PROFIBUS DP

SLAVE CONVERTER FOR

OPUS POWER SYSTEMS

USER MANUAL

Wago 750-8216/025-001:

- PROFIBUS DP-V0 Slave controller
- Modbus TCP/IP master controller
    - Modbus TCP/IP Slave Enedo OPUS VIDI+

1.1.1 Document Version History

Author	Version	Summary
Pasi Lauri, V. Haarahiltunen	B	updates
Nina Hakkarainen	C	Enedo re-branding

Table of Contents

2 Introduction

This document describes some information of Profibus (Process Field Bus) and basic instructions how to install, setup and use Wago PLC unit in OPUS HE system

2.1 Revision history

Revision	Date	Revision history	Author
A	2019-12-18	This is the first revision of the document.	Pasi Lauri/P2 Engineering Oy V.Haarahiltunen
B	2020-01-17	Finalized	V. Haarahiltunen

3 Abbreviations and terminology

Acronyms	Term
BMBF	Bundesministeriums für Bildung und Forschung
DP	Decentralised Peripherals
GSD	General Station Description
IEC	International Electrotechnical Commission
PA	Process Automation
PLC	Programmable Logic Control
PROFIBUS	Process Field Bus

4 Order information

Enedo part numbers for PROFIBUS DP-V0 adapter and DC/DC supply converters are presented on the table below.

Order number	Description
C01354	Wago 750-8216/025-001 PROFIBUS DP slave/ Modbus master controller KIT (OPUS VIDI+ slave), DC 24V input
C01352	DC/DC converter 40-90VDC / 24VDC 2A, Wago 787-1014/072-000
ADC5721	DC/DC converter 85-200VDC / 24VDC 2,5A, Powernet ADC5721
C01353	DC/DC converter 120-373VDC / 24VDC 2,5A, Wago 787-1012

5 General information about the system

5.1 Profibus DP generally

PROFIBUS (Process Field Bus) is a standard for fieldbus communication in automation technology and was first promoted in 1989 by BMBF (German department of education and research) and then used by Siemens. PROFIBUS is openly published as part of IEC 61158 standard. PROFIBUS DP uses a physical EIA 485 (RS-485, differential TTL level, three-state input/output) bus based on a twisted, highly

shielded cable and precise installation regulations. The protocol allows for relatively fast real-time communication (9.6 kbit/s to 12 Mbit/s). PROFIBUS DP (Decentralised Peripherals) has three service levels:

- DP-V0 is the simplest, mostly used and has cyclic master dominant data exchange (slaves communicate only when the master has given the floor)
- DP-V1 is more advanced and has also acyclic data exchange and alarm handling
- DP-V2 is the most advanced. It is used for isochronous (accurate synchronizing) mode and data exchange broadcast (slave-to-slave communication).

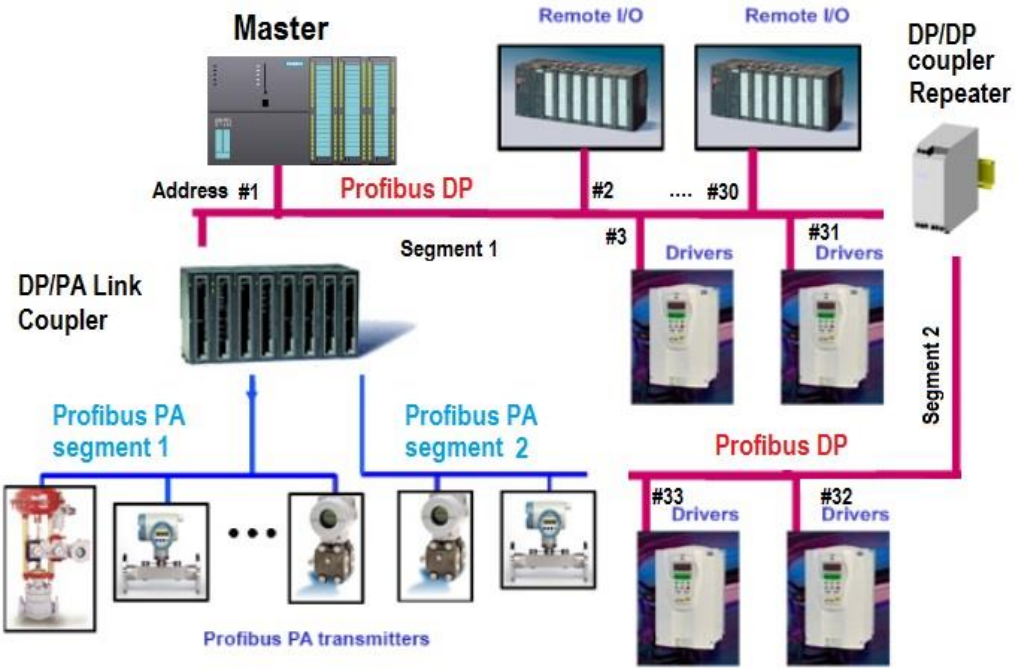
Note: The Wago converter application uses only DP-V0 service level.

PROFIBUS messages/telegrams are quite simple, but an extra PLC or a commercial simulation program is needed to explore and control the messages.

In PROFIBUS each byte has always with one start bit, 8 data bits, even parity and one stop bit.

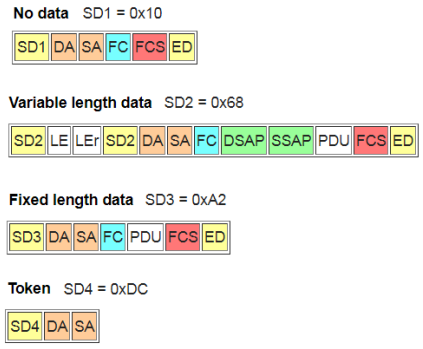
PROFIBUS network which is divided to segments can be extended by repeater. PROFIBUS PA is a simpler protocol for measuring instruments and automation

Figure 1 Example of PROFIBUS network



Different PROFIBUS devices always require a cable length of at least 1 meter between devices. This is necessary for avoid the data collisions when the speed is high. In DP-V0 service level there is only 4 different telegram formats

