ELPROMA

NTS-pico3

Miniature NTP Time Server for Small Networks

User Manual

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Imprint

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Safety instructions

Except external power supply (230VAC), this equipment contains DC (9-30VDC) voltages. Do not handle any metallic part until the 230VAC power supply has been disconnected! Do not assemble, disassemble set when the power reminds switched ON. Making wiring and touching cables is strongly prohibited when power is ON. Never work alone under hazardous voltage conditions. Always check that the power cord(s), plug(s), and sockets are in good conditions. Always use qualified service personnel to install permanently wired equipment and surge antenna arrestors.

Release notes and firmware

The latest “Release notes” document and the current firmware version can be found here:

https://cloud.elpromaelectronics.com/index.php/s/m7beaxAZzDQ3m5L

Introduction

NTS-pico3 is next generation ultra-miniature time server. Unit has built-in antenna module that allows it to synchronize to GNSS and package has 30 meter coax cable (SMA ended) included. It delivers time directly to network using NTP and PTP/IEEE1588 protocols. It is equipped with single 100/10Mbps Ethernet port working with IPv4/IPv6*. Unit is very small and has natural air cooling. It has been designed for small industrial networks and it can operate 24/7. It is powered in range 9-30VDC. Marine antenna has built-in GPS signal amplifier (38dB gain) and TCXO holdover oscillator for GNSS less operations.

With hardware timestamping **NTS-pico3** can achieve accuracy < 200ns. Server has multi-satellites receiver simultaneously supporting: GPS, GLONASS. Server has very fast (less than 0.5ms +/- 1ppm) Time To First Fix TTFF synchronization start up. The GNSS receiver accuracy is better than 15ns (at 2 sigma). Server supports cryptographic authentication for NTP. Holdover mode ensure synchronization accuracy to be better than 4ms in first hour. After 24h the max. holdover error is not bigger than 100ms on server output.

The **NTS-pico3** GNSS receiver is designed for automatic operation without the need for user intervention. It can however, be accessed via a serial port (RS232 or USB) for configuration and debug purposes. Following synchronization Ethernet protocols are supported:

- **NTP Network Time Protocol (rfc5905)**
- **SNTP Simple NTP (rfc 4330)**
- **PTP Precision Time Protocol IEEE1588:2008**

Referential UTC is drawn from GPS & Glonass via built-in GNSS receiver, using NMEA183 frame. NTS-pico3 can also act as an 1PPS frequency reference clock. It can distribute 1PPS using NTP or PTP IEE1588 protocol. It has also 1 SMA 1PPS output.

General presentation

NTS-pico3 includes:

- **1 x GNSS (SMA)**
- **1 x PWR (VDC)**
- **1 x 1PPS (SMA)**

NTS-pico3 picture view

Installation

Hardware

The **NTS-pico3** box on arrive includes:

1. NTS-pico3 miniature time server (pcs 1)
2. Power supply 12VDC/230VAC (pcs 1)
3. Outdoor active GNSS antenna w/ 30m coax H-155 and accessories (pcs 1)

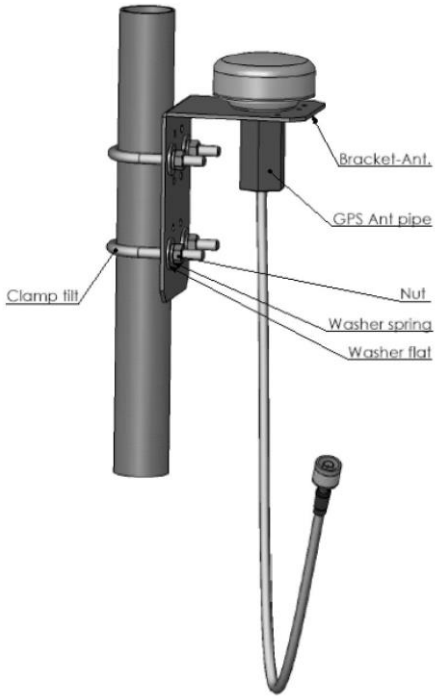
Options (not included in standard set):

4. Ethernet cable 1m RJ45/RJ45 (pcs 1)
5. RS232 cable 1m DB-9/RJ45 (pcs 1)

Note: Set does not include antenna mast, but antenna can be mounted directly using attached accessories: claps, bracket, nuts etc. - they are included.

Antenna mounting

Installing a basic system will require the following (a) **mounting of the antenna** (b) optionally **mounting 1 or 2 lightning arrestors** (not included to product set). The antenna supplied is of the active type, and is suitable for almost all applications. It is supplied with a pre-attached, 30-meter H-155 coax cable, terminated with a male SMA connector. Before commencing installation, check that all the items detailed in the contents list have been supplied. The antenna is supplied with mounting clamps for attachment to a mounting pole, included too. Mast antenna suspension (H=0.5m) is not included but it is available as separate products from Elproma. Following figure shows an example of how mounting antenna might be achieved.



Mounting GNSS antenna

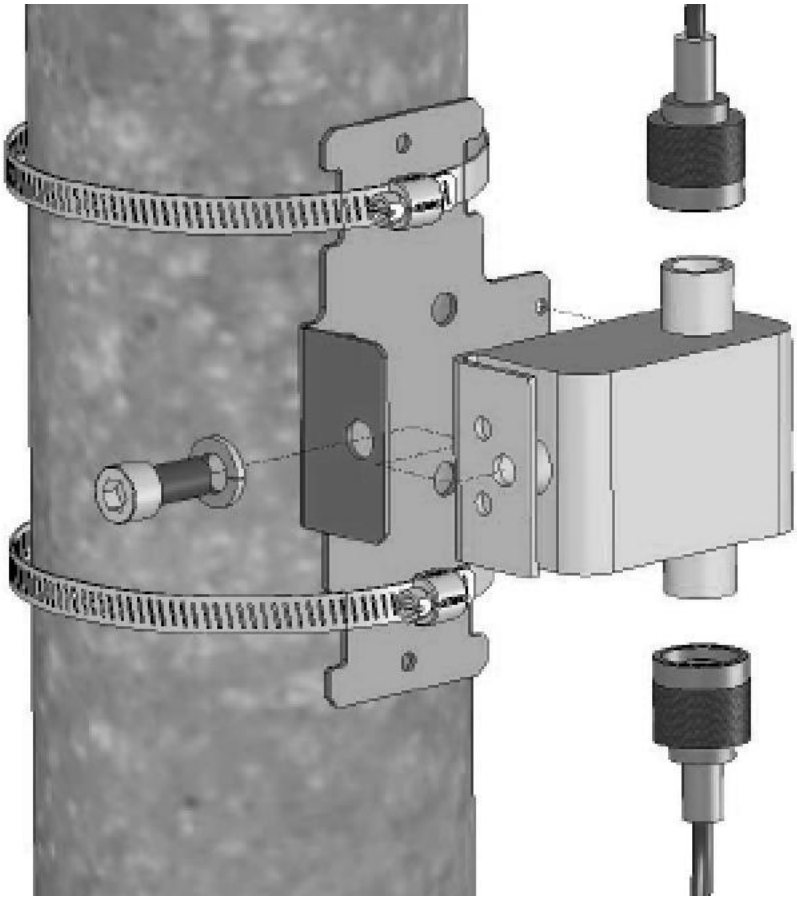
Note: The most important consideration in selecting a position for the antenna is the presence of objects which obscure the sky or horizon. Where possible, there should be no obstruction to a full view of the sky.

