Library for SNTP Server Functionality in SIMATIC S7 CPUs (LSNTP)

SIMATIC, TIA Portal

https://support.industry.siemens.com/cs/ww/en/view/82203451

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1 Introduction

1.1 Overview

NTP and SNTP are used to synchronize clocks in a network. The PROFINET CPUs of the SIMATIC S7-300, S7-400, WinAC RTX, S7-1200, S7-1500 series and ET 200SP CPUs can be configured as NTP clients for time synchronization as a standard feature. With regard to the firmware, the S7 CPUs are generally not designated as NTP servers. For time synchronization in an automation cell, a suitable timer system such as SICLOCK or - for synchronization using the SIMATIC process - additional hardware (communication processors) has to be used.

Possible application of the "LSNTP" library

For automation cells or plant sections, the use of the exact International Atomic Time (TAI) is often secondary. It is usually sufficient to have a common time base for all automation components.

Using a SIMATIC S7 CPU as SNTP server allows for flexible and simple synchronization of plants and plant sections, for example, to receive meaningful time stamps for error messages and logging data plant-wide.

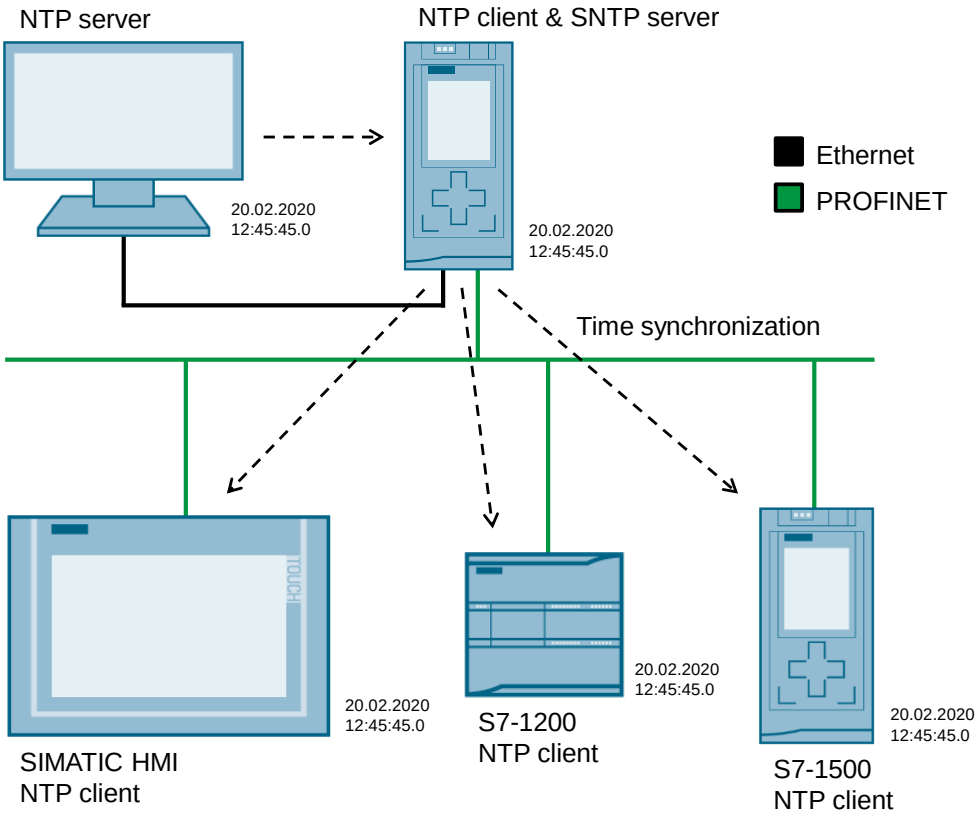
The inaccuracy of the SNTP server is below 10 ms.

1.2 Mode of operation

Example scenario

The following figure shows a possible sample configuration with a SIMATIC S7-1500 CPU as SNTP server. Here, the CPU synchronizes its time with an external NTP server. However, any other configuration with a different timer is also possible.

Figure 1-1: Example scenario



Function

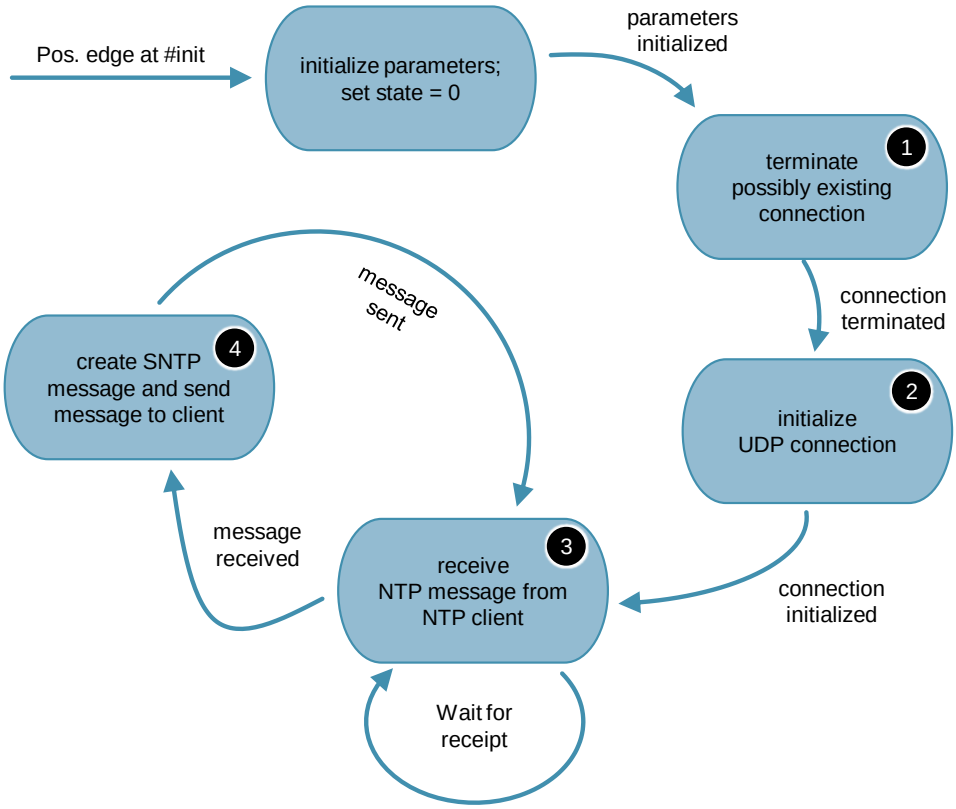
The library provides a function block that accomplishes the following functions:

- Receipt and analysis of an NTP message from an NTP client.
- Creation and sending of an SNTP message to the client for time synchronization.

