubscribed / mapping changed, see Figure 36.
2. If the mapping requires changes reload the SCL file and start the subscribe procedure again.

To disable a GOOSE subscriber, untick the “Enable” checkbox and click “Save”.

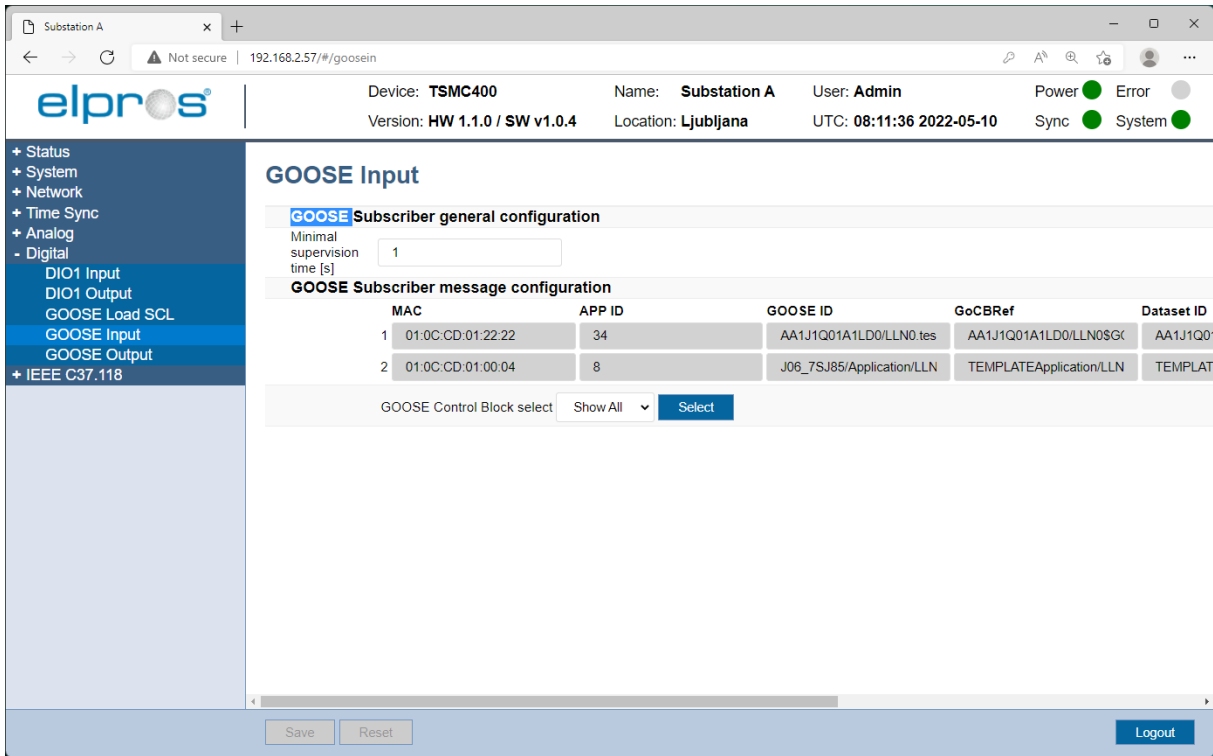


Figure 35: GOOSE input configuration 1/2

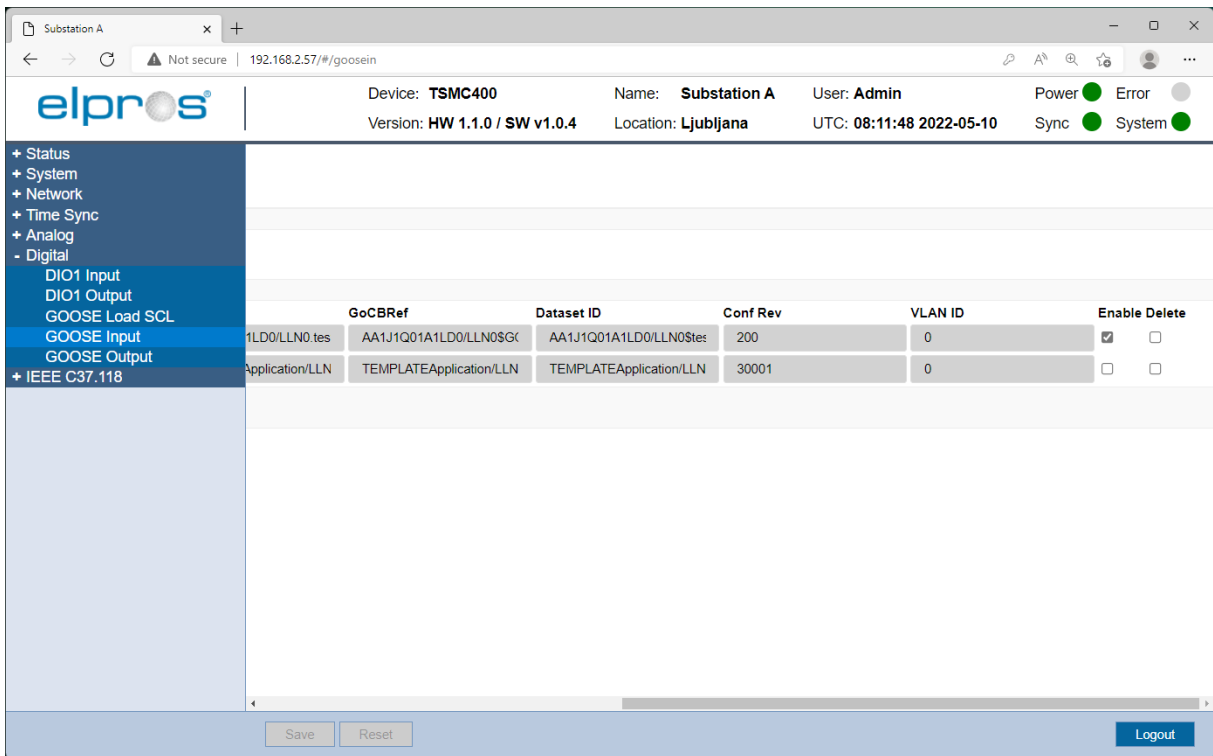


Figure 36: GOOSE input configuration 2/2

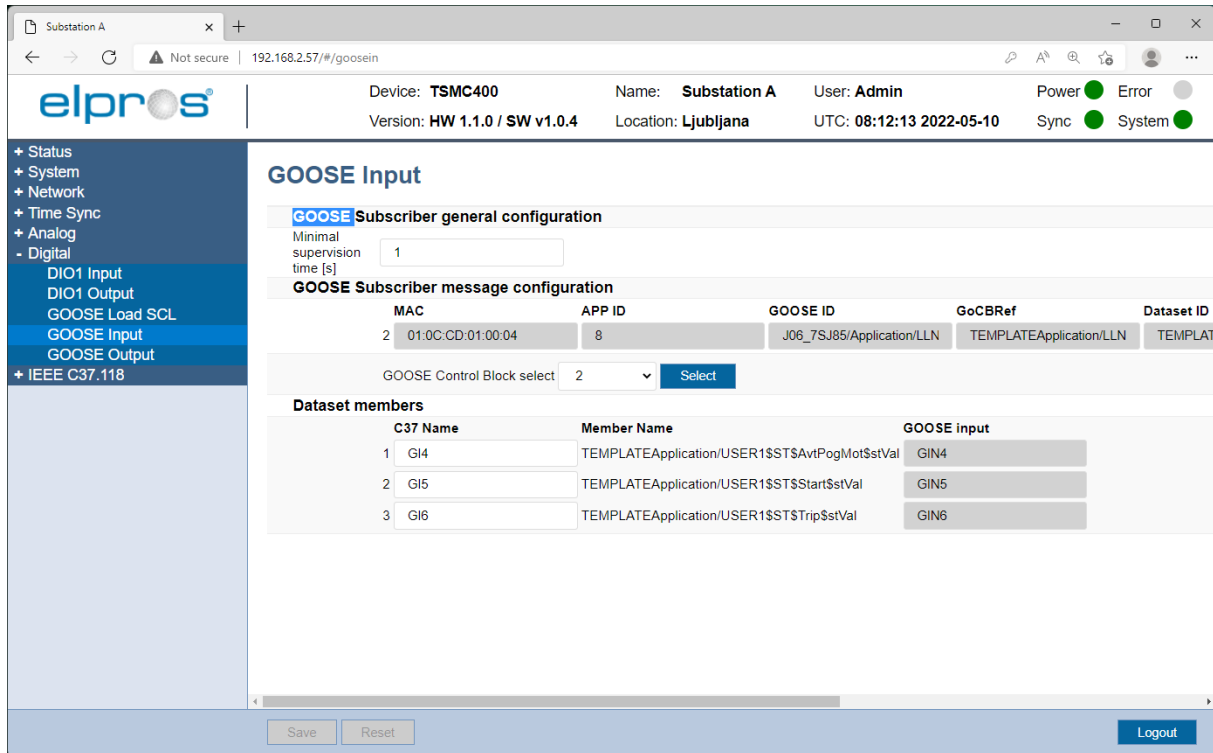


Figure 37: Dataset member configuration

3.6.3.1 GOOSE Load SCL

SCL (Substation Configuration description Language) file includes all necessary information about GOOSE outputs of specific manufacturer device.