Overhead wires and other very narrow obstructions may be considered as invisible to the signals, provided that they are a few meters away. Large flat surfaces can decrease performance of the receiver. Be especially wary about mounting the antenna directly onto the fascia of a flat roof. To overcome this situation, elevate the pole about 1 meter above the flat surface. A satellite prediction mobile phone program may usefully be employed to check a potential installation, and also to identify directions in which obstructions may be a particular source of problems.

Note: When the **NTS-pico3** is operational, the GNSS antenna assembly may be disconnected for short periods (e.g. maintenance or repair) without interruption to the unit synchronization LAN output.

Additional lightning protection considerations

As the antenna is roof mounted (to have a clear view of the sky) it is likely to be exposed to lightning strikes.



Protection against this is afforded by ensuring adequate grounding of the mountings as described below. There is no way to provide 100% protection for electronic equipment from direct

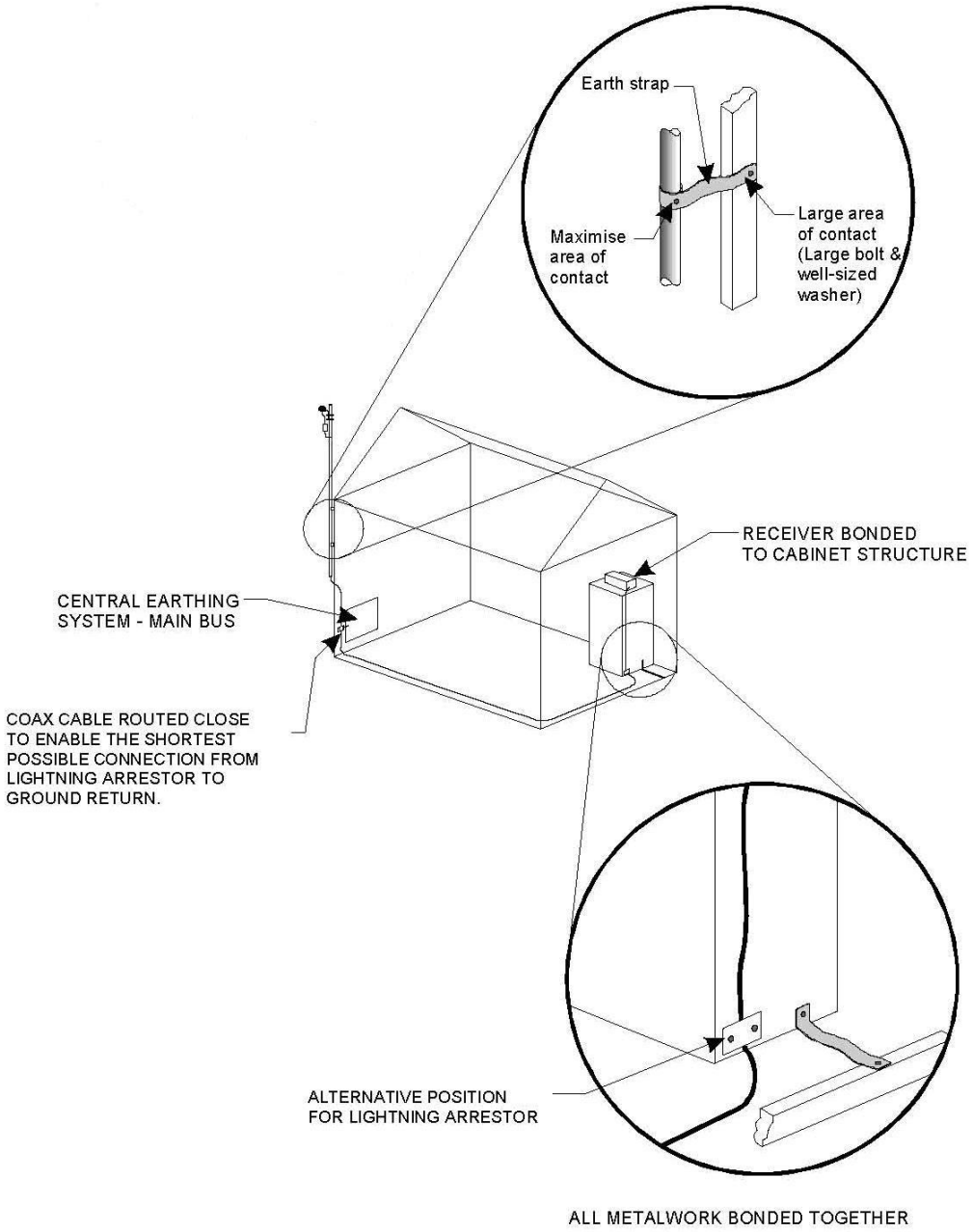
strike damage. It is possible however, to reduce the likelihood of damage from near strike induced fields by ensuring the installation obeys some fundamental rules.

A proprietary lightning arrestor should be installed, of a type which does not reduce GNSS signal transfer. Install the lightning arrestor near to the antenna (e.g. on the mounting pole), ensuring all connections maintain electrical and environmental protection.

