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Runtime Measurement using SIMATIC S7-1500 Profiling

SIMATIC S7-1500 Profiling V1.0.2

<https://support.industry.siemens.com/cs/ww/en/view/109750245>

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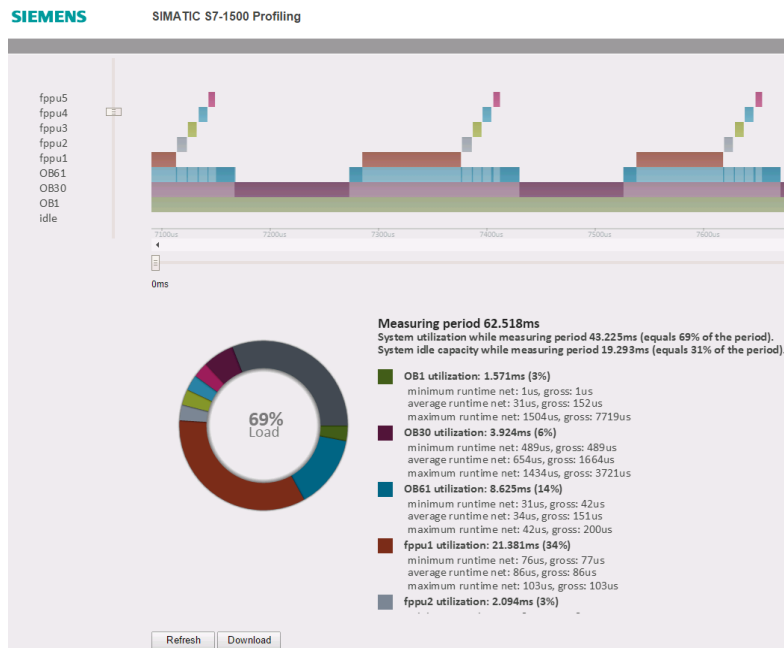
1 Introduction

The "SIMATIC S7-1500 Profiling" library by Siemens provides a comprehensive analysis tool for your user programs.

1.1 Overview

The runtime behavior of an application on a SIMATIC S7-1500 controller can be analyzed and evaluated in-depth using SIMATIC S7-1500 Profiling. All relevant information is displayed graphically via web-based visualization (see [Figure 1-1](#)). For further analysis purposes, you can output the recorded data as CSV file and evaluate it in a spreadsheet.

Figure 1-1: Example visualization of the web interface in an evaluation



SIMATIC S7-1500 Profiling provides answers to the following questions:

- To what extent is the PLC used to capacity by the user program?
- What blocks (OBs, FBs, FCs) create what share in the runtime?
- Is the call structure of the blocks correct?
- When are the blocks called?

Technical information

- Transparency regarding process levels and program parts
- Suitable for runtime optimizations and error diagnostic
- Quality assurance of the application (e.g. as proof of IBN that runtimes are adequate)
- Monitoring and evaluation in the event of an error (e.g. export of data if the runtime is longer than planned)
- Evaluation of the power reserves of the system (e.g. in order to be able to make a statement whether a certain function is still runnable)
- Export of profile data in CSV format

