MANUAL

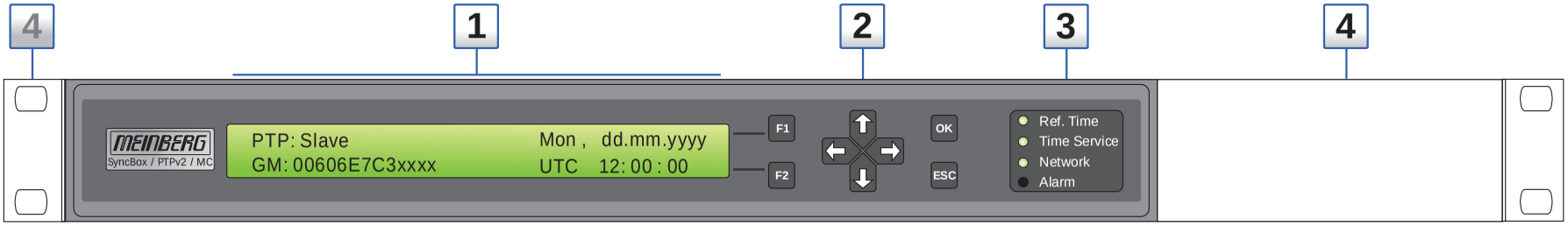
SyncBox

PTPv2/MC

20th August 2013

Meinberg Radio Clocks GmbH & Co. KG

Front view (Frontansicht) SyncBox



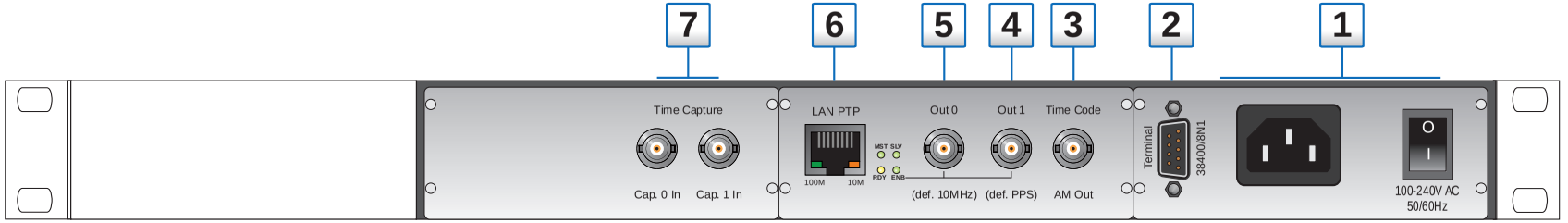
ENGLISH

1. LC Display, 2 x 40 characters
2. Function buttons: 4-way navigation; F1, F2, OK, ESC
3. Status LEDs: Ref. Time, Time Service, Network, Alarm
4. *Optional:* brackets for 19" rack mount

DEUTSCH

1. LC Display, 2 x 40 Zeichen
2. Funktionstasten: 4 Wege Navigation; F1, F2; OK, ESC
3. Status LEDs: Ref. Time, Time Service, Network, Alarm
4. *Optional:* Zusatzwinkel für 19" Einschub

Rear view (Rückansicht) SyncBox



ENGLISH

1. Power supply connector
2. Terminal / VT100, 38400 Baud, 8N1, 9pin. D-SUB male
3. Time Code AM output, BNC
4. defined PPS output, BNC
5. defined 10MHz output, BNC
6. LAN PTP 10/100MBit, RJ45
7. Time Capture input, BNC

DEUTSCH

1. Spannungsversorgung
2. Terminal / VT100, 38400 Baud, 8N1, 9pol. D-SUB Stecker
3. Time Code AM Ausgang, BNC
4. definierter PPS Ausgang, BNC
5. definierter 10MHz Ausgang, BNC
6. LAN PTP 10/100MBit, Rj45
7. Time Capture Eingang, BNC

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1 Impressum

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Date: 2012-01-26

2 Safety instructions for building-in equipment

This building-in equipment has been designed and tested in accordance with the requirements of Standard IEC60950-1 "Safety of Information Technology Equipment, including Electrical Business Equipment".

During installation of the building-in equipment in an end application (i.e. rack) additional requirements in accordance with Standard IEC60950-1 have to be taken into account.

- The building-in equipment is a class 1 - equipment and must be connected to an earthed outlet (TN Power System).
- The building-in equipment has been evaluated for use in office environment (pollution degree 2) and may be only used in this environment. For use in rooms with a higher pollution degree more stringent requirements are applicable.
- The building-in equipment may not be opened.
- Protection against fire must be assured in the end application.
- The ventilation opening may not be covered.
- The equipment/building-in equipment was evaluated for use in a maximum ambient temperature of 40°C.
- For safe operation the building-in equipment must be protected by max 16 A fuse in the power installation system.
- Disconnection of the equipment from mains is done by pulling the mains plug.

3 Quick Start

One minute after power up you can connect via a null modem cable a serial terminal from your PC.When booting the system the following message will be displayed while dots will be counted up in the lower line:

```
Starting up..............please wait
```

You can use e.g. the standard Hyperterminal program shipped with your Windows operating system. Configure your terminal program with 38400 Baud, 8 Data bits, no parity and 1 Stop bit. The terminal emulation have to set to VT100 (press RETURN for first connection):

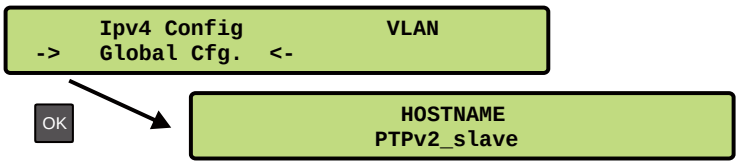
Main Menu will be displayed with some important status informations after booting has finished:

```
PTP: UNCALIBRATED        Su,  01.01.2012
Error: no Lnk detected   UTC  14:33:10
```

If the Grandmaster is identified, the Main Menu will be displayed the PTP status information, with the MAC-Address of the Grandmaster.

```
PTP:SLAVE                Su,  01.01.2012
GM:0050C2DExxxx          UTC  14:33:10
```

For first time installation enter TCP/IP address, netmask and default gateway. To get an overview of the current configuration press F2 from main menu. Press F2 again to enter SETUP configuration page. Please ask your administrator for propper TCP/IP configuration:



With the different Options "Global Configuration" and "Interfaces" you can have to configure the Hostname or IP-Address.

After this all further settings can be done via network interface, either by using a WEB browser or a Telnet Session.

Die Ausgänge der SyncBox (10MHz, PPS und IRIG) werden erst freigeschaltet, wenn das System einmal mit einem PTP Grandmaster synchronisiert hat und der interne Oszillator (OCXO HQ) eingeschwungen ist (warmed up). Das Einschaltverhalten der Ausgänge kann in der Konfiguration eingestellt werden. Ohne einen externen PTP Grandmaster hat die SyncBox keine gültige Zeit.

The outputs of the SyncBox (10MHz, PPS and IRIG) will be enabled if the system has been synchronized

by an external PTP grandmaster once and the internal oscillator (OCXO HQ) has warmed up. When outputs will be enabled can be set up in the PTP configuration. The SyncBox will start with a non valid time until it synchronized by an external PTP IEEE1588 grandmaster once.

4 PTPv2 Slave with high accuracy Oscillator

The SyncBox provides a high precision time base (OCXO HQ) with multiple outputs for 10MHz, PPS and IRIG via TCP/IP network, synchronized by a PTP IEEE1588 grandmaster reference clock. The SyncBox act as a PTP slave with high precision oscillator to produce different timing and frequency outputs. SyncBox is a set of equipment composed of a PTP IEEE1588 Time Stamp Unit (TSU) and a power supply. Two user configurable outputs for 1 PPS, 10 MHz and unmodulated time code (IRIG) can be set up next to a modulated time code (IRIG) output. Also two capture inputs are integrated to get high precision time stamps of external events. A simplified LINUX operating system is installed on the single-board computers flash disk. After the network connection has been established the timeserver can also be configured and monitored remotely from a workstation via TELNET or SSH. An integrated HTTP server enables access to the SyncBox by using an ordinary WEB browser.

5 The Modular System SyncBox

The SyncBox is a set of equipment composed of a PTP IEEE1588 Time Stamp Unit (TSU) and a power supply unit, all installed in a metal rail mount case and ready to operate. The interfaces provided by the SyncBox are accessible via connectors in the front panel of the case. Details of the components are described below.

SyncBox has one PTP IEEE1588 network interface. The outputs of the SyncBox (10MHz, PPS and IRIG) will be enabled if the System has been synchronized by an external PTP grandmaster once and the internal oscillator (OCXO HQ) has warmed up. The SyncBox will start with a non valid time until it it synchronized by an external PTP IEEE1588 gradmaster once. Next to PTP IEEE1588 a the Linux system supports a number of further network protocols: HTTP(S), SSH and Telnet. Because of this remote configuration or status requests can come from any WEB browser. Changes in the receiver status, errors or other important events are logged on the local Linux system.

5.1 PTP Status LEDs MST und SLV

To get the time from a PTP IEEE1588 grandmaster clock a valid IPv4 address and the gateway have to be set up on the ethernet port. The state of the PTP on the SyncBox will be reflect by the LEDs „MST“ and „SLV“. the „SLV“ LED will flash green if a valid PTP paket will receive from an external PTP IEEE1588 grandmaster; the „MST“ LED will flash if the SyncBox will send a PTP paket to the PTP network. While normal operation of the SyncBox the „SLV“ LED should be flashing every 2 seconds.

5.2 User defined outputs OUT0, OUT1

Both outputs OUT0 and OUT1 can be set to 10 MHz, 1 PPS or unmodulated Time Code (IRIG) each. The default configuration is:

OUT0: 10 MHz
OUT1: 1 PPS

To change configuration of outputs open a Telnet or SSH session to the SyncBox and edit the file /mnt/flash/-config/ptp/tsu_conf. The type of Time Code will be set for both outputs and also for the unmodulated output.