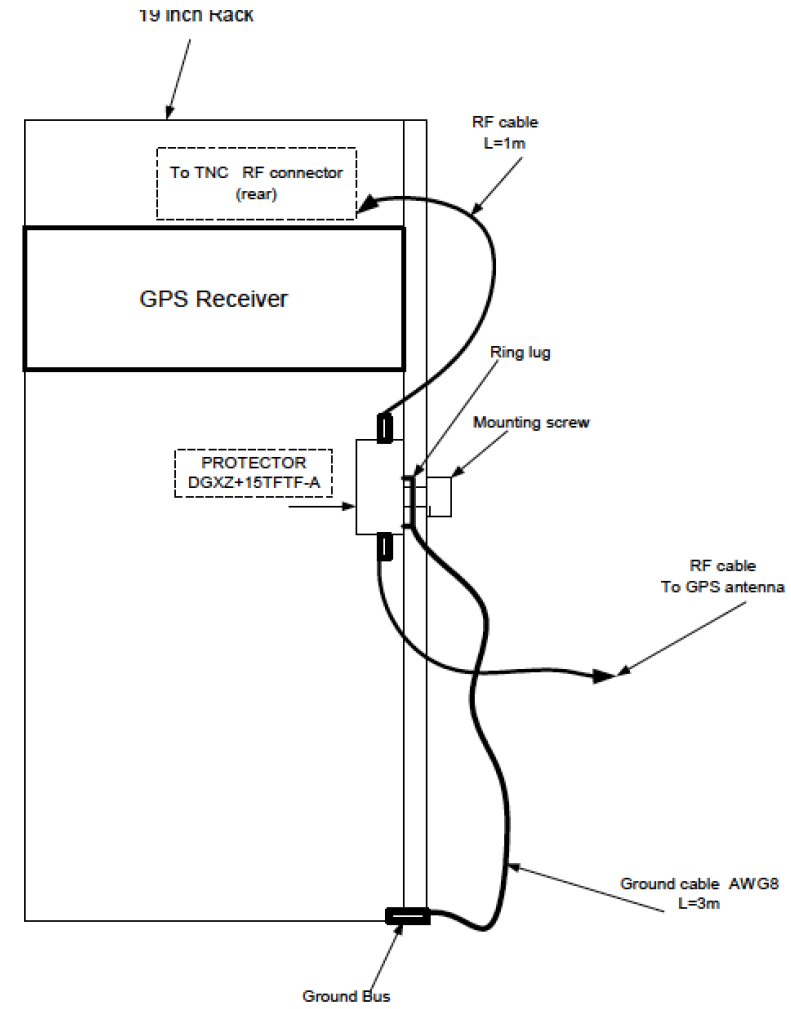
After taking the precautions described previously in the antenna installation, it should be understood that a destructive residual current may still be present in the cable coming down from the antenna to the **NTS-pico3** unit.

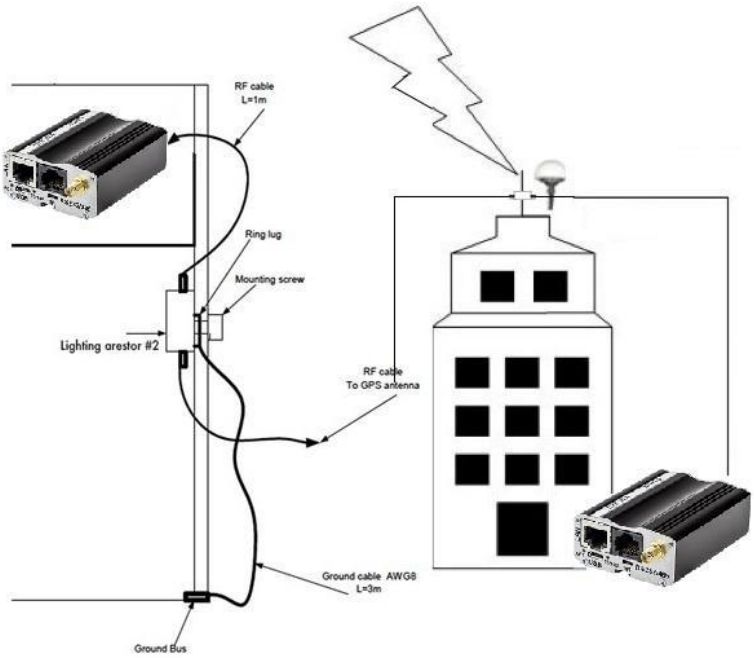
A second lightning arrestor should be installed near to the **NTS-pico3** to further dissipate any remaining lightning energy. At the earth end please use multiple connection points if at all possible.

All connections should incorporate as large an area of contact as possible, which is made more probable using large bolts, and substantial washers. Where there is no access to the metal framework of the building, it is imperative to erect a suitable lightning conductor. Failure to do so is almost certain to result in destruction of **NTS-pico3** and connected into it equipment in the event of the antenna receiving a near lightning strike.



Grounding system





NTS-pico3 surge protection

Serial port, either RS232/RS485

Serial RS232/RS485 (RJ-45 connector marked as “RS232/485”) is placed on front panel of router. Serial connector pinout is described in a tables below.

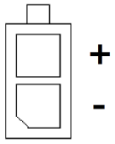
RS232 RS485 signal	NTS-pico3 RJ-45
A	1
5V	2
B	3
GND	4
TX	5
RX	6
RTS	7
CTS	8

	NTS-pico3	RS232	RS485
	RJ45	DB9F	DB9F
A	1	nc	1
5V	2	2	2
B	3	3	nc
GND	4	nc	nc
TX	5	5	5
RX	6	ns	6
RTS	7	7	nc
CTS	8	8	nc

First start and usage

Powering up

1. Connect GNSS antenna to SMA connector in NTS-pico3
2. Connect Ethernet LAN cable to RJ45 connector
3. Plug-in DC power supply to power input and turn power ON. Power supply connector pinout:



LED indicators

The device has four LEDs that indicates its operation. The LEDs are described in the table below.

Diode	Color	Description
U1	Red	GNSS fix indication
U2	Blue	Heartbeat
S	Yellow	GNSS active antenna power supply
PWR	Green	Power supply