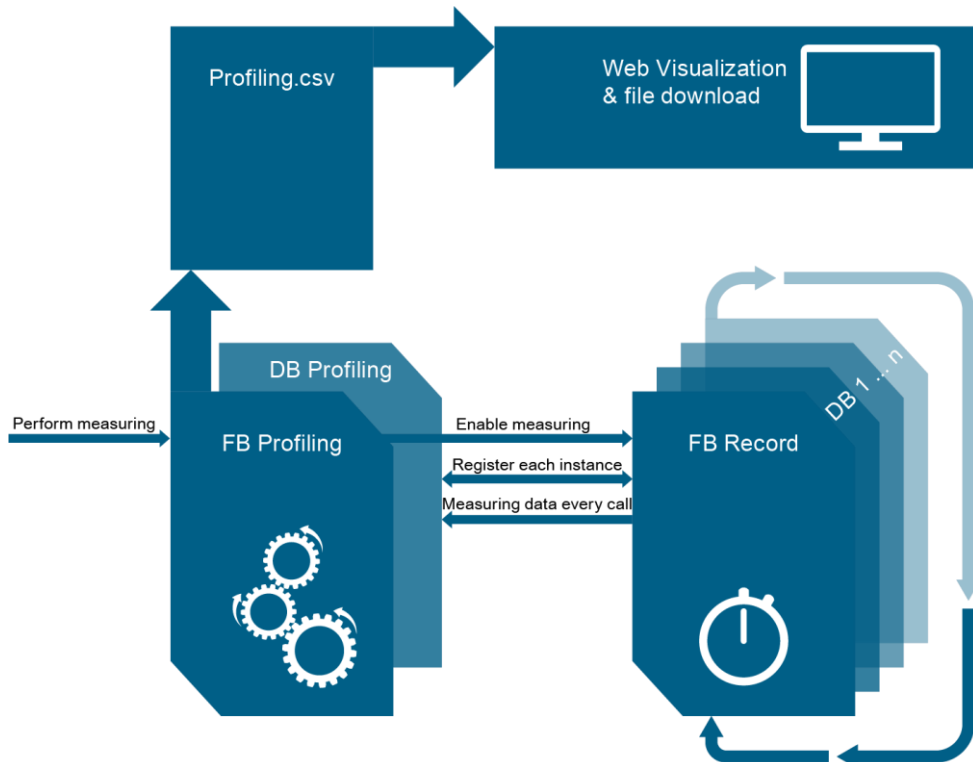
- Example library for the TIA Portal that can be easily integrated (as of STEP 7 Prof. V14; S7-15xx Firmware V1.7)
- Web-based visualization of runtimes

1.2 Mode of operation

The library includes two function blocks (FBs). The "FB_Profiling" FB takes on the calculation of the measurement results and the display in the web server.

The "FB_Record_Profile" FB is called before and after the program part to be called. The FB determines the required runtime between the two calls.

Figure 1-2: Functionality of the profiling



Each measuring range of the "FB_Record_Profile" uses its own instance data block (instance DB). When the signal for the start of the measurement arrives, the "FB_Profiling" initializes the measuring range in the "DB_Profiling" instance DB and releases the measurement (see Figure 1-2). The respective first call of each "FB_Record_Profile" registers in "DB_Profiling" and determines with what priority and under which name the instance DB is called. The time additionally required for this is also measured and output. The cyclic measurement acquires the current system time for each call and stores it in the "DB_Profiling" until (depending on the operating mode) the defined memory (see chapter 3.1) is fully occupied or the pre-trigger signal has been triggered (see chapter 2.1).

Once the measurement is finished, the data is sorted and evaluated in the "FB_Profiling" FB and exported as "DB_Profiling.csv".

With the help of the integrated web server of the controller, the data is visualized as user-defined web page. The data can also be downloaded from the controller and evaluated in a spreadsheet.

1.3 Components used

This application example has been created for the following hardware and software components:

Table 1-1: Components used

Component	Number	Article number	Note
STEP 7 Professional V14	1	6ES7822-1..04-..	-
SIMATIC S7-1500 controller	1	-	As of firmware V1.7
SIMATIC S7-1500 software controller	1	-	incl. SIMATIC ET 200SP open controller as of firmware V1.7
Google Chrome V54.0	-	-	Internet Explorer is not supported

This application example consists of the following components:

Table 1-2: Components of the application example

Component	File name
Documentation	109750245_S71500Profiling_DOC_V102_en.pdf
Library	109750245_S71500Profiling_LIB_V102.zip

Note

SIMATIC S7-1500 Profiling cannot be simulated using PLCSIM.