To subscribe the device to a GOOSE stream, a SCL file must be loaded on the load page *Digital->GOOSE Load SCL*, see Figure 38.

Once the file is loaded all available GOOSE control blocks are displayed, see Figure 39.

To use a control block for GOOSE input, select the control block number from “GOOSE Control Block select” drop down menu and click “Select”.

Usable dataset members of the selected control block are displayed.

Dataset members can be mapped to GOOSE inputs by selecting the inputs “GINx” from the “GOOSE input selection” drop down menu.

Once all desired dataset members are mapped to GOOSE inputs click “Save”.

A GOOSE input configuration will be automatically generated, and the browser will jump to *Digital->GOOSE Input* page.

Substation A | Device: TSMC400 | Name: Substation A | User: Admin | Power: ● Error: ●
 Version: HW 1.1.0 / SW v1.0.4 | Location: Ljubljana | UTC: 08:20:52 2022-05-10 | Sync: ● System: ●

GOOSE Load SCL

Load SCL file
 Use a station SCL file to configure the GOOSE subscriber
 SCL File:

GOOSE control blocks found

IED	LD	LN	MAC	APP ID
1	TEMPLATE	Application	LLN0	01:0C:CD:01:00:04

GOOSE Control Block select:

Figure 38: SCL file loaded

Substation A | Device: TSMC400 | Name: Substation A | User: Admin | Power: ● Error: ●
 Version: HW 1.1.0 / SW v1.0.4 | Location: Ljubljana | UTC: 08:21:20 2022-05-10 | Sync: ● System: ●

GOOSE Load SCL

Load SCL file
 Use a station SCL file to configure the GOOSE subscriber
 SCL File:

GOOSE control blocks selected

IED	LD	LN	MAC	APP ID
1	TEMPLATE	Application	LLN0	01:0C:CD:01:00:04

GOOSE Control Block select:

Dataset members

Member Name	GOOSE input selection
1 TEMPLATEApplication/USER1\$ST\$AvtPogMot\$stVal	<input type="text" value="GIN6"/>
2 TEMPLATEApplication/USER1\$ST\$AvtPogMot\$stSq	<input type="text" value="Not Selected"/>
3 TEMPLATEApplication/USER1\$ST\$Start\$stVal	<input type="text" value="Not Selected"/>
4 TEMPLATEApplication/USER1\$ST\$Start\$stSq	<input type="text" value="Not Selected"/>
5 TEMPLATEApplication/USER1\$ST\$Trip\$stVal	<input type="text" value="Not Selected"/>
6 TEMPLATEApplication/USER1\$ST\$Trip\$stSq	<input type="text" value="Not Selected"/>

Figure 39: Select GOOSE input

3.6.4 GOOSE output

The device can publish up to 4 different GOOSE messages. Functional constraint data attributes (FCDA) in the dataset are controlled using a proprietary IEEE C37.118 command frame. The dataset has 16 status values. The dataset is hardcoded and cannot be changed. Each of the four GOOSE control block configurations use the same dataset. To setup a GOOSE publisher the following properties should be configured:

- **Max retransmission timeout:** This is the GOOSE keep alive time in seconds. If subscribed GOOSE does not reach the GOOSE Subscribers within this time interval the GOOSE Subscribers can conclude that the error occurred on the GOOSE Publisher side. This property is used for all four publishers.
- **Name:** Descriptor name for the GOOSE object. This is for user reference only.
- **APP ID:** APP ID of the publisher GOOSE frame.
- **GOOSE ID:** GOOSE ID of the publisher GOOSE frame. This property cannot be changed.
- **GoCBRef:** GOOSE control block reference of the publisher GOOSE frame. This property cannot be changed.
- **Dataset ID:** Dataset name. This property cannot be changed.
- **Conf Rev:** Configuration revision of the GOOSE publisher. It is automatically incremented upon any properties change.
- **VLAN ID:** VLAN ID of the publisher GOOSE frames.
- **VLAN Priority:** VLAN priority of the publisher GOOSE frames.
- **Test:** Test flag of the publisher GOOSE frames.
- **Commis.:** Commissioning flag of the publisher GOOSE frames.
- **Enable:** Enable / Disable publisher.

Once publishers are configured and configuration saved, a SCL file can be downloaded by clicking "Download SCL" button.

GOOSE publisher dataset values are mapped to the fourth digital word of the IEEE C37.118 data frame for supervision purposes.

Substation A | 192.168.2.57/#/gooseout

Device: **TSMC400** Name: **Substation A** User: **Admin** Power Error
 Version: **HW 1.1.0 / SW v1.0.4** Location: **Ljubljana** UTC: **08:24:26 2022-05-10** Sync System

GOOSE Output

GOOSE Publisher general configuration

Maximum retransmission timeout [s]

GOOSE Publisher message configuration

Name	MAC	APP ID	GOOSE ID	GoC
GO1 GBO1	01:0C:CD:01:01:21	1	TSMC400_1	TSI
GO2 GBO2	01:0C:CD:01:01:22	2	TSMC400_2	TSI
GO3 GBO3	01:0C:CD:01:01:23	3	TSMC400_3	TSI
GO4 GBO4	01:0C:CD:01:01:24	4	TSMC400_4	TSI

[Download SCL](#)

Save Reset Logout

Figure 40: GOOSE output configuration 1/2

Substation A | 192.168.2.57/#/gooseout

Device: **TSMC400** Name: **Substation A** User: **Admin** Power Error
 Version: **HW 1.1.0 / SW v1.0.4** Location: **Ljubljana** UTC: **08:25:04 2022-05-10** Sync System

Dataset ID	Conf Rev	VLAN ID	VLAN Priority	Test Commis. Enable
/E/LLN0\$G TSMC400/GOOSE/LLN0\$T:	3	0	0	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>
/E/LLN0\$G TSMC400/GOOSE/LLN0\$T:	3	0	0	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>
/E/LLN0\$G TSMC400/GOOSE/LLN0\$T:	3	0	0	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>
/E/LLN0\$G TSMC400/GOOSE/LLN0\$T:	3	0	0	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>

Save Reset Logout

Figure 41: GOOSE output configuration 2/2

3.7 IEEE C37.118 Configuration

Data transmission by IEEE C37.118 protocol is configured on the *IEEE C37.118* page, see Figure 45.

The TSMC 400 enables four sets for sending data. Each set enables customised selection of the phasors, sampling rate and metering class if device supports two analog cards.

Example:

- Set 1 sends all data with maximal sampling rate,
- Set 2 sends only voltage positive phasor with sampling rate 10 samples per second.

3.7.1 PMU sets configurations for data sending

The device enables four independent PMU configuration sets available on pages:

- IEEE C37.118 -> PMU-1,
- IEEE C37.118 -> PMU-2,
- IEEE C37.118 -> PMU-3
- IEEE C37.118 -> PMU-4.

If TSCM 400 device has two analog input modules each PMU configuration has two stations named: Station 1 and Station 2. These use the analog modules as measurement data sources. The measurements are mapped as follows:

- AIN1 -> Station 1
- AIN2 -> Station 2

Each station is configured separately. An example of configuration is given in Figure 45.