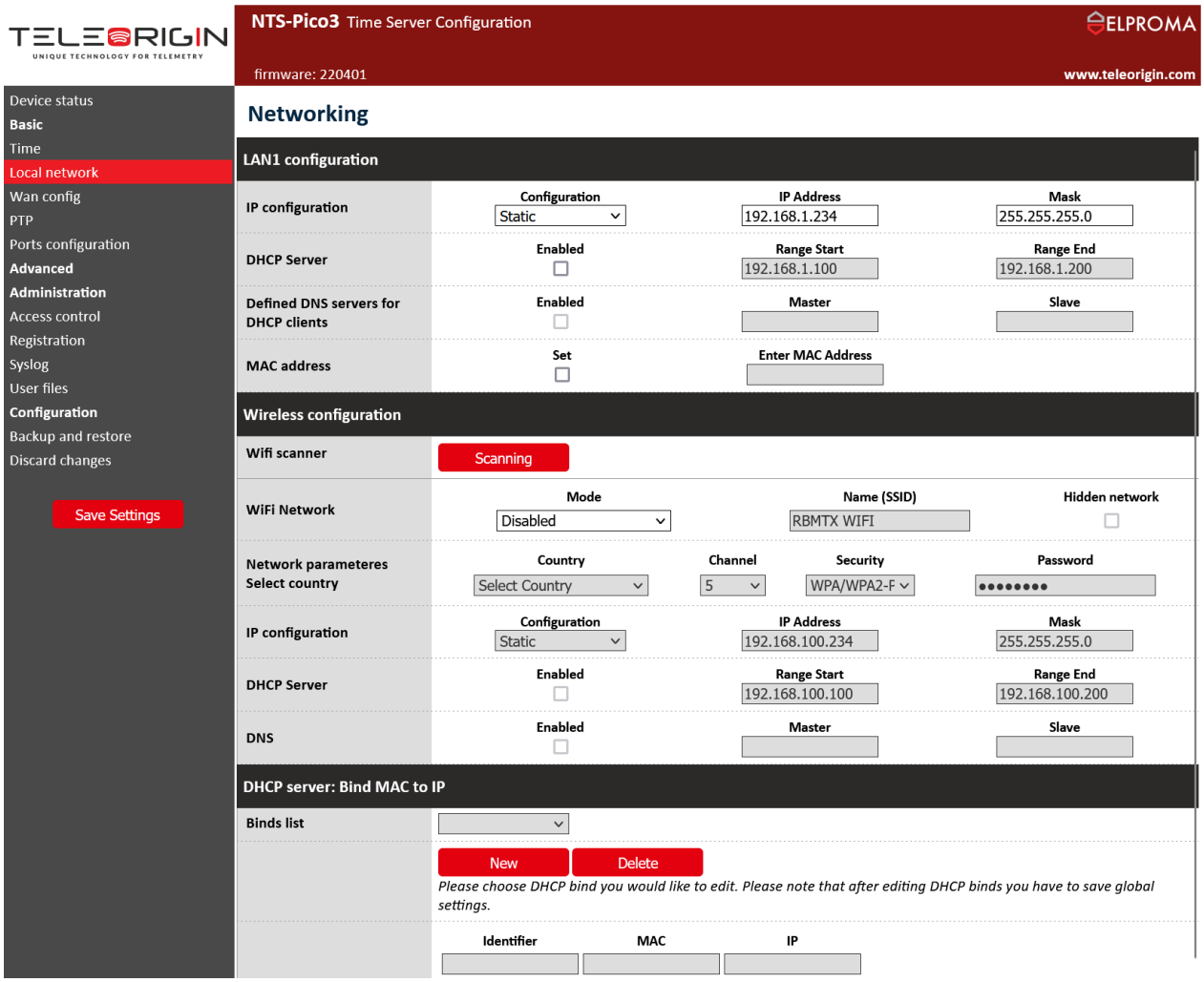
Basic SETUP

Go to your web browser and put IP address 192.168.1.234 (netmask 255.255.255.0). You will be asked for username and password. By defaults they are:

Username: ***admin***
Password: ***12345***

IP addressing

On LAN configuration page you can find essential parameters needed for LAN connection. Here you can set IPv4 address, netmask, default gateway and DHCP server.

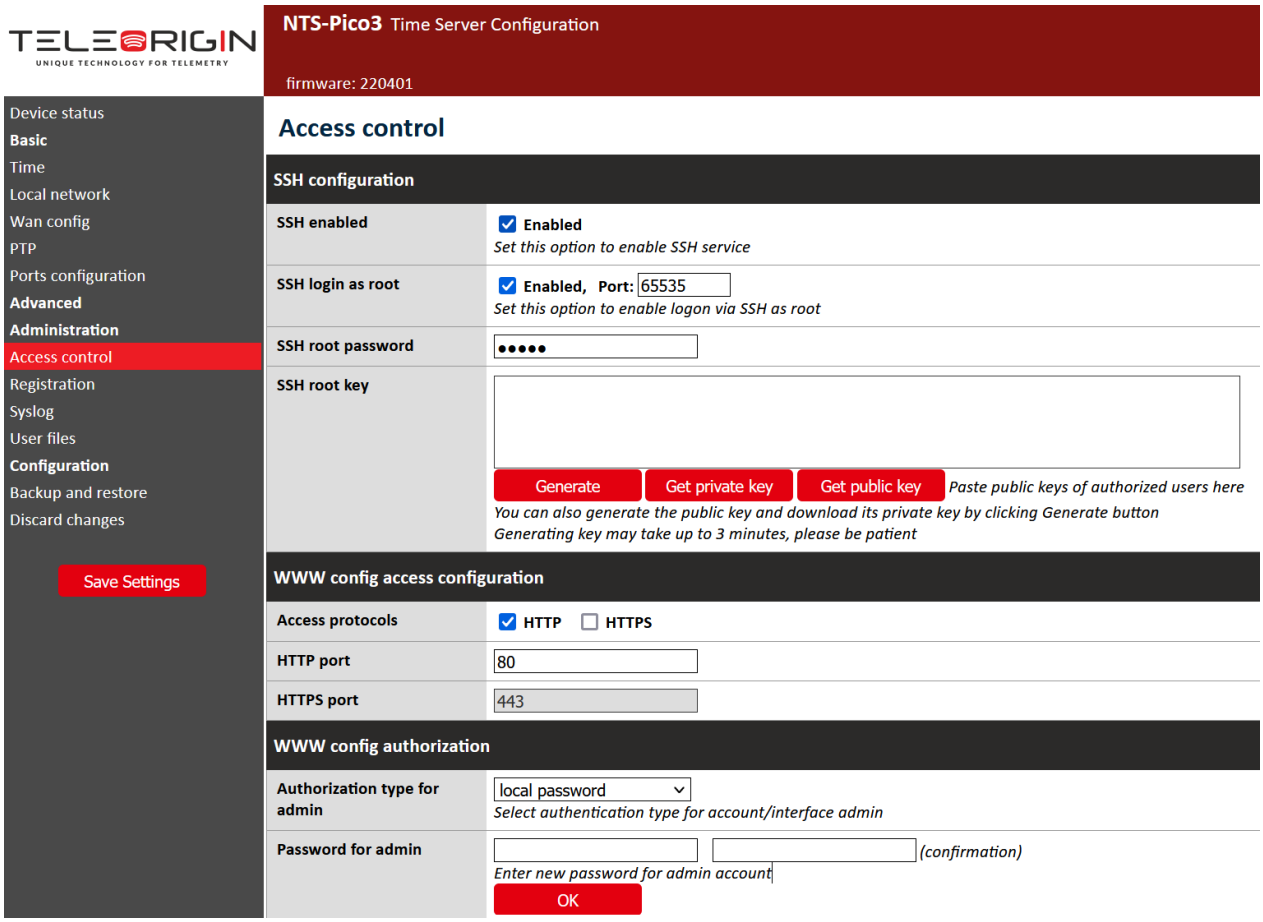


Minimum configuration requires setup IPv4

IMPORTANT NOTE!
For time synchronization purpose please do not use DHCP/DNS.
You will need to keep SSH communication ON for GNSS signals tracing. Also, devices synchronizing to NTS-pico3 may assume it has statis IP address.

SSH access control

Enable SSH access for easier device GNSS & PTP monitoring if needed.