2 Engineering

2.1 Interface description

2.1.1 "FB_Profiling" function block

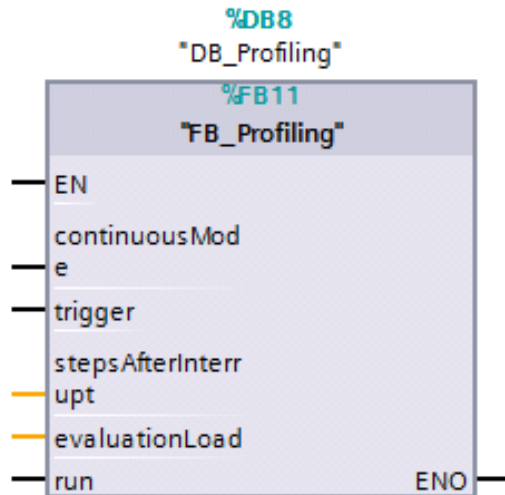


Table 2-1: Input parameters of the block interface

Parameter	Data type	Start value	Description
continuousMode (optional)	Bool	false	Operating modes: 0: Single measured value acquisition 1: Continuous measured value acquisition
trigger (optional)	Bool	false	0->1: Start of the evaluation for continuous measured value acquisition
stepsAfterInterrupt (optional)	Int	20	Number of the values to be acquired when the continuous measurement is finished by trigger
evaluationLoad (optional)	Int	10	Number of the maximum cycle time load by evaluating the measurement results [%]

Table 2-2: Input/output parameters of the block interface

Designation	Data type	Start value	Description
run (obligatory)	Bool	-	0->1: Start of measurement (reset by the block)

Function description

The "FB_Profiling" function block should be called before "FB_Record_Profile" in the cycle OB (OB1). The FB calculates the runtimes for the measurements and for the periods in which no measurement took place. The FB sorts the results and exports them on the memory card in the "DB_Profiling.csv" file in the "Recipe" folder. The web server accesses this data and provides it to the user in the browser.

There are two operating modes:

1. Single measured value acquisition (continuousMode = 0):
A measurement is started depending on the requirement. If the first storage area of a measurement is full, the measurement is finished. Subsequently, the data is sorted, processed and exported.
2. Continuous measured value acquisition (continuousMode = 1):
Time stamps of the user program are saved cyclically. Once the storage area is full, the storage area is overwritten again. A positive signal on the "trigger" parameter ends the measurement after the acquisition of n measurements and the calculation of cycle times and their preparation is started. The number of n measurements is specified on the "stepsAfterInterrupt" parameter. The trigger can, for example, be set in an error OB, in order to evaluate measured values before and after an error event.
The continuous measured value acquisition makes sense if frequently accessed program parts (e.g. all 250µs) and rarely accessed program parts (e.g. all x seconds) are to be acquired in one measurement. This means that measured values are acquired for all program parts. For a single measurement, the storage area of a frequently accessed program part might be already full and the measurement thus be finished, before a measurement of the rarely called program part was carried out.

The "evaluationLoad" input parameter limits the cycle load on the evaluation of the controller to a share of the actual cycle time.

Example:

The program cycle time is 10ms and "evaluationLoad" is preset to 10 (in percent). The "FB_Profiling" would thus process a maximum of ~1ms per cycle until the data is ready for export.

Note

For controllers that do not have a high-performance, a considerable cycle load can be created by communication, if the web server provides the export file. In this case, it may be advisable to restrict the maximum permitted cycle load by communication (e.g. to 15%) (see chapter 3.3).

2.1.2 "FB_Record_Profile" block

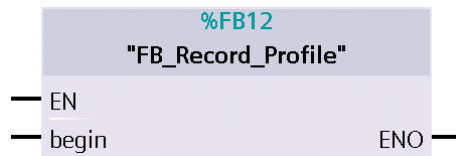


Table 2-3: Input parameters of the block interface

Designation	Data type	Start value	Description
begin	Bool	-	1: Start of measurement 0: End of measurement

Function description

The "FB_Record_Profile" FB acquires the time stamps during a measurement. It is called before and after the program part to be measured.