Configuration parameters of each IEEE C37.118 PMU are:

- **Active:** Enable or disable PMU configuration.
- **IDCODE:** IDCODE is 16-bit integer, assigned by user that uniquely identifies the device sending and receiving messages, 1–65534 (0 and 65535 are reserved). If a device only hosts one data stream, the IDCODE identifies the device as well as the stream. If the device hosts more than one data stream, there shall be a different IDCODE for each stream.
- **PMU Class:** Class of the PMU (P or M) according to IEEE C37.118.1. **This configuration must match the configured class of the Analog Module. If there is a mismatch between PMU class and Analog Module class, the corresponding station will not be available in the PMU data stream.**
- **PMU Station:** Enable / Disable Station 1 and / or Station 2 which use the analog input modules as phasor data sources. Analog module AIN1 is mapped to "Station 1" and AIN2 is mapped to "Station 2".
- **Reporting rate:** Rate of transmitted phasor reports:
 - Nominal frequency 50 Hz:
 - 10 Hz
 - 25 Hz
 - 50 Hz
 - 100 Hz
 - 200 Hz
 - Nominal frequency 60 Hz:
 - 10 Hz
 - 12 Hz
 - 15 Hz
 - 20 Hz
 - 30 Hz
 - 60 Hz
 - 120 Hz

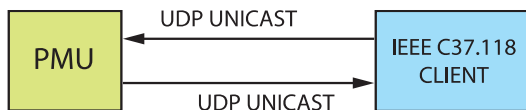
- 240 Hz

• **Protocol:** IP Protocol to be used for IEEE C37.118 report transmission:

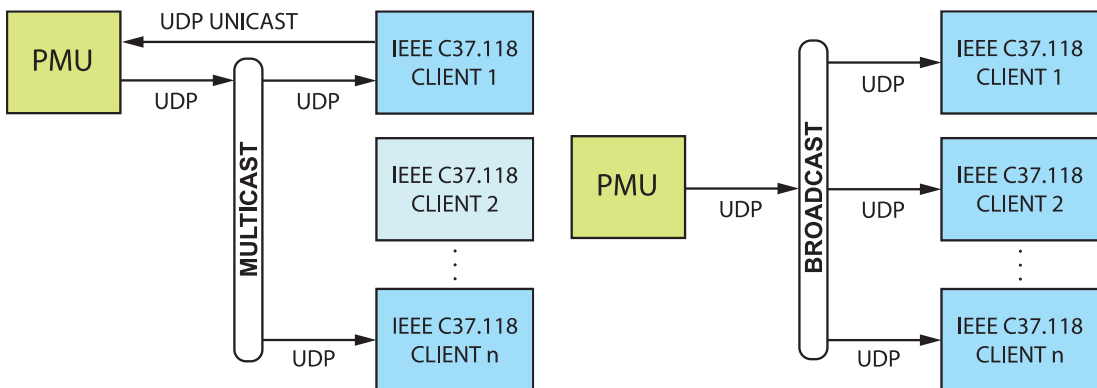
- **TCP:** This method has a single TCP connection over which commands, data, header, and configuration frames are passed.



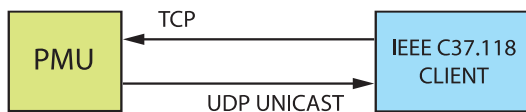
- **UDP unicast:** This method uses straight UDP for communication in both directions for PMU messages, including commands, data, header, and configuration.



- **UDP multi-purpose:** This method supports UDP unicast, UDP multicast and UDP broadcast communication. In case of multicast, commands are passed from client to PMU over UDP unicast communication. In case of broadcast, clients can only receive data and are not able to send commands to server.



- **TCP/UDP:** This method uses TCP for commands, header, and configuration communications, and UDP for sending data.



The screenshot shows the 'PMU-1' configuration page. At the top, there is a header with the elpros logo and system information: Device: TSMC400, Name: Substation A, User: Admin, Version: HW 1.1.0 / SW v1.0.4, Location: Ljubljana, UTC: 09:08:20 2022-05-10. On the right, there are status indicators for Power, Error, Sync, and System, all of which are green. A left sidebar contains a navigation menu with options like Status, System, Network, Time Sync, Analog, Digital, and IEEE C37.118. The main content area is titled 'PMU-1' and contains the following configuration fields:

- IEEE C37.118** (Section Header)
- Active:
- IDCODE:
- PMU Class:
- PMU Station** (Table):

Station	Bay	Enable
Station 1	Bay 1	<input checked="" type="checkbox"/>
Station 2	Bay 2	<input checked="" type="checkbox"/>
- Reporting Rate:
- Network Method** (Section Header)
- Protocol:

At the bottom of the page, there are 'Save', 'Reset', and 'Logout' buttons.

Figure 42: PMU configuration page for data transfer by IEEE C37.118 protocol

3.7.2 Network Configuration

Network Configuration parameters are divided into five sections:

- Network settings
- TCP
- UDP unicast
- UDP multi-purpose
- TCP/UDP.

Based on PMU selected protocol in PMU configuration (see 3.7.1 (TCP or UDP unicast or UDP multi-purpose or TCP/UDP)), the relevant configuration section must be configured.

NOTE: A total of up to sixteen trusted clients IPs in different PMU configurations can be configured, but maximum four simultaneous TCP sessions are allowed. Any new TCP session request will be rejected. TCP connections in TCP/UDP mode are not counted in general TCP connections limitation.

Network settings section

- **Port:** Specifies IEEE C37.118 port number.

TCP section parameters

This mode uses TCP network transport protocol for transmitting C37.118 data, command, or header frame.

This mode can be configured to transmit data to up to four TCP clients, registered in TCP "Trusted Clients" IP table.

- **Trusted Clients:** Specifies trusted clients IP addresses. "Enable" checkbox enables the trusted client IP.

UDP unicast section parameters

This mode can be configured to transmit data to up to four UDP clients, registered in UDP “Trusted Clients” IP table.

- **Command Mode** (drop down menu):
 - **Command driven:** In “Command driven” mode device accepts IEEE C37.118 command frames from trusted clients IPs specified in “Trusted Clients” IP table and enables or disables data streams for those clients.
 - **Spontaneous CFG-2/3:** PMU periodically sends spontaneous IEEE C37.118 CFG-2 or CFG-3 frames to trusted clients specified in “Trusted Clients” IP table. Data is constantly streamed and cannot be enabled / disabled with IEEE C37.118 command frame from the client side.
 - **Spontaneous CFG-2/3 + Header:** PMU periodically send spontaneous IEEE C37.118 CFG-2 or CFG-3 frames together with header frame to trusted clients specified in “Trusted Clients” IP table Data is constantly streamed and cannot be enabled / disabled with IEEE C37.118 command frame from the client side.
- **Trusted Clients:**
 - **IP:** Specifies trusted clients IP addresses.
 - **PORT:** Specifies trusted clients destination port for sending IEEE C37.118 data frames.
 - **TTL:** Specifies trusted clients Time To Live value used in multicast communication. It defines maximum number of forwarding over routers before packet ends its life.
 - **Enable:** Enable checkbox enables the trusted clients.

NOTE: In UDP mode, request from any IP and PORT, not specified in Trusted Clients” table, for CFG-2 and CFG-3 or Header frame are allowed. Only configuration frames are sent to these IP clients. Data streams are not sent to these IP clients.

UDP multi-purpose section parameters

This mode can be used for UDP unicast, UDP multicast or UDP broadcast type of data transmission. This mode has one data sending stream and up to four incoming trusted clients IPs together with port numbers for receiving command frames.

- **Command Mode** (drop down menu):
 - **Command driven:** In “Command driven” mode device accepts IEEE C37.118 command frames from trusted clients IPs specified in “Trusted Clients” IP table and enables or disables data streams for those clients.
 - **Spontaneous CFG-2/3:** PMU periodically sends spontaneous IEEE C37.118 CFG-2 or CFG-3 frames to trusted clients specified in “Trusted Clients” IP table. Data is constantly streamed and cannot be enabled / disabled with IEEE C37.118 command frame from the client side.
 - **Spontaneous CFG-2/3 + Header:** PMU periodically send spontaneous IEEE C37.118 CFG-2 or CFG-3 frames together with header frame to trusted clients specified in “Trusted Clients” IP table Data is constantly streamed and cannot be enabled / disabled with IEEE C37.118 command frame from the client side.
- **Trusted Clients:**
 - **IP:** Specifies trusted clients IP addresses.
 - **PORT:** Specifies trusted clients destination port for sending IEEE C37.118 data frames.
 - **Enable:** Enable checkbox enables the trusted clients.

TCP/UDP section parameters

This method uses TCP for commands, header, and configuration communications, and UDP for sending data.

This mode can use UDP unicast, UDP multicast or UDP broadcast for sending IEEE C37.118 data frames. This mode support just one destination for sending data stream. TCP sessions can be established by clients which are defined in Trusted Clients table.

- **UDP Destination:**
 - **IP:** Specifies destination IP. In case of broadcast IP address, broadcast checkbox must be selected. IP can be a multicast address for sending data to a multicast group.
 - **PORT:** Specifies destination port number.
 - **TTL:** Specifies trusted clients Time To Live value used in multicast communication. It defines maximum number of forwarding over routers before packet ends its life.
- **Trusted Clients:** IP filter for accepting TCP sessions.
 - **IP:** Specifies trusted clients IP addresses.
 - **Enable:** Enable checkbox enables the trusted clients.