Figure 2 Telegram formats in DP-V0 service



Fields

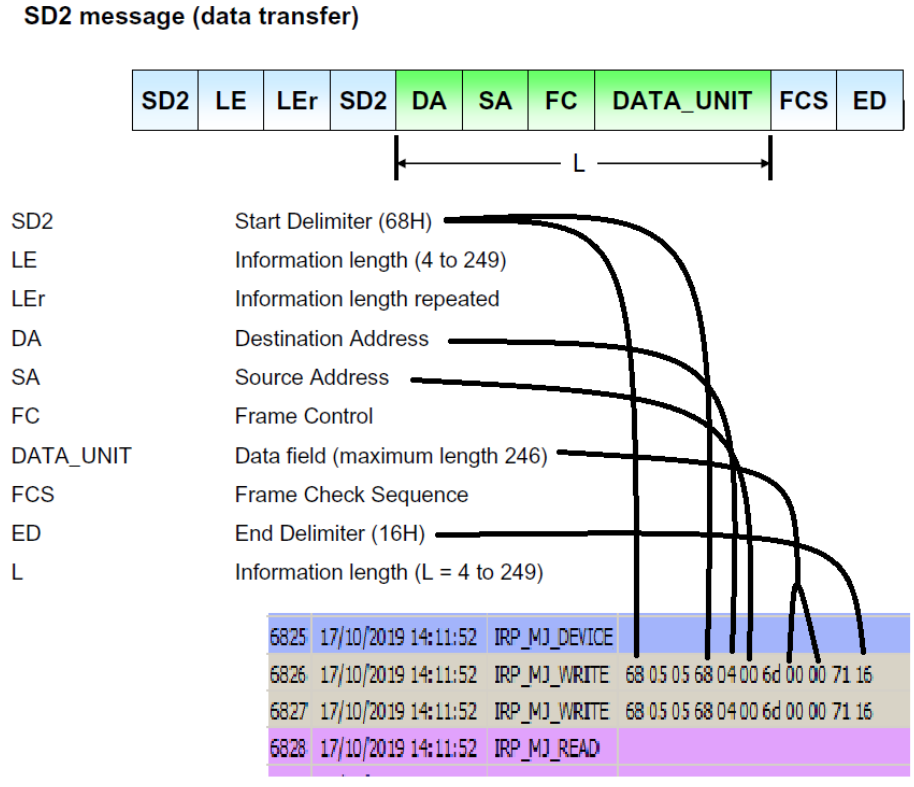
SD	Start Delimiter
LE	Length of protocol data unit, (incl. DA,SA,FC,DSAP,SSAP)
LEr	Repetition of length of protocol data unit, (Hamming distance = 4)
FC	Function Code
DA	Destination Address
SA	Source Address
DSAP	Destination Service Access Point
SSAP	Source Service Access Point
PDU	Protocol Data Unit (protocol data)
FCS	Frame Checking Sequence, calculated by simply adding up the bytes within the specified length. An overflow is ignored here.
ED	End Delimiter (= 0x16)

5.2 Profibus Telegrams between PLC and VIDI+

The telegrams of Wago controller application in OPUS HE system are mostly SD2 types: master sends two output bytes for testing and slave sends 61 bytes containing all VIDI+ variables in defined format.

Master's telegram to a slave 04 consisting 5 information bytes (destination address 04, source address 00, frame control 6d $_h$, data_units 00 00) and frame sum = 04$_h$+6d $_h$ = 71 $_h$.

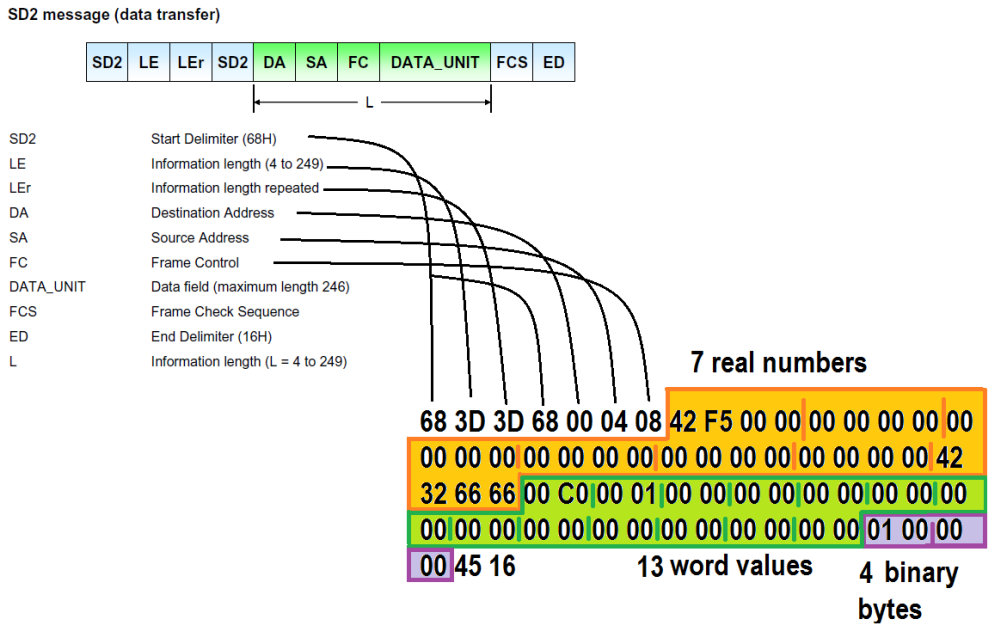
Figure 3 Master's (Wago PLC) telegram to a slave (VIDI+ controller)



The slave's telegram to the master is longer:

Slave 04 sends a telegram to the master 00 consisting $3D_h$ information bytes (destination address 00, source address 04, frame control 08, data_units 7 decimals, 13 words and 4 binary bytes) and frame sum = 04_h +08_h +42_h +$F5_h$ +42_h +32_h +66_h +66_h +$C0_h$ +01_h +01_h = 345_h.

Figure 4 The slave's (VIDI+) telegram to the master (Wago PLC)



PROFIBUS master doesn't know the byte format and what kind of variables they are without further information. This information is given in the slave's GSD file, which must be provided to the master.

5.3 General Station Description File

General Station Description, GSD file typically defines the device manufacturer's information, communication speeds, communication delays and cyclic data transmission signals modules. It is a text type of file and can be opened for example with Notepad. All PROFIBUS device manufacturers provide GSD files that are just right for their device. This ensures that the system configuration is quite simple and that the speed of the communication is maxim. GSD file consist of lot of commands which are strictly defined in PROFIBUS specification for example GSD-Spec_2122_V51_Jul08.

When a slave is a versatile PLC like Wago PLC, the GSD file is very long and consist all possibilities which this PLC can handle. When loading a GSD file to the master, the variables that are sent and received must be manually defined before a configuration of a master is ready.

Wago manufacturer's GSD file for a PLC 750-8216/025-001 CPU is named "**A206_V10.GSD**". This same file is used with a PLC 750-8206/025-00X CPU. It is freely downloadable among others from Wago's www-pages.

