Manual TD/CEM-DAS-DI-EN Rev. A

# CEM-DAS – Digital interface
# Data acquisition and handling system for continuous emission monitoring – Software version 1.2.4

Performance-tested program system for acquisition and handling of continuous emission data

Measurement made easy

# CEM-DAS – Digital interface

Data acquisition and handling system for continuous emission monitoring – Software version 1.2.4

## Manual

TD/CEM-DAS-DI-EN
Revision A
Edition June 2017

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# 1 Introduction

## 1.1 Digital interface

This document describes the parameterization and application of the digital interface in the product CEM-DAS / DAA pursuant to the guideline VDI 4201 “Performance criteria on automated measuring and electronic data evaluation systems for monitoring emissions”.

At this time, only the connection of the automated measuring system (AMS) via Modbus pursuant to VDI 4201 Part 3 is realized. Modbus via TCP/IP (hereafter abbreviated “Modbus TCP”) and Modbus RTU via serial interface (hereafter abbreviated “Modbus RTU”) are supported.

If the connection is established via Modbus RTU a protocol converter (see Section 6) is required for serial communication with the AMS.

## 1.2 Protocol converter

The protocol converter UNIGATE CL-FE manufactured by Deutschmann Automation is used (see /3/). It is connected via Ethernet to DAA and via its serial interface to the AMS. A Modbus TCP server runs on the Ethernet side, which receives requests from DAA and forwards them via Modbus RTU as a Modbus RTU master.

The script file “UNIGATE-TCP-RTU.DCS” must be loaded on the protocol converter. This is then executed in the data execution mode of the device.

8 data bits, 1 stop bit and 1 start bit are permanently set on the RS interface of the UNIGATE CL-FE. The baud rate, parity and interface type can be set via the rotary code switches (see Section 6.2.3).

## 1.3 Terms and abbreviations

The abbreviations and terminology pursuant to VDI 4201 (see /1/ and /2/) apply.

The following applies for the purpose of disambiguation of the abbreviation AMS:

- AMS refers to the automatic measuring system according to item 3 in /1/.
- AMS-T7 refers to an “analog” entity in DAA.

# 2 System overview

## 2.1 Functions overview

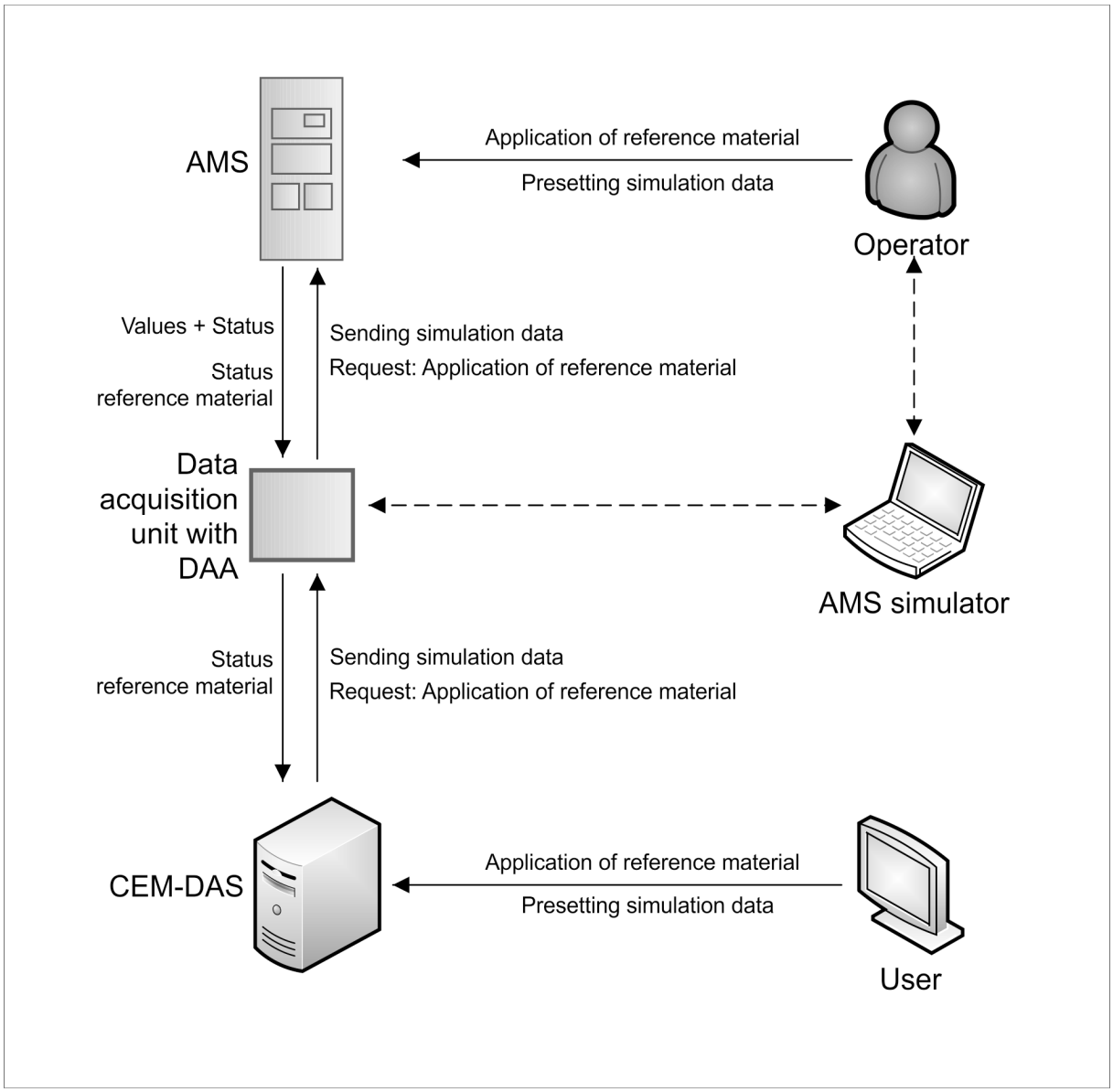


Figure 1: CEM-DAS / DAA and their environment

The external interfaces of DAA are summarized in the context diagram depicted in Figure 1.

The users can parameterize the AMS for CEM-DAS / DAA and check its current status via the web browser. They can also define simulation data or apply reference material.

## 2.2 Configuration

DAA always communicates with the AMS via Modbus TCP. A protocol converter is used in case the AMS can only communicate via Modbus RTU. The converter reads in the request from DAA and forwards it via Modbus RTU to the AMS. The reply of the AMS is then sent back to DAA via Modbus TCP.

The Modbus RTU address of the AMS is included in the Modbus TCP telegram, so that the gateway can correctly address the AMS.