Process

Internally, the "LSNTP_Server" FB works as a simple state machine which is processed after an initialization. The following figure schematically shows the successful processing of the "LSNTP_Server" FB.

Figure 1-2: Process



The following table describes an error-free time synchronization:

Table 1-1: Process

No.	Action
1.	The FB is called with "init" = TRUE for one cycle, and the parameters of the FB are initialized.
2.	Possibly existing connections with parameterized connection ID are terminated (the TDISCON instruction).
3.	The local communication access point is set up at port 123 reserved for NTP (the TCON instruction).
4.	The request message from an NTP client is awaited (the TURCV instruction).
5.	When the time request from an NTP client has been detected, the SNTP message is created and then sent to the client (TUSEND).
6.	Afterwards, a new request message is awaited again (from the same or a different client).

NOTE From any status, it is possible to return to the initialization status with another change of edge at the "init" input.

Effect of cycle time

The SNTP message is sent by the server in the same function block and cycle in which the NTP message is received from a client, and the system time is read out. The SNTP message is completely sent within a cycle. As a result, the cycle time has no effect on the accuracy of the transferred time.

1.3 Components used

Requirements for this library

To make use of the full functionality of the library described here, the hardware and software requirements listed below must be met:

Hardware

The "LSNTP" library can be used with all PROFINET S7 CPUs with which Open User Communication (OUC) can be programmed.

These can be CPUs of the following series:

- S7-300
- S7-400
- S7-1200 (CPUs FW ≤ 3.0 or FW ≥ 4.1.3)
- S7-1500
- ET 200SP
- WinAC RTX

Software

The library is available for TIA Portal V15.1 and STEP 7 V5.5:

https://support.industry.siemens.com/cs/ww/en/view/82203451

2 Engineering

2.1 Components of the block library

The "LSNTP" library consists of the following blocks and data types.

S7-1200 und S7-1500

Table 2-1: Blocks and types of the library for S7-1200 und S7-1500

Name	Type	Version	Description
LSNTP_Server	FB	V3.0.2	Implements the function of the SNTP server.
LSNTP_Param	DB	-	Data block for interconnecting the inputs of "LSNTP_Server".

S7-300, S7-400 and WinAC RTX

Table 2-2: Blocks and types of the library for S7-300, S7-400 and WinAC RTX

Name	Type	Version	Description
LSNTP_Server	FB	V2.0.1	Implements the function of the SNTP server.
LSNTP_Param	DB	-	Data block for interconnecting the inputs of "LSNTP_Server".

Common

Table 2-3: Blocks and types of the library for common use

Name	Type	Version	Description
LSNTP_typeTelegram	Data type	V1.0.0	Describes the structure of the NTP message.
LSNTP_typeTimestamp	Data type	V1.0.0	Describes the structure of the time stamp.
LSNTP_Diag	DB	-	Data block for interconnecting the outputs of "LSNTP_Server".

2.2 Description of interface

2.2.1 LSNTP_Server for S7-1200 and S7-1500

The following figure shows the call interface of the "LSNTP_Server" FB. The table describes the parameters of the function block.

Figure 2-1: "LSNTP_Server" for S7-1200 and S7-1500

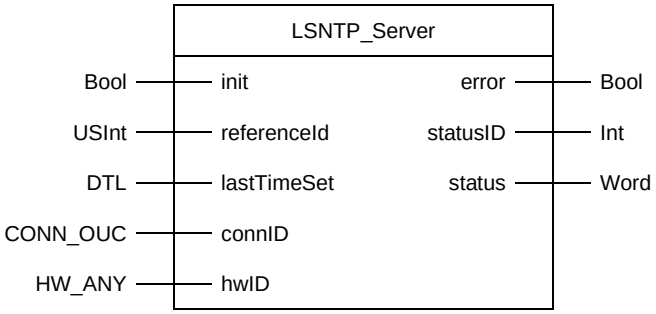


Table 2-4: Parameters of "LSNTP_Server"

Parameters	Type	Remark
init	IN: Bool	The function of the block is activated with a positive edge. This can occur, for example, during the start-up of the CPU in OB100.
referenceId	IN: USInt	The input specifies from which time source the server CPU obtains the time: • 0: uncalibrated (set "manually") • 1: primary reference (e.g., DCF 77) • 2: secondary reference (e.g., from GPS receiver) The information is forwarded to the NTP client in SNTP.
lastTimeSet	IN: DTL	If the information on when the time was set last is available, this information is connected to the input. The information is forwarded to the NTP client in SNTP. If the parameter is not assigned, the current time of the CPU is transferred instead.
connID	IN: CONN_OUC	Is assigned with a free connection ID. The parameter is used internally by the OUC blocks also for connection establishment.
hwID	IN: HW_ANY	Hardware identifier of the Ethernet interface.
error	OUT: Bool	Shows a configuration error or error of the OUC blocks. Depending on the error type, the output can also be set only for one cycle.
status	OUT: Word	Specifies the error (see Chapter 2.4).
statusID	OUT: Int	Specifies the source of the error (see Chapter 2.4).

2.2.2 LSNTP_Server for S7-300, S7-400 and WinAC RTX

The following figure shows the call interface of the "LSNTP_Server" FB. The table describes the parameters of the function block.