 # Time Code Types for IRIG Mode:
 # 0: B002_B122
 # 1: B003_B123
 # 2: A002_A132
 # 3: A003_A133
 # 4: AFNOR
 # 5: IEEE1344
 # 6: B220_1344
 # 7: B222
 # 8: B223

IRIG Mode: 4

 # Output Modes:
 # 0 : Idle
 # 1 : 1PPS
 # 2 : 10MHz
 # 3 : IRIG

OUT0 Mode: 2
OUT1 Mode: 1

OUT0 inverted: 0
OUT1 inverted: 0

OUT0 active: 1
OUT1 active: 1

When outputs will be enabled can be set up in this file. By default all outputs will be enabled after booting the SyncBox (LED „ENB“ will flash green). Be aware that the time of the SyncBox is not valid after reboot until the internal PTP has not synchronized by an external PTP grandmaster. To enable outputs when the internal PTP has synchronized and the OCXO HQ has been fine adjusted you have to set the parameter „OCXO HQ control:“ to „1“. It could take several hours to do the fine adjusting of the OCXO HQ.

5.3 Modulated Time Code (IRIG)

This output will provide a modulated Time Code (IRIG). The type of Time Code is the same as the outputs OUT0 and OUT1.

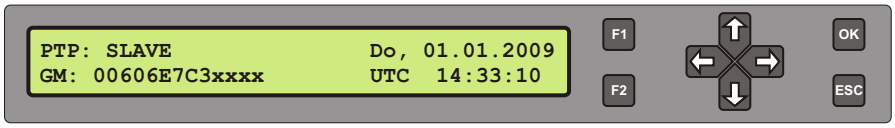
5.4 Capture Inputs CAP0, CAP1

Two time capture inputs called User Capture 0 and 1 are provided at the rear panel of the SYNCBOXV2 (CAP0 and CAP1) to measure asynchronous time events. A falling TTL slope at one of these inputs lets the microprocessor

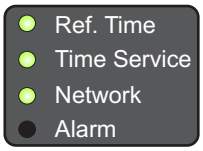
save the current real time in its capture buffer. Before every capture the ports have to be enabled by software. This could be done by a command from Telnet or SSh session on the SyncBox. The command „show_ucap“ will cyclic enable the capture ports and print the time in nano seconds and the channel number.

6 Root Menu

The root menu is shown when the receiver has completed initialization after power-up. With the four arrow buttons and the buttons „OK“, „ESC“, „F1“ and „F2“ the navigation and setting of parameters can be managed. Main menu can be reached by pressing „ESC“ some times. The main menu reflect some of the main parameters of the time server.



Current time and date of the syncbox with the name of the time zone will be monitored on the right side.
The multicolor LEDs will reflect the current state of the device:

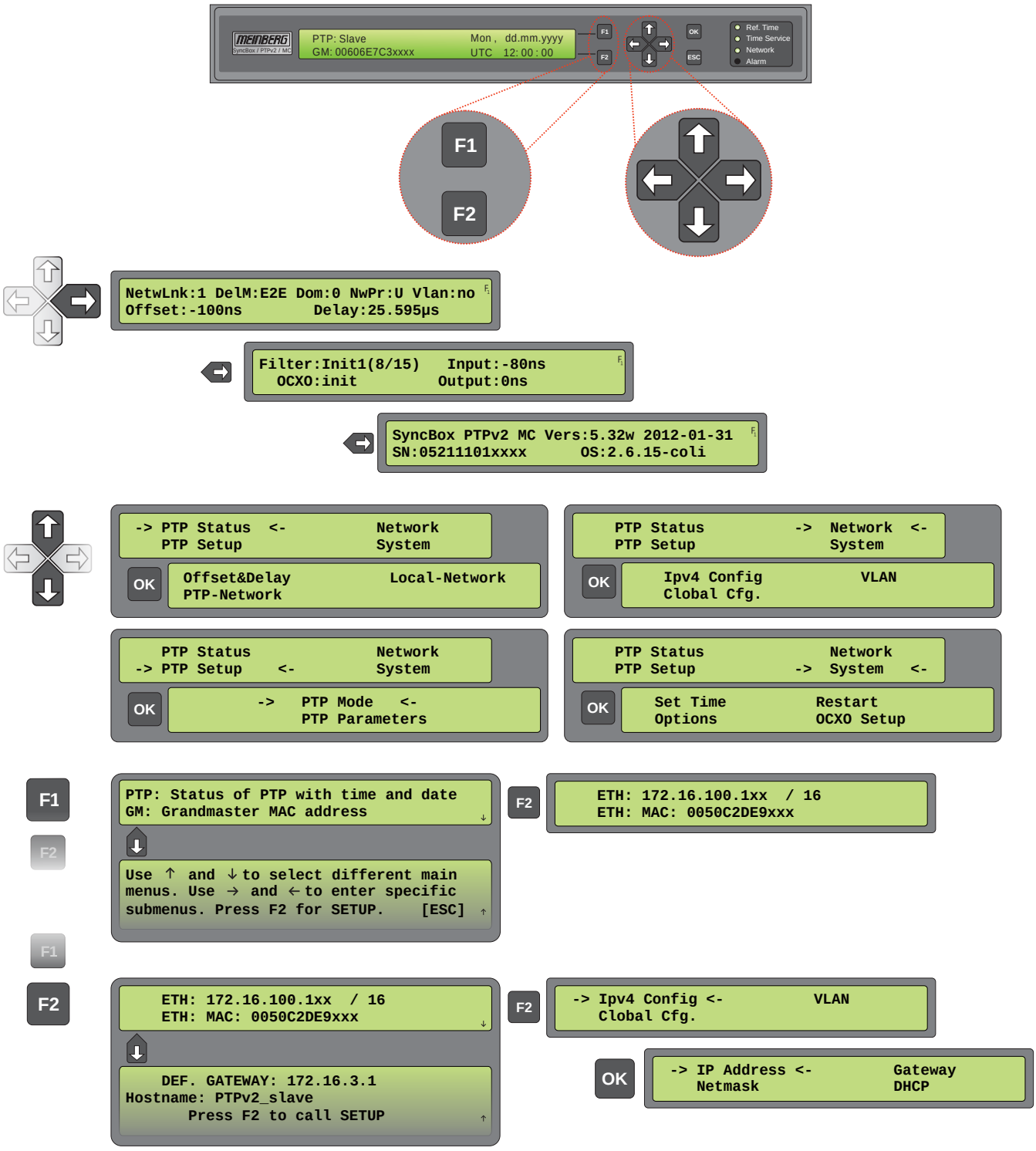


„Ref. Time“
green: the reference clock is synchronized for one-time.
red: the reference clock is in the mode: free-running.

„Time Service“
green: the reference clock is synchronized by PTP.
red: PTP is not synchronous to reference clock.

„Network“
green: the network port has been “link up“ detected
red: at least the watched network port is not connected

„Alarm“
off: no error at moment
ret: general error – more information will be shown on display.

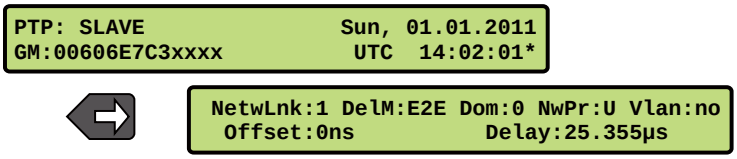


Different status pages will be shown when pressing button "RIGHT" in main menu. Depending on the HQ Filter there will be shown more pages with additional informations. Last page will display the software version and the serial number of the device.

The current network configuration will be shown in a summary when pressing F2 from the main menu. Press F2 again to switch directly to the network configuration setup pages.

The following main menus will be displayed when pressing the „UP“ and „DOWN“ arrow buttons:

6.1 Menu: PTP State



Two PTP status pages will reflect the current state of the PTP protocol. First page will show the "PTP State" of the PTP deamon. The PTP deamon will always be started in slave mode. When SyncBox has been found a PTP grandmaster the state will change to "SLAVE". If HQ-Filter has been activated a "init" will be added to the current state while HQ-Filter is in initializing mode. If no grandmaster is available or the pathdelay meassurement has not been finished the state will show "UNCALIBRATED". If no network link has been detected on the PTP port the message "PTP Error: no link detected on PTP port" will be shown. If no grandmaster is available the state changes to "LISTENING no master found".

GmMac: MAC address (hardware address) of the current grandmaster. If no grandmaster is available, its own MAC adress will be shown.

The second line will show the last offset and pathdelay meassured to the grandmaster. Pressing the button "Up" or "Down" once the second PTP status page will be displayed. This page will reflect the main parameters of the PTP daemon:

NetwLink: Link state of the PTP network port.

DelM: PTP Delay Mechanism with E2E (End to End Delay meassurement) or P2P (Peer to Peer Delay meassurement)

Dom: PTP Domain. There could be different PTP Domains (0 to 5) in one subnet be used.

NwPr: Network protocol: 0=Ethernet Layer2 or 1=UDP Layer 3

VLan: VLAN ID: 0 up to 4095

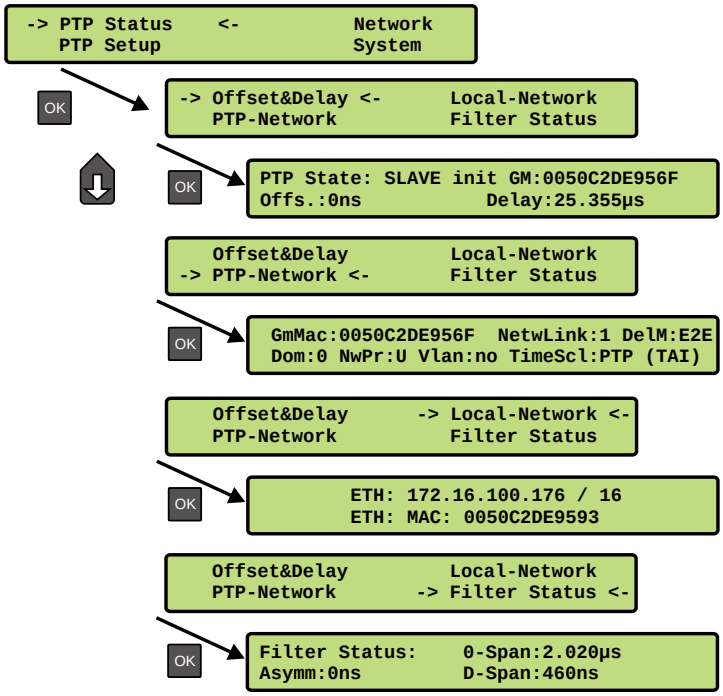
If HQ-Filter has been activated an extra status page will shown when pressing "right" on front panel. This page will reflect the current PTP state:

Filter: While initializing the HQ-Filter will use two init phases. After initialization the range of the Filter will be displayed (e.g.: >1000ns meant that all values greater than 1us will be discarded)

OCXO: if HQ Oscillator has been settled the new state will be shown

Input: raw input values to the filter

Output: output values coming out of the filter (used for adjusting the OCXO)



PTP Status: Offset&Delay

This page will show the current state of the PTP stack. The following modes are possible:

INITIALIZING:	Initialization of the network port (e.g. no link detected)
LISTENING:	no PTP Grandmaster found
MASTER:	PTP Mode Master
PASSIVE:	there is an other PTP Master in the network active
UNCALIBRATED:	could not calculate path delay to Grandmaster
SLAVE:	PTP Mode Slave

When SyncBox has been found a PTP grandmaster the state will change to "SLAVE". If HQ-Filter has been activated a "init" will be added to the current state while HQ-Filter is in initializing mode. If no grandmaster is available or the pathdelay meassurement has not been finished the state will show "UNCALIBRATED". If no network link has been detected on the PTP port the message "PTP Error: no link detected on PTP port" will be shown. If no grandmaster is available the state changes to "LISTENING no master found".