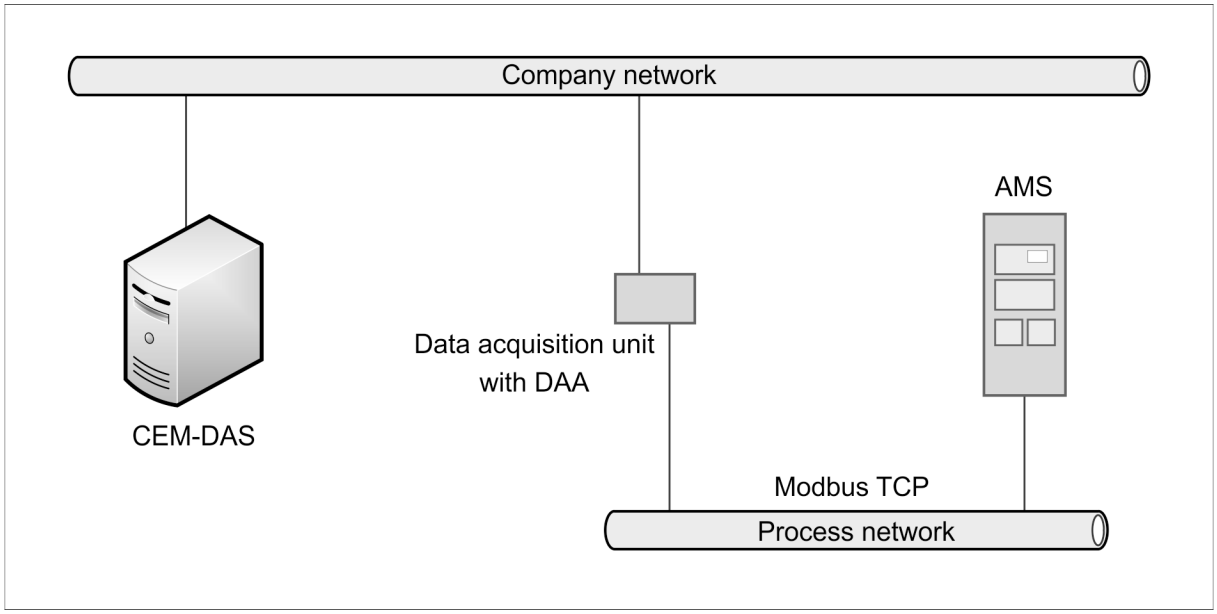


Figure 2: Modbus TCP

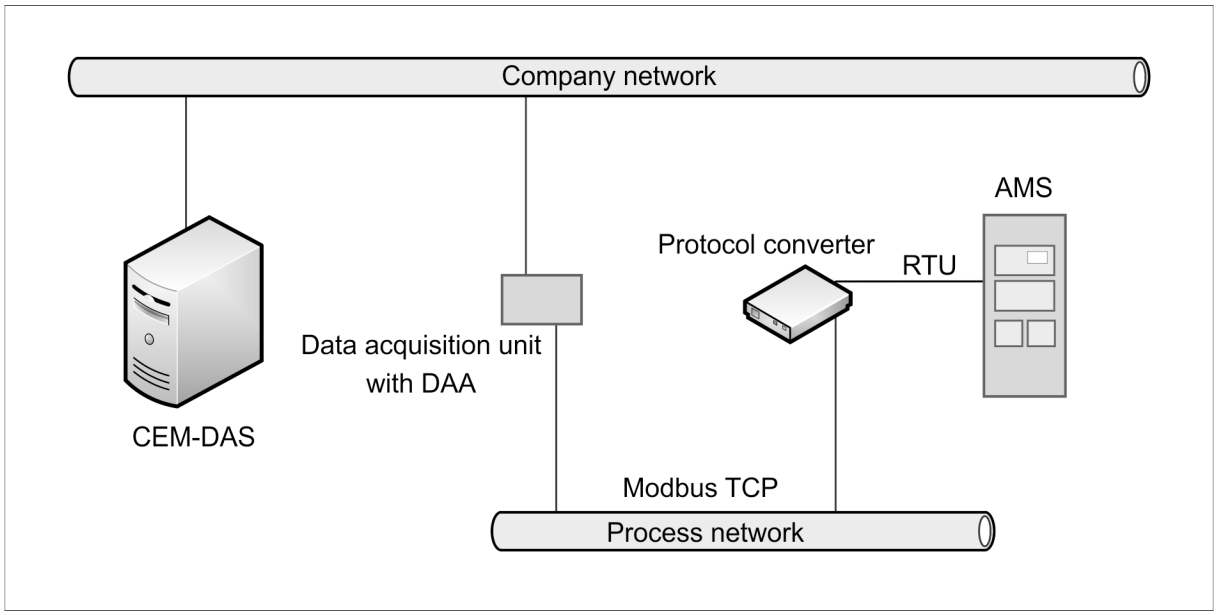


Figure 3: Modbus RTU

The following applies:

- DAA always works as a Modbus TCP client.
- The AMS always works either as a Modbus TCP server or as a Modbus RTU slave.
- The protocol converter works as a Modbus TCP server on one side and as a Modbus RTU master on the other side.

## 2.3 DAA

All direct communication with the AMS occurs via a DAA. This means that DAA permanently communicates with the AMS and provides the current state of the AMS to the user. The following tasks are performed by DAA.

### 2.3.1 Initializing phase

After startup of DAA or after an interruption of the communication DAA will retrieve the device parameters (meta data) from the AMS. After this initialization DAA will proceed to the operation phase.

### 2.3.2 Operation phase

DAA will cyclically perform the following actions in the operation phase. Pursuant to VDI 4201 Part 1 the cycle time must not exceed 1 second.

1. Retrieval of measurement signals (value on status) from the AMS and further processing of the signals
2. Status inquiry of the reference application in this AMS. This status is then forwarded to CEM-DAS.
3. If the user has defined new simulation data or ended the simulation, this change will be transmitted to the AMS.
4. If the user has applied new reference material or has ended the application of reference material, this change will be transmitted to the AMS.

DAA will switch into initializing phase in case there is a communication error with the AMS during operation phase.

### 2.3.3 System messages

A system message will be displayed by DAA upon a change in the operation mode of the AMS. This message shows the new operation mode. The following operation modes can be reported:

| Operation mode | Description |
|---|---|
| with reference material | There is only one application of reference material. |
| in simulation | The status “Test operation, simulation measuring value” is set for at least one measurement component. |
| in normal operation | There is no application of reference material, and the status “Test operation, simulation measuring value” is not set for any measurement component. |

Table 1: Operation modes of the AMS

# 3 Parameterization

All required parameterization takes place via the web interface of CEM-DAS.

## 3.1 Device

The AMS must be parameterized as a device in DAA before it can be used. The parameterization form consists of three sections. In the first section, general settings of the AMS are parameterized. In the second section, the measurement components are created and the measurement signals and status signals are allocated to an AIN or BIN of DAA. In the third section the created measurement components are allocated to the measurement components of the AMS.

### 3.1.1 General


Figure 4: AMS general

After the new device has been created and the type has been set to “Digital interface Modbus” the form depicted in Figure 4 will be displayed. The type of Modbus communication and the required parameters are entered in this form.

| Parameter | Range | Default | Remark |
|---|---|---|---|
| IP Address | | | IP4 address of the AMS or of the protocol converter. |
| IP Port | 1 – 65535 | 502 | IP port number of the AMS or of the protocol converter. Port 502 is the standard value for Modbus TCP. |
| Modbus RTU | Yes / No | No | If this input is activated the AMS will be connected via a protocol converter. This input must be deactivated for Modbus TCP. |
| Address RTU | 1 – 247 | | Modbus RTU address of the AMS. The protocol converter limits the RTU address to this range. |

Table 2: General parameters

In the second section, measurement components can be created or existing measurement components can be deleted with the two control buttons.

### 3.1.2 Measurement components

The measurement components of the AMS and their receipt in DAA are parameterized in this section. A maximum of 30[1] measurement components can be parameterized.