Figure 2-2: LSNTP_Server for S7-300, S7-400 and WinAC RTX

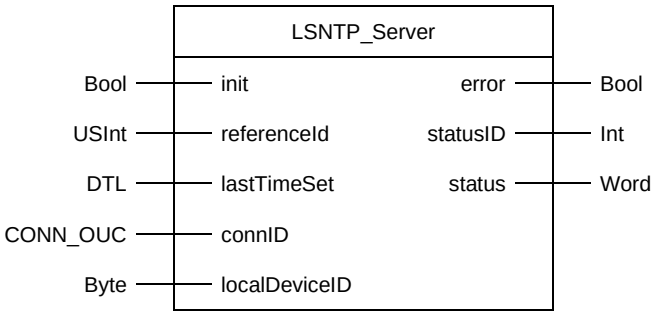


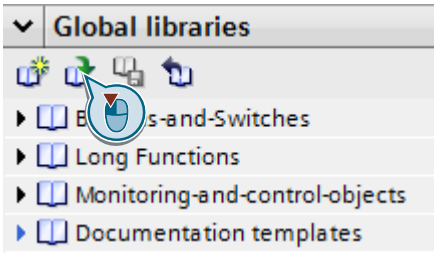
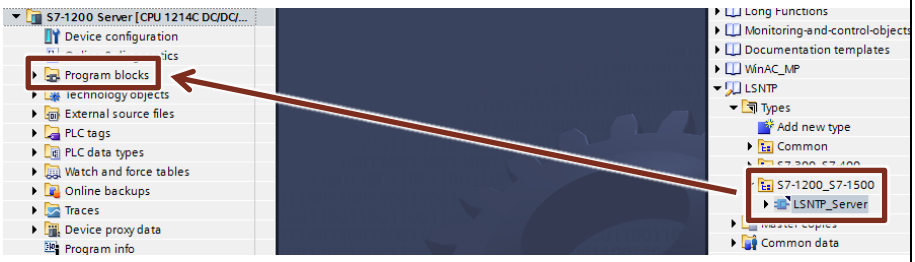
Table 2-5: Parameters of "LSNTP_Server"

Parameters	Type	Remark
init	IN: Bool	The function of the block is activated with a positive edge. This can occur, for example, during the start-up of the CPU in OB100.
referenceId	IN: Int	The input specifies from which time source the server CPU obtains the time: • 0: uncalibrated (set "manually") • 1: primary reference (e.g., DCF 77) • 2: secondary reference (e.g., from GPS receiver) The information is forwarded to the NTP client in SNTP.
lastTimeSet	IN: Date_and_Time	If the information on when the time was set last is available, this information is connected to the input. The information is forwarded to the NTP client in SNTP. If the parameter is not assigned, the current time of the CPU is transferred instead.
connID	IN: Word	Is assigned with a free connection ID. The parameter is used internally by the OUC blocks also for connection establishment.
localDeviceID	IN: Byte	Specifies the device ID. Further information can be found in the online help of STEP 7 or at \5\.
error	OUT: Bool	Shows a configuration error or error of the OUC blocks. Depending on the error type, the output can also be set only for one cycle.
status	OUT: Word	Specifies the error (see Chapter 2.4).
statusID	OUT: Int	Specifies the source of the error (see Chapter 2.4).

2.3 Project integration

2.3.1 Opening the library and loading it into the project

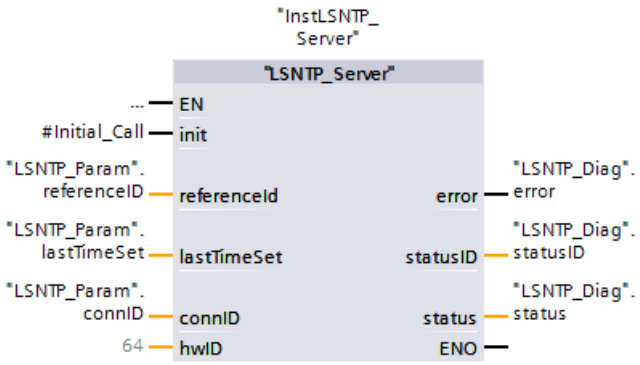
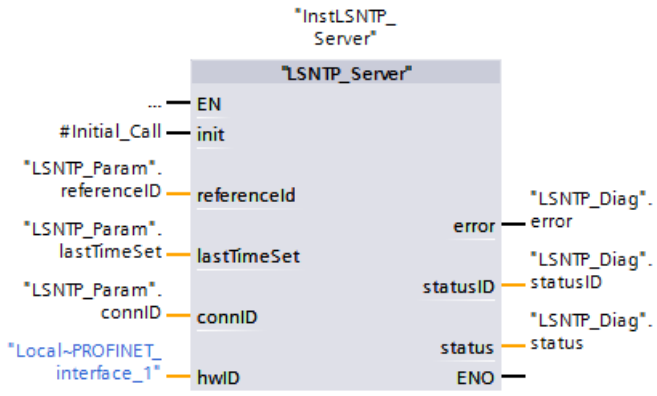
Table 2-6: Opening the library and loading it into the project

No.	Instruction
1.	Download the "LSNTP" library and extract the file.
2.	Open TIA Portal and your existing project.
3.	Go to the project view.
4.	Open the "Libraries" pane in the right part of the display.
5.	Expand the "Global libraries" tab.
6.	Click on the "Open global library" icon and select the extracted library. 
7.	Select the "LSNTP.alxx" global library from the extracted folder.
8.	Depending on the CPU used, drag and drop the blocks from the "Types > S7-300_S7-400" or "Types > S7-1200_S7-1500" folder to the "Program blocks" folder of your device.  The associated data types are instantiated automatically.

2.3.2 Setting up an S7-1200/1500 CPU as SNTP server

The following table describes the procedure for setting up an S7-1200/1500 CPU as SNTP server.