PTP Status: PTP-Network

This page will show the network specific PTP information:

GmMac:	MAC address (hardware address) of the current grandmaster. If no grandmaster is available, its own MAC adress will be shown.
NetwLink:	Link state of the PTP network port.
DelM:	PTP Delay Mechanism with E2E (End to End Delay meassurement) or P2P (Peer to Peer Delay meassurement)
Dom:	PTP Domain. There could be different PTP Domains (0 to 5) in one subnet be used.
NwPr:	Network protocol: 0=Ethernet Layer2 or 1=UDP Layer 3
VLan:	VLAN ID: 0 up to 4095
TimeScale:	PTP (TAI) Time Scale or other (UTC)

PTP Status: Local-Network

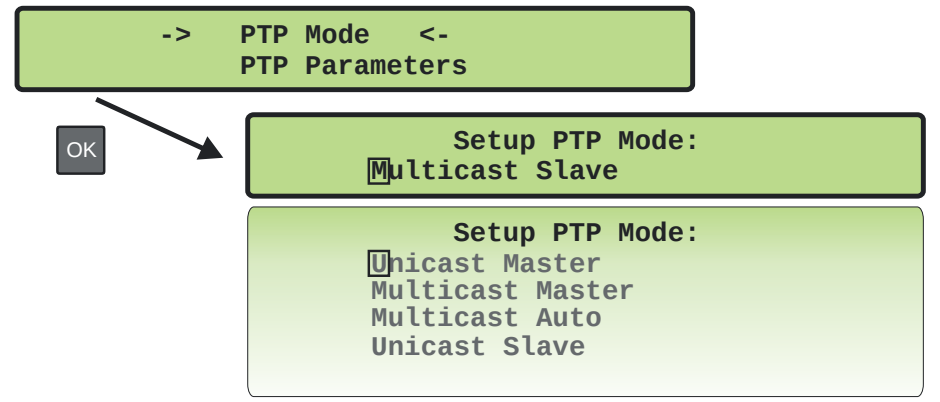
This page will reflect the current network configuration like IP address with netmask and the MAC address of the PTP ethernet port.

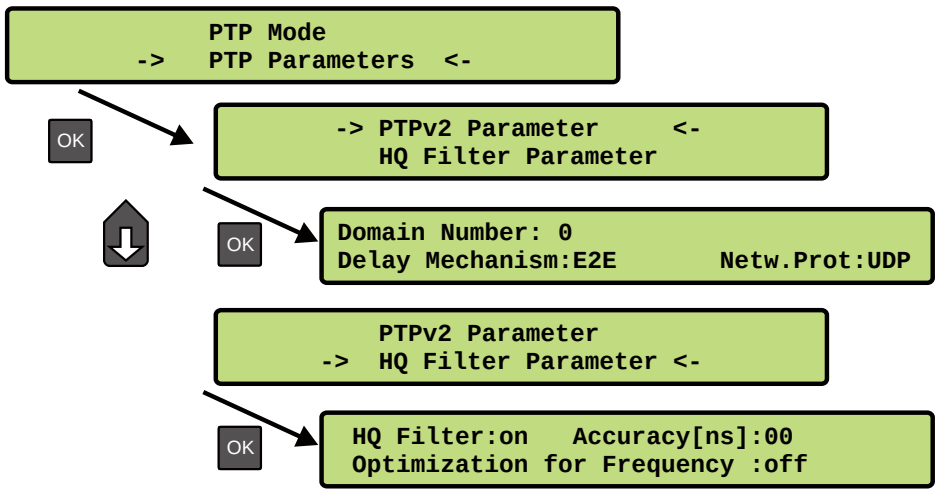
PTP Status: Filter Status

This page will show HQ-Filter specific values.

Asymm:	current configured Asymmetry Offset (fix Offset for PTP)
O-Span:	Offset-Span: current calculated jitter of the PTP offset values before filter
D-Span:	Delay-Span: current calculated jitter of the PTP path delay values before filter

6.2 PTP Setup





The submenu "PTP Setup" will manage the different parameters for the internal PTP daemon. These parameters will be stored in some files on the flash Disk: "/config/ptp2_global_configuration" and "/config/ptp2_profile_*". In the submenu "PTP Profile" different profiles can be selected:

Default Profile: PTPv2 Standard Multicast Daemon
Unicast Profile: PTPv2 Unicast Daemon

The Defaults Profile has no specific "Profile Settings". All other profile can be configured with specific settings.

The "Profile UNICAST" has a bunch of specific parameters. The following parameter has to be configured:

Clock ID: is the IP address of the PTP UNICAST Grandmaster

Announce: setup the interval and the duration of the PTP Announce Messages has to be sent by the PTP UNICAST Master.

Delay resp: setup the interval and the duration of the PTP Delay Response Messages has to be sent by the PTP UNICAST Master.

PDelay resp: setup the interval and the duration of the PTP PDelay Response Messages hast to be sent by the PTP UNICAST Master.

SyncMsg: setup the interval and the duration of the PTP Sync Messages hast to be sent by the PTP UNICAST Master.

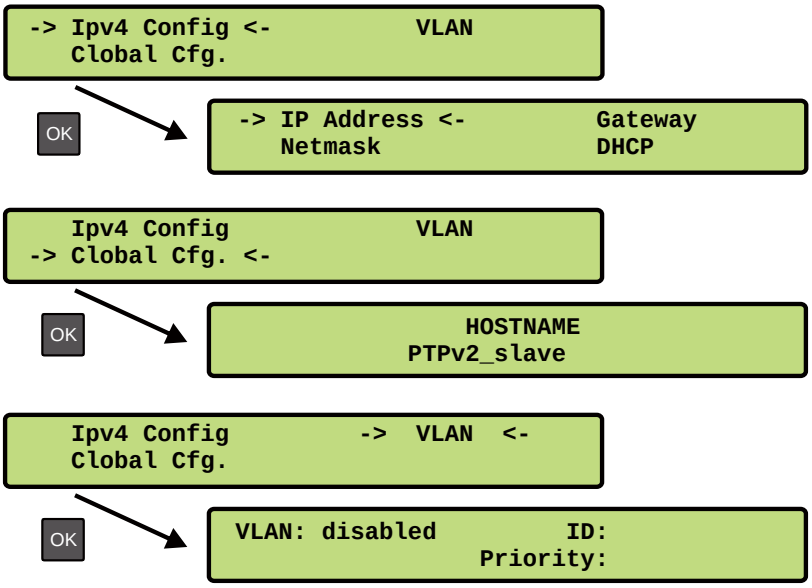
The submenu "PTP Settings" will reflect common PTP Slave Parameter which can be set:

Delay Mechanism: PTP Delay Mechanism with E2E (End to End Delay meassurement) or P2P (Peer to Peer Delay meassurement)

Domain Number: PTP Domain. There could be different PTP Domains (0 to 5) in one subnet be used.

NetwProt: Network Protocol: 0=Ethernet Layer 2 or 1=UDP Layer 3

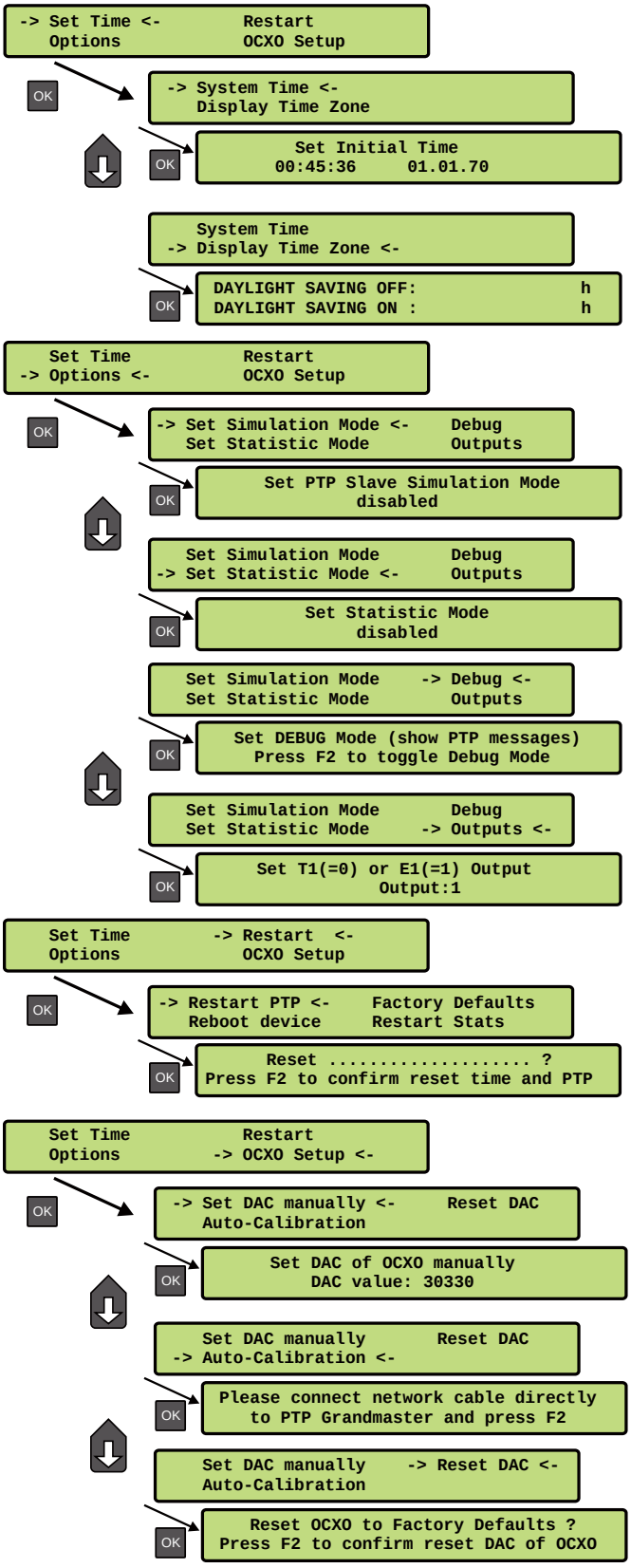
6.3 Menu: Network



In this submenu the network configuration parameters related to the network interfaces can be changed. In the chapter "Global Cfg." you can configure the Server Hostname, in the chapter "Interfaces" you can change DHCP, IP address and the Netmask.