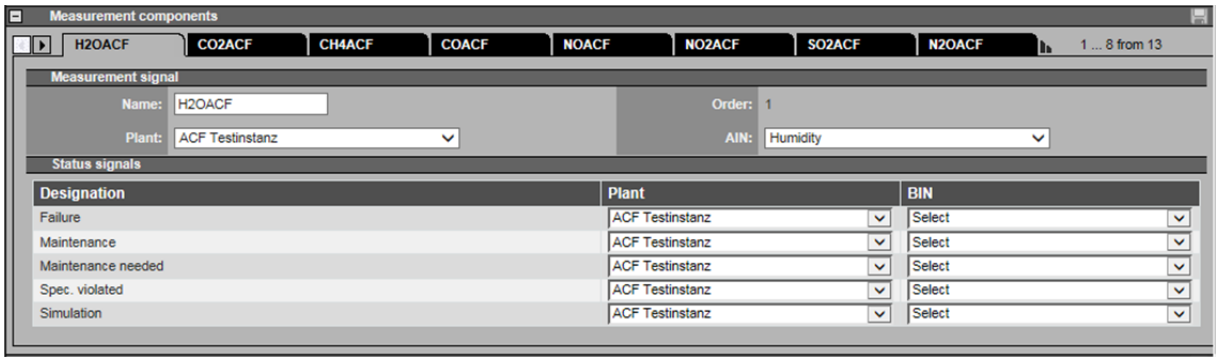


Figure 5: AMS measurement components

An existing AIN can be allocated to a measurement component in the section “Measurement signal”. This AIN then contains the scale value of the measurement component and can be converted into a physical value via a calibration curve. The status signals of the measurement component can be allocated to an existing BIN in the section “Status signals”. The status signals “Maintenance”, “Malfunction”, “Simulation” and “Specification violated” are automatically considered for the measurement signal. If maintenance or malfunction appear in 50% of the time of a measured values sequence the measured value will automatically be classified as maintenance or malfunction.

Upon its first occurrence within a measured values sequence the status signal “Simulation” will set the relevant status bit of the measured value. Upon its first occurrence the status signal “Specification” will set the status bit “Current plausibility”, but does not invalidate the measured value.

### 3.1.3 Assignment

The parameterized measurement components are allocated to the measurement components of the AMS in the section “Assignment to the AMS (Analyzer)”.

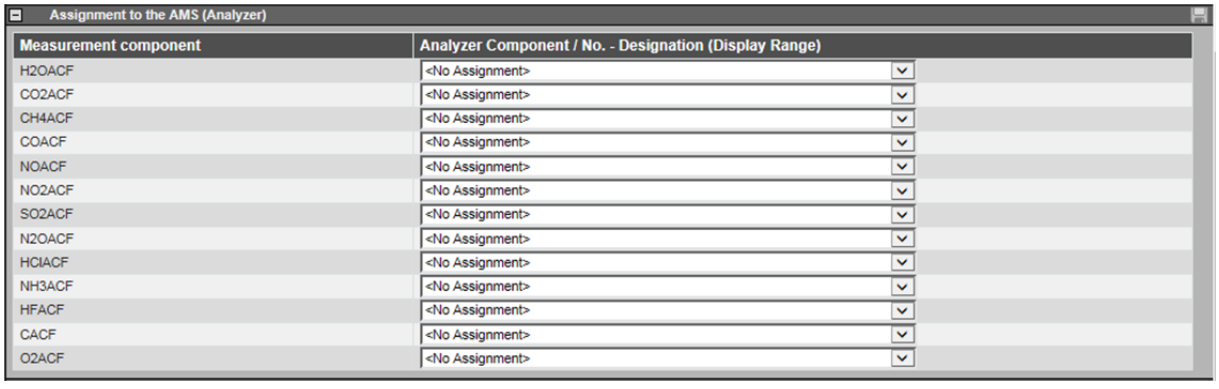


Figure 6: AMS assignment

[1] Only meta data for 30 measurement components are available pursuant to VDI 4201 Part 3.

The information shown in the second column is only displayed after DAA has read out the meta data of the AMS. With this allocation it is possible to harmonize the sequences of the measurement components in DAA and the AMS. Entries in the second column are structured as follows: “Sequence in AMS“ ”Name of Component“ (Measuring range bottom-up unit). The component’s sequence, name, measuring range and unit are provided in AMS by the meta data.

## 3.2 AIN

The allocation of the AMS measurement signal is also shown in the parameter form of the AIN and can also be performed there.

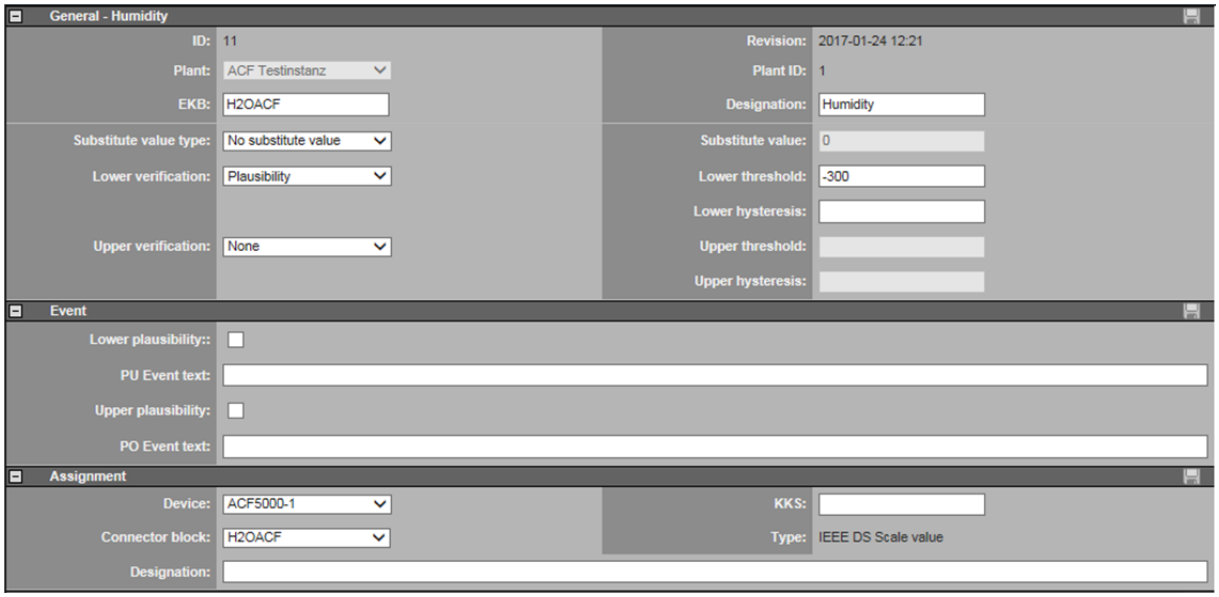


Figure 7: AIN assignment

## 3.3 BIN

The allocation of the AMS measurement status is also shown in the parameter form of the BIN and can also be performed there.

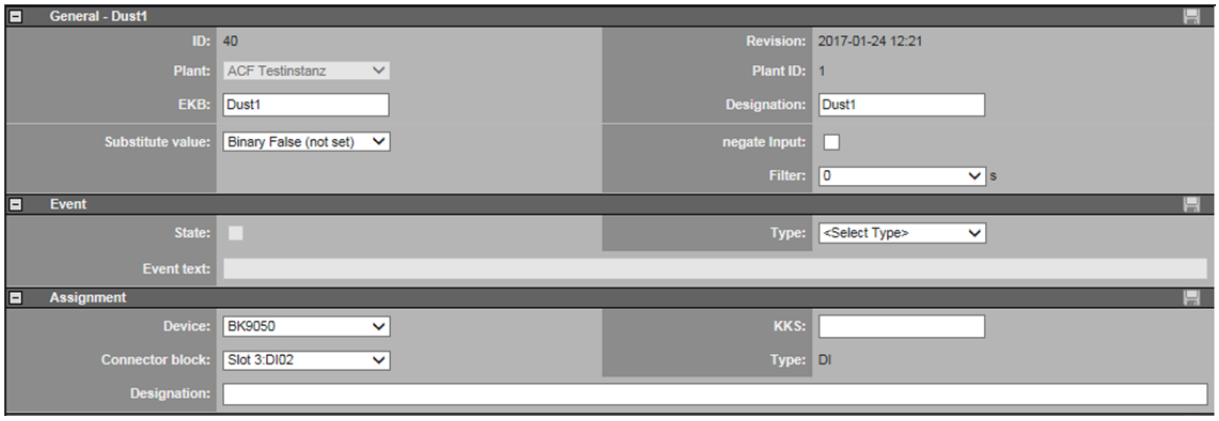


Figure 8: BIN assignment

# 4 Status monitor

## 4.1 General

The current status of the AMS can be checked in the tab “State” in the menu item “Output/ Status Monitor”[2]. This form is visible for all CEM-DAS users. It is a read-only form.