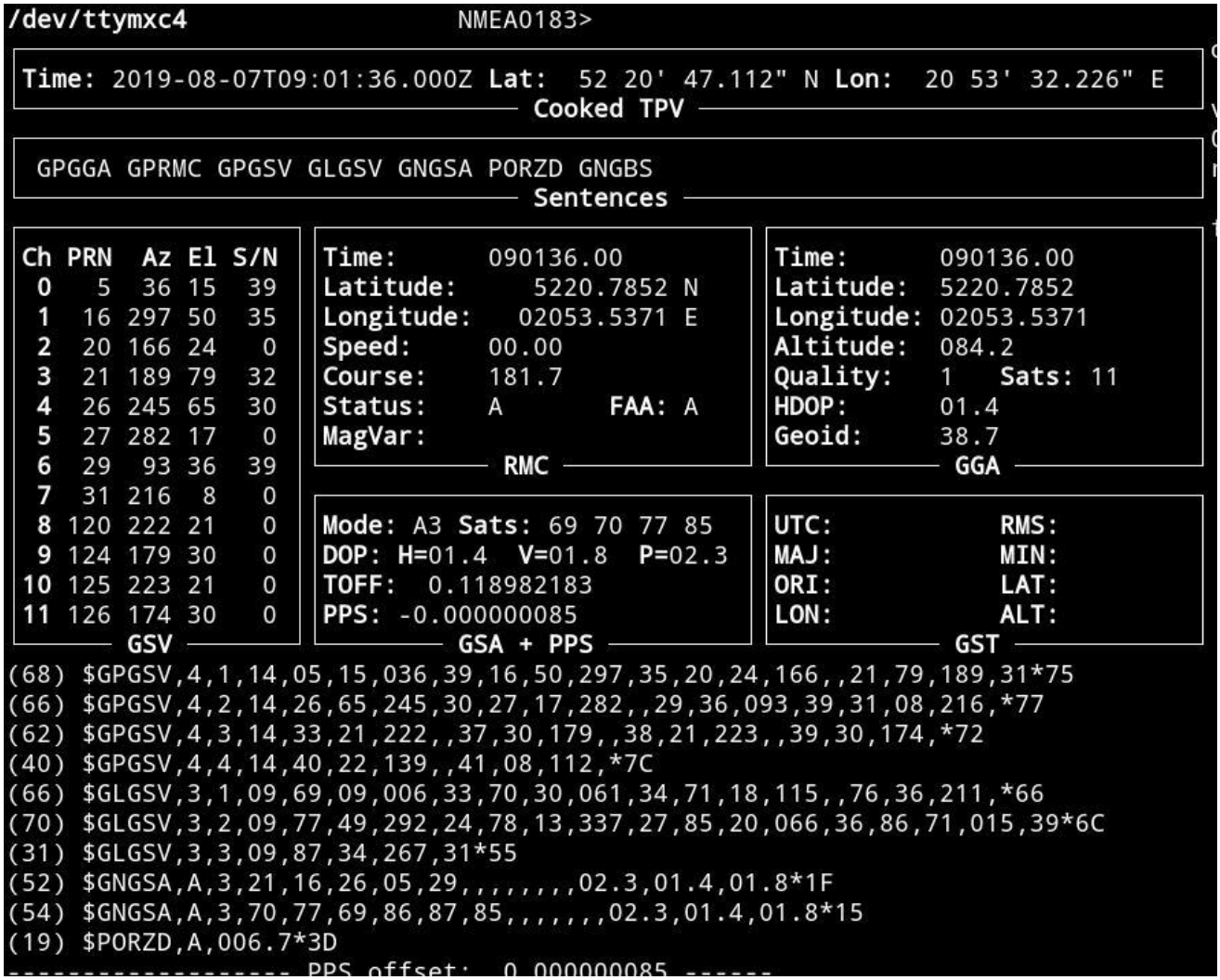


SSH enable (ON) and password is necessary for tracing on-line GNSS signals

Monitoring GNSS satellite signals ON-LINE

SSH communication must be enabled first. Please execute the following commands from terminal:

```
ssh root@192.168.1.234 -p 65535
root@192.168.1.139's password: 12345
[root@rbmtx ~]# TERM=vt220
[root@rbmtx ~]# gpsmon
```



GPSmon tool let you trace satellite signals on-line

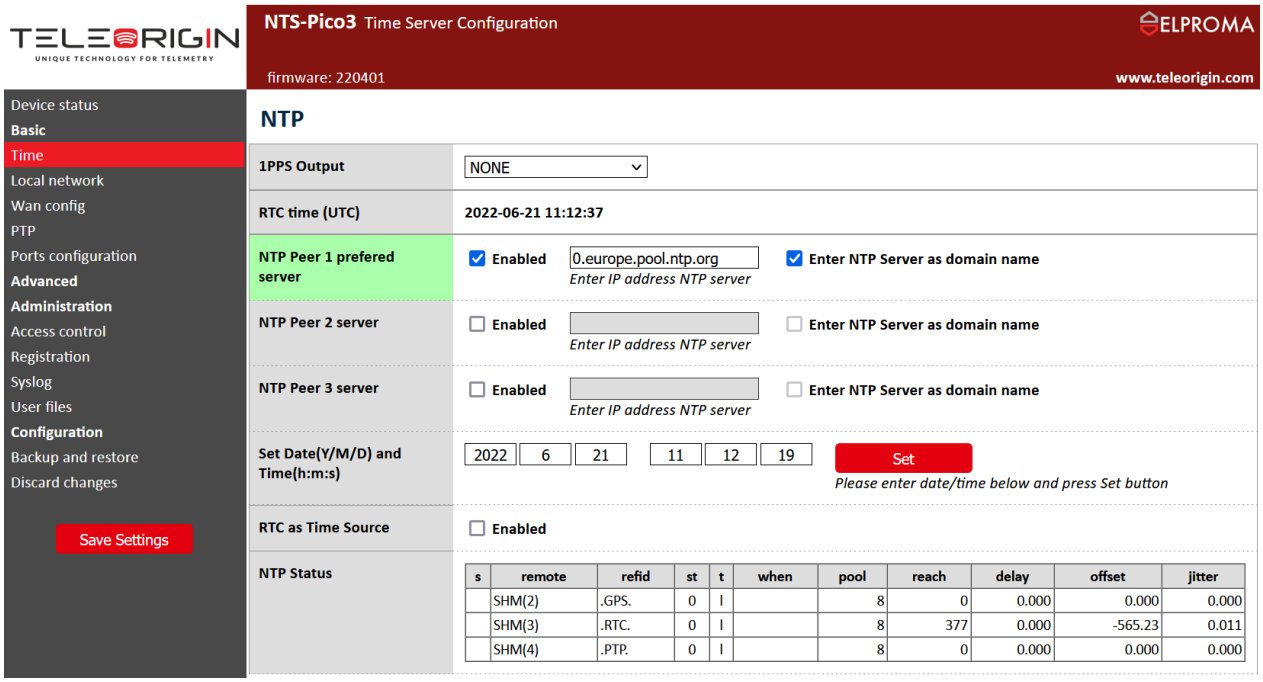
This screen is the tool to monitor GNSS (GPS & Glonass) satellite signal performance. You should be able to receive signals from at least not less than 4 satellites. Well done installation mostly let view 10-20 GNSS satellites in view. It takes approx. 5-10 minutes since power on to get minimum #sats in view.