As soon as an IP address is configured, additional network configuration can be done via network connection with SSH or the WEB interface. Ask your network administrator for network specific parameters. If you change the network-parameters, the configurationfile written be new and the PTP Daemon become a reboot.

6.4 Menu: System



In this submenu system specific parameters can be configured:

- With **Set time zone** the time zone displayed on the front panel display can be configured (see below).
- With **Restart PTP** you can stop the currently running PTP daemon and restart it afterwards.

- The command **Reboot time server** reboots the Linux operating system – the build-in reference clock will be restarted.
- When **Reset to factory defaults** is called, all system parameters will be reset to initial values. However the parameters of each network interface do not change.

7 Precision Time Protocol (PTP) / IEEE1588

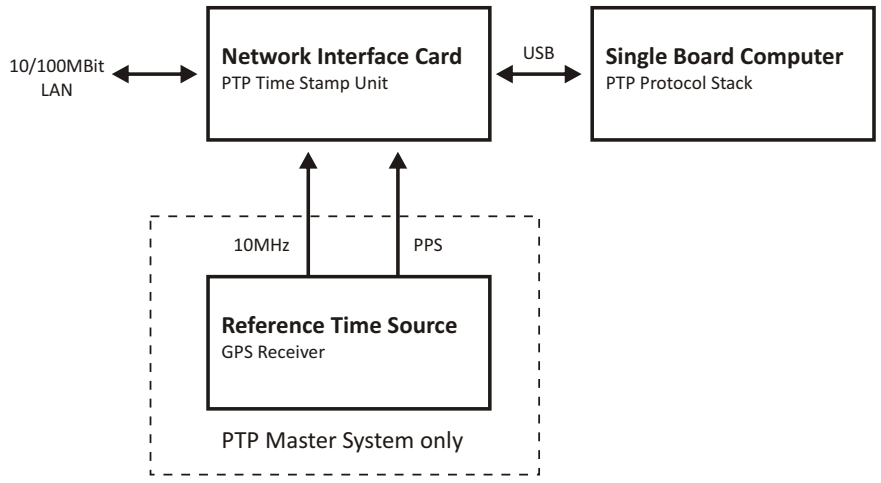
Precision Time Protocol (PTP or IEEE 1588) is a time synchronization protocol that offers sub-microsecond accuracy over a standard Ethernet connection. This accuracy can be achieved by adding a hardware timestamping unit to the network ports that are used for PTP time synchronization. The timestamping unit captures the exact time when a PTP synchronization packet is sent or received. These timestamps are then taken into account to compensate for transfer delays introduced by the Ethernet network.

In PTP networks there is only one recognized active source of time, referred to as the Grandmaster Clock. If two or more Grandmaster Clocks exist in a single network, an algorithm defined in the PTP standard is used to determine which one is the „best“ source of time. This „Best Master Clock“ algorithm must be implemented on every PTP/IEEE1588 compliant system to insure that all clients („Slave Clocks“) will select the same Grandmaster. The remaining deselected Grandmaster Clocks will „step back“ and enter a passive mode, meaning that they do not send synchronization packets as long as that is being done by the designated Grandmaster.

The existing network infrastructure components play a big role in a PTP network and directly influence the level of accuracy that can be achieved by the clients. Asymmetric network connections degrade the accuracy, therefore classic layer 2 and 3 Ethernet switches with their “store and forward” technology are not suitable for PTP networks and should be avoided. With activating the HQ-Filter (see chapter HQ-Filter) the Jitter can be eliminated. Simple Ethernet hubs with fixed pass-through times are not a problem. In large networks, special switches with built-in PTP functionality help to maintain high accuracy even over several subnets and longer distances. These components act as "Boundary Clocks" (BC) or "Transparent Clocks" (TC). They compensate their internal packet processing times by using timestamping units on each port. When acting as a Boundary Clock, they synchronize to the Grandmaster clock, and in turn act as a Master to the other subnets they are connected to. When acting as a Transparent Clock, then the "residence time" of the Masters' Sync-Packet is measured and added to the packet as a correction value. Internally the PTP timescale TAI (see chapter Timescale in Global Parameters).

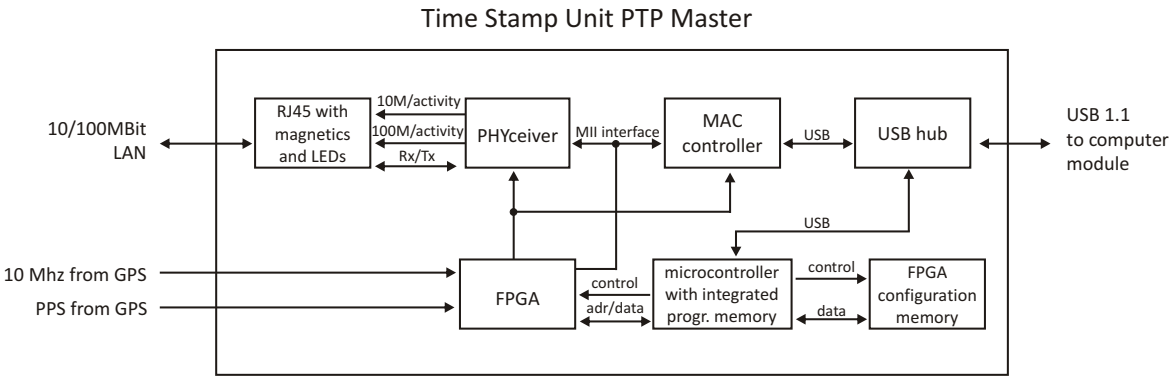
7.1 General Information

The internal PTP card acts as a network interface card (10/100MBit) with an integrated hardware time stamp unit to obtain time stamps in PTP compatible networks. In conjunction with a single board computer running the PTP protocol stack and a reference time source (PTP master only) the module is capable of building a PTP Master or Slave system:



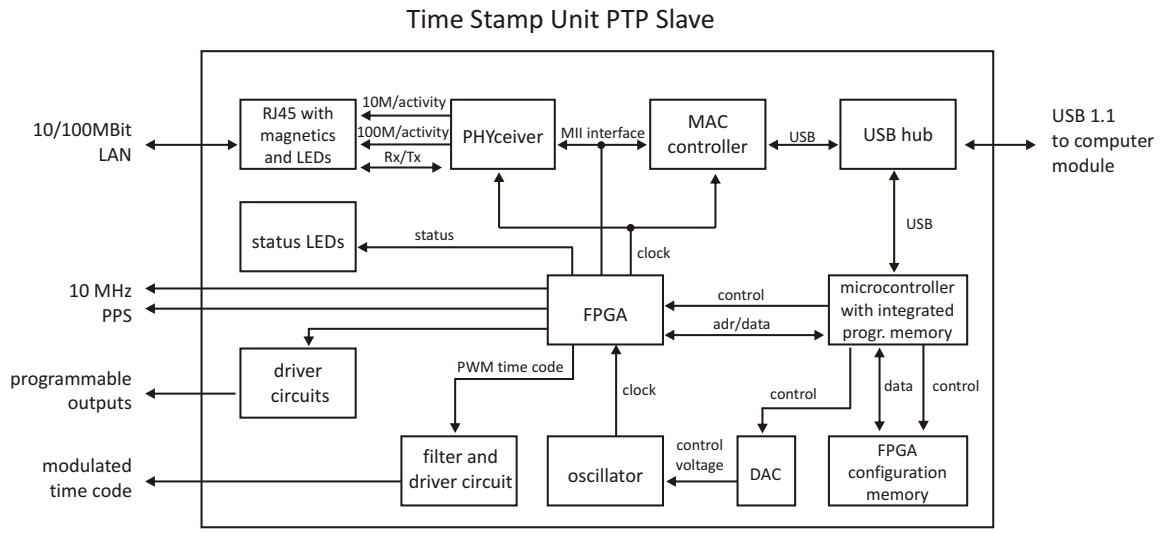
The Time Stamp Unit, integrated in an FPGA (Field Programmable Gate Array, a programmable logic device), checks the data traffic on the MII-interface between the PHY receiver (physical connection to the network) and the Ethernet controller (MAC) on the PTP module. If a valid PTP packet is detected, the time stamp unit takes a time stamp of that packet which is read by a single board computer (SBC) running the PTP software. The configuration and status traffic between the PTP board and main SBC is done over a USB connection.

7.2 Functionality in Master Systems



After power up, the module accepts the absolute time information (PTP seconds) of a reference time source (GPS reference clock) only once, and the PTP nanoseconds are set to zero. If the oscillator frequency of the reference time source has reached its nominal value, the nanoseconds are reset again. This procedure leads to a maximum deviation of 20 nsec of the pulse per second (1PPS) of the PTP Master compared to the 1PPS of the GPS reference clock. The reference clock of the PTP board's time stamp unit (50 MHz) is derived from the GPS disciplined oscillator of the reference time source using a PLL (Phase Locked Loop) of the FPGA. The achieves a direct coupling of the time stamp unit to the GPS system.