The input parameter "begin" is set to "true" before the measuring range; after the measuring range it is set to "false". Use the same block instance for both calls.

The measuring results are linked with the name of the instance of the call.

Note

The automatic application of the instance name of the measurement can be deactivated by the statistic value "db_to_name" (Bool)[1->0] in "DB_Profiling". Instead, the measurement gets the name of the accessed organization block (z. B. OB1). This slightly reduces the cycle load during initialization.

Due to the static value "add_info" (Bool) [1->0] in "DB_Profiling" it can be prevented that additional information is generated and exported (statistic data at cycle time such as min., max., average value).

Figure 2-1 additional settings in "DB_Profiling"

9	Static							
10	init	Bool	false	Non-retain	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	initiate this function
11	proceed	Bool	false	Non-retain	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	proceed measuring
12	done	Bool	false	Non-retain	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	measuring complete
13	db_to_name	Bool	true	Non-retain	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	use the DB-instance name as export
14	add_info	Bool	true	Non-retain	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	create additional information in fron
15	block_count	Int	#C_BLOCKS	Non-retain	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
16	block_array	Int	#C_ARRAY	Non-retain	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
17	error	Byte	16#0	Non-retain	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
18	error_information	Struct		Non-retain	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
19	P_Index	Int	1	Non-retain	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
20	internal	Struct		Non-retain	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	

2.2 Integration into the user project

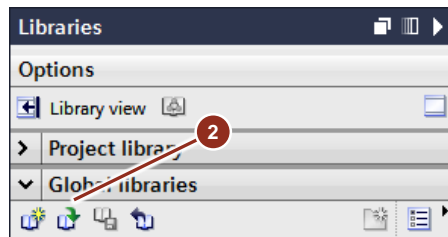
The application example described here can be fully integrated into your existing project. The necessary steps are described below.

2.2.1 Copying library elements into the TIA Portal project.

In order to copy library elements into your TIA Portal project, proceed as follows:

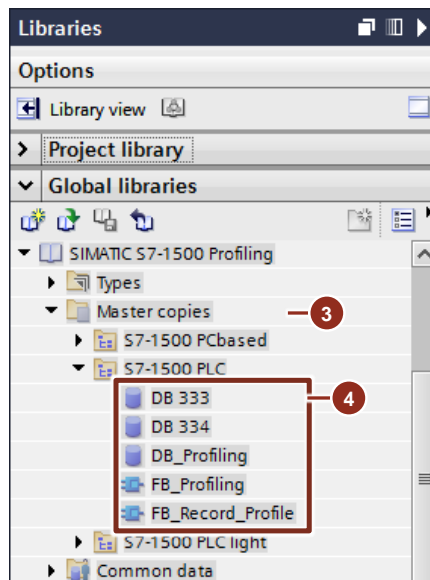
1. Unzip the library of the application example in a local folder.
2. Open the "SIMATIC S7-1500 Profiling" library in the "Libraries > Global libraries" task card.
Select the "Open library write protected" option.

Figure 2-2: Retrieving global library



3. Open "Master copies" folder of the library.
The library includes three application cases (see [Application cases](#)).
4. Copy all blocks of your application case into your TIA Portal project.

Figure 2-3: Library structure



Application cases

The blocks of the three application cases are saved in the following folders in the library:

- S7-1500 PCbased:
Includes the blocks for S7-1500 software controllers.
- S7-1500 PLC:
Includes the blocks for the S7-1500 controllers.
- S7-1500 PLC Light:
Includes the blocks for the S7-1500 controllers with a reduced number of parallel measurements [8->4] as well as reduced storage areas [500-> 250].

Each folder contains the following blocks:

- FB_Profiling
- FB_RecordProfile
- DB_Profiling
- DB333
- DB334

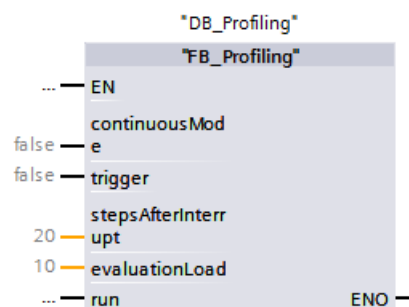
The data blocks DB333 and DB334 include the user-defined web page for visualization. The "WWW" instruction for the synchronization of the user-defined web page is accessed in the "FB_Profiling" FB.