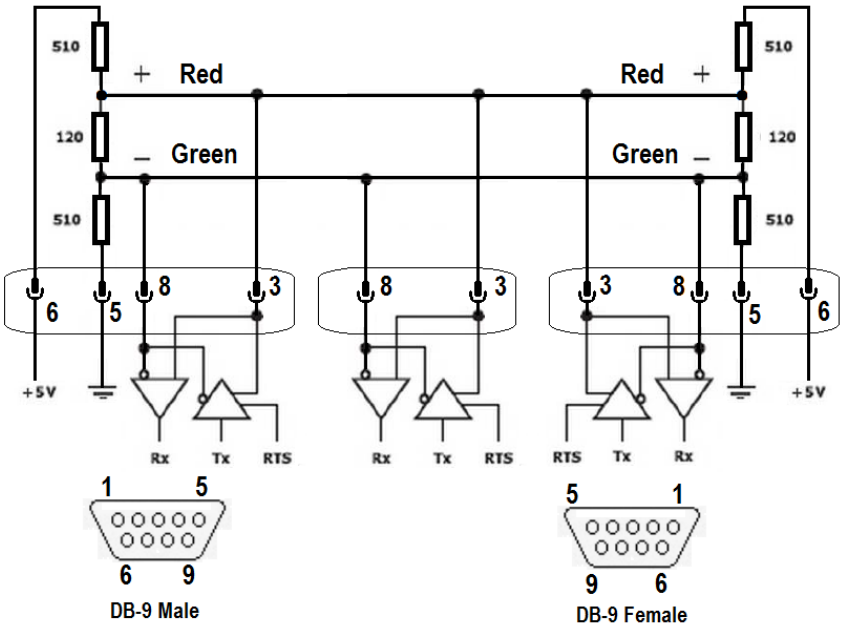
For making the configuration of the Wago PLC unit in the OPUS system easier an edited version of the manufacturer's GSD file is available. It is named "**Enedo_A206_V10.GSD**".

Loading of the GSD file to the Wago PLC unit is instructed in the chapter 7.4 Loading the GSD file to the MASTER and test the communication.

5.4 PROFIBUS cabling and hardware

PROFIBUS cabling has a lot of rules that must be followed carefully. This is necessary to reach high communication speed and to avoid distortion, which is typical in industry environment.

Figure 5 PROFIBUS device D-9 male connector and switchable resistors inside the connector



PROFIBUS device connection cable has D-9 male connector and switchable resistors are inside the connector cover.

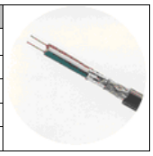
Note: that the cable ends needs the terminating resistors which are for suppressed reflection. Here are some other PROFIBUS installation rules:

Figure 6 Some rules for PROFIBUS installation

Cable type:

For new installations, use cable type A exclusively.

	Type A	Type B	
Wave impedance R_w	135...165	100...130	Ohm
Capacitance/unit length C'	< 30	< 60	pF/m
Loop resistance R'	110	--	Ohm/km
Core diameter d	0.64	0.32	mm
Core cross section q	> 0.34	>0.22	mm²



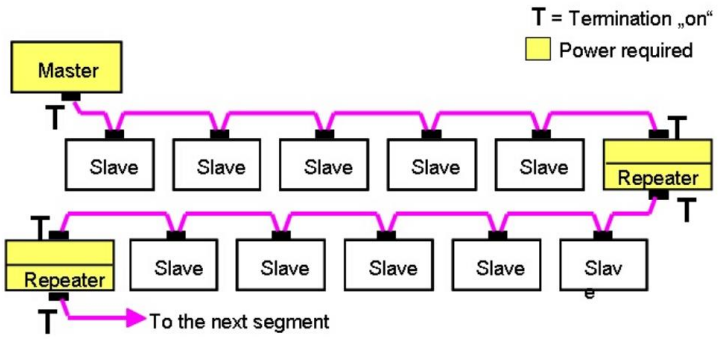
Cable length defines the maximum speed:

Baud rate in kbit/s	Max. length, cable type A	Max. length, cable type B
9.6	1200 m	1200 m
19.2	1200 m	1200 m
45.45	1200 m	1200 m
93.75	1200 m	1200 m
187.5	1000 m	600 m
500	400 m	200 m
1500	200 m	70 m
3000	100 m	--
6000	100 m	--
12000	100 m	--

It is easy to strip off insulation from Fast-Connect (FC) cables with a special tool.

Cable marked as suitable for Fast-Connect (FC)

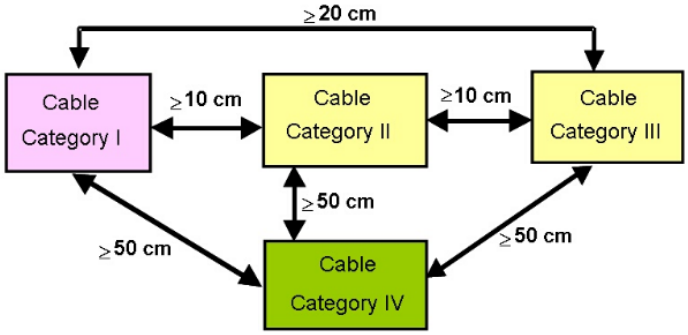
A maximum of 32 participants may be connected on any one segment. These participants include not only the stations (e.g. DP masters, DP slaves) but also the individual repeaters or FO C converters. A maximum of 126 stations can be addressed on a PROFIBUS



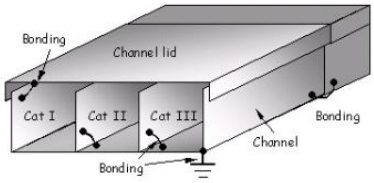
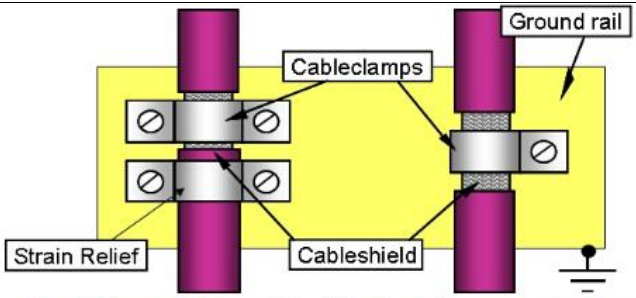
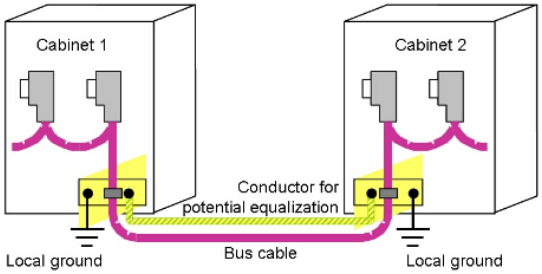
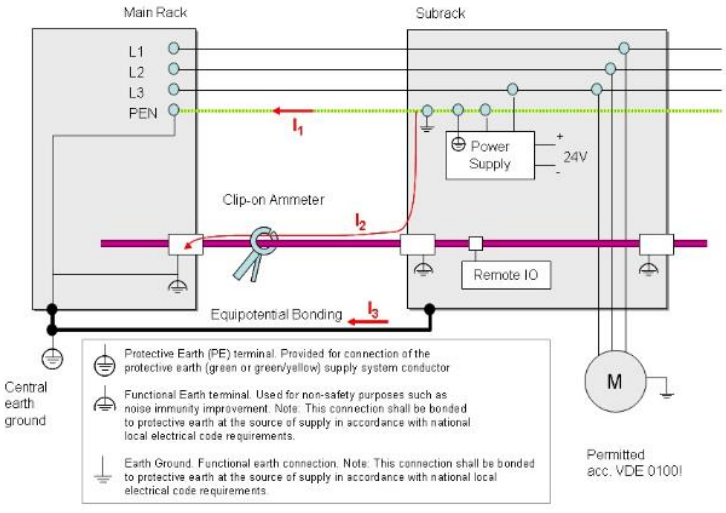
Install other cables far enough away:

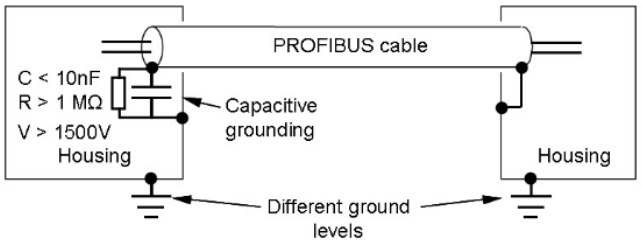
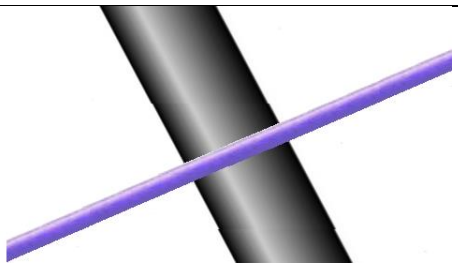
- Category I: signal cables (like PROFIBUS cables)
- Category II: low voltage
- Category III: high voltage and high frequency
- Category IV: overhead lines

When cables are laid in a common channel,



Distances between the cables of different categories

distances must be respected.	
If the metallic cable channel is divided into different parts, the cables can be laid directly alongside each other	 Separated cable channels
All incoming cable shields must be connected to ground as close as possible to where they enter the cabinet. The clamps must ensure large-area connection of the cable shield to the cabinet's frame ground.	 Grounding of the cable shield at the entry in the cabinet
Potential equalization lines should be laid parallel to the bus cable and as near as possible, so that the area between the two cables is as small as possible.	 Installation of a conductor for potential equalization
If the building LV distribution system is TN-C (4-core system) with PEN wire (combined neutral and protective ground), measure the PROFIBUS cable current with current probe. In practice, over 30 mA of current on the shield is viewed as problematic. Current in excess of 300 mA can heat up the cable unduly and be the cause of fire damage.	

If have too high PROFIBUS cable shield current: • improve Potential equalization or • use capacitive grounding in one end • or use TN-S (5-core LV system)	 Capacitive grounding of the schield
Cross the other cables at right angles.	

6 Profibus converter description

6.1 Wago 750-8216/025-001 controller

- Two Ethernet interfaces and an integrated switch enable line topology wiring.
- An integrated Webserver provides user configuration options, while displaying controller status information.
- Programming standard IEC 61131-3, when using PROFIBUS protocol with WAGO-I/O-PRO (Codesys) V2.3
- RS-232/RS-485
- Linux operating system
- Micro SD memory card and remote programming/updating is possible.
- Firewall, OpenVPN and IPsec features
- Dimensions: H 71,9 mm x W 124 mm (with 600 module) x D 100 mm
- Weight 267 g
- Enclosure IP20, material polycarbonate, polamide 6.6
- Operating temperature -20 … 60 °C

Fieldbus/System Indicating Elements

Designation	Color	Description
SYS	Red/Green/ Orange/Off	System status
RUN	Red/Green/ Orange/Off	PLC program status
I/O	Red/Green/ Orange/Off	Local bus status
MS	Red/Green/ Orange/Off	Module status
NS	Red/Green/ Orange/Off	Without function
CAN	Red/Green/ Orange/Off	CANopen status
BF	Red/Green/ Orange/Off	PROFIBUS status
DIA	Red/Green/ Orange/Off	PROFIBUS Diagnostics
U4	Red/Green/ Orange/Off	User LED 4, programmable using function blocks from the WAGO libraries to control the LEDs
U3	Red/Green/ Orange/Off	User LED 3, programmable using function blocks from the WAGO libraries to control the LEDs
U2	Red/Green/ Orange/Off	User LED 2, programmable using function blocks from the WAGO libraries to control the LEDs
U1	Red/Green/ Orange/Off	User LED 1, programmable using function blocks from the WAGO libraries to control the LEDs

The BF LED indicates following diagnostics:

Status	Explanation	Solution
Green	Error-free PROFIBUS communication	---
Red	No PROFIBUS communication taking place. The PROFIBUS interface is establishing the baud rate.	Ensure that communication with the PROFIBUS master is error-free.
Red, flashing	PROFIBUS communication has been established, but no process data is being exchanged.	Eliminate any parameterization or configuration errors and start the device PLC.
Off	The PROFIBUS interface was not included in the configuration and is therefore deactivated.	---

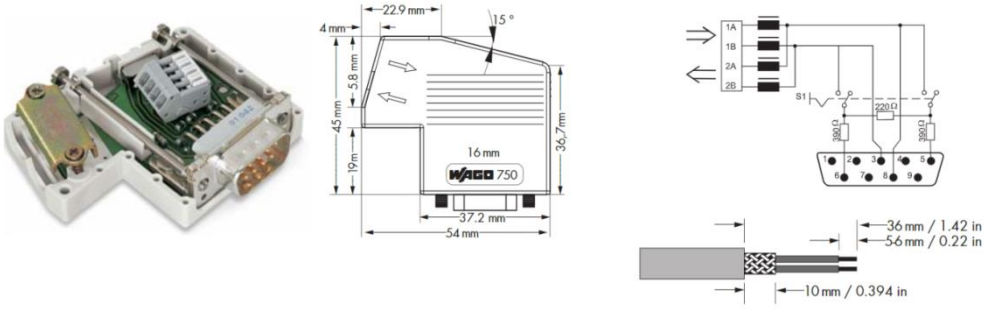
The DIA LED indicates following diagnostics:

Status	Explanation	Solution
Green	No PROFIBUS diagnostics	---
Red	PROFIBUS diagnostics present.	---
Off	The PROFIBUS interface was not included in the configuration and is therefore deactivated.	---