7.3 Functionality in Slave Systems



After decoding valid time information from a PTP Master, the system sets its own PTP seconds and nanoseconds accordingly. The PTP offset calculated by the PTP driver software of the single board computer is used to adjust the master oscillator of the TSU-USB. This allows the PTP Slave to generate very high accuracy output signals (10 MHz/1PPS/IRIG).

7.4 PTPv2 IEEE 1588-2008 Configuration Guide

Setting up all devices in a PTP synchronization infrastructure is one of the most important parts in a network time synchronization project. The settings of the involved Grandmaster clocks as the source of time and the end devices ("Slaves") have to match in order to allow them to synchronize and avoid problems later, when the PTP infrastructure is deployed to production environments. In addition to that, the use of PTP aware network infrastructure components, namely network switches, introduces another set of parameters that have to be harmonized with the masters and slaves in a PTP setup.

It is therefore very important to start with making decisions how the to-be-installed PTP synchronization solution should operate, e.g. should the communication between the devices be based on multicast or unicast network traffic or how often should the masters send SYNC messages to the slaves.

This chapter lists the most important options and their implications on a synchronization environment in general. A detailed explanation of the configuration settings within the LANTIME configuration interfaces can be found later within this documentation.

7.4.1 General Options

The following general mode options have to be decided before deploying the infrastructure:

1) Layer 2 (Ethernet) or Layer 3 (UDP/IPv4) connections
2) Multicast or Unicast
3) Two-Step or One-Step Operation
4) End-to-End or Peer-to-Peer Delay Mechanism

The above options need to be defined for the whole setup, if devices do not stick to the same settings, they will not be able to establish a working synchronization link.

7.4.2 Network Layer 2 or Layer 3

PTP/IEEE 1588-2008 offers a number of so-called mappings on different network communication layers. For Meinberg products you can choose between running PTP over IEEE 802.3 Ethernet connections (network Layer 2) or UDP/IPv4 connections (Layer 3).

Layer 3 is the recommended mode, because it works in most environments. For Layer 2 mode the network needs to be able to provide Ethernet connections between master and slave devices, which is often not the case when your network is divided into different network segments and you have no layer 2 routing capabilities in your network infrastructure.

The only benefit of using Layer 2 mode would be a reduced traffic load, because the transmitted network frames do not need to include the IP and UDP header, saving 28 bytes per PTP packet/frame. Due to the fact that PTP is a low traffic protocol (when compared to other protocols), the reduced bandwidth consumption only plays a role when low-bandwidth network links (e.g. 2Mbit/s) have to be used or in pay-per-traffic scenarios, for example over leased-line connections.

7.4.3 Multicast or Unicast

The initial version of PTP (IEEE 1588-2002 also known as PTPv1) was a multicast-only protocol. Multicast mode has the great advantage that the master clock needs to send only one SYNC packet to a Multicast address and it is received by all slave devices that listen to that multicast address.

In version 2 of the protocol (IEEE 1588-2008) the unicast mode was introduced in addition to the multicast mode. In unicast mode, the master has to send one packet each to every slave device, requiring much more CPU performance on the master and producing orders of magnitudes more traffic.

On the other hand, some switches might block multicast traffic, so that in certain environments, Unicast mode has to be used.

7.4.4 Two-Step or One-Step

The PTP protocol requires the master to periodically send SYNC messages to the slave devices. The hardware time stamping approach of PTP requires that the master records the exact time when such a SYNC packet is going on the network wire and needs to communicate this time stamp to the slaves. This can be achieved by either sending this time stamp in a separate packet (a so-called FOLLOW-UP message) or by directly manipulating the outgoing SYNC message, writing the hardware time stamp directly into the packet just before it leaves the network port.

At the time of delivery of this product, Meinberg devices support only the former approach, called Two-Step (because two packets are required).

7.4.5 End-To-End (E2E) or Peer-To-Peer (P2P) Delay Measurements

In addition to receiving the SYNC/FOLLOWUP messages a PTP slave device needs to be able to measure the network delay, i.e. the time it took the SYNC message to traverse the network path between the master and the slave. This delay is required to correct the received time information accordingly and it is measured by the slave in a configured interval (more about the message intervals later). A delay measurement is performed by sending a so-called DELAY_REQUEST to the master which timestamps it and returns the timestamp in a DELAY_RESPONSE message.

IEEE 1588-2008 offers two different mechanisms for performing the delay measurements. A slave can either measure the delay all the way to the master, this is called End-To-End (or E2E in short) or to its direct network neighbors (which would in almost all cases be a switch – or two in a redundant setup), using the Peer-To-Peer delay measurement mechanism (P2P). The delay measurements of all links between the master and the slave are then added and accumulated while a SYNC packet is traversing the network.

The advantage of this method is that it can dramatically reduce the degradation of accuracy after topology changes. For example: in a redundant network ring topology the network delay will be affected when the ring breaks open and network traffic needs to be redirected and flows into the other direction. A PTP slave in a sync infrastructure using E2E would in this case apply the wrong delay correction calculations until it performs the next delay measurement (and finds out that the network path delay has changed). The same scenario in a P2P setup would see much less time error, because the delay of all changed network links were already available.

The drawback: the P2P approach requires that all involved PTP devices and all switches support this mechanism. A switch/hub without P2P support would in the best case simply pass the so-called PDELAY messages through and as a result degrade the accuracy of the delay measurements. In the worst case it would block/drop the PDELAY messages completely, which effectively would result in no delay measurements at all.

So, E2E is the only available choice if you are running PTP traffic through non-PTP-aware switches. It is a reasonable choice if you are not using redundant network topologies or can accept that the delay measurements are wrong for a certain amount of time.

7.4.6 Mode Recommendations

Meinberg recommends to set up your PTP infrastructure to use Layer 3, Multicast, Two-Step and End-To-End Delay measurements if that is possible. This will provide the largest possible compatibility and reduces interoperability problems.

7.4.7 Message Rate Settings

The decision between the different general mode options is mainly dictated on the network environment in which the PTP infrastructure is installed.
In addition to the mode selection, a number of intervals for certain types of PTP network messages needs to be defined. In most cases, the default values as defined in the standard are a safe bet, but there are applications and scenarios where a custom message rate is required.

A possible example is a situation where the PTP infrastructure is integrated within an environment with high network load. In this case, the PTP packets can be affected by the effect of packet delay variation (PDV). An increase of the PTP message rate(s) can avoid synchronization problems due to packet queuing within non-PTP compliant switches which might cause false measurements. At higher rates, these false measurements can be detected and corrected faster as compared to lower rates at the cost of increased traffic.

The message rates for the following message types can be changed:

1) ANNOUNCE messages
2) SYNC/FOLLOWUP messages
3) (P)DELAY_REQUEST messages

7.4.8 ANNOUNCE Messages

These PTP messages are used to inform the PTP network participants about existing and available master clock devices. They include a number of values that indicate the potential synchronization accuracy.

The procedure used to decide which of the available devices (that could become masters) is selected is called the "best master clock algorithm" (BMCA). The values that are used in this BMCA are read from the ANNOUNCE messages that potential masters send out periodically.

The rate at which these messages are sent out are directly affecting the time that is required by a slave device to select a master and to switch to a different master in case the selected one fails.

Multiple devices can simultaneously transmit ANNOUNCE messages during periods in which no master has been selected (yet). This happens for example when a PTP network is powered up, i.e. all devices are starting to work at the same time. In this case all devices that consider themselves (based on their configuration and status) being capable of providing synchronization to all the other PTP devices will start to send out ANNOUNCE messages. They will receive the other candidates' ANNOUNCE messages as well and perform the BMCA. If they determine that another candidate is more suitable to become the master clock, they stop sending ANNOUNCE messages and either become slave devices or go into "PASSIVE" mode, waiting for the selected master to stop sending ANNOUNCE messages. This is determined to be the case when no ANNOUNCE message is received within 3 ANNOUNCE message intervals.

As an example, if the ANNOUNCE interval has been configured to be 2 seconds (one message every 2 seconds, the default value), the master is considered to have failed when no message has been received for 6 seconds.

In order to choose a master (a backup master clock or the primary one during initialization) the devices require to receive at least two consecutive ANNOUNCE messages. Continuing our example, it would take the 6 seconds to determine that the current master has failed and another 4 seconds to select the new one. That means an ANNOUNCE interval of 2 seconds translates into at least 10 seconds of "switching time" and 4 seconds of "initial master clock selection time". So, choosing a shorter ANNOUNCE message interval will allow a faster switching to a backup master clock, but it can lead to false positives when the chosen interval is too short for the network environment.

7.4.9 SYNC/FOLLOWUP Messages

The selected master clock sends out SYNC (and, in Two-Step environments, the corresponding FOLLOWUP) messages in a configured interval. This interval (default value is one SYNC/FOLLOWUP packet every second) determines how often the slave devices receive synchronization data that allows them to adjust their internal clocks in order to follow the master clock time. Between receiving two SYNC messages, a slave clock runs free with the stability determined by its own internal time base, for example a crystal oscillator. One important factor for deciding on the SYNC interval is the stability of this oscillator. A very good oscillator requires a lower SYNC message rate than a cheaper, low-accuracy model. On the other hand you directly affect the required network bandwidth by changing the SYNC interval.

For Meinberg slave devices, the default one-SYNC-every-second setting is more than enough to achieve the highest possible synchronization accuracy.

7.4.10 (P)DELAY_REQUEST Messages

As explained in the General Mode Options chapter (see the "End-To-End or Peer-to-Peer" section), the delay measurements are an important factor for achieving the required accuracy. Especially in E2E mode, the network path delay measurements play a crucial part in the synchronization process. Per default, the slaves will perform delay measurements every 8 seconds, resulting in sending and receiving one packet. This can be increased in case the network path delay variation in the network is relatively large (i.e. the time it takes for the SYNC message

to reach the slave varies a lot) or the slave devices have to tightly follow the master and adjust their time base (oscillator) very often due to its instability.

Meinberg slave devices will limit the effect of an outdated path delay measurement by using filters and optimized PLL algorithms. This avoids that a clock "jumps around" and basically monitors the time difference to the master clock carefully for a certain amount of time before adjusting its own clock. With a low cost time base this is not possible, because the instability (i.e. temperature-dependent drift and overall short term stability/aging effects) and therefore these slaves would require to perform as many delay measurements and receive as many SYNC/FOLLOWUP messages as possible.