Reference material can be applied and simulation values can be entered in a second tab, “Simulation/Reference material”. This tab is only visible to CEM-DAS managers or users with proper authorization.

## 4.2 Status

The current scale values, measurement status, measurement signals and the AMS mode are displayed. The AMS mode is determined by DAA and indicates whether a simulation or reference application is in place. If none of these two modes is in place the AMS is in “Normal operation”.

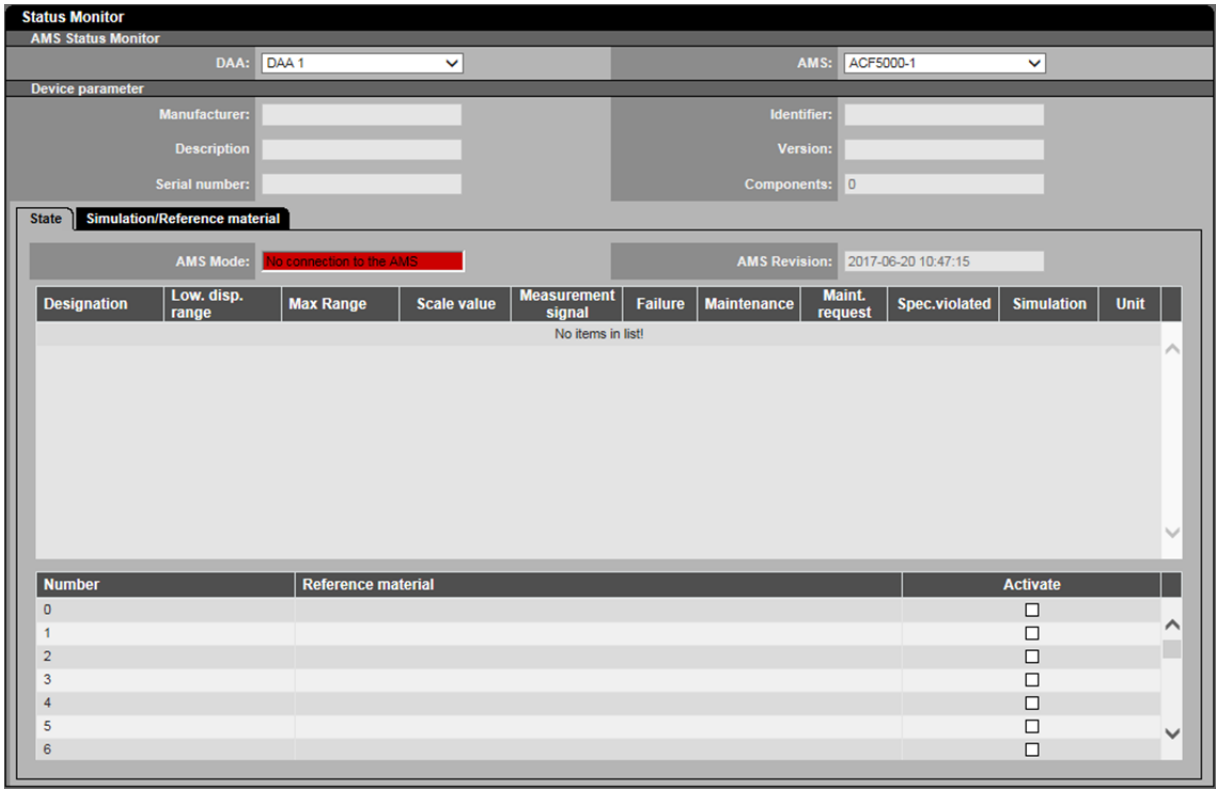


Figure 9: AMS status control

The “AMS Mode” display is color-coded as follows:
Green: AMS in normal operation
Yellow: AMS in simulation mode or application of reference material
Red: There is no connection to the AMS

[2] This menu item is visible if a device „Digital Interface“ is configured.

## 4.3 Changes

The user can enter simulation data for each measurement component or apply reference material in the tab “Simulation/Reference material”. It is not possible to simultaneously use simulation data and reference material. Also, the simulation can be ended and reference material can be switched off in this tab.

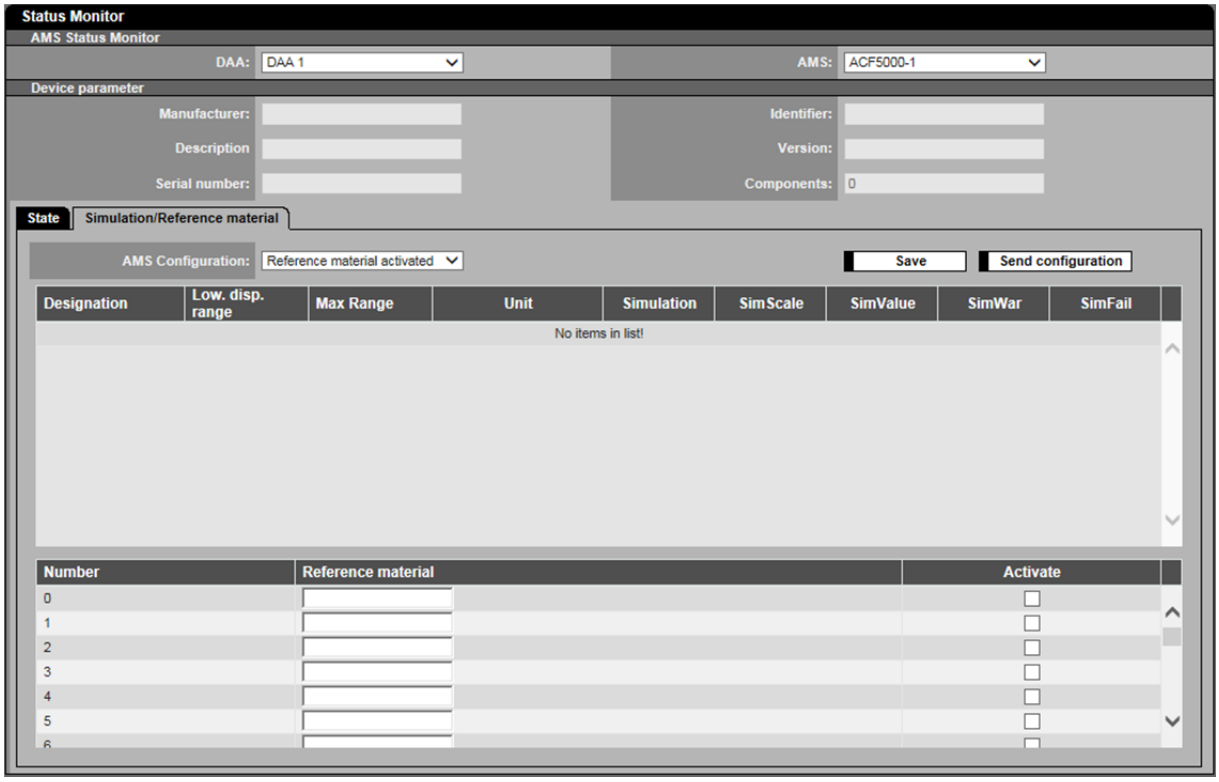


Figure 10: AMS simulation / reference material

After selecting “Simulation mode” for “AMS Configuration” the simulation data can be edited. The simulation data can be entered either as scale values “SimScale” or as physical values “SimValue”. Conversion into the other value happens automatically.