2.2.2 Accessing function blocks of the library

In order to perform a measurement, you have to access the blocks of library as follows.

1. Access the "FB_Profiling" FB with the appropriate "DB_Profiling" instance DB in a cycle OB, e.g. OB1.

Figure 2-4: "FB_Profiling" access



Note The "DB_Profiling" instance DB must not be renamed, because otherwise the profiling can no longer be performed correctly.

2. Call the "FB_Record_Profile" FB before the program code, whose runtime you want to measure. Assign a name for the instance DB, e.g. "DB_OB1".
3. Assign the value "true" to the "begin" input parameter.

Figure 2-5: "FB_Profiling" access before the program code



4. Access the "FB_Record_Profile" FB after the program code whose runtime you want to measure. Use the same instance DB, e.g. "DB_OB1".
5. Assign the value "false" to the "begin" input parameter.

Figure 2-6: "FB_Profiling" access after program code



Per measuring area you require an instance DB for "FB_Record_Profile". You have to use the same instance DB for both calls, before and after a measurement.

The name of the instance DB is applied as name of the measuring range. In the example the measuring range is called "DB_OB1" and is listed as such in the evaluation.

Note The maximum length of the name for a measuring range is limited to 8 characters (cut off).

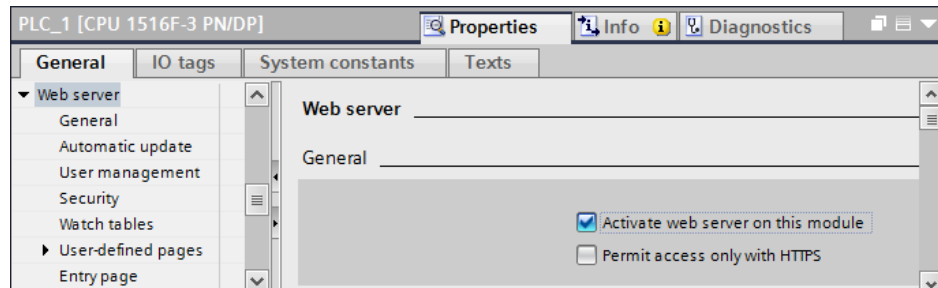
Note For a loadable cycle analysis at least each of the cyclically called OBs have to be measured (e.g. OB1, OB3x, OB61..).

2.2.3 Configuring the web server

In order to display the visualization in the web server, it has to be configured. To do this, proceed as follows:

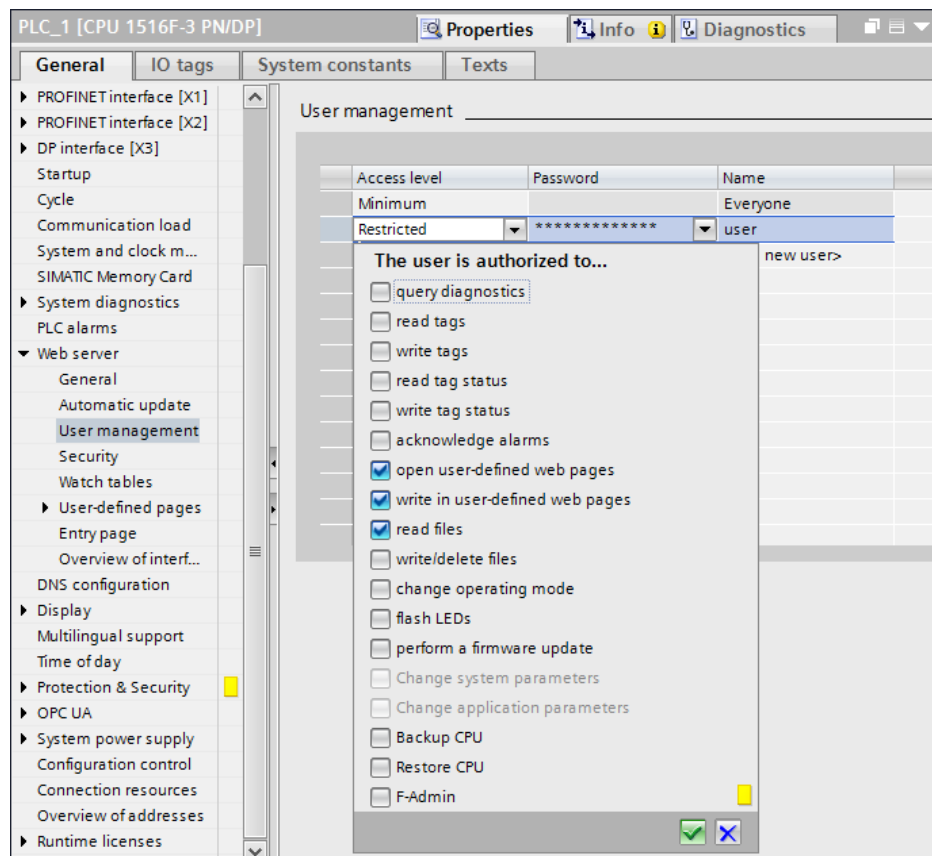
1. Enable the web server in the properties of the controller.

Figure 2-7: Enabling the web server



2. Enable the following rights for your user in the user administration of the web server:
 - "open user-defined web pages"
 - "write in user-defined web pages"
 - "read files"

Figure 2-8: Enabling the user rights

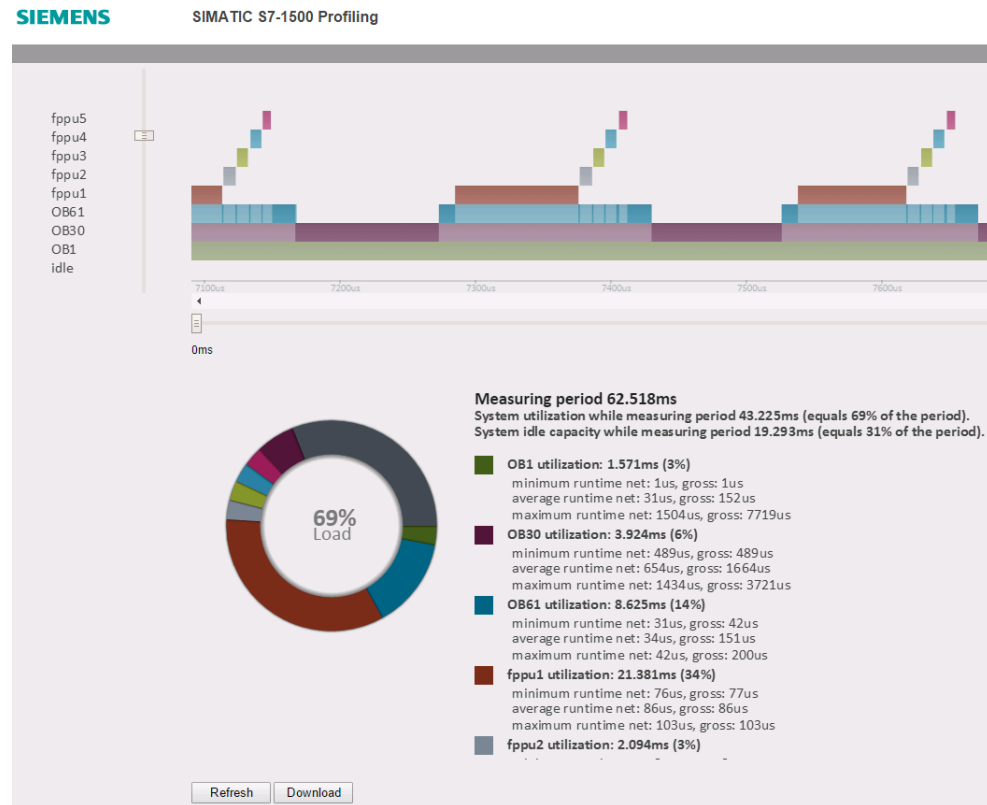


2.3 Operation

Functions of the web interface

The following figure shows the web page of the application example.