Recommendation! For Linux/Unix and Mac OSX please use BASH std. terminal. For Microsoft Windows there are various of 3rd party SSH software suppliers. One of the most popular one is free available *putty.exe*

Running NTP (Network Time Protocol)

Configuring NTP

NTS-pico3 firmware starts NTP server and synchronizes to UTC time received from GPS by default. You can add backup NTP servers in NTP Peer 1...3 fields.



Monitoring NTP on-line

SSH communication must be enabled first. Please execute the following commands from terminal:

```
ssh root@192.168.1.234 -p 65535
root@192.168.1.139's password: 12345
[root@rbmtx ~]# ntpq
```

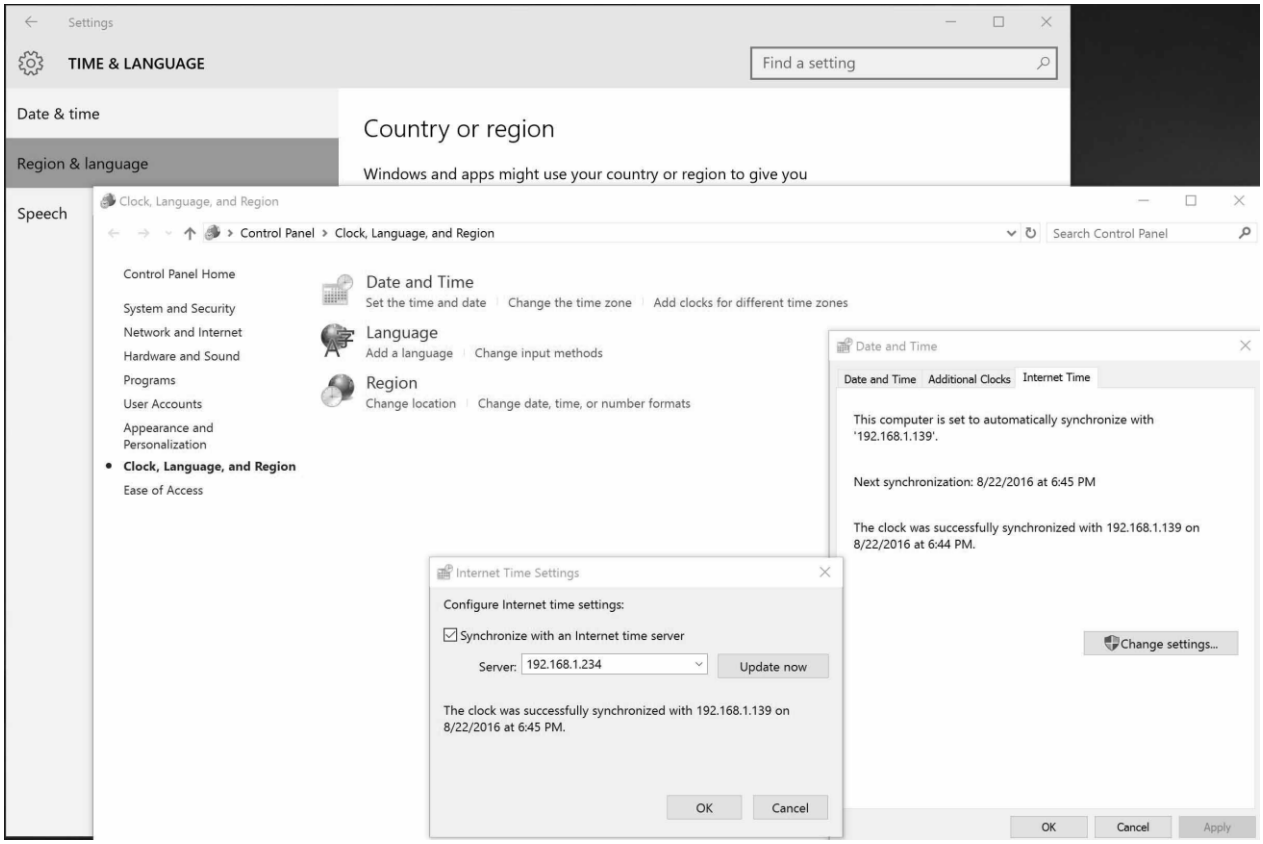
You can use full spectrum of std. NTP monitoring tools incl. ***ntpq*** and ***ntpdc*** to trace and monitor Network Time Protocol. For more information please refer to www.ntp.org

```
[root@pico3 ~]# ntpq
ntpq> pe
     remote           refid      st t when poll reach   delay   offset  jitter
==============================================================================
*SHM(2)          .GPS.            0 l    6    8  377    0.000   -0.002   0.002
 SHM(3)          .RTC.            0 l    -    8    0    0.000    0.000   0.000
ntpq> rv
associd=0 status=0415 leap_none, sync_uhf_radio, 1 event, clock_sync,
version="ntpd 4.2.8p8@1.3265-o Thu Jul  4 13:56:37 UTC 2019 (1)",
processor="armv7l", system="Linux/3.14.52+", leap=00, stratum=1,
precision=-19, rootdelay=0.000, rootdisp=1.015, refid=GPS,
reftime=e0f504b3.8a8cd3f3  Wed, Aug  7 2019  8:05:07.541,
clock=e0f504b4.b9da49b0  Wed, Aug  7 2019  8:05:08.725, peer=2944, tc=3,
mintc=3, offset=-0.001697, frequency=0.187, sys_jitter=0.001907,
clk_jitter=0.002, clk_wander=0.001, tai=37, leapsec=201701010000,
expire=201912280000
ntpq>
```

ntpq debugging tool for NTP

Synchronizing Microsoft Windows clock

You can simply synchronize any version of Microsoft Windows system by selecting “Time from Internet” and providing **NTS-pico3** IPv4 address. Below is an example for Windows 10 system.



Using NTS-pico3 as primary source of NTP time for Microsoft Windows

Synchronizing Linux & Mac OSX clock

Both Linux and OSX systems includes built-in NTP protocol. You can simply modify ntp.conf file by providing your **NTS-pico3** IPv4 address, however we recommend to use similar Microsoft Windows high level OS Time & Date operations.