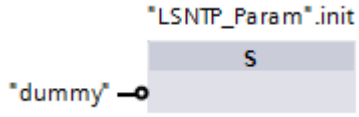
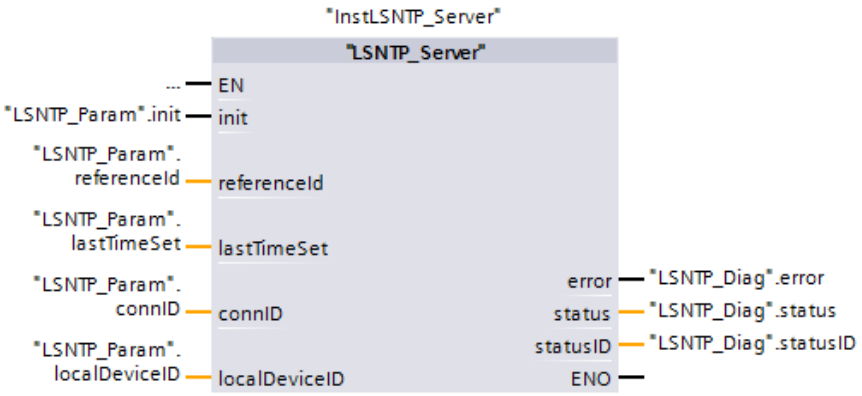
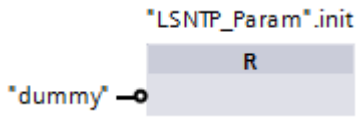
Table 2-7: Setting up an S7-1200/1500 CPU as SNTP server

No.	Instruction
1.	Create a data block for interconnecting the input and output parameters of the "LSNTP_Server" FB. In the library master copies, data blocks are available for the inputs and outputs.
2.	Insert the "LSNTP_Server" FB into OB1 and create an instance data block.
3.	Interconnect the temporary tag "Initial_Call" to the input "init".
4.	Interconnect the input and output parameters with the parameters of the same name of the data block created in step 1.  Adapt the input parameters according to your application (for example, the "connID" connection ID can be used only once in the project).
5.	Interconnect the hardware identifier of your Ethernet interface to the input "hwID". 
6.	Load your user program into the CPU and restart the CPU. The CPU then works as SNTP server.

2.3.3 Setting up an S7-300/400 CPU as SNTP server

The following table describes the procedure for setting up an S7-300/400 CPU as SNTP server.

Table 2-8: Setting up an S7-300/400 CPU as SNTP server

No.	Instruction
1.	Create a data block for interconnecting the input and output parameters of the "LSNTP_Server" FB. In the library master copies, data blocks are available for the inputs and outputs.
2.	Insert the COMPLETE RESTART-OB (OB100) into your project, and in this OB, set the "init" tag of the block created in step 1. 
3.	Insert the "LSNTP_Server" FB into OB1 and create an instance data block.
4.	Interconnect the input and output parameters with the parameters of the same name of the data block created in step 1.  Adapt the input parameters according to your application (for example, the "connID" connection ID can be used only once in the project).
5.	Insert a new network into OB1 and there reset the "init" tag of the block created in step 1. 
6.	Load your user program into the CPU and restart the CPU. The CPU then works as SNTP server.

2.4 Error handling

If an error is detected, the "error" output is set for a cycle. If the error remains permanent, the setting of the output is retained accordingly. In addition, the "status" output specifies the error, and "statusID" specifies the error source. The "status" and "statusID" outputs remain set as long as "error".

The table below shows the meaning of the "status" and "statusID" output parameters.

Table 2-9: Status codes

statusID	status	Meaning
1	16#xxxx	An error has occurred at the TCON instruction. The meaning of the status is described in the TIA Portal information system.
2	16#xxxx	An error has occurred at the TUSEND instruction. The meaning of the status is described in the TIA Portal information system.
3	16#xxxx	An error has occurred at the TURCV instruction. The meaning of the status is described in the TIA Portal information system.
4	16#8000	The "localDeviceID" input parameter is connected to an unaccepted value.

Note Interconnect the output parameters in order to recognize an error of the block and to perform adequate error handling.

3 Additional information

3.1 Background

3.1.1 System time (UTC) and local time

Explanation of terms

Based on the Universal Time Coordinated (UTC), the local time is determined starting from the prime meridian, taking into account the time shift and summer/winter times, if applicable.

The Central European Time (CET) is calculated as UTC plus one hour. In the summer, the Central European Summer Time (CEST) applies, which is calculated as UTC plus two hours.

The NTP and SNTP always send the UTC according to specification. If the current local time is to be kept, corresponding settings or calculations are required.

S7-1200 and S7-1500

S7-1200 and S7-1500 CPUs include a system time as well as a local time.

When the time of these CPUs is synchronized via an NTP/SNTP server, the UTC is applied as system time and the local time is calculated automatically on the basis of the settings made (also see chapter 3.2.2).

S7-300 and S7-400

S7-300 and S7-400 CPUs include only a system time which is set to the UTC during synchronization via the CPU using an NTP/SNTP server.

In order to have the local time also available, for example, for the generation of messages, the local time has to be calculated using system-internal functions (see chapter 3.2.3 or \4\).

3.1.2 Network Time Protocol (NTP)

Task

NTP serves for the synchronization of clocks in a network. PCs, panels, CPUs, etc. can synchronize time via a (or several) server(s).

Mode of operation

An NTP client sends a message which is already assigned time stamps to the NTP server. The server responds to this message (by using an algorithm, for example, to consider packet runtimes), and the client then sets its clock according to the information received in the message.

An NTP client can have several time servers entered. On the basis of the "stratum" entered in the message and other factors, the client decides in favor of the optimal server and sends the request message to it.