6.2 Wago 750-960 fieldbus connector

The fieldbus connector has the following features:

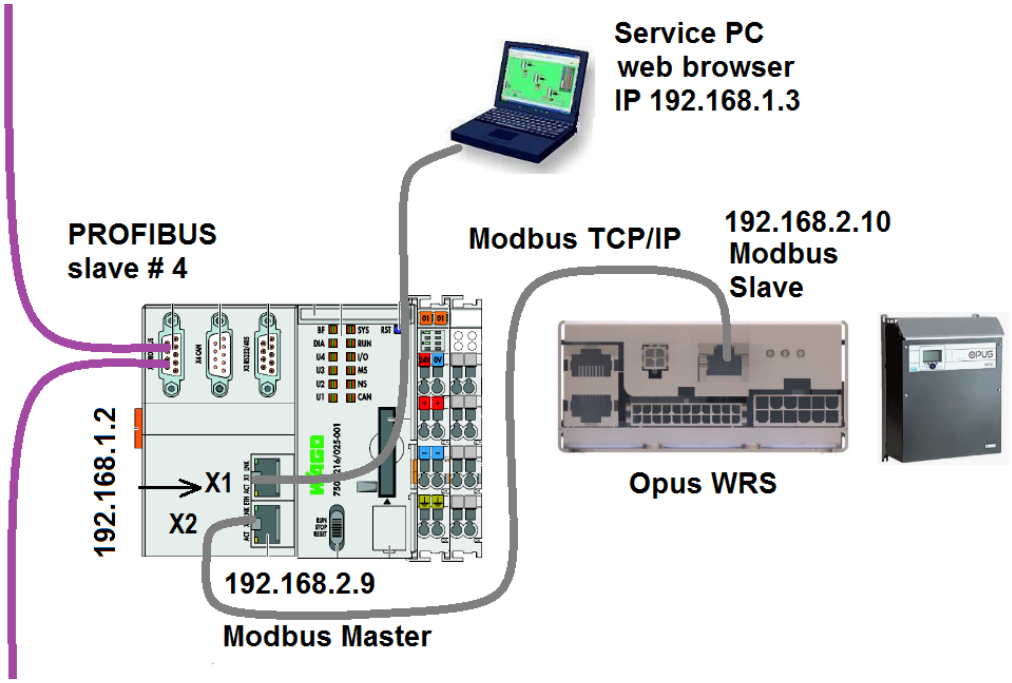
- 2 horizontal cable entries.
- One input and one output.
- Fast and maintenance-free CAGE CLAMP® connection, can be held in the open position with the help of an actuation slide mechanism.
- Externally operable switch to activate and/or deactivate the network terminating resistor.



6.3 Data cables and IPs in protocol converter application

The Wago controller Ethernet is defined that the lower RJ-45 port X2 is for Modbus IP master communication with Enedo VIDI/OPUS which is slave. This is a separate subnet and therefore the IP-addresses can be constant in both ends (Wago and Enedo). The upper RJ-45 port X1 is free for use the converter's WebVisu or Wago Web-based Management (WBM)

Figure 7 Connections between Wago PLC and VIDI+



6.4 Powering Wago

Wago 750-8216 controller auxiliary voltage is 24 VDC. It can vary between 18.0 - 31.2V (-25+30%). Current consumption is 120 mA with this application.

The 24VDC power supply to the PLC is supplied via 48/24VDC converter with battery backup ensuring the operation of the SCADA connection during mains supply failure.

Figure 8 24VDC power supply to the PLC unit

Position	Description
1	System supply DC 24 V (-25 % … +30 %)
2	System supply 0 V
Field supply	
3	24 V (-15 % / +20 %)
4	0 V
5	Optional ground potential

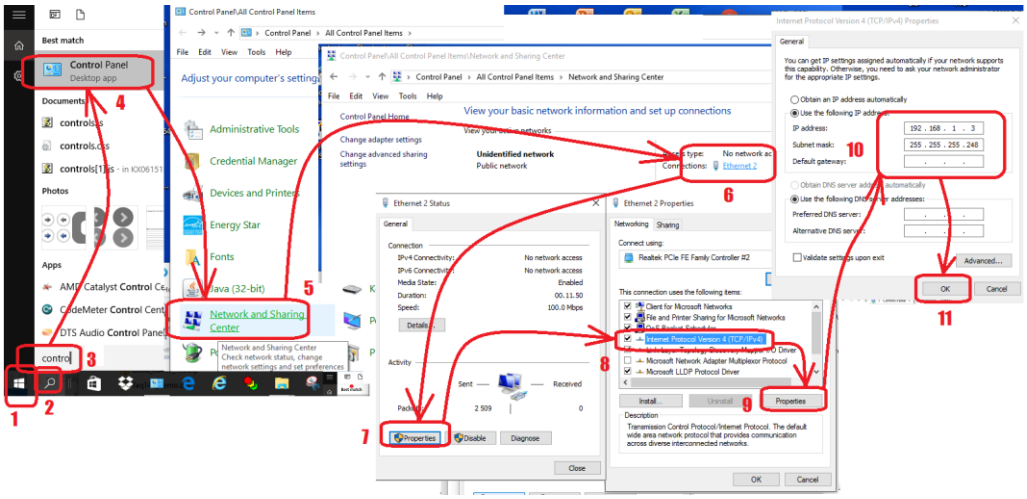
7 Commissioning

7.1 Defining the IP addresses and routing (if necessary)

In the beginning the service computer must be directly connected to the Wagon's upper X1 RJ-45 port. The cable is an ordinary (direct) data cable. The factory setting of the Wago IP address port X1 is 192.168.1.2, so the address of the computer can be for example 192.168.1.3.

When the RJ-45 cable is connected the computer's IP setting in Windows 7 version can be checked with following instruction:

Figure 9 Actions how to set/check IP settings of the computer



After this you can enter to the Wago WBM by calling the factory setting ip "**192.168.1.2/wbm**" by web browser for example MS Explorer.