After selecting “Reference Material activated” for “AMS Configuration” the desired reference material can be activated in the lower list. In addition, the reference materials can be named.

Simulation operation or activation of reference material are ended by selecting “Normal Operation” for “AMS Configuration”.

### 4.3.1 Sending

Settings or changes are sent to DAA by clicking “Send configuration” (see Figure 10). A process window will pop up, where messages relating to the transmission status are displayed.


Figure 11: Set AMS mode

After sending, the answer from DAA will be awaited. DAA will then forward the settings or changes to the AMS.

At the end of a day DAA will always reset the AMS into normal mode, which means that existing simulations or reference applications are discarded.

# 5 Data model

## 5.1 Measurement signal

Pursuant to 5.2 in /1/, the measurement signal of the AMS is transmitted as a scale value. The zero point is set to scale value 0 and the end of the nominal range is mapped to +10000. The scale value can be converted into the measurement signal with the following formula:

$$Measurement\ signal = \left(\frac{Scale\ value}{10000}\right) * End\ of\ nominal\ range$$

The scale value is not limited by the AMS and must not be limited in the evaluation system either.

Pursuant to 5.2.1 para 2 item 3 the scale value must be saved in the evaluation computer. In CEM-DAS this value is stored as an input value with its measured value, much like a “current value”. It can then be displayed via the values list “Input Values”[3].

The calibration function is determined by the authority according to the scale values, which means that the calibration function converts the scale values into the (physical) measured values.

## 5.2 Unit

The scale value’s unit can be modified in an AMS-T7 in the input position “Input Unit”. The default setting upon creation of the AMS-T7 is “mA”.

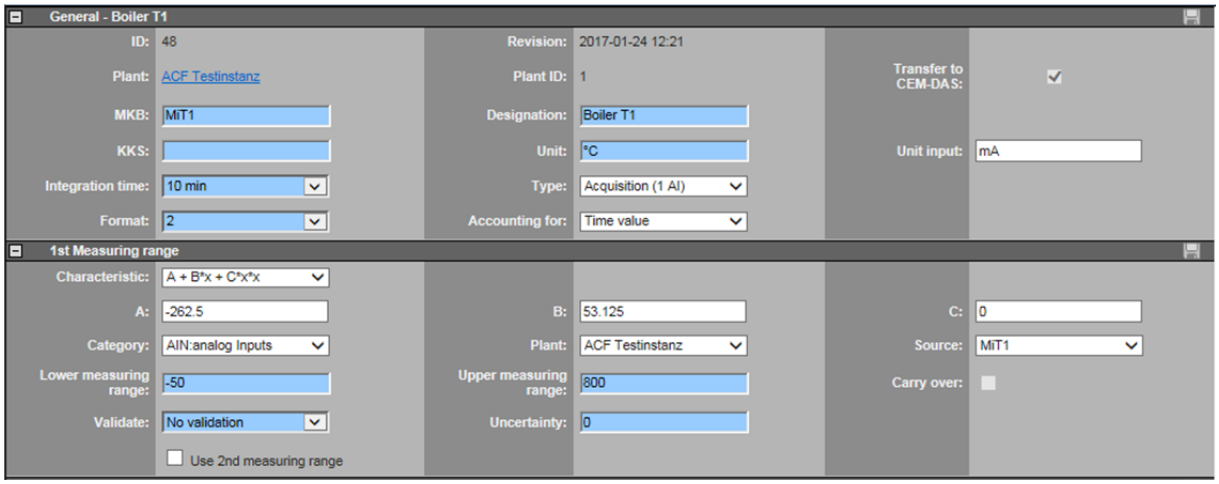


Figure 12: Scale value’s unit

[3] Corresponds to the previous values list „Current Values“.

# 6 Protocol converter

## 6.1 Connections

### 6.1.1 Supply voltage

The 4-pin plug adapter for the supply voltage is located on the bottom of the protocol converter. The device must be supplied with 10 – 33 VDC (DC voltage, standard power adapter pursuant to DIN 19240). Pins 1 and 2 must be used.

| Pin number | Name | Function |
|---|---|---|
| 1 | UB (Pwr) | 10 to 33 V DC |
| 2 | 0 V (Pwr) | 0 V DC |
| 3 | Rx - debug | Receive signal debug[4] |
| 4 | Tx - debug | Transmit signal debug |

Table 3: Pin assignment for supply voltage

### 6.1.2 Ethernet interface

The plug “RJ 45 Ethernet” for Ethernet connection is located on the bottom of the protocol converter. The device supports 10/100 MB and “auto crossover”.

| Pin number | Name | Function |
|---|---|---|
| 1 | TD+ (RD+) | Transmit line + (Receive line +) |
| 2 | TD– (RD–) | Transmit line – (Receive line –) |
| 3 | RD+ (TD+) | Receive line + (Transmit line +) |
| 4 | | |
| 5 | | |
| 6 | RD– (TD–) | Receive line – (Transmit line –) |
| 7 | | |
| 8 | | |

Table 4: Pin assignment Ethernet interface

### 6.1.3 RS Interface

The (serial) RS interface (3-pin + 4-pin plug adapter) is located on the topside of the protocol converter and must be connected to the S5 master.

This interface can be used as either RS232, RS422 or RS485. For RS485, the two pins “485+” resp. “485–“ must be connected together.

In addition, the terminating resistors (termination Rx 422 and Tx 422) must be set correctly for RS422 and RS485.

[4] At isolated devices (option GT) Ground for the Debug-Interface must be connected with pin 3 of the RS-interface. At devices that are not isolated also the 0 V (Pwr) signal can be used as reference.

| Pin Number | Name | Function |
|---|---|---|
| 1 | Rx 232 | Receive signal |
| 2 | Tx 232 | Transmit signal |
| 3 | GND | Ground signal |
| 4 | Rx 422+ (485+) | Receive signal |
| 5 | Rx 422– (485–) | Receive signal |
| 6 | Tx 422+ (485+) | Transmit signal |
| 7 | Tx 422– (485–) | Transmit signal |

Table 5: Pin assignment RS interface

## 6.2 Operating modes

The protocol converter /3/ can be used in various operating modes. The operating mode is determined by means of the rotary code switches when the protocol converter is started / switched on.

| S4 | S5 | Operating mode |
|---|---|---|
| D | D | Reserved |
| E | E | Test mode[5] |
| F | F | Configuration mode[5] |
| 0 – B | 0 – B | Data exchange mode[6] |

Table 6: Operating modes

### 6.2.1 Configuration mode

This mode is used for configuration of the protocol converter. It is started when both rotary code switches S4 and S5 are in position “F” upon start. In this mode, the device will work in a fixed setting with 9600 baud, no parity and 1 stop bit. The RS state LED will continually blink in red. The following operations are possible in this mode when the WINGATE program is connected to the RS interface of the device.