The screenshot shows the elpros web interface for 'Substation A'. The header displays device information: Device: TSMC400, Name: Substation A, User: Admin, Version: HW 1.1.0 / SW v1.0.4, Location: Ljubljana, and UTC: 09:15:18 2022-05-10. The left navigation menu includes Status, System, Network, Time Sync, Analog, Digital, IEEE C37.118, PMU-1, Network, Station 1, Station 2, PMU-2, PMU-3, and PMU-4. The main configuration area is titled 'Network' and contains the following sections:

- Network settings:** Port: 4712
- TCP:**
 - Trusted Clients Enable IP:

TCP-IP[1]	<input checked="" type="checkbox"/>	192.168.2.69
TCP-IP[2]	<input checked="" type="checkbox"/>	192.168.2.59
TCP-IP[3]	<input checked="" type="checkbox"/>	192.168.2.60
TCP-IP[4]	<input checked="" type="checkbox"/>	192.168.2.70
- UDP:**
 - Unicast: Command Mode: Command driven
 - Trusted Clients:

Trusted Clients	Enable IP	IP	PORT	TTL
UDP-IP[1]	<input checked="" type="checkbox"/>	192.168.2.69	1000	64
UDP-IP[2]	<input checked="" type="checkbox"/>	192.168.2.70	1000	64
UDP-IP[3]	<input type="checkbox"/>	0.0.0.0	4814	64
UDP-IP[4]	<input type="checkbox"/>	0.0.0.0	4815	64
- UDP multi-purpose:** Unicast/Multicast/Broadcast

At the bottom of the configuration area, there are 'Save', 'Reset', and 'Logout' buttons.

Figure 43: PMU server network configuration 1/2

Figure 44: PMU server network configuration 2/2

3.7.3 Station Configuration

If TSCM device has two analog input modules each PMU configuration has two stations named: Station 1 and Station 2. These use the analog modules as measurement data sources. The measurements are mapped as follows:

- AIN1 -> Station 1
- AIN2 -> Station 2

Stations can be configured separately. The configuration parameters are (see Figure 45):

IEEE C37.118

- **Active:** Activate / Deactivate the station - this adds or removes the whole station data from the IEEE C37.118 frame.
- **Configuration change counter:** This is an info field and cannot be changed. The counter is increased each time a configuration change of the IEEE C37.118 protocol is made.
- **Station name:** This is an info field and cannot be changed. It shows the name assigned to analog modules in the Analog tab. This name is also used as the IEEE C37.118 station name.
- **IDCODE:** IDCODE of the station.
- **Global PMU ID:** This is unique PMU ID (128-bit), generated by the device manufacturer. It is a part of config 3 message. It allows uniquely identifying PMUs in a system that has more than 65535 PMUs since config 2 enables only 16-bits.

Data Format

- **Phasor Data Format** specifies phasor data format:
 - Float (Floating point format)
 - Int (Integer format)
- **Phasor Coordinates:** specifies phasor presentation in coordinate system
 - Polar (magnitude and angle)

- Cartesian (rectangular) (real and imaginary)
- **Analog Data Format:** specifies data format of the analog values:
 - Float (Floating point format)
 - Int (Integer format)
- **Analog Measure Type:** specifies measurement methodology of the analog value:
 - Single point
 - RMS
 - Peak value
- **Frequency Data Format:** specifies data format of frequency value:
 - Float (Floating point format)
 - Int (Integer format)

Voltage

- **V1 V2 V3 Voltage:** Enable / Disable sending V1 V2 and V3 voltage input channel phasors in IEEE C37.118 frame.
- **Voltage Positive Sequence:** Enable / Disable sending voltage positive sequence phasors in IEEE C37.118 frame.
- **Voltage Negative Sequence:** Enable / Disable sending voltage negative sequence phasors in IEEE C37.118 frame.
- **Voltage Zero Sequence:** Enable / Disable sending voltage zero sequence phasors in IEEE C37.118 frame.
- **V4 Voltage:** Enable / Disable sending V4 voltage input channel phasors in C37.118 frame.

Current

- **I1 I2 I3 Current:** Enable / Disable sending I1 I2 and I3 current input channel phasors in IEEE C37.118 frame.
- **Current Positive Sequence:** Enable / Disable sending current positive sequence phasors in IEEE C37.118 frame.
- **Current Negative Sequence:** Enable / Disable sending current negative sequence phasors in IEEE C37.118 frame.
- **Current Zero Sequence:** Enable / Disable sending current zero sequence phasors in IEEE C37.118 frame.
- **I4 Current:** Enable / Disable sending I4 current input channel phasors in C37.118 frame.

Analog

- **Analog 4 - 20 mA AI1:** Enable / Disable sending analog DC 4 – 20 mA measurement in IEEE C37.118 frame.

Digital

- **Binary / GOOSE Inputs / Outputs:** Enable / Disable sending and receiving binary input / outputs state in IEEE C37.118 frames.
- Digital word 1: All digital inputs are directly mapped to the first digital word; first 6 bits are valid the rest are always 0.
- Digital word 2: All digital outputs states are directly mapped to the second digital word in the IEEE C37.118 frame, first 6 bits are valid the rest are always 0. A proprietary IEEE C37.118 command frame is used to control the outputs states.
- Digital word 3: All GOOSE inputs are directly mapped to the third digital word of IEEE C37.118 frame.
- Digital word 4: Validity of goose messages.
- Digital word 5: All GOOSE outputs are directly mapped to the fifth digital word of IEEE C37.118 frame. A proprietary IEEE C37.118 command frame is used to control the output GOOSE states.