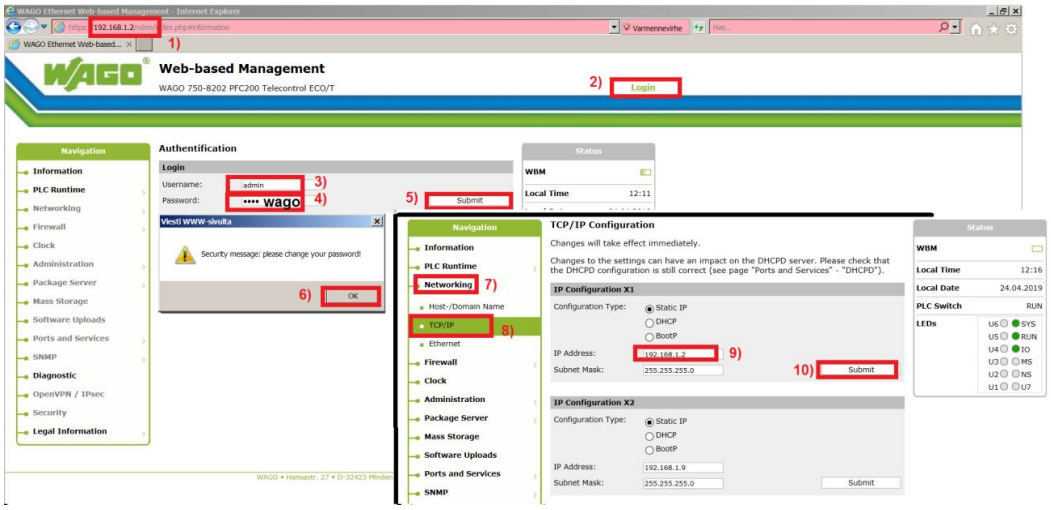
Note: It is not allowed to use same subnet address in substation and in OPUS network if Wago ports X1 and X2 are in separated connection. This means for example that if substation IP is 192.168.1.x the Opus IP must be different for example 192.168.2.x (netmask 255.255.255.0).

Changing IP address of the PLC

See instructions in the points 1-10 of the Figure 10 to change IP address of the Wago PLC

Note: In the Figure 10 are shown a username (admin) and password (wago) to a login information

Figure 10 Setting IP address to the Wago PLC unit



Note: RJ-45 port X1 is needed only for configuration. This means that the change of IP address is not normally necessary.

VIDI+ communicated through the PLC

It is also possible to change the Wago internal routing so that VIDI can be communicated through the Wago PLC. In this case the Opus gateway must be set to 192.168.2.9 which is the IP address of the Wago port X2 and in the computer's COMMAND program must be given ROUTE ADD command.

In the Figure 11 point 2) defines the substation subnet address which is in terminal X1. Routing Gateway address 5) must be equal like address 2).

Figure 11 PLC IP address settings

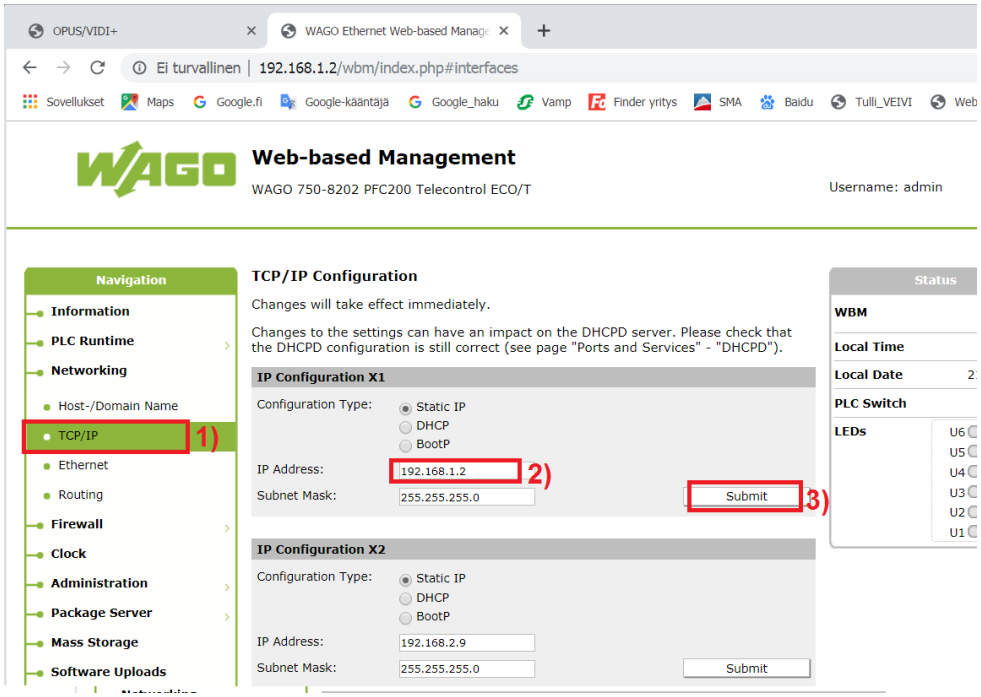
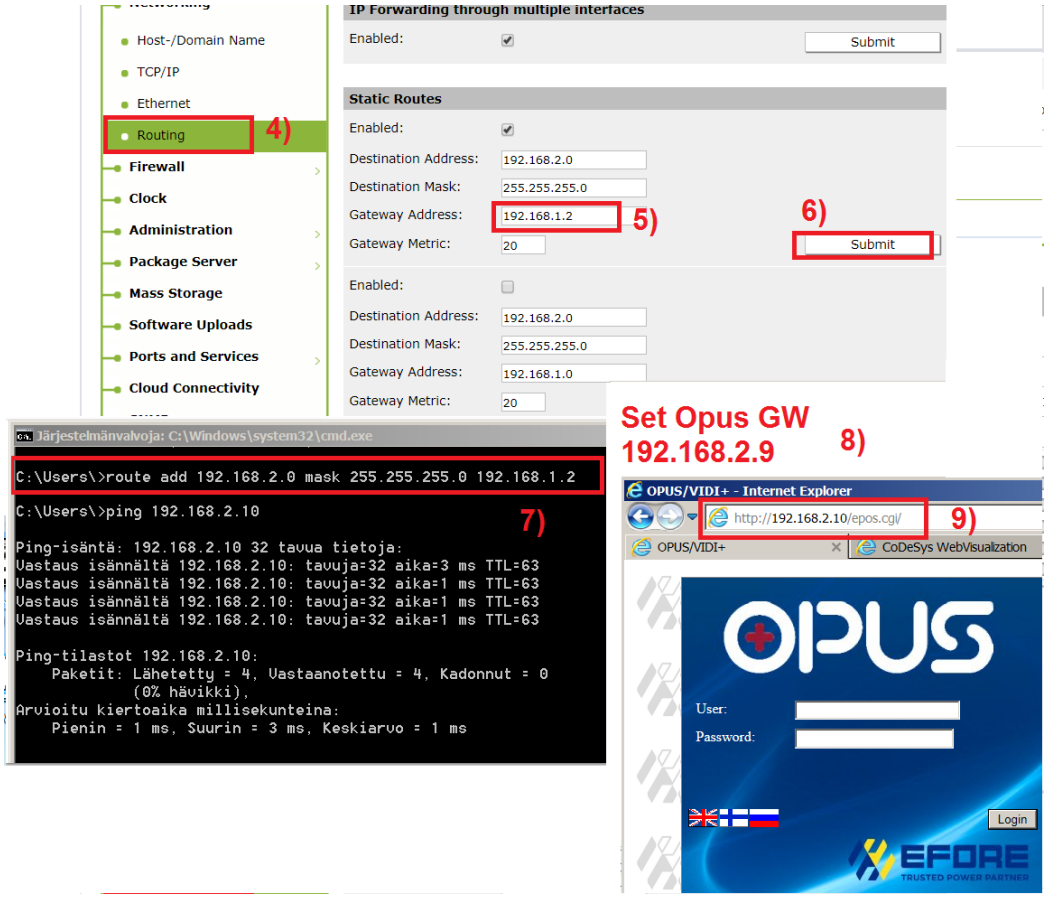