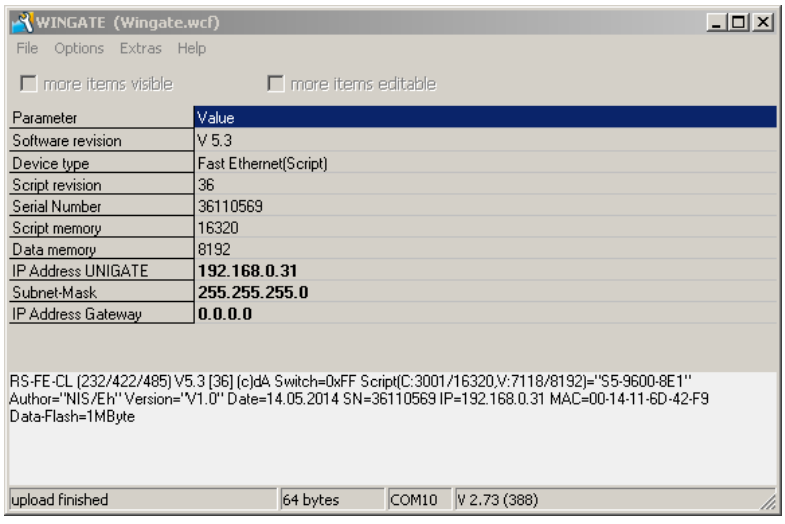


Figure 13: Start of WINGATE

Configuration is also possible via the debug interface (see 9).

[5] These operating modes are not possible for RS422 or RS485 operation.
[6] The positions can be retrieved and used by the application.

### 6.2.1.1 General configuration

After WINGATE has been started the parameters displayed in bold can be modified by double-clicking them.

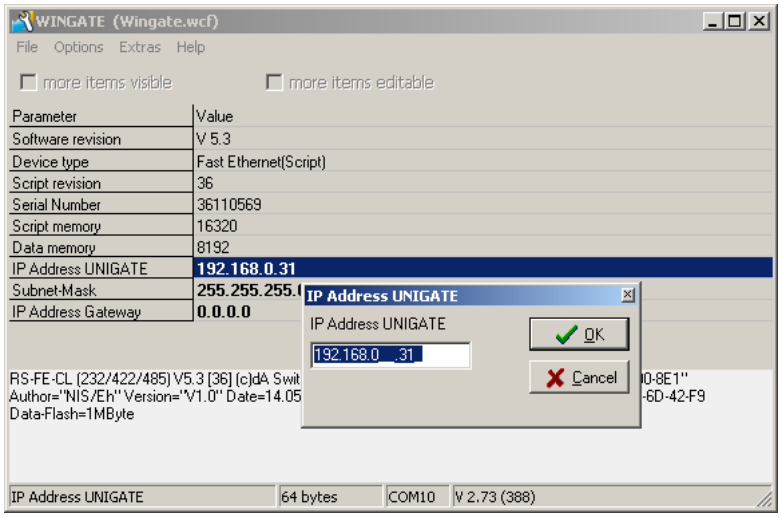


Figure 14: WINGATE Change of IP address

The changes are then transmitted to the protocol converter using the command “Download (Write to Device)”. The display of the parameters can be refreshed using the command “Upload (Read from Device)”.

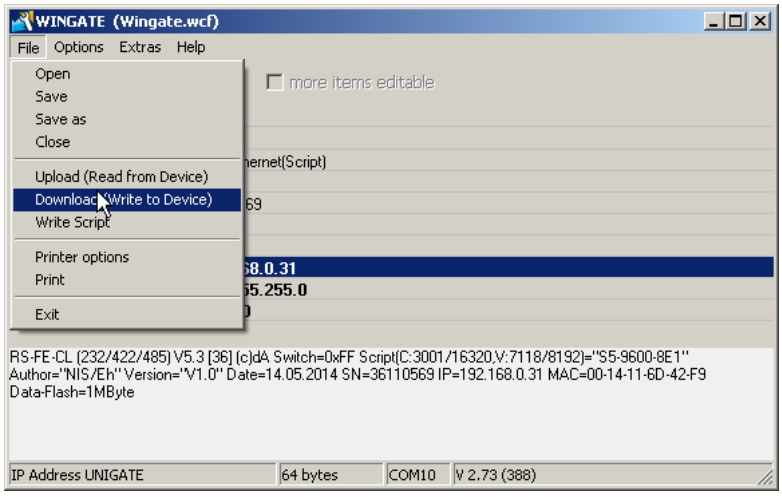


Figure 15: WINGATE Transmission of changes

### 6.2.1.2 Loading a script

The script is available as a file named “UNIGATE-TCP-RTU.DCS”. It is transmitted to the protocol converter using the command “Write Script”. After the script has been loaded the rotary code switches S4/S5 must be set according to the application and the protocol converter must be reset. Another way of loading the script file is shown in Section 8.

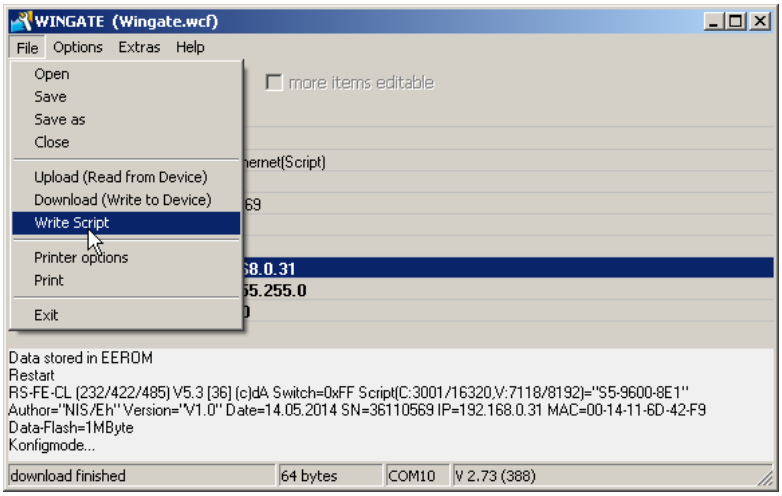


Figure 16: WINGATE Transmission of a script

### 6.2.2 Test mode

The device will start in test mode if both rotary code switches S4 and S5 are in position “E” upon start. Please refer to page 13 in /3/ for additional information on the test mode.

### 6.2.3 Data exchange mode

This mode is always executed whenever the device is not in configuration or test mode. The loaded script will then be executed with the parameters set. After that, the two rotary code switches S4 and S5 will be evaluated by the application (script). The communication parameters for Modbus RTU are set via these switches. The rotary code switch S4 shows the communication baud rate. The rotary code switch S5 shows the communication type and parity. 1 start and stop bit and 8 data bits are fixed.

| Position | Baud rate/ bits/s |
|---|---|
| 0 | 2.400 |
| 1 | 4.800 |
| 2 | 9.600 |
| 3 | 19.200 |
| 4 | 38.400 |
| 5 | 57.600 |
| 6 | 115.000 |
| 7 – F | reserved |

Table 7: Rotary code switch S4

| Position | Type | Parity |
|---|---|---|
| 0 | RS232 | Even |
| 1 | RS442 | Even |
| 2 | RS485 | Even |
| 3 | RS232 | None |
| 4 | RS442 | None |
| 5 | RS485 | None |
| 6 | RS232 | Odd |
| 7 | RS442 | Odd |
| 8 | RS485 | Odd |
| 10 – E | reserved | |
| F[7] | RS232 | Even |

Table 8: Rotary code switch S5

[7] The Modbus RTU slave UID is set fixed as 1. The UID sent via Modbus TCP is discarded (as of script version 1.3).