For P2P mode the delay request interval is not as critical, simply because the delay variation on a single-hop link (i.e. from your slave device to its switch) is very stable and does not change dramatically in typical environments.

Current firmware versions of Meinberg Grandmaster clocks (V5.32a and older) do not offer changing the Delay message rate in Multicast mode, it is fixed to one delay request every 8 seconds. Since this is actually a value that is transmitted in the DELAY_RESPONSE message as a maximum value, the slave devices are not allowed to perform delay measurements more often.

7.4.11 HQ Filter

If you use non PTP aware switches in a network where PTP should be used then the timing accuracy of the offset depends on the characteristic of the switches. Non PTP switches will cause time jitters (due to non deterministic delays in each path direction) in PTP measurement. In this section, the term "jitter" is used to describe the maximum deviation of the measured offsets around a certain mean value. This time jitter of standard non-PTP compliant switches can be in the range of 100 ns up to 10000 ns. When using routers this jitter can be even higher. To reduce this time jitter the HQ filter can be activated to achieve a better PTP slave synchronization quality. With Layer2 switches the accuracy can be achieved in the range of submicro seconds. Also Jitter caused by high network load and faulty measurements will be eliminated

Functionality
After activating the HQ-Filter some PTP measurements will be done first without controlling the timing of the PTP slave. This phase will be indicated by an extra hint "init" in the current status of the PTP slave. During this phase the maximum jitter of the PTP offset, the path delay and the current drift of the internal oscillator will be calculated by statistical methods. The only filter parameter which can be set by the user is the **estimated accuracy** which will set the maximum expected range of the incoming time jitter. All input values that are out of this range will be dropped. The maximum jitter of the input will be updated continuously during normal operation. By default **estimated accuracy** will be set to 1s to determine the maximum jitter automatically.

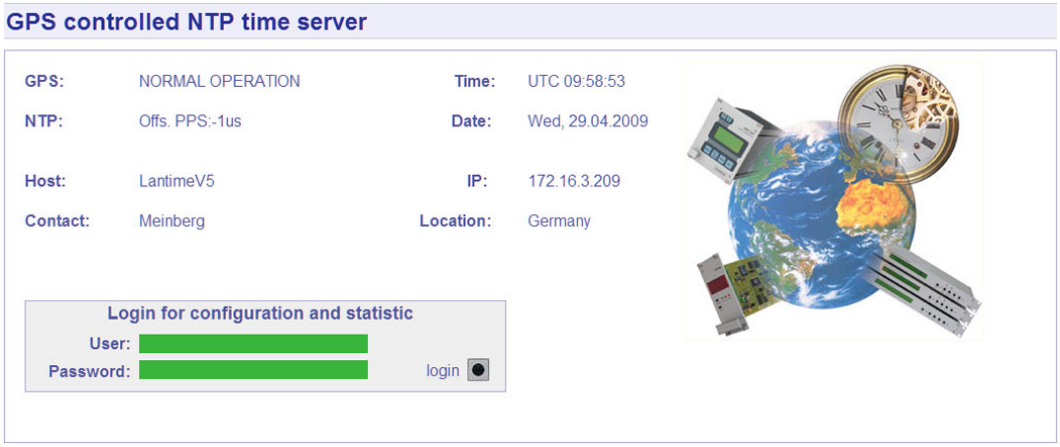
PDSC
PDSC means "Path Delay Step Compensation". The PDSC feature tries to eliminate jumps of the PTP path delay, so that there will be no effect on the timing accuracy. Such a jump of the PTP path delay (which should be usually constant) will be caused by changing the topology of the PTP network which could happen in SDH networks for example. The change of the PTP path delay is only detected, if the step is larger than the measured time jitter. This feature is an extension of the HQ-Filter and therefore the HQ-Filter has to be activated.

8 The WEB Interface

Connect to the web interface by entering the following address into the address field of your web browser:

http://198.168.10.10
(You need to replace 198.168.10.10 with the IP address of your SyncBox).

If you want to use an encrypted connection, replace the http:// with https:// in the above address. You may be prompted to accept the SSL certificate of your SyncBox the first time you are connecting to the system via HTTPS. In both HTTP and HTTPS mode, you will see the following login screen:



On this start page you see a short status display. The upper line shows the operation mode.

This page will be reloaded every 30 seconds in order to reflect the current status of the unit. Please bear this in mind when you try to login and enter your password. If you do not press ENTER or the Login button within 30 seconds, the user and password field is cleared and you have to start over again.

8.1 Configuration: Main Menu

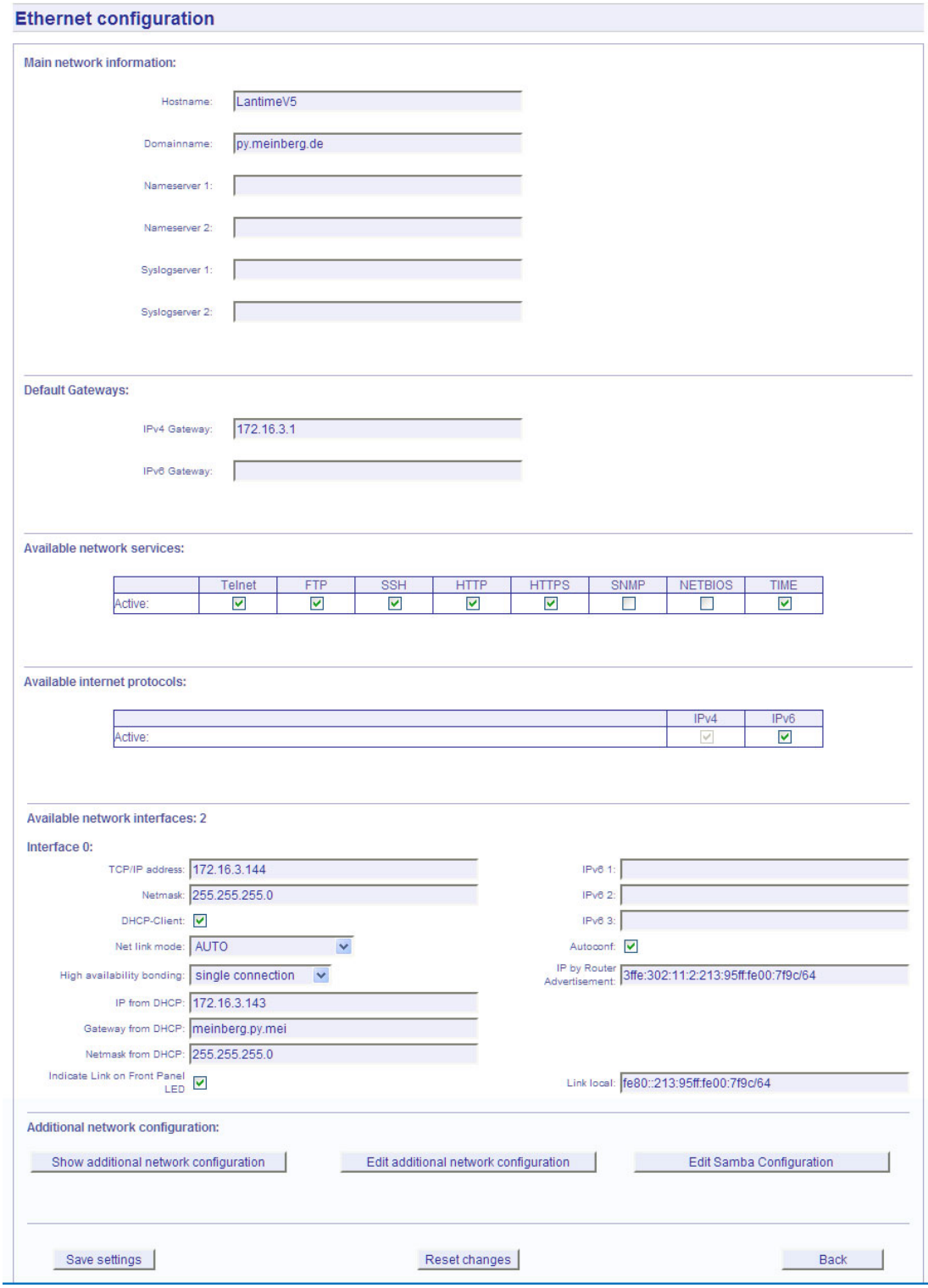
After entering the right password, the main menu page shows up. This page contains an overview of the most important configuration and status parameters for the system.

The start page gives a short overview of the most important configuration parameters and the runtime statistics of the unit. In the upper left corner you can read which SyncBox model and which version of the SyncBox software

you are using.

By using the buttons in the lower part of the screen, you can reach a number of configuration pages, which are described below.

8.2 Configuration: Ethernet



In the network configuration all parameters related to the network interface can be changed. In the first section you can change the hostname and domain name. You can also specify two nameserver. In the nameserver fields you have to enter an IPv4.

8.3 IPv4 addresses and DHCP

IPv4 addresses are built of 32 bits, which are grouped in four octets, each containing 8 bits. You can specify an IP address in this mask by entering four decimal numbers, separated by a point ".".

Example: 192.168.10.2

Additionally you can specify the IPv4 netmask and your default gateway address. Please contact your network administrator, who can provide you with the settings suitable for your specific network.

If there is a DHCP (Dynamic Host Configuration Protocol) server available in your network, the LANTIME system can obtain its IPv4 settings automatically from this server. If you want to use this feature (again, you should ask your network administrator whether this is applicable in your network), you can change the DHCP Client parameter to "ENABLED". In order to activate the DHCP client functionality, you can also enter the IP address "000.000.000.000" in the LCD menu by using the front panel buttons of the LANTIME. Using DHCP is the default factory setting.