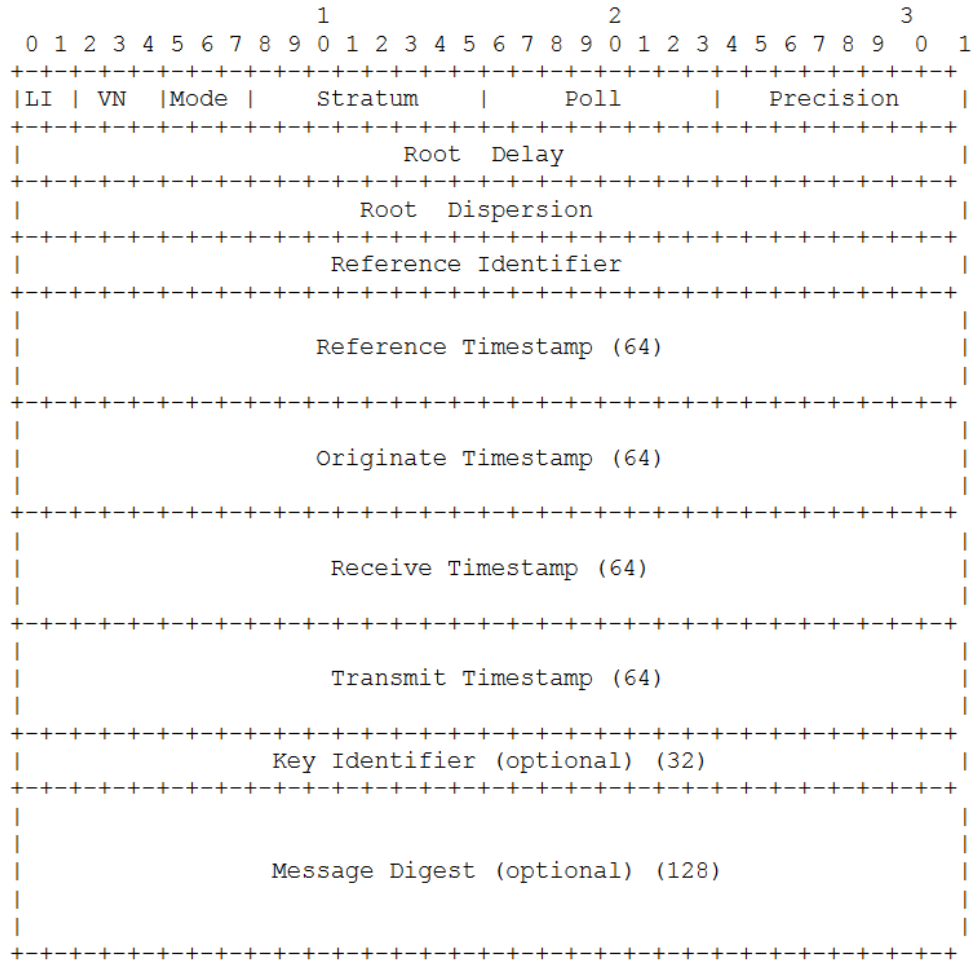
3.1.3 Simple Network Time Protocol (SNTP)

Differentiation between NTP and SNTP

SNTP is a simplified form of the NTP. Due to the simpler algorithms used, the SNTP is less accurate than the NTP. However, for the use in automation cells, the accuracy of the SNTP time synchronization is usually absolutely sufficient.

The structure of the messages is identical in both protocols, which means that NTP clients can also obtain the time from SNTP servers.

Figure 3-1: Structure of the NTP/SNTP message



A detailed description of the SNTP can be found on the website of the Internet Engineering Task Force:

http://tools.ietf.org/html/rfc4330

Using SNTP

Since its implementation is easy and its accuracy is sufficient for automation technology, the SNTP is used by the "LSNTP" library.

3.1.4 Open User Communication

The basis of the SNTP is UDP which is implemented with the help of Open User Communication (OUC) in the PROFINET CPUs of SIMATIC S7.

The current version V2.1.0 of the "LSNTP" block library uses instructions of the OUC library V5.0.

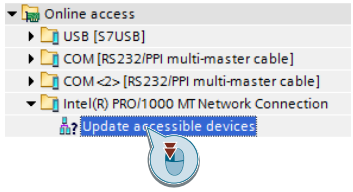
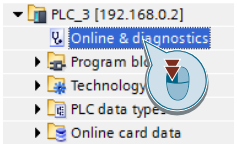
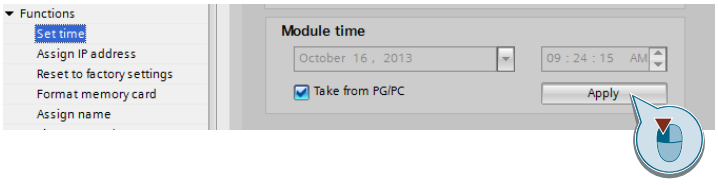
3.2 Notes and support

3.2.1 Timer

In order to set the time of the SNTP server, you can use one of the following options:

- Synchronizing the time with an external NTP server
- Setting the CPU clock to the time of the connected PG (see Table 3-1)
- Reading out the time of a commercially available GPS receiver

Table 3-1: Setting the time of an S7-1500 CPU with the help of TIA Portal

No.	Instruction
1.	In your project tree, double-click on "Online access > [YOUR_NETWORK_DEVICE] > Update accessible devices". 
2.	Select the CPU for which you want to set the time and click on "Online & diagnostics". 
3.	In the editor section, click on "Functions > Set time". Check the "Take from PG/PC" box and then click on "Apply".  Now the time of the PG/PC is applied by the S7 CPU.

NOTE Further information on time synchronization in the automation environment can found on the topic page "Time synchronization":