### 6.3 Status indication

The protocol converter has 11 LEDs with the following meanings.

| LED | Color | Meaning |
|---|---|---|
| (Ethernet) Power | Green | Supply voltage Ethernet |
| Full Duplex | Green | Duplex communication |
| 100 MB | Green | 100 MB network |
| Link/Act. | Green | Link pulse found / data traffic |
| (Ethernet) State | Red / Green:<br>Permanent green<br>Flashing green<br>Flashing green/red<br>Permanent red | Interface status Ethernet:<br>Connection established and active<br>Device waiting for connection buildup<br>Device waiting for Ethernet initialization<br>General network error |
| Power | Green | Supply voltage RS interface |
| State | Red / Green:<br>Permanent green<br>Flashing green<br>Flashing green/red<br>Permanent red<br>Flashing red | System or application:<br>–<br>–<br>–<br>System error (LED error) / application error[8]<br>Configuration / test mode active |
| Error 1 / 2 / 4 / 8 | Green | System error / application error<br>Numbers 0 to 15 bit-coded |

Table 9: LEDs on the protocol converter

#### 6.3.1 System errors

Errors detected by the protocol converter are signalized with a red “State” LED. At the same time the error number is displayed bit-coded via the “Error” LEDs. In case of severe errors (1–5) the device must be switched off and on again. If the error occurs again the device must be replaced. In case of warnings (6–15) the LEDs will light up for 1 minute and will then be automatically reset.

| LED 8 / 4 / 2 / 1 | Error | Description |
|---|---|---|
| 0 0 0 0 | 0 | - |
| 0 0 0 1 | 1 | Hardware error |
| 0 0 1 0 | 2 | EEPROM error |
| 0 0 1 1 | 3 | Internal memory error |
| 0 1 0 0 | 4 | Ethernet (fieldbus) hardware error |
| 0 1 0 1 | 5 | Script error |
| 0 1 1 0 | 6 | - |
| 0 1 1 1 | 7 | RS transmit buffer overflow |
| 1 0 0 0 | 8 | RS receive buffer overflow |
| 1 0 0 1 | 9 | RS timeout |
| 1 0 1 0 | 10 | General Ethernet (fieldbus) error |
| 1 0 1 1 | 11 | Parity check or frame check error |
| 1 1 0 0 | 12 | - |
| 1 1 0 1 | 13 | Ethernet (fieldbus) configuration error |
| 1 1 1 0 | 14 | Ethernet (fieldbus) data buffer overflow |
| 1 1 1 1 | 15 | - |

Table 10: System errors

[8] In this case the red LED will flash with 0.5 Hertz.

### 6.3.2 Application

The application (script) sets the “State” LED as follows.

| Color | Meaning |
|---|---|
| Off | Switched off during start. |
| Flashing green/red | Set before initialization of the network and the RS interface. |
| Flashing green | Application ready and waiting for telegrams on the network. |
| Permanent green | Request successfully completed. |
| Permanent red | Error during receipt of telegrams on RS interface. LEDs 8/4/2/1 are switched off. |
| Flashing red | Error on execution of a request. |

Table 11: LED application

The application (script) tallies the requests of the measurement signals and status information with a counter from 0 to 15. After 15, the counter will restart at 0. The current counter is continually displayed on LEDs 1/2/4/8.

## 7 Related documents

| No. | Document title |
|---|---|
| /1/ | VDI 4201 Part 1 Digital interface – General requirements, September 2010 |
| /2/ | VDI 4201 Part 3 Digital interface – Specific requirements for Modbus, July 2012 |
| /3/ | Instruction Manual Universal Fieldbus Gateway UNIGATE® CL – Fast Ethernet V. 2.5, Deutschmann Automation GmbH & Co. KG |

# 8 Annex A: Script programming tool

There is a small program called “Script Programming Tool” (SPT), which can also load a script as a DCS file to the UNIGATE CL-FE via the RS interface or the DEBUG interface. For this purpose, the protocol converter must be in data exchange mode. It is not necessary to switch on the configuration mode.

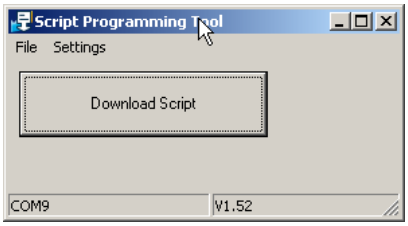


Figure 17: SPT for loading of scripts

Loading of a script is described in the following. First, the PC’s serial interface that is connected to the UNIGATE CL-FE must be selected via the menu item “Settings”.

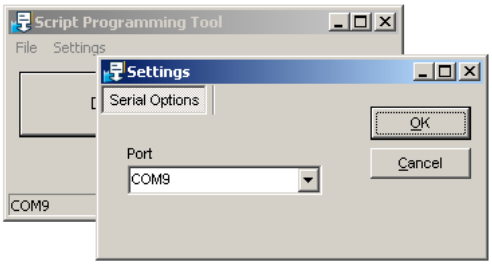


Figure 18: SPT Selection of the PC interface

Then the script file “UNIGATE-TCP-RTU.DCS” must be selected.

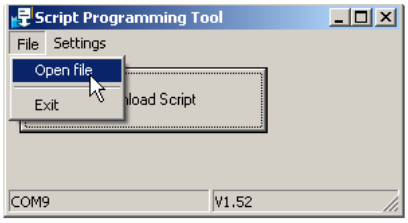


Figure 19: SPT Selection of the script file

After the script file has been selected the button “Download Script” must be clicked. A message will pop up, requesting the user to restart UNIGATE CL-FE (interrupt power supply). Please make sure to only confirm this message after restarting UNIGATE CL-FE.

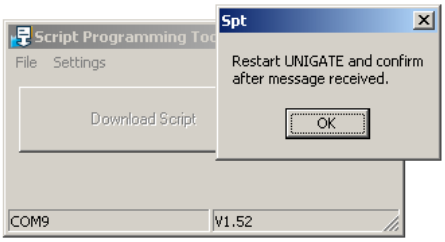


Figure 20: Start SPT download

After the restart SPT will search for UNIGATE CL-FE. As soon as it is found, a message “Debug Port connected” will appear in the status bar. The “State” LED on the UNIGATE CL-FE will no longer flash. After clicking the OK button the download of the script will commence.

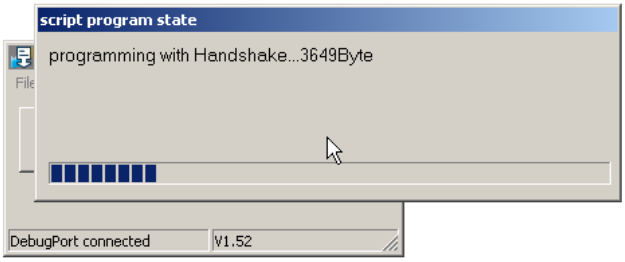


Figure 21: SPT download active

When the download is finished – a message will only pop up in case of an error – UNIGATE CL-FE must be restarted again, so that the loaded script is executed. The “State” LED on the UNIGATE CL-FE will flash again.

Remark: In case of any errors during script loading the program should be started in Windows 7/8 or Server 2008/2012 with administrator rights.

# 9 Annex B: Alternative configuration

In case WINGATE is not connected to the RS interface, but to the debug interface, the configuration can also be read, modified and transmitted. For this purpose the protocol converter must be in data exchange mode. It is not necessary to switch on the configuration mode. In this case, the commands in the menu item EXTRAS shall be used.