Figure 2-9: Web page of the application example



Call the web pages of the controller via the IP address of the controller. The web page of the application example is called via the default web pages of the controller under the point "User-defined web page".

If no measurement has been carried out, this page is empty at first. The "Refresh" button allows you to trigger a new measurement. The lettering of the "Refresh" button changes to "Measuring..". If the profiling is set for to "Single measurement" mode, the page is updated as soon as the measuring ranges are full, evaluated and exported. Depending on the frequency of the calls and performance of the controller, this takes some seconds.

If the "Continuous measurement" mode is selected, the measurement runs until the trigger signal is triggered. The page is automatically reloaded when the measurement is ready, evaluated and exported.

The measurement result can be downloaded via the "Download" button as csv file in both modes. Alternatively, the file can also be downloaded via the file browser of the controller in recipes.

Note

The export file is overwritten for each measurement and cannot be recreated.

The following figure shows the zoomed web page of the application example.

Figure 2-10: Zoomed web page of the application example



The active times for each measurement are displayed in the top area. Times, in which no measurement is active are displayed as "idle". In these periods internal processes are calculated (e.g. cyclic communication) or program parts are executed that are not monitored. Links from the timeline are in a bar for zooming. There are two scroll bars underneath the timeline. The top scroll bar moves the close range. With the bottom one the entire measurement can be scrolled.

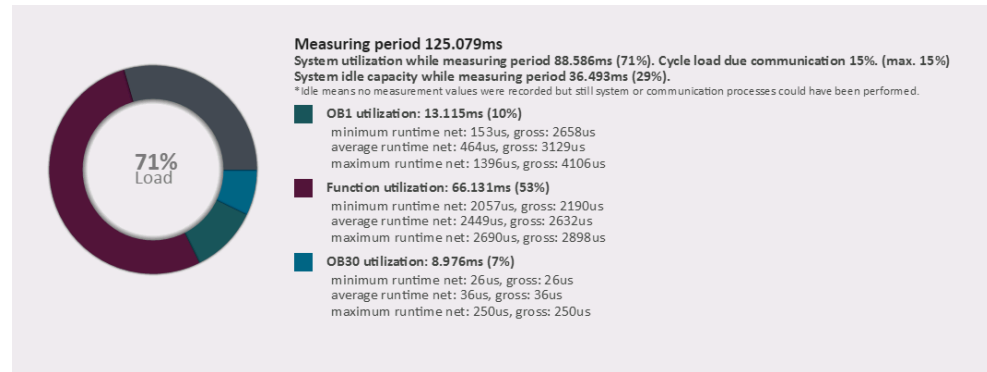
Note

The maximum displayable measuring period is limited to 32.7s due to the maximum number of displayable pixels, the zoom as well as the scroll area. Measurements beyond this have to be evaluated in a spreadsheet or the measuring range has to be shifted accordingly, using the pre and post trigger function.

The smallest displayable measurement has a minimum width of 1px. As a result, periods that are theoretically too small to be displayed, can also be displayed. This is particularly useful if only one condition is to be displayed (e.g. an error BIT).

The following figure shows additional information "additional_info".

Figure 2-11 Additional information ("additional_info")



The ring diagram shows the shares of the program parts of the entire measurement period. Gray corresponds to idle time. The idle time occurs when the program cycle time is smaller than the set minimum cycle time. Functionalities and system functions that are not measured are also displayed as idle time.