Figure 12 Setting/actions to get VIDI be communicated through the PLC



7.2 Defining the PROFIBUS slave address

Because the PROFIBUS converter is designed for DP-V0 commands, the slave address is entered manually without the master being able to do it. It is very important to design the PROFIBUS network so that all slaves have unique addresses and each segment has maximum 32 participants containing masters, slaves (= stations) and repeaters, which have no station address. PROFIBUS can handle maximum 126 stations. If there is need to connect more devices many separate buses can be used or for example DP/PA link and PROFIBUS PA for controlling simpler instruments.

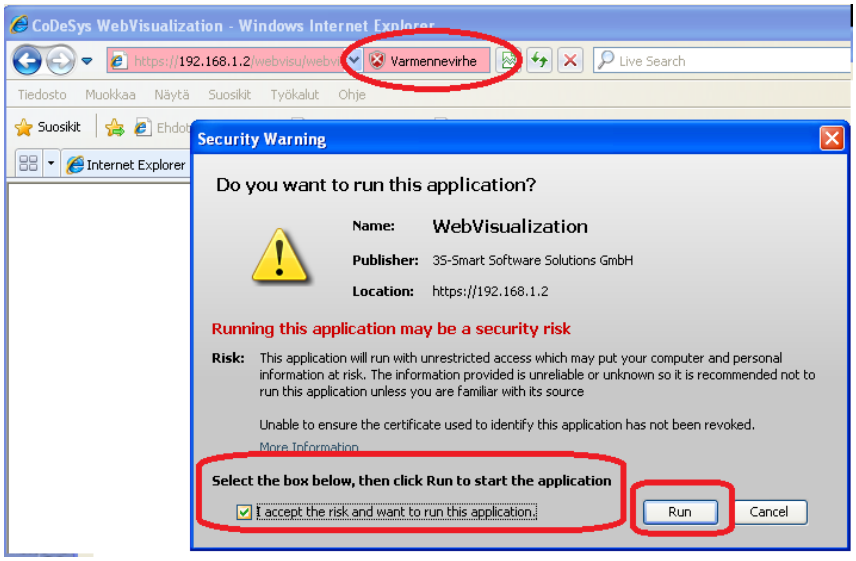
The PROFIBUS slave address can be changed by using browser and WebVisu Server application on the PLC green color “PROFIBUS Slave Address:” cell. See the chapter 7.3 how to enter to the WebVisu.

After changing the PROFIBUS slave address the new setting is valid only after the CPU cold start.

7.3 Checking the OPUS Modbus registers on Wago WebVisu

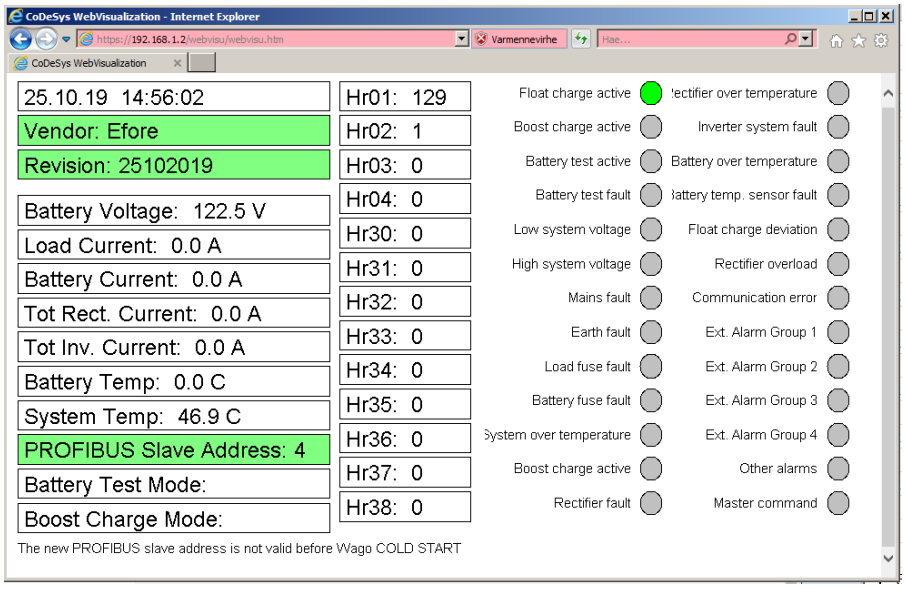
The Wago WebVisu Server which shows all OPUS Modbus registers can be entered by using MS Explorer browser (all browser doesn’t work well) and the computer must have Java. Calling of the Wago PLC is done by giving its IP address alone to the browser’s address field. Running Java causes warnings which must be passed. It is not absolutely necessary in commissioning to use the Wago WebVisu Server but it is useful.

Figure 13 Connection to WebVisu application in the Wago PLC



All Modbus registers, measurements and the most important alarms are visible in Wago WebVisu sheet.

Figure 14 View from the WebVisu application showing VIDI+ information



7.4 Loading the GSD file to the MASTER and test the communication

After loading the GSD file, the correct variables, number of the variables and order of the variables must be chosen in master's configuration. More information about the GSD file and configuration is in the chapter 5.3 General Station Description File.

When the PROFIBUS communication works, in Wago CPU the upmost left BF LED is GREEN. When the communication doesn't work the BF LED is blinking RED.

Steps to configure PLC in the PROFIBUS Master Simulator software:

1) Select *File**Open GSD…* (see step 1) in the Figure 15)
2) Find a correct GSD file (see step 2) in the Figure 15)
3) Press *Open* (see step red 3) in the Figure 15)
4) Select from the Module List one by one needed variables in correct order and press *Insert* after each variable selection (see steps 4) and 5) in the Figure 15)

Using Wago's GSD file:

If Wago's A206_V10.GSD file is used, you will need to select the right variable type, numbers of the variables and order of the variables among the hundreds of alternatives (see red markings 4) and 5) in the Figure 15).

Using Enedo_A206_V10.GSD file:

When using the Enedo_A206_V10.GSD only four alternatives in correct order need to be activated. If this doesn't work, you must use Wago's GSD file.