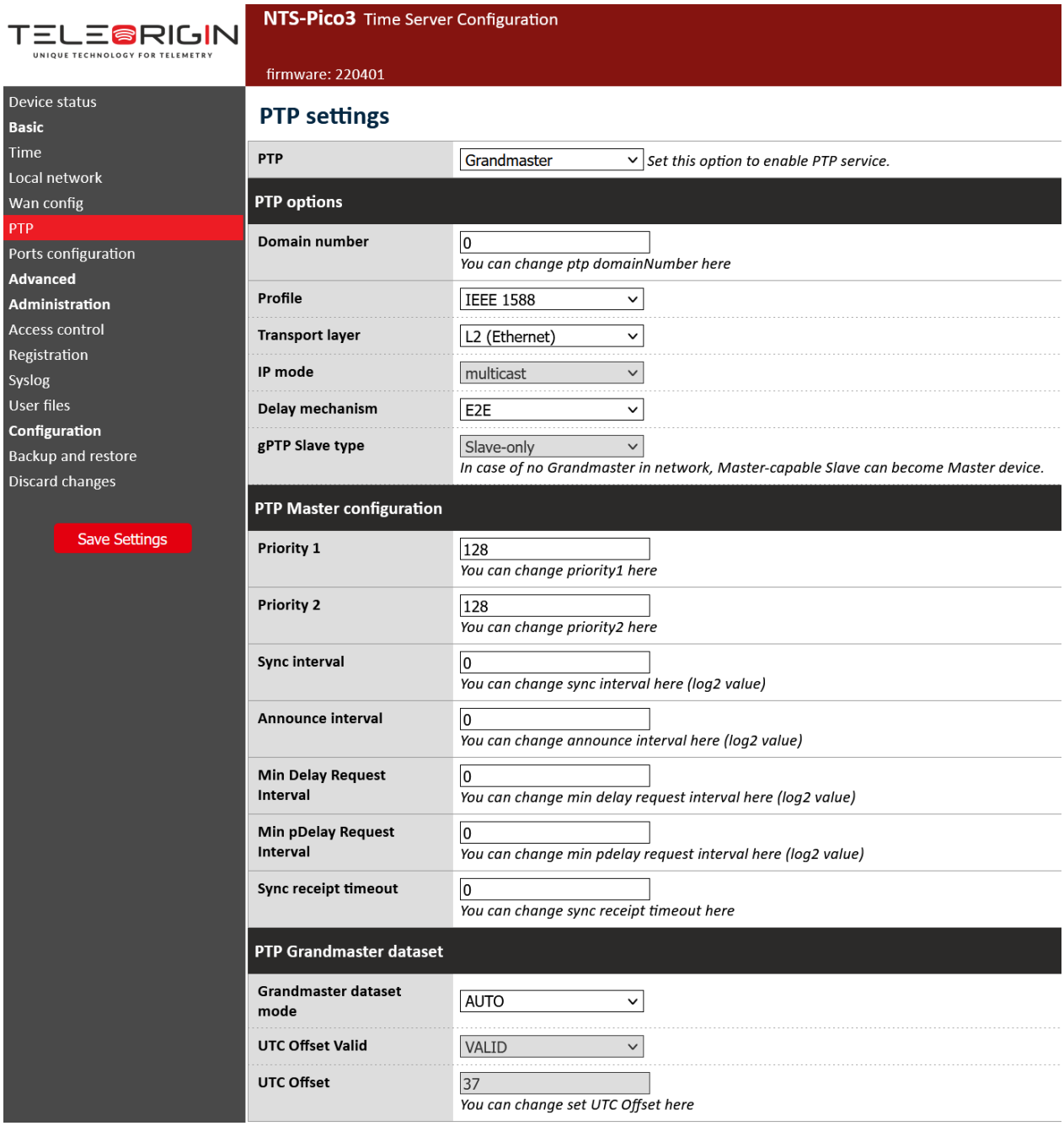
Serial ports configuration

Available modes for RS232:

- None.
- Forwarding.
- Terminal – Unlocks standard SSH like console on serial port.
- ModBus gateway.
- GPS NMEA – copies NMEA output from GNSS module and sends it to serial port. Included messages are: RMC, GSV, GSA, GGA.
- PTP NMEA – simulates NMEA messages based on PTP synchronization status. Requires PTP to be enabled. Included messages are: RMC, ZDA.

Running PTP (Precision Time Protocol)

Switching on PTP enables PTP grandmaster daemon.



PTP options:

Option name	Value type/possible values	Description
PTP	Disabled/Grandmaster/Slave	Enabled PTP as Master/Slave.
PTP Options		
Domain number	Number [0...255]	A domain does define the scope of PTP message communication, state, operations, data sets, and timescale. Devices synchronize only to PTP devices within same domain. Multiple domains mayy be used in signle network.
Profile	IEEE1588/802.1AS	Defines whether synchronization is performed using standard PTP (**IEEE1588**) or gPTP (**802.1AS**).
Transport layer	L2/L4	**L2 (Ethernet)**: PTP packets are encapsulated directly in Ethernet frames (IEEE 802.3 network transport) **L4 (UDP)**: PTP packets are exchanged over UDP/IPv4
IP mode	multicast/unicast/hybrid	
Delay mechanism	E2E/P2P	**E2E:** Delay is measured end-to-end. Delay is calculated for the whole path **P2P:** Delay is measured peer-to-peer. If transparent clocks are present in a network, they need to support peer-delay mechanism (and have it enabled)
gPTP Slave type	Slave-only/Master-capable	Defines whether gPTP Slave device may become a Master in the network in case there is no other available. Cannot become Grandmaster.
PTP Master configuration		
Priority1	Number [0...255]	The attribute priority1 is used in the execution of the best master clock algorithm. Lower values take precedence. This is primarily checked field in best master clock algorithm.
Priority2	Number [0...255]	The attribute priority2 is used in the execution of the best master clock algorithm. Lower values take precedence. This field is after clock class, accuracy and variance.
Sync interval	Number (log2) [-7...7] (recommended [-3...3])	Interval for PTP Sync messages to be sent. Unit used is log2 (logarithm 2), e.g. -4: 62.5ms (1/16 s) -3: 125ms (1/8 s) -2: 250ms (1/4 s) -1: 0.5s (1/2 s) 0: 1 second (typical interval) 1: 2 seconds (default) 2: 4 seconds 3: 8 seconds 4: 16 seconds **NOTE:** Editing this and following attributes must be done with caution.
Announce interval	Number (log2)	Interval for PTP Announce messages to be sent.
Min Delay Request Interval	Number (log2)	Interval for PTP Delay_Request messages to be sent to host.
Min pDelay Request Interval	Number (log2)	Interval for PTP Peer_Delay_Request messages to be sent to host.

Sync receipt timeout	Number (log2)	Timeout value of PTP Sync messages. Defines for how long obtained time is marked as valid.
PTP Grandmaster dataset		
Grandmaster dataset mode	Auto/Manual	Allows selection between constant UTC-TAI offset and automatically calculated measured one. Usage of this (manual) is for testing purposes mostly.
UTC Offset Valid	Valid/Invalid	Allows to mark whether custom UTC-TAI offset shall be marked as valid.
UTC offset	Number	Defines custom UTC-TAI offset if used.

Additional settings: (available via SSH only)

- All settings listed in https://linux.die.net/man/8/ptp4l, located in /etc/ptp4l.cfg file on system. Note that some are automatically adjusted by software.