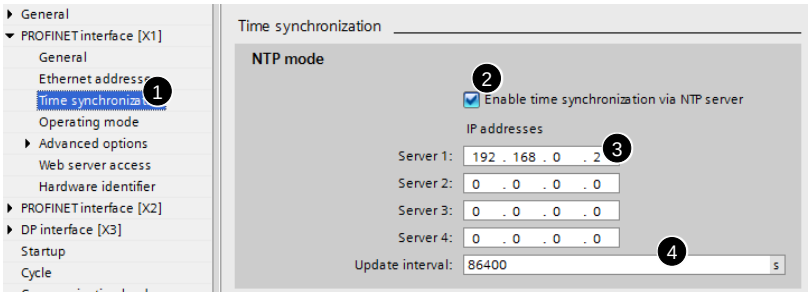
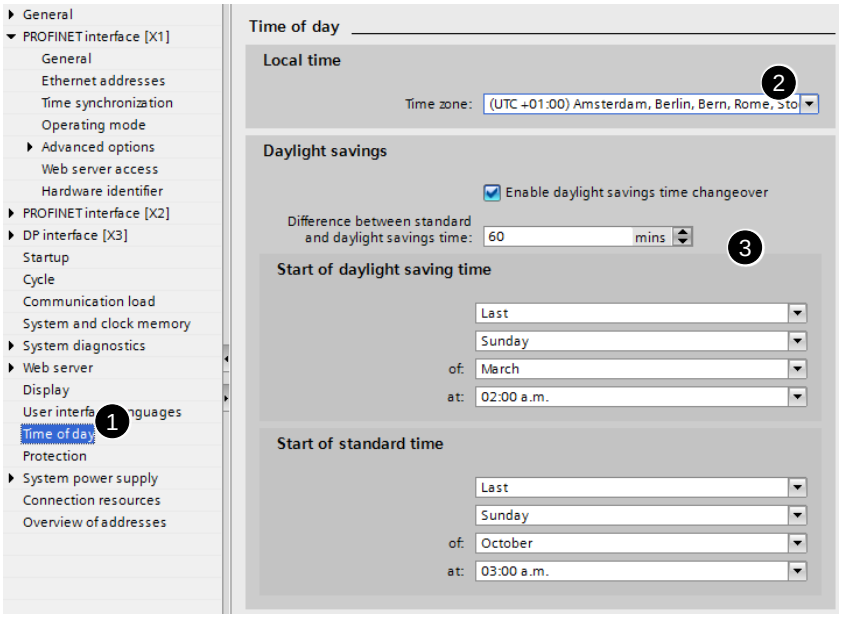
https://support.industry.siemens.com/cs/ww/en/view/86535497

3.2.2 Setting up an S7-1200/S7-1500 as NTP client

Hardware configuration settings

The following table describes how to set up the CPU as NTP client.

Table 3-2: Setting up an S7-1200/S7-1500 as NTP client

No.	Instruction
1.	In the project navigation, select "[YOUR_PROJECT] > [YOUR_CPU] > device configuration" and in the inspector window, click on the "Properties" tab.
2.	Select the PROFINET interface of the CPU and click on "Time synchronization" (❶). Check the "Enable time synchronization via NTP server" box (❷) and confirm the prompt. Then enter the IP address of the server CPU (❸) and the required update interval (❹). 
3.	Then go to the entry "Time of day" (❶) and adjust the time zone (❷) and the difference between standard and daylight savings time (❸). 

Differentiation: system time and local time

The system time of the CPU is the internal time of the CPU, in this case, transferred by the NTP. It is usually provided as UTC.

The local time is the time of the location of the CPU (time zone, summer/winter time) calculated dependent on the system time.

Reading out the system time

The system time can be read out with the "RD_SYS_T" instruction. The "RET_VAL" output parameter of the instruction corresponds to "0" if read-out is completed successfully.

The time is written to a variable via the "OUT" output parameter with one of the following data types:

- DT
- LDT
- DTL

Reading out the local time

The local time of the CPU can be read out with the "RD_LOC_T" instruction. The "RET_VAL" output parameter of the instruction corresponds to "0" if read-out was successful. It corresponds to "1" if read-out was successful, and the local time is currently set to daylight savings time.

The time is written to a variable via the "OUT" output parameter with one of the following data types:

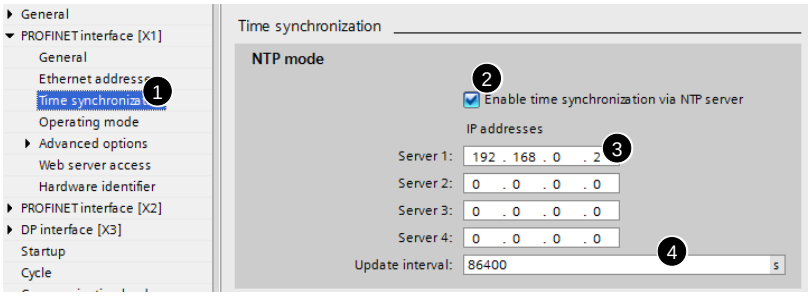
- DT
- LDT
- DTL

3.2.3 Setting up an S7-300/400 as NTP client

Hardware configuration settings (HWCN)

The following table describes how to set up the CPU as NTP client.

Table 3-3: Setting up an S7-300/400 as NTP client

No.	Instruction
1.	In the project navigation, select "[YOUR_PROJECT] > [YOUR_CPU] > device configuration" and in the inspector window, click on the "Properties" tab.
2.	Select the PROFINET interface of the CPU and click on "Time synchronization" (❶). Check the "Enable time synchronization via NTP server" box (❷) and confirm the prompt. Then enter the IP address of the server CPU (❸) and the required update interval (❹). 

Reading out the system time

The system time can be read out with the "RD_SYS_T" instruction. The "RET_VAL" output parameter of the instruction corresponds to "0" if read-out is completed successfully.

The time is written to a variable of the Date_and_Time (DT) type via the "OUT" output parameter.