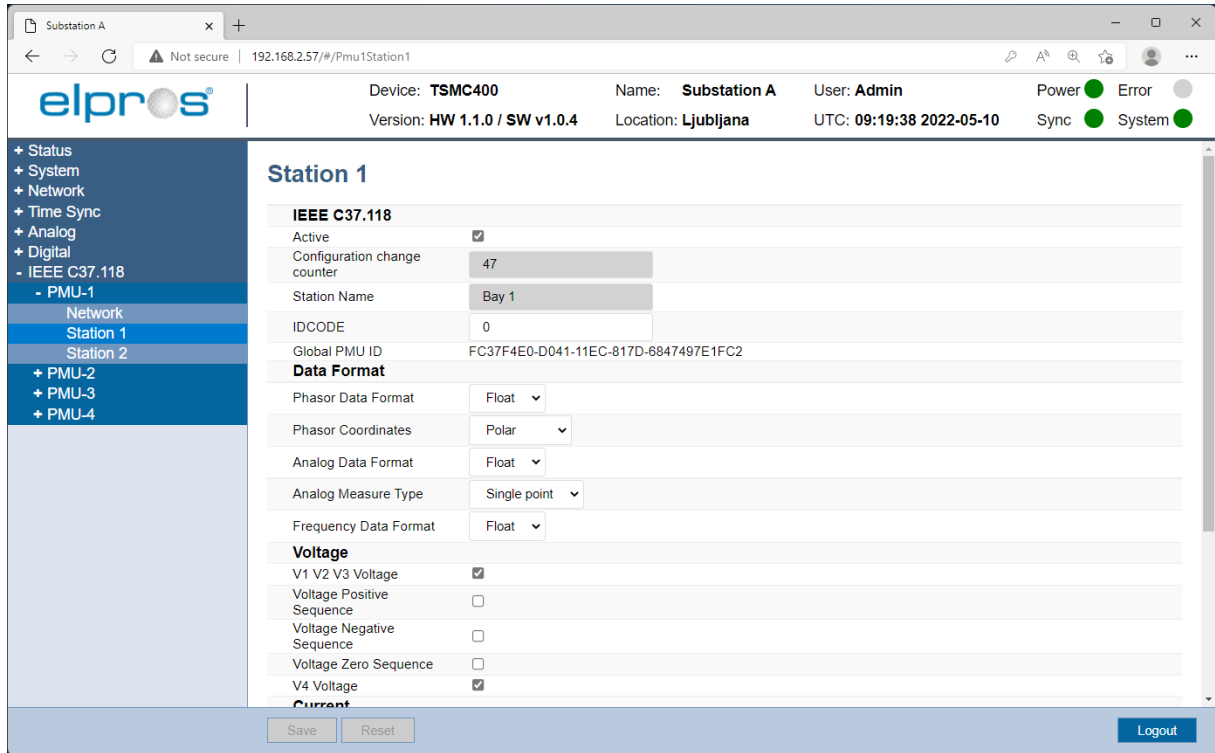


Figure 45: PMU Station configuration 1 / 2

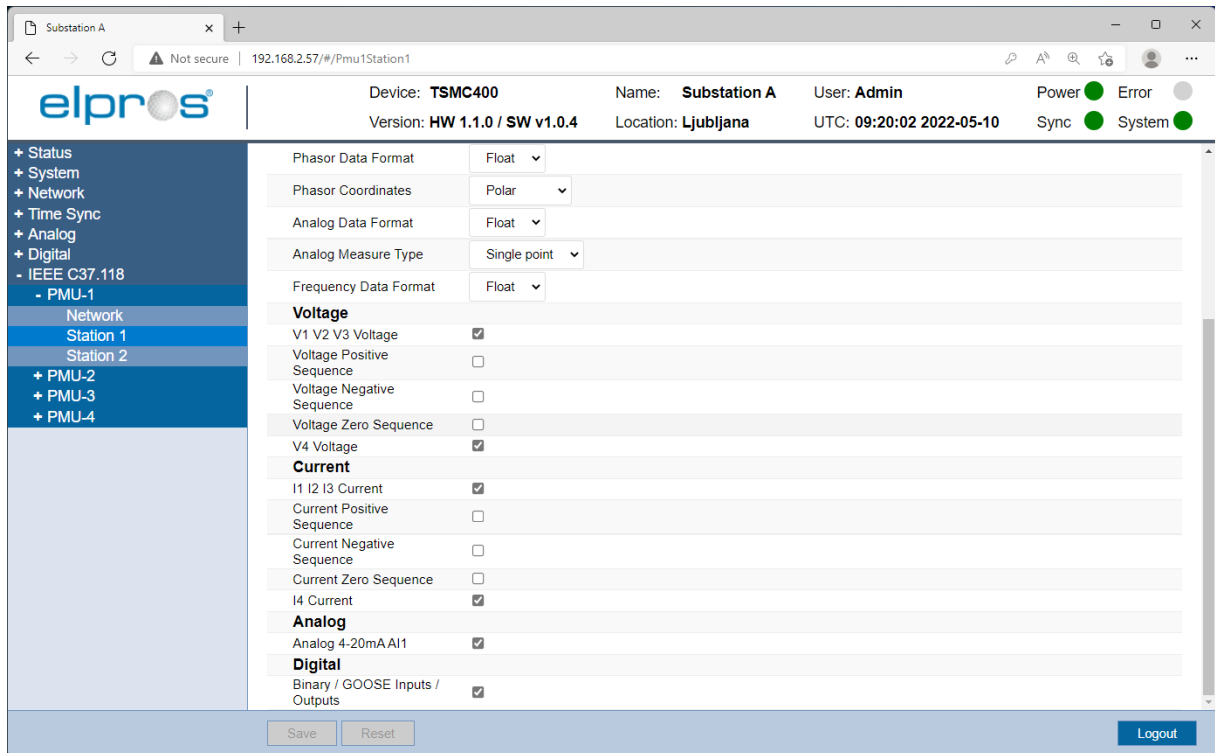


Figure 46: PMU Station configuration 2 / 2

4 Device Status

Multiple levels of general and detailed device statuses are provided over the Web interface.

All users can access all status pages.

4.1 General device status

A quick overview of the device status is provided on the "Status bar" on the top of the Web interface see 2.2 Web interface layout. The status bar is always visible.

A more detail status of the device operation can be observed on the *Status* page as shown in Figure 47. Following information is available:

- **CPU Load:** The current device Central Processing Unit (CPU) load.
- **Device time synchronized:** Status of device time synchronisation. (Is the device synchronized to a traceable time source or not, Yes / No).
- **Measurements AINx:** If synchro-phasor measurements from the input module AINx are available for transferring by IEEE C37.118 protocol, the status is "Running" otherwise "Not running".
- **Current network configuration:** Show the current configuration of the devices network interface:
 - **IP:** Device static IP.
 - **Subnet Mask:** Network subnet mask.
 - **Default Gateway:** Network gateway IP.
 - **DNS Server:** DNS server IP.
 - **MAC address:** Network adapter hardware address.

The screenshot shows the elpros web interface for 'Substation A'. At the top, there is a status bar with the following information: Device: TSMC400, Name: Substation A, User: Admin, Power: On (green dot), Error: Off (grey dot), Version: HW 1.1.0 / SW v1.0.4, Location: Ljubljana, UTC: 09:22:56 2022-05-10, Sync: On (green dot), System: On (green dot). Below the status bar is a navigation menu on the left with options like Status, Process, Sessions, Time Sync, Analog AIN1, Analog AIN2, Digital DIO1, Digital GOOSE Input, Digital GOOSE Output, Log, System, Network, Time Sync, Analog, Digital, and IEEE C37.118. The main content area is titled 'Status' and contains a table of device metrics and a section for 'Current network configuration'.

Status	
CPU load	24 %
Device time synchronized	Yes
Measurement AIN1	Running
Measurement AIN2	Running
Current network configuration	
IP	192.168.2.57
Subnet mask	255.255.255.0
Default gateway	192.168.1.1
DNS server	0.0.0.0
MAC address	68:47:49:7E:1F:C2

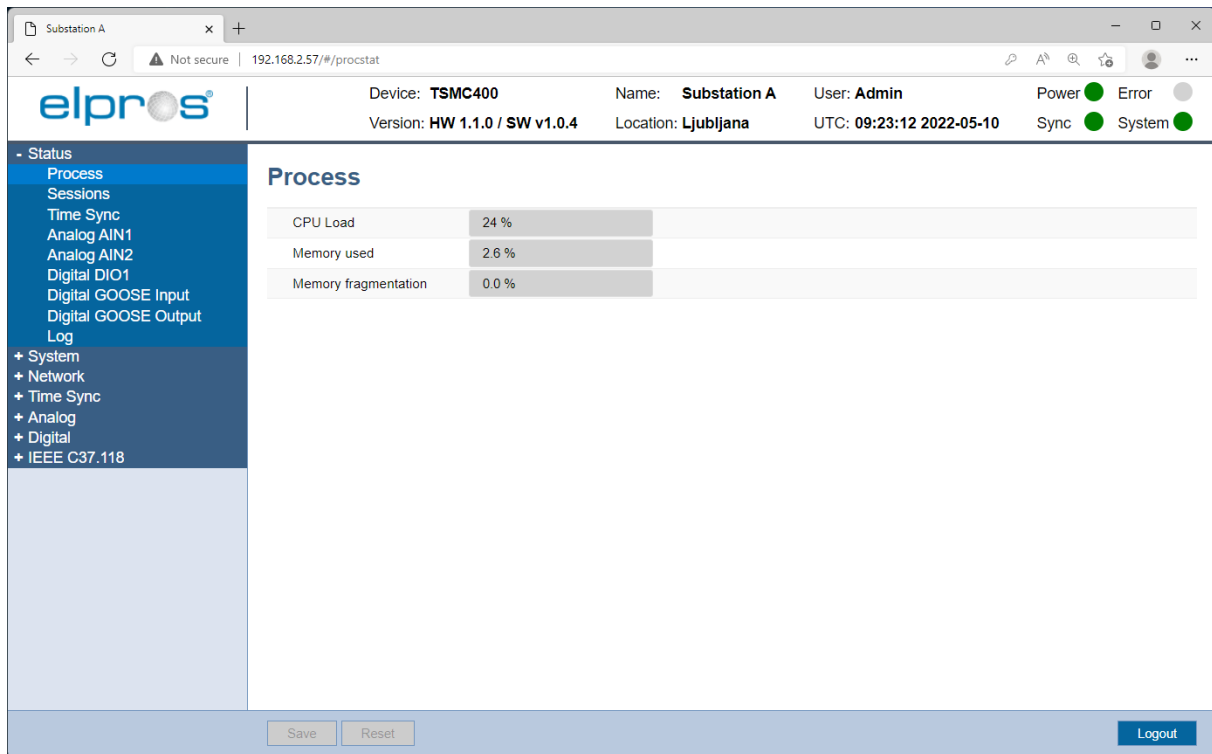
At the bottom of the page, there are 'Save', 'Reset', and 'Logout' buttons.

Figure 47: Status page

4.2 Process

A more detailed view of the device process status can be observed on *Status->Process* page. The following information is available:

- **CPU Load:** The current device CPU load.
- **Memory used:** Amount of device memory used.
- **Memory fragmentation:** Amount of device memory fragmentation.



The screenshot shows the elpros web interface for Substation A. The top status bar displays: Device: TSMC400, Name: Substation A, User: Admin, Power: On, Error: Off, Version: HW 1.1.0 / SW v1.0.4, Location: Ljubljana, UTC: 09:23:12 2022-05-10, Sync: On, System: On. The left navigation menu is expanded to show the Process page. The main content area displays the following process status:

Metric	Value
CPU Load	24 %
Memory used	2.6 %
Memory fragmentation	0.0 %

At the bottom of the page, there are buttons for Save, Reset, and Logout.

Figure 48: Process status

4.3 Sessions

The current ongoing IEEE C37.118 sessions can be observed on *Status->Sessions* page, see Figure 49.

A client IP address and PMU configuration number are provided for each ongoing session.