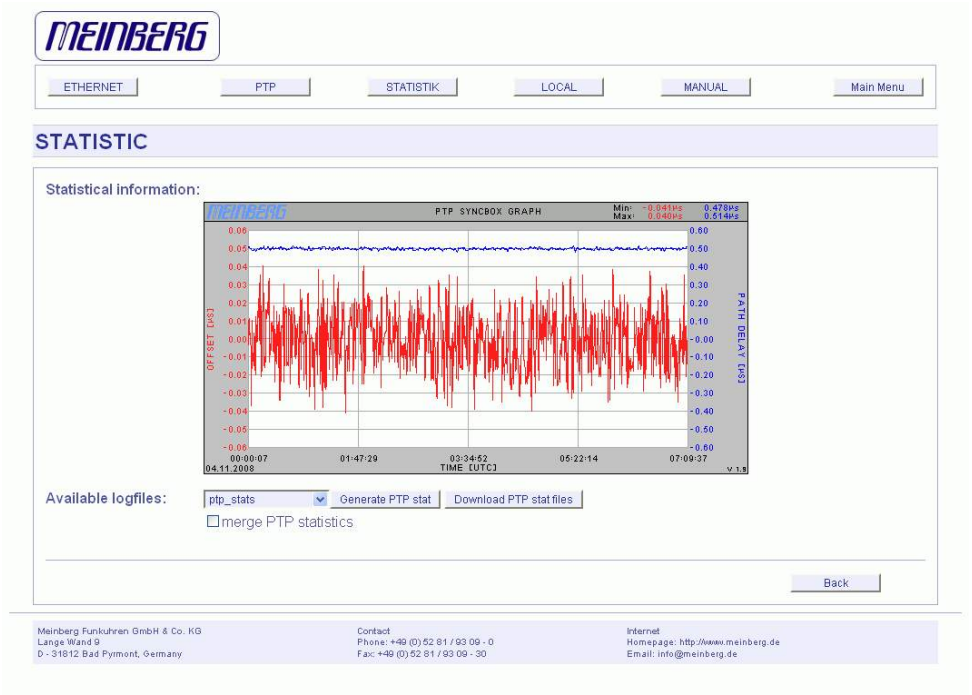
The MAC address of your timeserver can be read in the LCD menu by pressing the NEXT button on the front panel twice. This value is often needed by the network administrator when setting up the DHCP parameters for your LANTIME at the DHCP server.

If the DHCP client has been activated, the automatically obtained parameters are shown in the appropriate fields (IPv4 address, netmask, gateway).

8.4 Configuration: Local

In the Local section you can activate an reboot of the SyncBox and set up a new password for the only user "root".

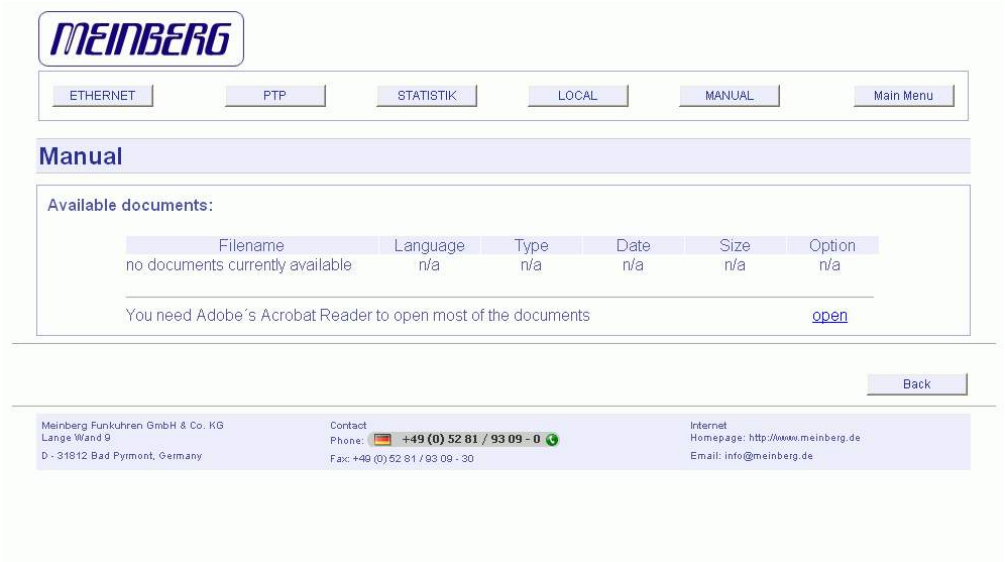
8.5 Configuration: Statistics



8.5.1 Statistical Information

In the first section a graphical diagram shows the running synchronization process. PTP is storing this statistical information in so-called "ptpstats" files, which are used here to draw the curves. The red line is describing the offset to the PTP grandmaster. The blue line shows the pathdelay to the PTP grandmaster. In the upper right corner of the diagram you will find the measurement range of the red and blue curve. The last 24 hours are shown initially, but you are able to select the last 10 days (or fewer days, depending on the system uptime) or download a specific ptpstat file. All time data is using UTC.

8.6 Configuration: Manual



This page gives you access to the documents stored on your SyncBox, especially the manuals and your own notes. The two lists include filename, language, file type, date and size of the documents/notes.

The SyncBox documents can be downloaded from here in order to read / print them on your workstation.

8.7 Configuration: PTP

In the PTP configuration all parameters related to the PTP protocol can be monitored and changed.

With the "Profile" parameter you can switch between the "Default" multicast profile and the "Unicast" PTP profile. Depending on the selected profile the corresponding TSU configuration file below will be used.

The delay mechanism is used to measure the propagation time between two nodes. You can choose the end-to-end (E2E) or the peer-to-peer mechanism. When using peer-to-peer (P2P) delay mechanism, every network node has to support peer-delay measurements.

Please keep in mind that peer-delay measurements are not supported when operating in Unicast mode.

A domain is a logical grouping of clocks that synchronize to each other using the protocol, but that are not necessarily synchronized to clocks in another domain. Be aware to use the same domain as configured on the grandmaster.

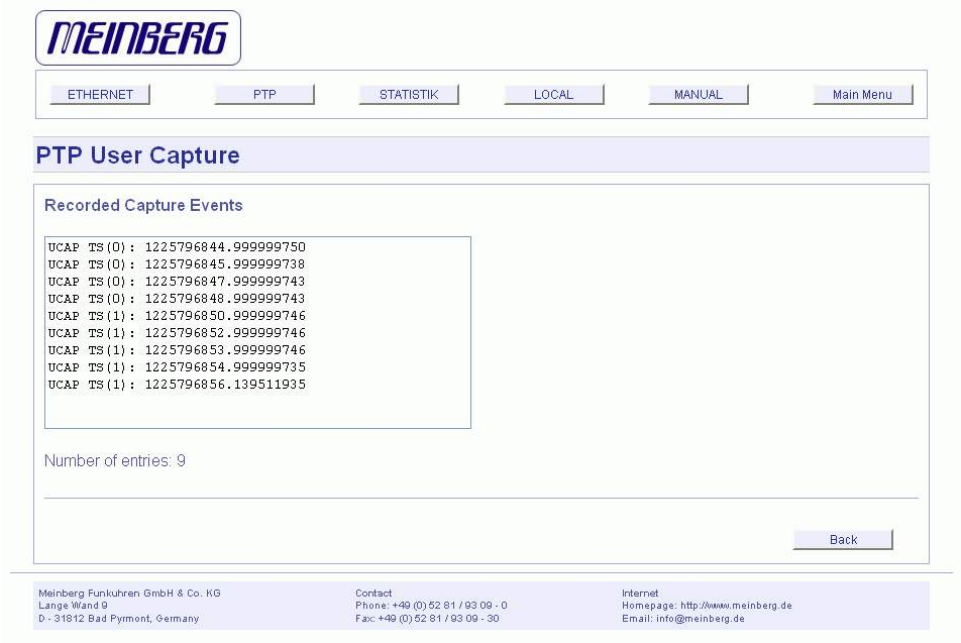
The PTP standard includes mappings to User Datagram Protocol (UDP), layer-2 Ethernet and other implementations. The SyncBoxV2 will support Layer 3 (IPv4/UDP) Layer-2 Ethernet (IEEE 802.3).

In the "Unicast Configuration" section the IP address of the PTP grandmaster can be configured. The UUID of the grandmaster should be left to default which is "FF:FF:FF:FF:FF:FF:FF:FF" if UDP/IPv4 is selected as network protocol. In case Layer 2 communication is used, the UUID of the grandmaster port should be entered here. Please make sure that the "Unicast" profile is selected if unicast negotiation shall be used.

Additional TSU (PTP time stamp unit) configuration parameters can be set directly in the text files that can be displayed in the „TSU Configuration files" section.

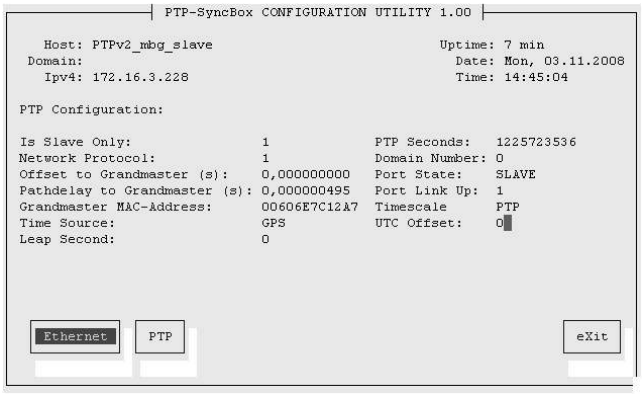
User Captures can be used to mark hardware events with high precision timestamps. SyncBox supports two User Capture inputs with TTL level. Time stamps will be taken with the rising edge of the input signal. With

the Option "show user captures" the user capture inputs of the SyncBox will be activated and current captures will be shown in a scrollbox. These user captures can be shown in a Telnet/SSH session with the command "show_ucap" also.



9 The Command Line Interface

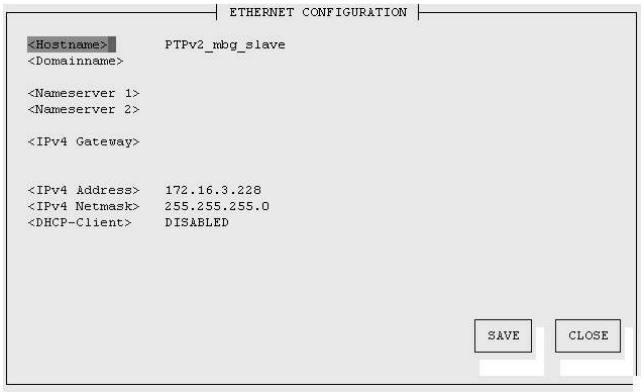
The command line interface (CLI) can be used within a TELNET or SSH session. After login, just enter "setup" to start the CLI setup tool.



The start page gives a short overview of the most important configuration parameters and the runtime statistics of the unit. In the upper left corner you can read the network parameters like hostname, domainname and IP address. The next section descibe the PTP specific parameters.