Calculating the local time

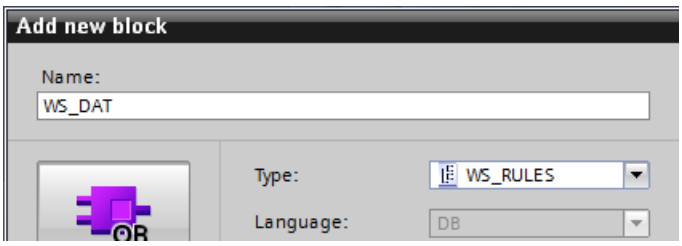
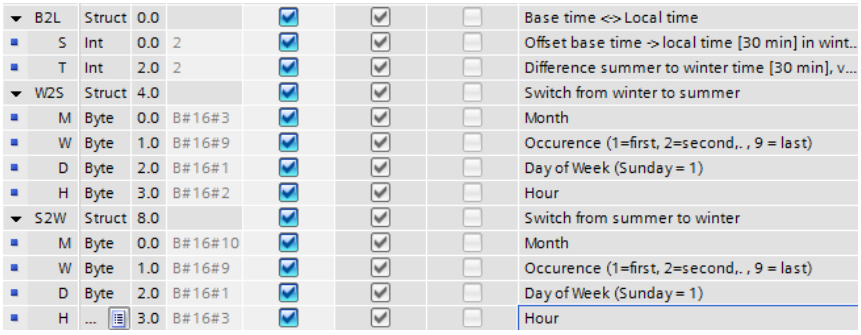
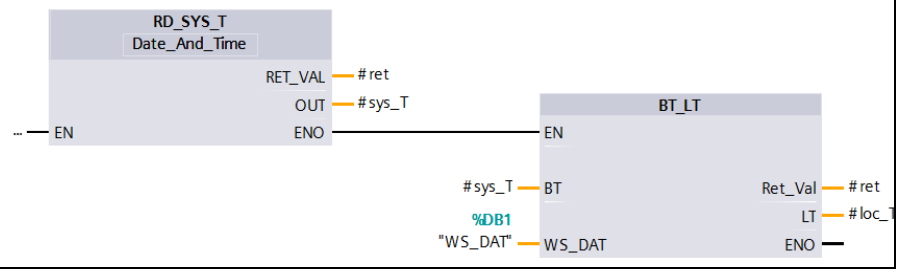
As the S7-300 and S7-400 CPUs do not automatically provide the local time in addition to the system time, the system time can be converted into the local time with the "BT_LT" instruction.

It might be reasonable to use the calculated local time also for the creation of messages etc.

The following table shows the calling of the "BT_LT" instruction in the FBD for the calculation of the current local time.

The screenshots originate from the provided sample project.

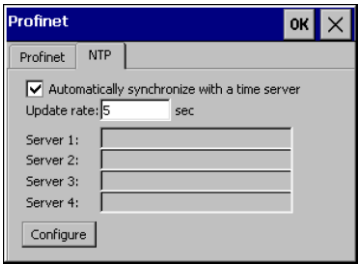
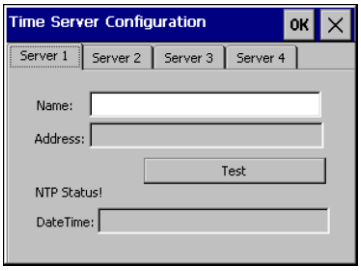
Table 3-4: Calculating the local time

No.	Instruction
1.	Add a data block of the "WS_RULES" type to your user program. 
2.	Set the default values of the data block dependent on your time zone. When inserting the data block into STEP 7 V13, the default values are preset to CET with daylight savings time changeover. For more help on the values, please refer to the STEP 7 help. 
3.	Then first read out the system time with the "RD_SYS_T" block.
4.	Call the "BT_LT" instruction and transfer the current system time as well as the data block created in steps 1 and 2. The instruction returns the local time. Save this time in such a way that it can be accessed CPU-wide. Thus, diagnostic messages etc. can be supplied with the local time as time stamp. 

3.2.4 Setting up HMI panels as NTP clients

The following table describes the procedure for setting up an HMI panel as NTP client.

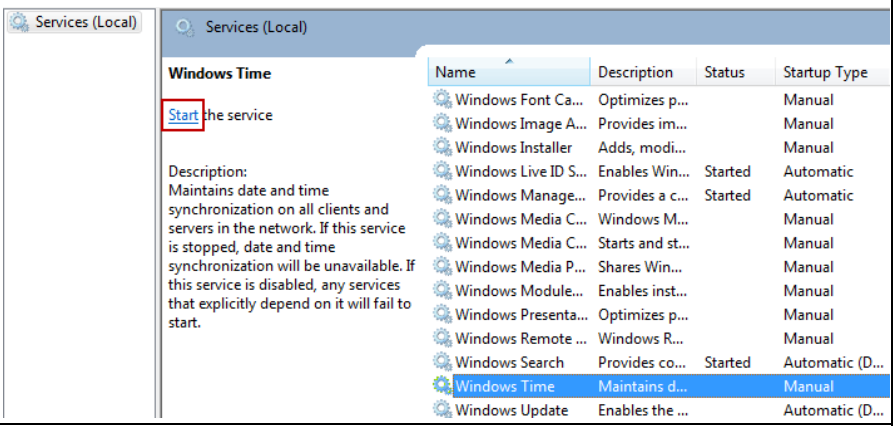
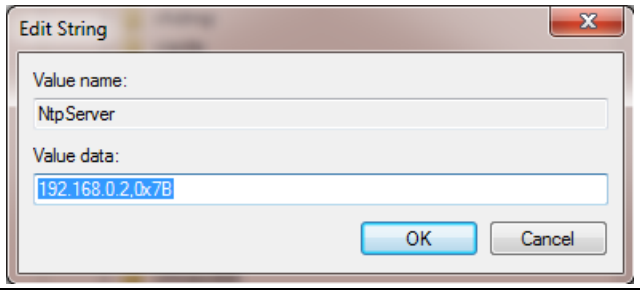
Table 3-5: Setting up HMI panels as NTP clients