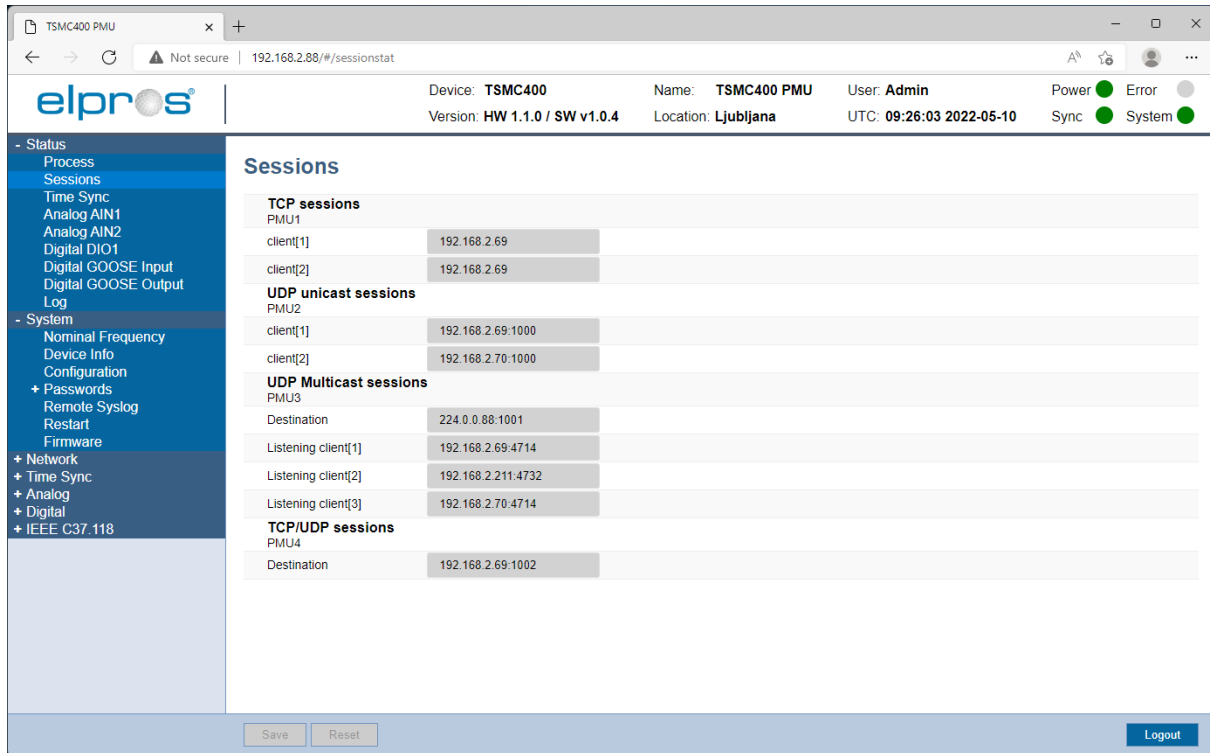


Figure 49: Session status

4.4 Time synchronization

The device time synchronization and input time signals status can be observed on *Status->Time sync* page, see Figure 50. The following information is available:

- **Device time synchronized:** Is the device synchronized to a traceable time source, Yes / No.
- **Selected time source:** Which time source is currently used for internal time synchronization: GPS / PTP / IRIG-B / NO VALID CLOCK SOURCE.
- **External Time Sources:**
 - **Time source quality:** Is “Message Time Quality” indication code of time source, according to the criteria of IEEE C37.118.2. this parameter can be “Lock” or “Fault”
 - **Estimated time quality:** Is maximum uncertainty estimation reported by time source (locked or unlocked), rated as PMU Time Quality indication codes (PMU_TQ) in standard IEEE C37.118.2 or Continuous Time quality (CTQ) specified for the IRIG-B profile in Annex D of IEEE Std C37.118.1-2011.
 - **Source to system PPS offset:** Synchronization offset between internal time and external time source measured at last internal 1PPS.
- **Time source difference:** Synchronization offset between external time sources.
- **System PLL state:** Status of internal main clock Phase Locked Loop (PLL):
 - **Init:** External clock source valid PLL start-up.
 - **Locking:** Internal clock synchronizing to external source.
 - **Lock:** Internal clock synchronized with external source.
 - **Holdover:** Internal clock was previously synchronized but external clock source was lost. Due to the high-quality internal oscillator synchronization under 1 microsecond can be held for several minutes without external source.
 - **Recovery:** Previous state was holdover and external clock source was reacquired. A resynchronization is being performed.

- **C37.118.2 MSG TQ:** Reported status of time synchronization “Message Time Quality” in all IEEE C37.118.2 frames.
- **C37.118.2 PMU TQ:** Reported estimated maximum uncertainty of internal clock “PMU Time Quality” in C37.118.2. data frame.

The screenshot shows the 'Time Sync' configuration page for 'Substation A'. The device is identified as 'TSMC400' with version 'HW 1.1.0 / SW v1.0.4'. The user is 'Admin' and the location is 'Ljubljana'. The UTC time is '09:31:23 2022-05-10'. The interface displays the following data:

External Time Sources			
	Time source quality	Estimated time quality	Source to system 1PPS offset
Time source	GPS Lock	< 100ns	2 ns
	PTP Fault	Max error	N/A
	IRIG Fault	TQ not used	N/A

Time source difference	GPS/PTP		GPS/IRIG		PTP/IRIG	
	1PPS offset	N/A	N/A	N/A	N/A	N/A
System PLL state	Lock					
C37.118.2 MSG TQ	Lock					
C37.118.2 PMU TQ	< 100ns					

Figure 50: Time synchronization status

4.5 Analog AIN1, AIN2

Overview status of the analog module measured values can be observed on *Status->Analog AIN1, AIN2* pages. Following information is available:

- **Frequency:** Measured input signal frequency.
- **Channel Name:** Configured channel names.
- **Value:** Last measured value of the input channel.

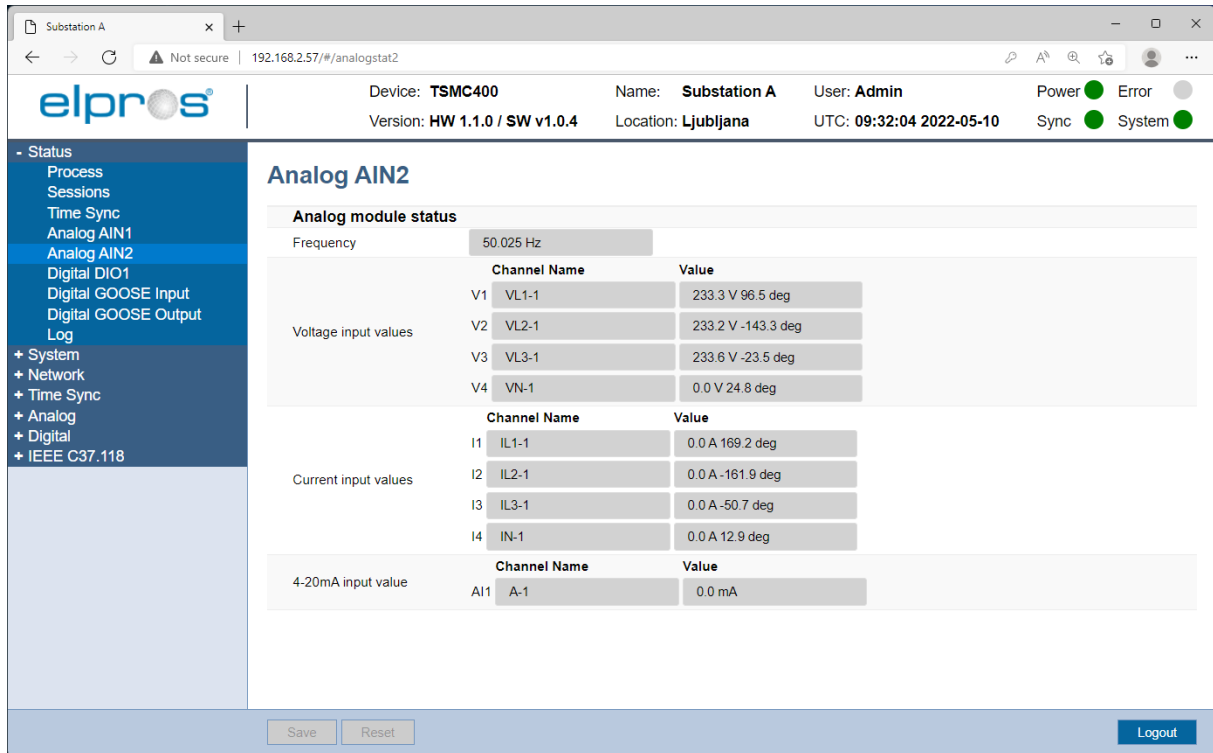


Figure 51: Analog module status

In case of hardware error, the following “Error” messages is displayed:

- **Error on AIN:** When AIN card did not respond in system initialization sequence.
- **One or more channels not calibrated:** If AIN is not fully calibrated.