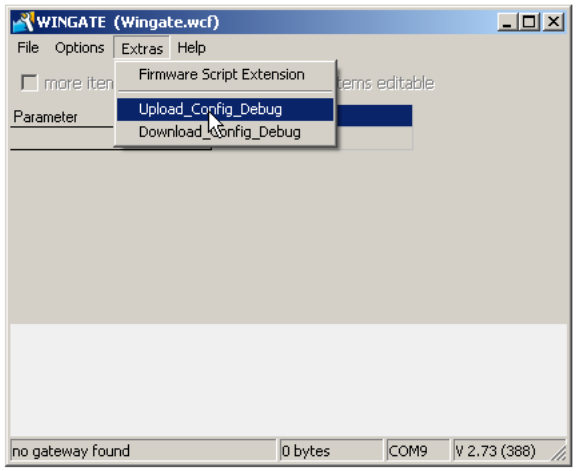


Figure 22: Retrieve configuration

After selecting “Upload_Config_Debug” the following message will pop up. The message can be confirmed by clicking OK after another restart of UNIGATE CL-FE.

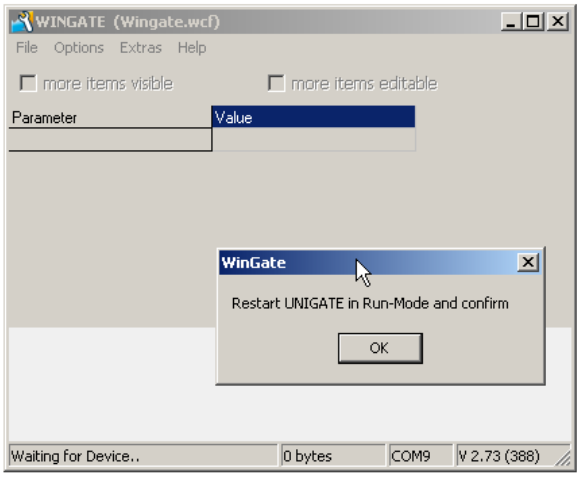


Figure 23: Upload via debug interface

As soon as the protocol converter detects WINGATE the message “Device started in WINGATE-Mode” will appear in the status bar. Upload of the configuration may take approx. 30 seconds. The message “Upload finished” will appear in the status bar once the upload is successfully completed.

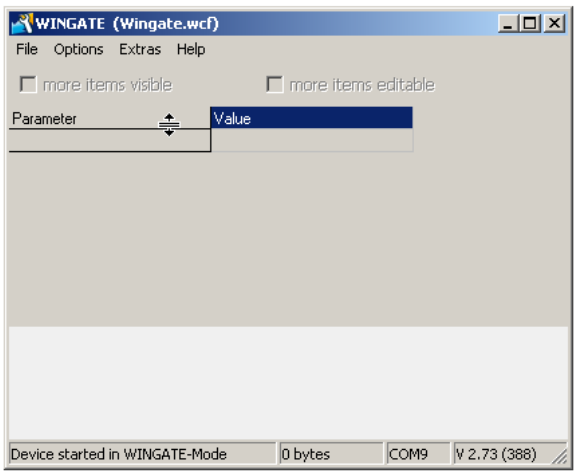


Figure 24: Device started in WINGATE mode

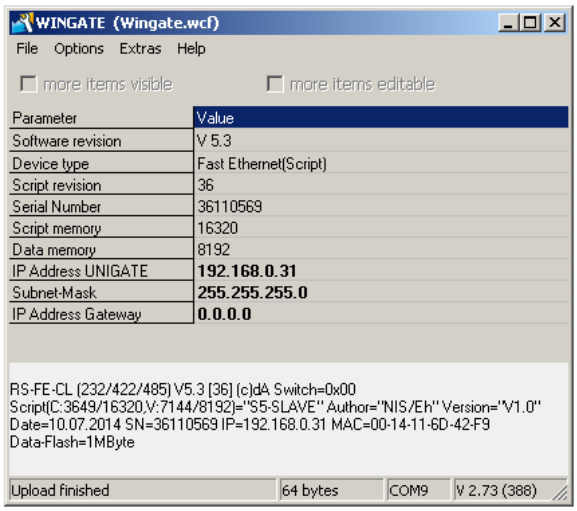


Figure 25: Upload of configuration finished

The changed configuration can then be loaded by using the command “Download_Config_Debug”.

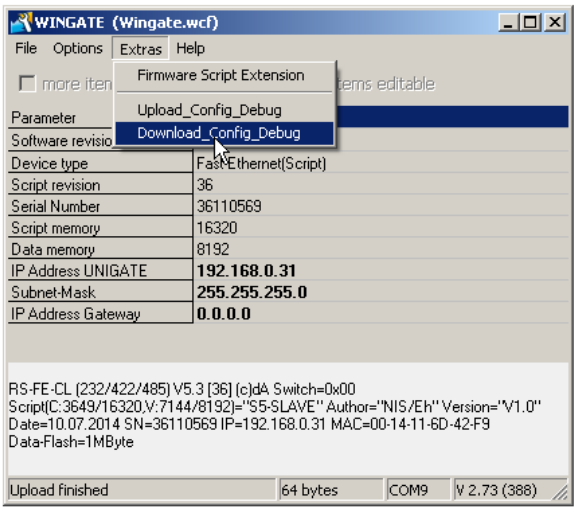


Figure 26: Transmit configuration

The following message pops up after selecting “Download_Config_Debug”. The message can be confirmed by clicking OK after a restart of UNIGATE CL-FE.

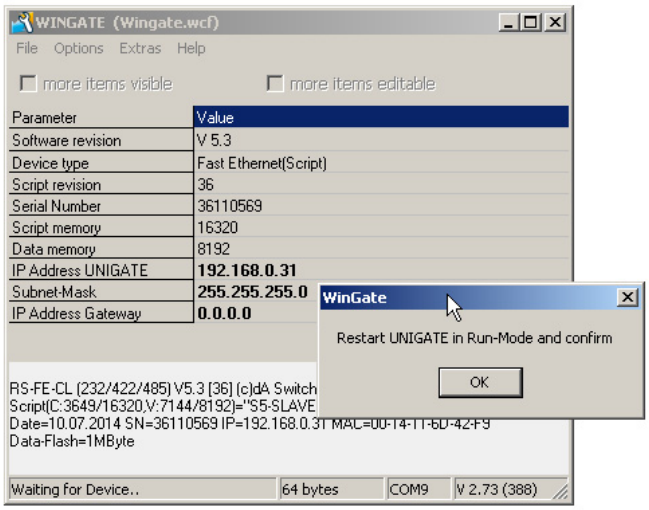


Figure 27: Download via debug interface

A message “Download finished” will appear in the status bar after successful download of the configuration.

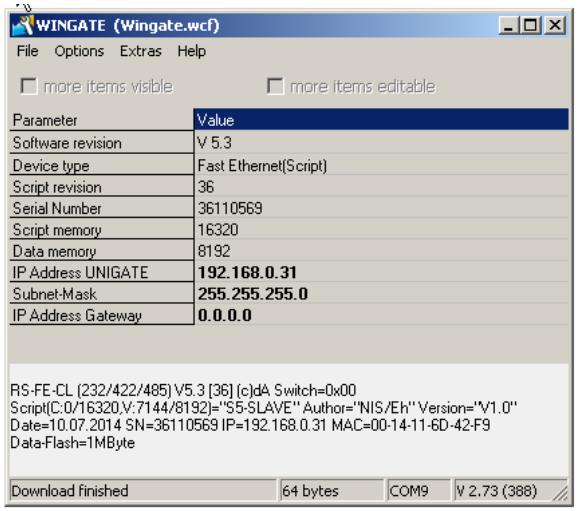


Figure 28: Download of configuration finished

After WINGATE has been closed, UNIGATE CL-FE must once more be restarted, so that the protocol converter is again in data exchange mode.

Remark: In case of any errors during upload/download of the configuration the program should be started in Windows 7/8 or Server 2008/2012 with administrator rights.

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