The "71% Load" displayed in [Figure 2-11](#) means that 71% of the program parts measured were active during the entire measurement period. This means 29% are for non-measured program parts, system functions and communication. There is no idle time in this measurement.

On the right, next to the ring diagram, the data of the entire measurement and the static values of all measurement ranges are output.

The following is displayed for the entire measurement:

- Measuring period
- System utilization while measuring period
- Cycle load due communication
- System idle capacity while measuring period

For the individual measuring ranges it is differentiated between net and gross runtimes. Gross runtimes occur when measuring ranges are interrupted by a function or an OB with higher priority.

The following is displayed per measuring range:

- Minimum runtime net
- Minimum runtime gross
- Average runtime net
- Average runtime gross
- Maximum runtime net
- Maximum runtime gross

3 Valuable Information

3.1 Number of measurements and measured values

There are two different versions of function implementation included in the library. The normal version and a light version. In the light version, fewer measurements can be active at the same time and fewer measured values can be acquired in succession. This allows a faster evaluation in the PLC with a lower storage need for the application.

Table 3-1 Maximum measured values

Version	Maximum measured instances	Maximum measured values per measured instance
Profiling PLC "Light"	4	250
Profiling PLC / PCbased	8	500

The maximum number of measured instances defines the maximum number of instances of the "FB_Record_Profile" block in the project.

The maximum measured values per measured instance influence the maximum of the acquired measuring period since the measurement is ended and the evaluation is started after the specified number of measurements.

The measurement is always ended as soon as the array is filled in a measured instance. In this case, less frequently measured program parts have not fully filled their arrays.

3.2 Resource requirements

In the following table the storage requirement of the application is displayed with 8 parallel measurements with 500 measurements each.

Table 3-2: Storage requirement of the blocks of the SIMATIC S7-1500 Profiling Library

Block name	Assignment of main memory [kByte]	Assignment of load memory [kByte]
FB_Profiling	10.7	15.0
DB_Profiling	325.0	330.0
FB_Record_Profile	1.5	23.8
Each instance data block of FB_Record_Profile	0.3	1.85
DB333	0.5	7.1
DB334	0.1	40.0

Moreover, the library has a light version where the number of measurements is reduced to four and the number of measured values per instance to 250. This reduces the storage requirement of the "DB_Profiling" (see [Table 3-3](#)) and finally the effort required for the evaluation.

Table 3-3: Different storage assignment of the blocks of the light version

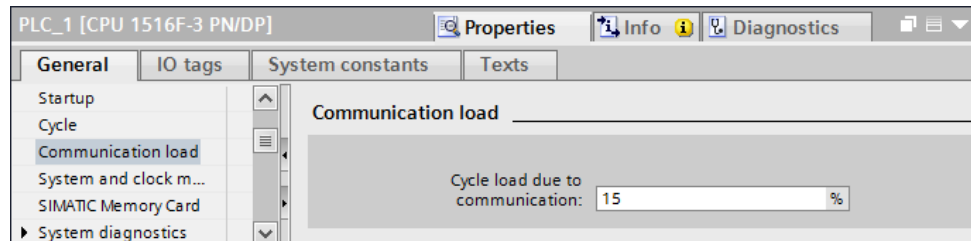
Block name	Assignment of main memory [kByte]	Assignment of load memory [kByte]
DB_Profiling	82.0	86.0

3.3 Limiting communication load

The communication between the PLC program and the web server can create a significant communication load, especially for PLCs with a reduced performance. In order to prevent load peaks, which can cause long PLC cycle times and a possible transition to STOP, you should limit the maximum communication load, e.g. to 15 %.

The default setting is 50%.

Figure 3-1: Limiting cycle load due to communication



4 Annex

4.1 Service and support

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<https://support.industry.siemens.com/cs/ww/en/sc/2067>

4.2 Links and literature

Table 4-1

No.	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	Link to the entry page of the application example https://support.industry.siemens.com/cs/ww/en/view/109750245

4.3 Change documentation

Table 4-2

Version	Date	Modification
V1.0.2	11/2017	First version