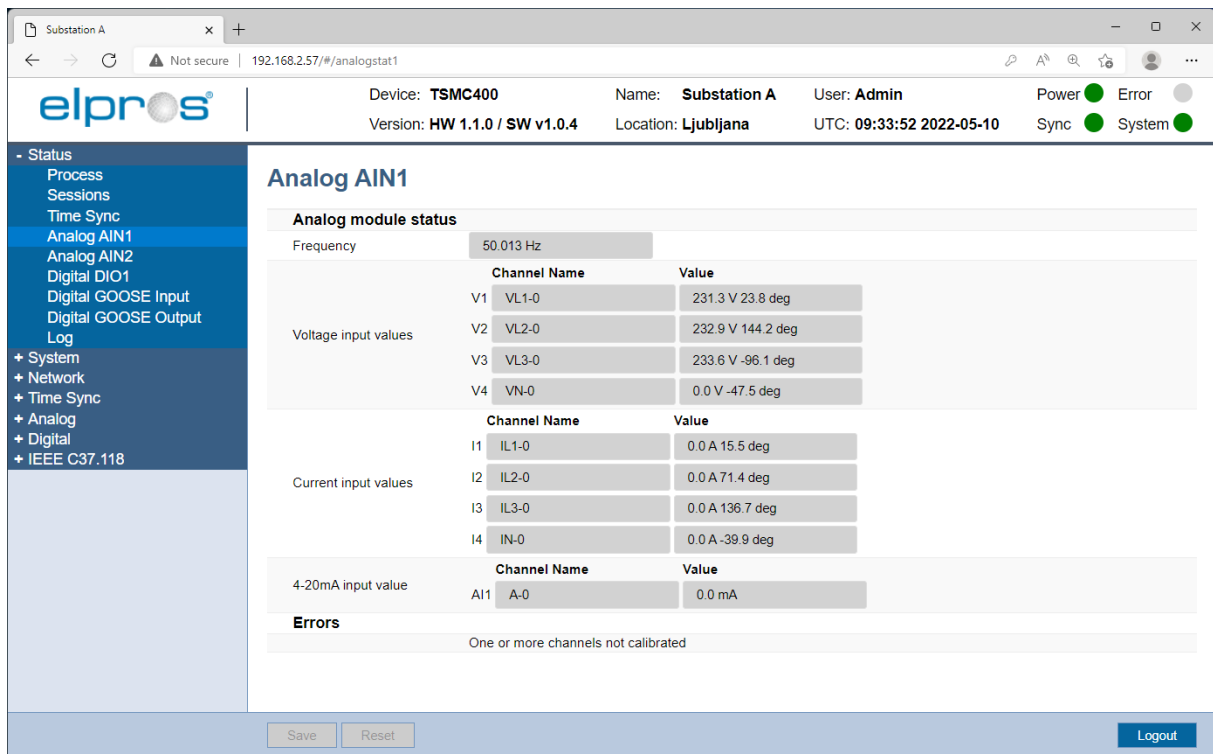


Figure 52: AIN calibration error

In case of sample capture or calculation problem the following “Measurement Status” can be displayed:

- **AIN read error:** Unsynchronized sampling or general data sampling problem.
- **AIN operation error:** Indicates AIN module problem or phasor calculation error.
- **Frequency out of range:** Indicate that calculated voltage signal frequency is more than +/- 5Hz of nominal frequency.
- **Frequency can't be calculated:** It indicates that frequency calculation algorithm can't calculate frequency because of too noisy or distorted voltage signal.
- **Internal error:** Indicate that phasor and frequency calculation algorithm detect invalid results.
- **AIN calibration read error:** It indicates invalid calibration data for AIN module.
- **Distorted signal detected:** It indicates Dynamic Limiter event, when voltage signal is too distorted and phasor cannot be calculated.
- **Below Under voltage high threshold:** Indicate Dynamic Limiter state, where voltage signal after “Under voltage event” didn't reach hysteresis threshold for normal operation.
- **Under voltage low threshold:** Indicate Dynamic Limiter state where voltage signal is under usable level.
- **Frequency hold:** It indicate Dynamic Limiter state where system reports last valid value of frequency.
- **Reporting modified data:** It indicate publishing of IEEE C37.118 data frame with raised “Modified data” flag in case of Dynamic Limiter event.
- **Pending clock synchronization:** Waiting for clock synchronize before sampling starts.

4.6 Digital DIO1

Overview status of the digital module measured and set values can be observed on *Status->Digital DIO1* page, see Figure 53. The following information is available:

- **Digital binary input:**
 - **Channel Name:** Configured channel names.
 - **Value:** Last measured value of the input channel.
 - **Logical Value:** Value of the input reported over IEEE C37.118.
 - **Inverted:** Is the channel configured as inverted. If enabled Logical Value = inverted measured value.
- **Digital binary output:**
 - **Channel Name:** Configured channel names.
 - **Value:** Last physical set value of the output channel.
 - **Logical Value:** Value of the output set by external command.
 - **Inverted:** Is the channel configured as inverted.

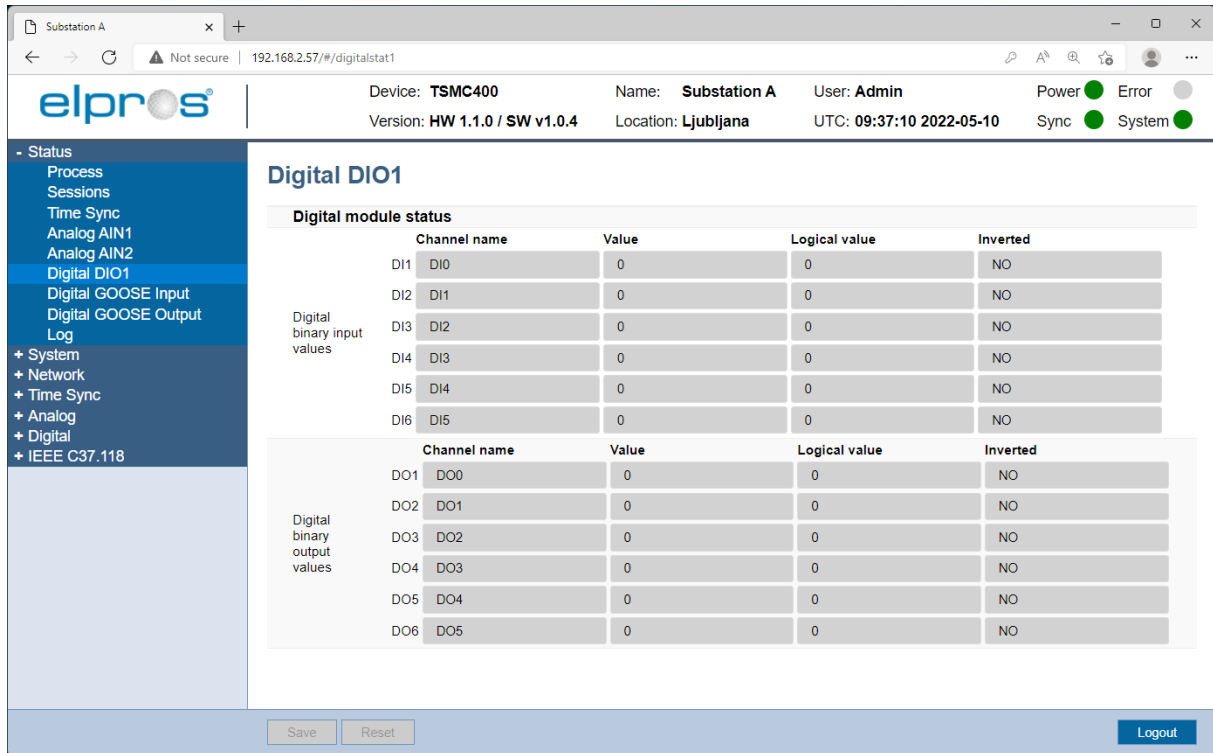


Figure 53: Digital module DIO1 status

4.7 Digital GOOSE Input

Overview of subscribed GOOSE statuses can be observed on *Status->Digital GOOSE Input* page, see Figure 54. The following information is available:

- **Number of GOOSE input:** GI1 to GI16.
- **C37 Name:** Configured input IEEE C37.118 name. This is also the name of the bit in the IEEE C37.118 data frame.
- **GOOSE variable Name:** Full name of the configured GOOSE variable for this input.
- **Test Flag:** Indicates the test flag status of the received GOOSE frame.
- **Value:** Last received binary value of the GOOSE variable.
- **Status:** Indicates status of the GOOSE input:
 - **Gray:** Input not configured.
 - **Green:** OK without timeout.
 - **Red:** GOOSE frame not received in time allowed to live timeframe, timeout.