PTP client implementation on Windows 10 and Server 2019:

Requirements

PTP client is supported on Windows 10 and Windows Server 2019. At least 1809 update version must be installed on the system

Implementation procedure

First add the *PtPClient* registry key to your Windows register. Already prepared file can be downloaded from below link:

https://cloud.elpromaelectronics.com/index.php/s/kLnpCMmzR6CGJ5s

Change the registry keys to configure PTP and disable other client providers (NTP, VMIC etc.). Please modify the below root keys manually:

HKLM\SYSTEM\CurrentControlSet\Services\W32Time\TimeProviders\PtpClient

Name	**Value**
PtPMasters	IP of NTS-pico3, default: 192.168.1.234
EnableMulticastRx	0

HKLM\SYSTEM\CurrentControlSet\Services\W32Time\TimeProviders\NtpClient

Name	**Value**
Enabled	0

HKLM\SYSTEM\CurrentControlSet\Services\W32Time\TimeProviders\VMICTimeProvider

Name	**Value**
Enabled	0

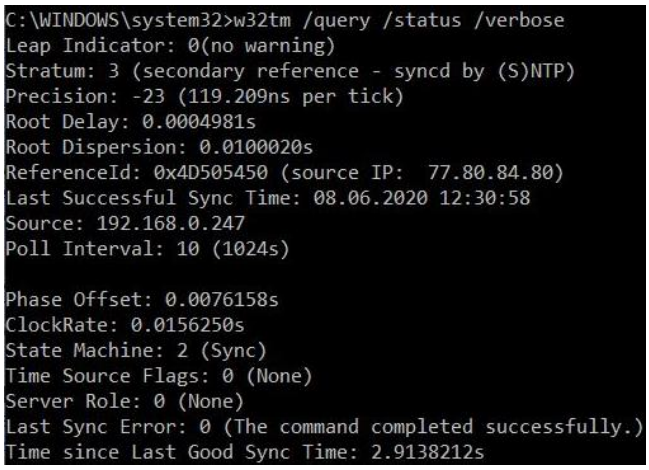
Then restart the Windows Time Service. You can do this by pressing Win + R keys, type *services.msc* and right click on W32tm (Windows Time) service -> Restart.

After W32tm restarting, create the rules in firewall to allow the PTP Client to communicate with the time server (UDP protocol):

Name	**Direction**	**Port**
PTP Event In	In	319
PTP Event Out	Out	319

PTP General In	In	320
PTP General Out	Out	320

Verify if PTP Time Provider is enabled using ***w32tm /query /configuration*** command. Then verify that the system is synchronizing with PTP Source Server using ***w32tm /query /status /verbose*** command. The output should be as below:



ReferenceId: 0x4D505450 indicates that the PTP provider is in use.

Troubleshooting

To troubleshoot **NTS-pico3** you need first to log into device console using serial cable or SSH.

How to check if PTP is working?

From **NTS-pico3** console you can check if ptp process is running. If everything is fine, you shall get 1 in return:

```
[root@pico3 ~]# ps aux | grep '[p]tp4l'  -c
1
[root@pico3 ~]#
```

If there is no ptp process you will get 0 (make sure, that you have enabled PTP in web panel):

```
[root@pico3 ~]# ps aux | grep '[p]tp4l' -c
0
[root@pico3 ~]#
```

How to check if NTS-pico3 sends PTP messages?

To check if **NTS-pico3** is actually sending PTP IEEE1588 messages over your LAN network you use *tcpdump* utility and see if PTP frames are going out of device:

1) PTP L2 (Ethernet)

To see only PTP (0x88F7) Ethernet packets:

```
[root@pico3 ~]# tcpdump ether proto 0x88F7 -c 3 -q
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on lan1, link-type EN10MB (Ethernet), capture size 262144 bytes
08:42:38.291470 36:07:13:13:5e:2e (oui Unknown) > 01:1b:19:00:00:00 (oui Unknown), Unknown Ethertype (0x88f7), length 58:
08:42:38.291984 36:07:13:13:5e:2e (oui Unknown) > 01:1b:19:00:00:00 (oui Unknown), Unknown Ethertype (0x88f7), length 58:
08:42:39.211428 36:07:13:13:5e:2e (oui Unknown) > 01:1b:19:00:00:00 (oui Unknown), Unknown Ethertype (0x88f7), length 78:
3 packets captured
3 packets received by filter
0 packets dropped by kernel
[root@pico3 ~]#
```

2) PTP L4 (UDP)

To capture PTP UDP transmission we need to dump tcp packets going to ports 319 and 320:

```
[root@pico3 ~]# tcpdump udp portrange 319-320 -c 3
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on lan1, link-type EN10MB (Ethernet), capture size 262144 bytes
08:46:59.042733 IP 192.168.1.234.319 > 224.0.1.129.319: UDP, length 44
08:46:59.043326 IP 192.168.1.234.320 > 224.0.1.129.320: UDP, length 44
08:47:00.042823 IP 192.168.1.234.319 > 224.0.1.129.319: UDP, length 44
3 packets captured
5 packets received by filter
0 packets dropped by kernel
[root@pico3 ~]#
```

APPENDIX

Technical Specification

Holdover OSC	TCXO
Supported synchronization protocols	NTP, PTP IEEE1588
NTP	RFC5905, RFC1305, RFC5906, RFC5907, RFC5908, RFC5909
SNTP	RFC4330, RFC2030, RFC1769
PTP	IEEE1588: 2008
1PPS output	1x SMA*
1PPS specification	PPS out - 3.3 VDC (50 Ohm) Pulse width - 1ms The PPS-out either directly from GNSS module or PTP.
Time/Daytime	RFC(867-8)*
LAN interfaces	10/100Mbps (RJ45) x 1
Supported TCP/IP protocols	IPv4, IPv6*, TCP, UDP
Management	HTTP, HTTPS, SSH, TELNET
Security	Autokey, DSA, SSL, MD5, RSA
SYSLOG	yes
Hardware stamping	accuracy < 200ns*
Antenna interface	1x SMA
Supported GNSS	GPS, GLONASS
Additional supported GNSS	GALILLEO*, BEIDOU*
SBAS	EGNOS, WAAS, GAGAN
FREQ #1	1575.42MHz (L1 GPS)
FREQ #2	1598.06-1605.38MHz GLONASS
Max concurrent GNSS channels	32
Antenna cable	30m coax H155
RS232 connector type	1x RJ45
USB interface	1x Micro-USB 2.0
Weight	0.3kg (3kg with all equipment)

Operating temperature	(-20°C…+70°C)
Storage temperature	(-40°C…+85°C)
Humidity	up to 95%
Power	9-30 VDC
Power consumption	• Typical: 1.2-1.6W • Max typical: < 2W (Peak when active GNSS antenna is not shorted and USB not connected) • Max. possible: < 8W (info for safety, when short-circuit on internal 5V)

* extra feature

Additional notes

Note: In new version of NTS-pico3 there are more options to choose and PPS-output can be set to baseline of NTP or PTP internal clocks of NTS-pico3.

The old version NTS-pico (manufactured 2016-2019) does not support above. This version of product cannot be hardware & software update to new NTS-pico3 and it is required to purchase new one.

For those customers who wants to move from NTS-pico to new NTS-pico3 the Elproma sales offers special discounted price.