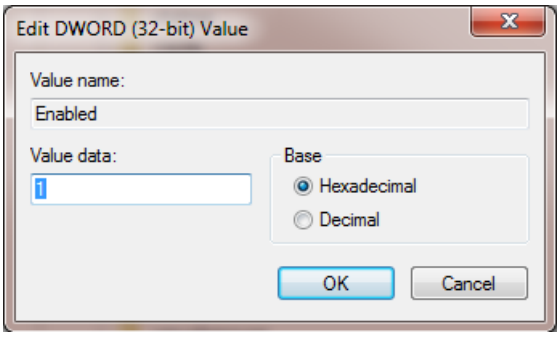
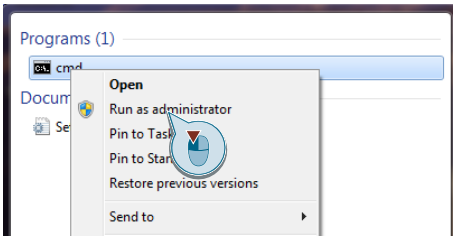
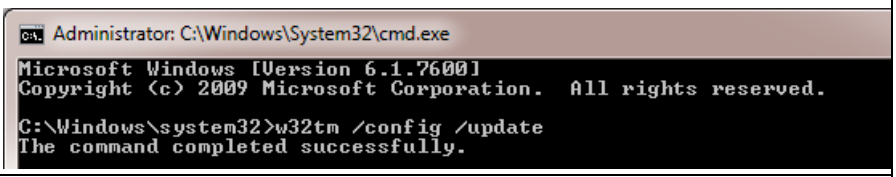
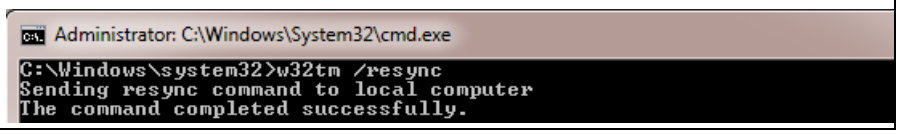
No.	Instruction
1.	Open the Control Panel.
2.	Open the "Profinet" dialog with the "PROFINET IO" icon. Go to the "NTP" tab.
3.	Activate "Automatically synchronize with a time server" and enter an update rate.  Then click on "Configure".
4.	Enter the IP address of the server CPU under "Name". In our example, this is 192.168.0.101 for the S7-1200. With a click on "Test", the availability of the server is tested. 
5.	Confirm the entries with OK.

3.2.5 Setting up Windows PCs as NTP clients

The following table describes the procedure for setting up a PC as NTP client in Windows 7.

Table 3-6: Setting up Windows PCs as NTP clients

No.	Instruction
1.	Click on "Start" and enter "services.msc" in the search line. Confirm with Return. A "Services" window opens.
2.	Select the "Windows Time" service and start the service via the blue link if it has not started yet. Additionally, set the service to "Automatic" so that it is started automatically by the operating system upon each start-up. 
3.	Click on "Start" and enter "regedit" in the search line. Confirm with Return. Confirm the dialog with “Yes”.
4.	Navigate to the "HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\W32Time\Parameters" folder and set the "NtpServer" key to the following value: "[IP_ADRESSE_DER_SERVER_CPU],0x7B". 

No.	Instruction
5.	Then edit the "HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\services\W32Time\Time Providers\NtpClient\Enabled" key and set it to the value 1. 
6.	Click on "Start" and enter "cmd" in the search line. Execute the command line with administrator rights. Confirm with "Yes". 
7.	Enter the command "w32tm /config /update" in the command line and confirm with Return. Windows thus refreshes the settings. 
8.	Now enter the command "w32tm /resync" and confirm with Return. Thus, the time is requested via NTP from the server entered in step 4 for the first time. 

Note Make sure that port 123 is opened in the firewall of your PC.

4 Appendix

4.1 Service and Support

Industry Online Support

Do you have any questions or need assistance?

Siemens Industry Online Support offers round the clock access to our entire service and support know-how and portfolio.

The Industry Online Support is the central address for information about our products, solutions and services.

Product information, manuals, downloads, FAQs, application examples and videos – all information is accessible with just a few mouse clicks:
https://support.industry.siemens.com

Technical Support

The Technical Support of Siemens Industry provides you fast and competent support regarding all technical queries with numerous tailor-made offers – ranging from basic support to individual support contracts. Please send queries to Technical Support via Web form:
www.siemens.com/industry/supportrequest

SITRAIN – Training for Industry

We support you with our globally available training courses for industry with practical experience, innovative learning methods and a concept that's tailored to the customer's specific needs.

For more information on our offered trainings and courses, as well as their locations and dates, refer to our web page:
www.siemens.com/sitrain

Service offer

Our range of services includes the following:

- Plant data services
- Spare parts services
- Repair services
- On-site and maintenance services
- Retrofitting and modernization services
- Service programs and contracts

You can find detailed information on our range of services in the service catalog web page:
https://support.industry.siemens.com/cs/sc

Industry Online Support app

You will receive optimum support wherever you are with the "Siemens Industry Online Support" app. The app is available for Apple iOS, Android and Windows Phone:
https://support.industry.siemens.com/cs/ww/en/sc/2067

4.2 Links and Literature

Table 4-1: Links and Literature

No.	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	Link to this entry page of this application example https://support.industry.siemens.com/cs/ww/en/view/82203451
\3\	Description of the SNTP, version 3 http://tools.ietf.org/html/rfc4330
\4\	Time synchronization – Time synchronization in the automation environment https://support.industry.siemens.com/cs/ww/en/view/86535497
\5\	FAQ: Which "local_device_id" do you parameterize in order to establish a connection to FB65 "TCON" for open communication via Industrial Ethernet? https://support.industry.siemens.com/cs/ww/en/view/51339682

4.3 Change documentation

Table 4-2: Change documentation

Version	Date	Modifications
V1.0.0	11/2013	First version
V1.0.1	05/2015	Validity of the V13 library for the S7-1200 CPUs in documentation has been adjusted
V2.0.0	03/2016	Upgrade to TIA Portal V13 SP1 Updating the OUC library to V4.0
V2.1.0	04/2017	Upgrade to TIA Portal V14 Parameter "hwID" added to FB "LSNTP_Server" for S7-1200/1500
V3.0.0	10/2017	Replacement of internal data type "TCON_Param" with "TCON_IP_V4" in "LSNTP_Server" for S7-1200/1500 Correction of the calculation of the fractional part of a second
V3.0.1	05/2018	Correction of the calculation of the reference timestamp if the date at "lastTimeSet" is before 1990
V3.0.2	07/2019	Upgrade to TIA Portal V15.1 Activated simulation support for FB "LSNTP_Server" for S7-1200/1500
V3.0.3	02/2020	Replaced the DCF77 with a generic NTP server in overview graphic