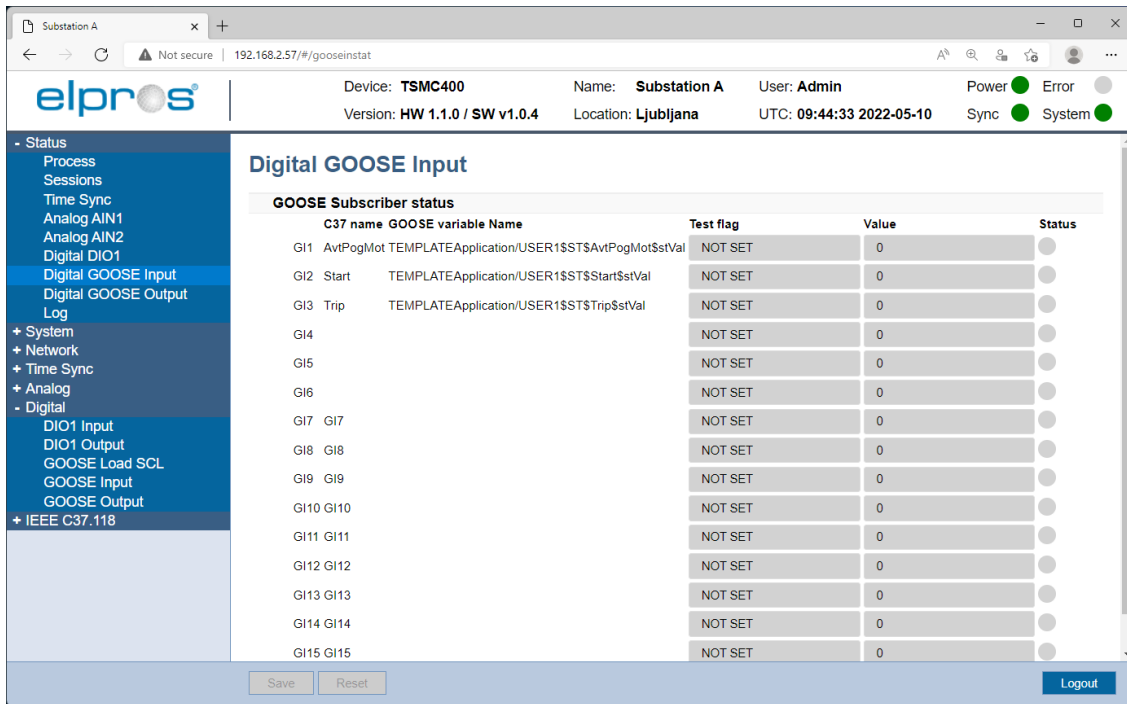


Figure 54: Digital GOOSE Input status

4.8 Digital GOOSE Output

Overview of published GOOSE statuses can be observed on *Status->Digital GOOSE output* page, see Figure 55. The following information is available:

- **Number of GOOSE output:** GO1 to GO16.
- **Value:** Current published value.

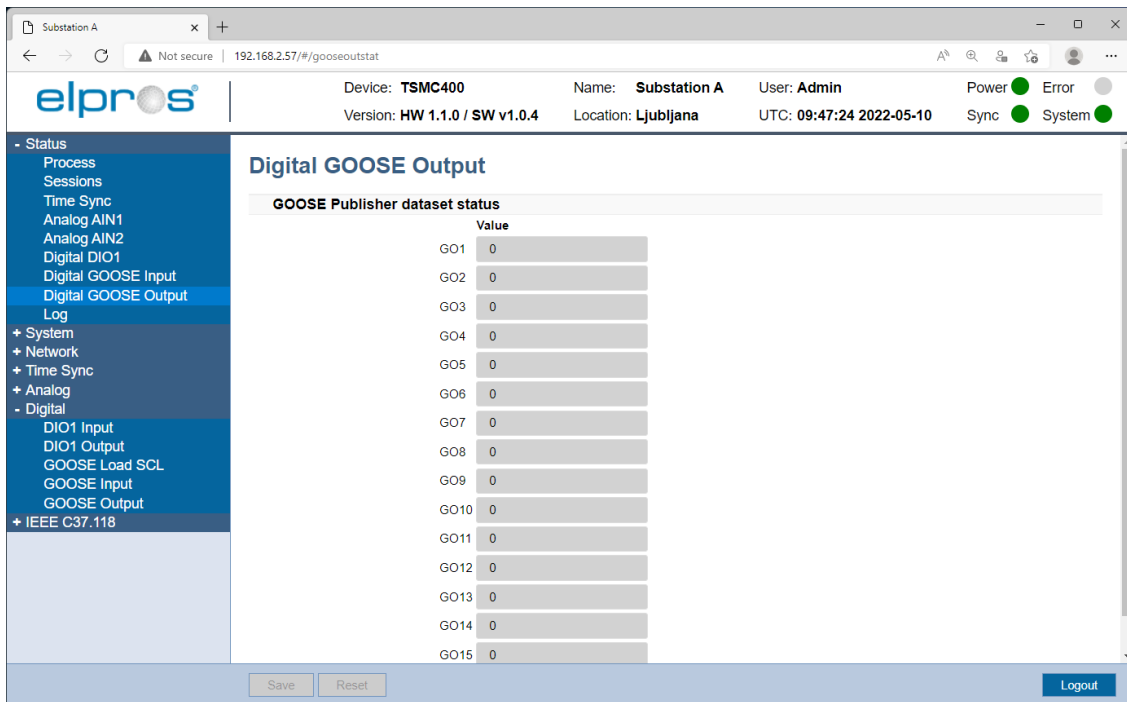


Figure 55: Digital GOOSE Output status

4.9 Log

Device logs can be observed on *Status->log* page, see Figure 56. The log is saved in volatile memory and is deleted at device reset.

To move through the log pages, select a page from the drop-down menu and click save.

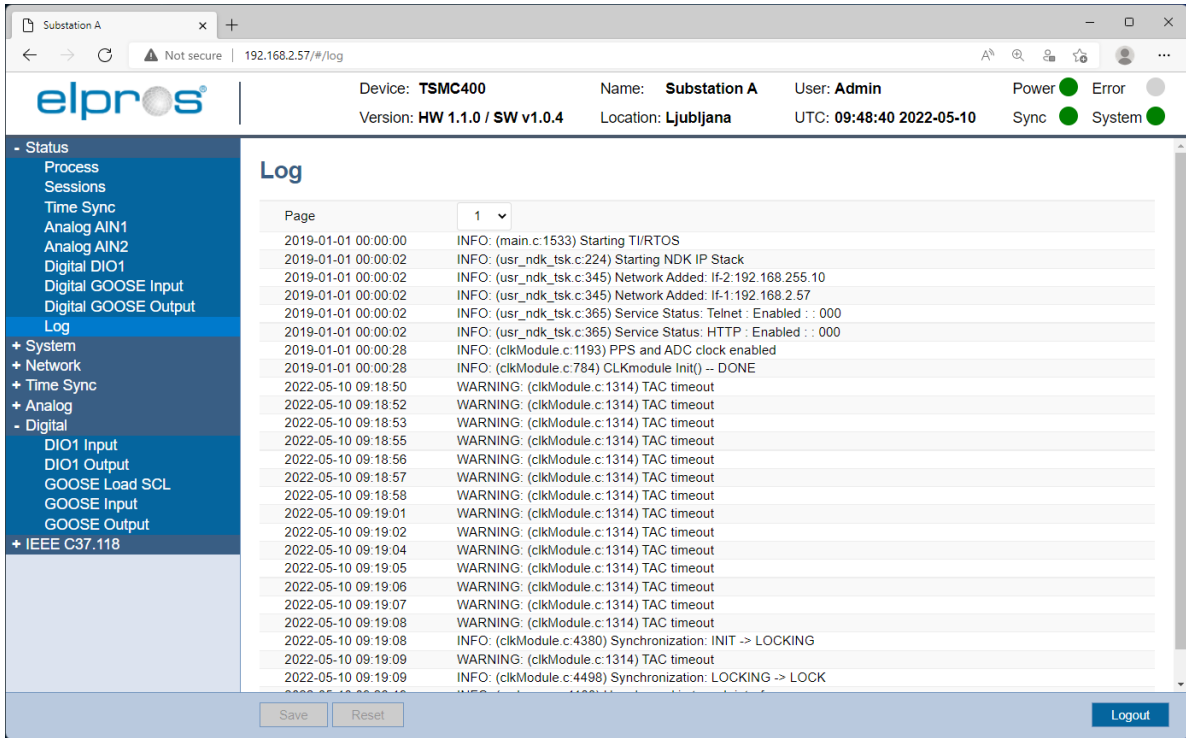


Figure 56: Log view



Elektronski in programski sistemi d.o.o.

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