By using the buttons in the lower part of the screen, you can reach a number of configuration pages, that are described below.

9.1 CLI Ethernet



In the network configuration all parameters related to the network interfaces can be changed. In the first section you can change the hostname and domain name. You can also specify two nameservers. In the nameserver fields you may enter an IPv4 address.

IPv4 addresses are built of 32 bits, which are grouped in four octets, each containing 8 bits. You can specify an IP address in this mask by entering four decimal numbers, separated by a point "." .

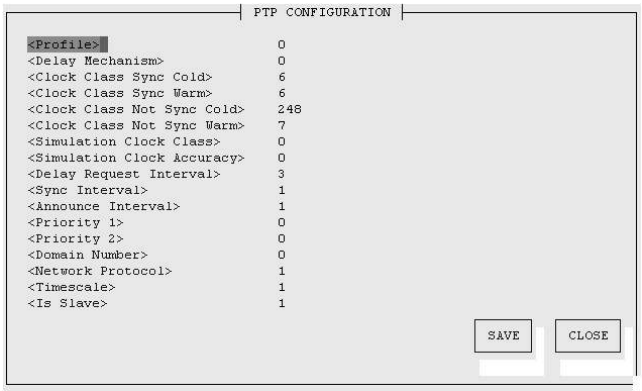
Example: 192.168.10.2

Additionally you can specify the IPv4 Netmask and your default gateway address.
Please contact your network administrator, who will provide you with the settings suitable for your specific network.
If you are running a DHCP (Dynamic Host Configuration Protocol) server in your network, the LANTIME system can obtain its IPv4 settings automatically from this server. If you want to use this feature (you should also ask

your network administrator if this is applicable in your network), you can change the DHCP Client parameter to "ENABLED". This is the default setting.

If the DHCP client has been activated, the automatically obtained parameters are shown in the appropriate fields (IPv4 address, netmask, gateway).

9.2 CLI PTP parameters



In the PTP configuration all parameters related to the PTP protocol can be monitored and changed.

The "Profile" parameter is for future releases to change the specific behavior of the PTP protocol. The delay mechanism is designed to measure the propagation time between two nodes. You can choose the end-to-end (default: 0) or the peer-to-peer mechanism (= 1).

The parameters for Clock Class will define the value for the PTP clock class in the different states of the internal clock. In case of the SyncBox as a PTP slave these parameters will not take account.

The delay request interval, the sync interval, the priorities, the timescale and the announce interval will be specified by the PTP grandmaster only.

A domain is a logical grouping of clocks that synchronize to each other using the protocol, but that are not necessarily synchronized to clocks in another domain. Be aware to use the same domain like the grandmaster.

The PTP standard includes mappings to User Datagram Protocol (UDP), layer-2 Ethernet and other implementations. The SyncBoxV2 will support UDP (default:0 or 1) and the layer-2 Ethernet (= 2).

More configuration parameters to set up the outputs of the SyncBox can be edit manually via SSH or Terminal in the file "/config/tsu_config".

10 Attachment: Technical Information

10.1 Safety Instructions

Skilled/Service-Personnel only: Replacing the Lithium Battery
The life time of the lithium battery on the board is at least 10 years. If the need arises to replace the battery, the following should be noted:

ATTENTION!

There is a Danger of explosion if the lithium battery is replaced incorrectly. Only identical batteries or batteries recommended by the manufacturer must be used for replacement. The waste battery has to be disposed as proposed by the manufacturer of the battery.

10.2 Technical Specifications SyncBox v2

HOUSING:	Metal desktop case, DIN Mounting Rails 125mm x 115 mm x 189 mm (W x H x D)
POWER SUPPLY:	100-240 VAC/VDC
INPUT FUSE:	Electronic
PROTECTION RATING:	IP20
POWER CONSUMPTION:	28W
INPUT FUSE:	UL/IEC127, 250V AC S 3.15A

10.3 CE-Label

Low voltage directive:
2006/95/EC EN 60950-1
Safety of Information Technology Equipment,
including Electrical Business Equipment
Electromagnetic compatibility.

EMV-directive:
89/336EEC EN50081-1
Electromagnetic compatibility (EMC).
Generic emission standard.
Part 1: Residential, commercial and light industry

EN50082-2
Electromagnetic compatibility (EMC).
Generic immunity standard.
Part 2: Industrial environment

CE

10.4 Rear panel connectors

Name	Type	Signal	Cable / connection
Rear panel			
Power supply	IEC (power) connector	100-240VAC	power cord
Terminal	9pin. D-SUB male	RS-232	shielded data line
Time Code AM Out	BNC	3Vpp into 50 Ohm	shielded coaxial line
PPS Out	BNC	TTL	shielded coaxial line
10MHz Out	BNC	TTL	shielded coaxial line
LAN PTP	RJ-45	Ethernet	shielded data line
Time Capture In	BNC	TTL	shielded coaxial line

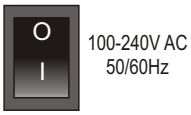
10.5 Power connect

INPUTVOLTAGE RANGE: 100-240V AC, 50...60Hz

INPUT FUSE: UL/IEC127, 250V AC S 3.15A

OUTPUT POWER: 25W max.

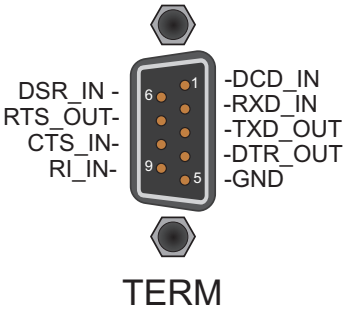
CONNECTORS: input IEC320 AC inlet



10.6 TERMINAL (Console)

To connect a serial terminal use 9 pin SUBD RS232 connector in the front panel. Via the serial terminal connection it is possible to configure parameters with the command line interface. You have to use a NULL-MODEM cable connecting to your PC or Laptop computer. You can use e.g. the standard Hyperterminal program shipped

with your Windows operating system. Configure your terminal program with 38400 Baud, 8 Databits, no parity and 1 Stopbit. The terminal emulation have to set to VT100. After connecting to the timeserver there will be displayed the login message (press RETURN for first connection; default user: root password: timeserver).



10.7 Time Code AM Output

Carrier frequency: 1kHz (IRIG-B)

Signal outputs: Unbalanced sine wave-signal:
3Vpp (MARK) / 1Vpp (SPACE) into 50 Ohm

Connector: BNC, female

Cable: shielded coax line

10.8 Pulse Per Second Output

Level: TTL 2,5V to 50 Ohm

Connector: BNC, female

Cable: shielded coax line

Pulselength: 200 ms

10.9 10MHz Output

Level: TTL 2,5V to 50 Ohm

Connector: BNC, female

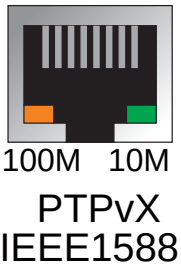
Cable: shielded coax line

10.10 PTP/IEEE 1588-2008

Network Protocols:
- UDP/IPv4 (Layer 3) (Multicast/Unicast)
- IEEE 802.3 (Layer 2) (Multicast)

Delay Mechanisms:
- End-to-End (Multicast/Unicast)
- Peer-to-Peer (Multicast)

Profiles:
- Default 1588-2008 (Multicast, Unicast, Hybrid)
- ITU-T G.8265.1 Telecom Profile
- IEEE C37.238-2011 Power Profile



10.11 Cap In

Cable: shielded coaxial line

Typ: TTL

Connector: BNC female

11 Third party software

The System is running a number of software products created and/or maintained by open source projects. A lot of people contributed to this and we explicitly want to thank everyone involved for her/his great work.

The used open source software comes with its own license which we want to mention below. If one of the licenses for a third party software product is violated, we will as soon as possible apply any changes needed in order to conform with the corresponding license after we acknowledged about that violation.

If a license for one of the software products states that we have to provide you with a copy of the source code or other material, we will gladly send it to you on data media via normal post or by e-mail upon request. Alternatively we can provide you with a link to a download location in the internet, allowing you to download the most actual version. Please note that we have to charge you for any incurred expenses if you choose to receive the source code on data media.

11.1 Operating System GNU/Linux

The distribution of the GNU/Linux operating system is covered by the GNU General Public License (GPL), which we included below.

More information about GNU/Linux can be found on the GNU website
www.gnu.org

and on the website of GNU/Linux
www.linux.org

11.2 mini_httpd

For our web based configuration tool (HTTP and HTTPS) we use mini_httpd from ACME Labs. The distribution and usage of this program is free provided as long as the following notice appears in the documentation:

Copyright © 2000 by Jef Poskanzer (jef@acme.com). All rights reserved.

Redistribution and use in source and binary forms, with or without
modification, are permitted provided that the following conditions
are met:

1. Redistributions of source code must retain the above copyright
   notice, this list of conditions and the following disclaimer.

2. Redistributions in binary form must reproduce the above copyright
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Konformitätserklärung

Declaration of Conformity

Hersteller Manufacturer	**Meinberg Funkuhren GmbH & Co. KG** **Lange Wand 9** **D-31812 Bad Pyrmont**

erklärt in alleiniger Verantwortung, daß das Produkt
declares under its sole responsibility, that the product

Produktbezeichnung Product Name	**IEEE 1588-2008 Ordinary Clock**
Modell / Typ Model Designation	**SyncBox PTPv2**

auf das sich diese Erklärung bezieht, mit den folgenden Normen übereinstimmt
to which this declaration relates is in conformity with the following standards

EN55022:1998 (+A1:2000 +A2:2003)	Grenzwerte und Meßverfahren für Funkstörungen von informationstechnischen Einrichtungen Limits and methods of measurement of radio interference characteristics of information technology equipment
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EN 60950-1:2001 (+A11:2004)	Sicherheit von Einrichtungen der Informationstechnik Safety of information technology equipment

gemäß den Richtlinien 2004/108/EG (Elektromagnetische Verträglichkeit), 2006/95/EG (Niederspannungsrichtlinie) und 93/68/EWG (CE Kennzeichnung) sowie deren Ergänzungen.
following the provisions of the directives 2004/108/EC (electromagnetic compatibility), 2006/95/EC (low voltage directive) and 93/68/EEC (CE marking) and its amendments.

Bad Pyrmont, den 28.10.2009

Günter Meinberg
Managing Director

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