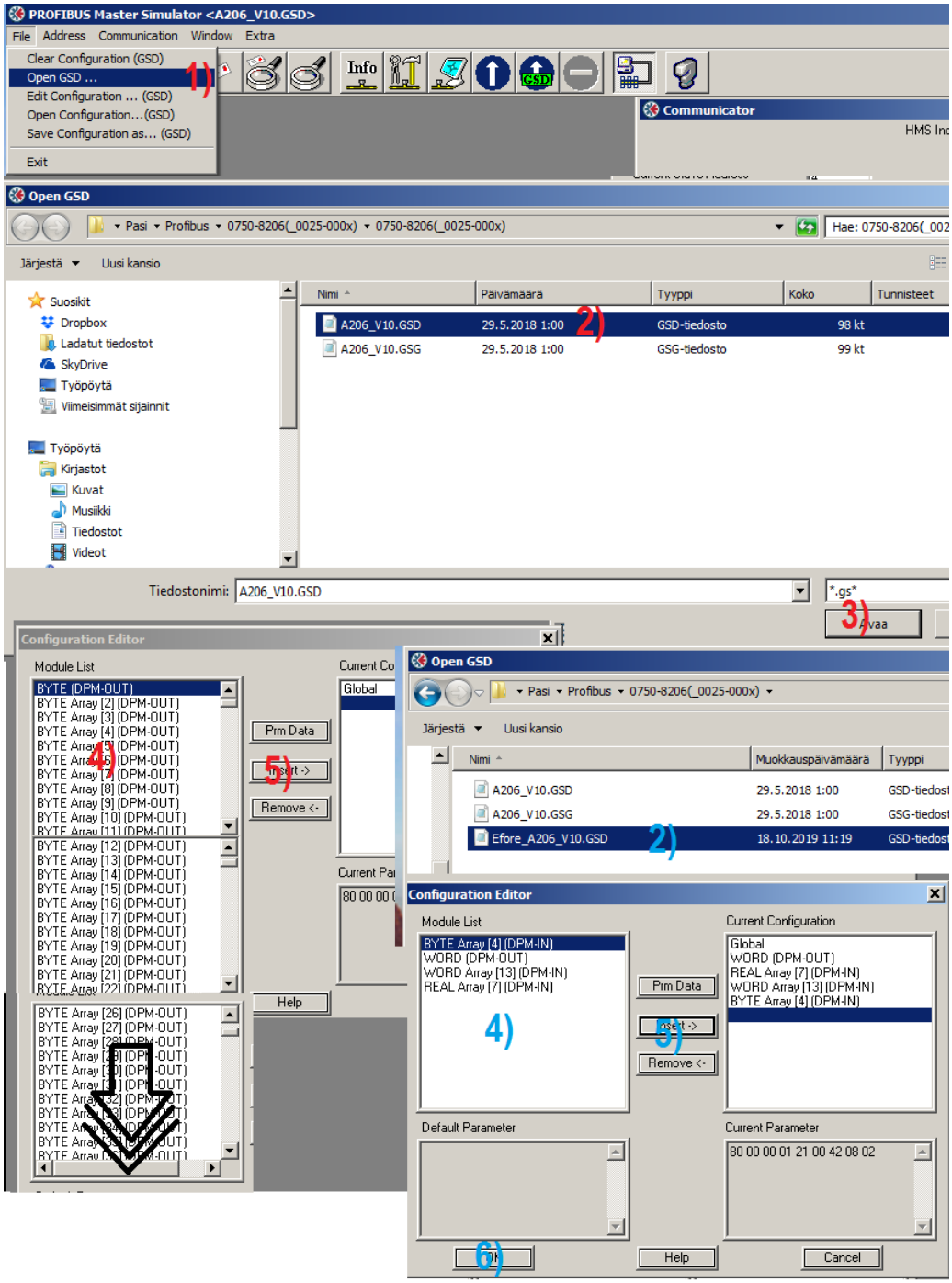
The correct order is:

1. Word Out
2. Real array 7 In
3. Word array 13 In
4. Byte array 4 In

Note: If the configuration selection order is wrong, the master accept it, but the variables are then in wrong places. This can mean that for example real numbers are in place of the words.

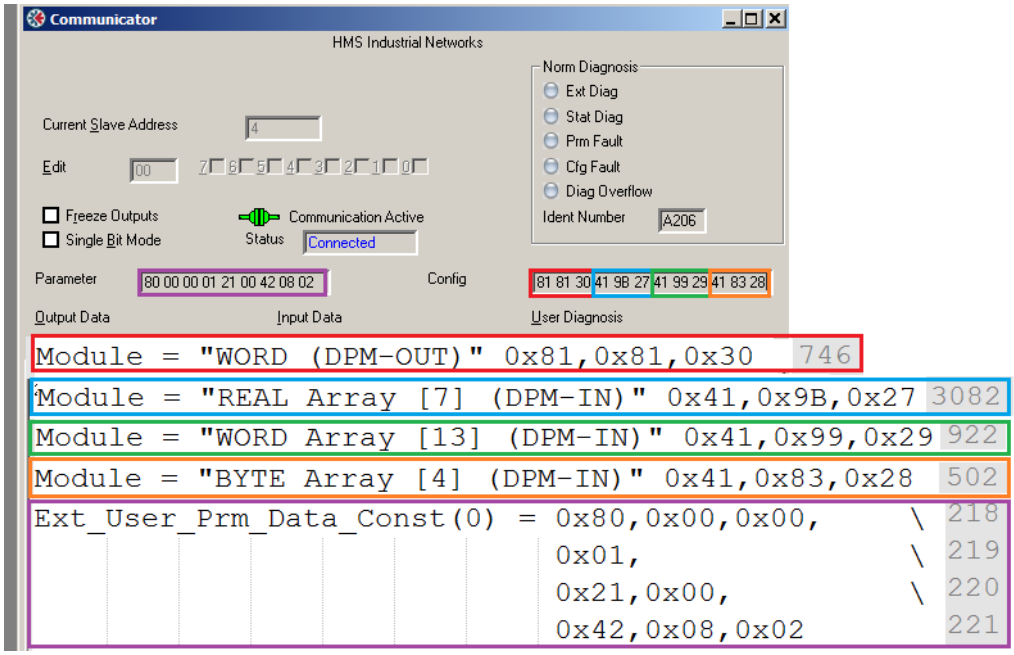
Note: The screen shoot in the Figure 15 is made by using HMS Industrial Networks / Anybus Master Simulator software which is not included to the delivery.

Figure 15 Operations when loading a GSD file to a PLC



Variable and module types of the GSD file configuration are also expressed in the Figure 16. The rightmost numbers are the line numbers of module definitions in Wago's GSD file.

Figure 16 Variable and module types of the GSD file configuration

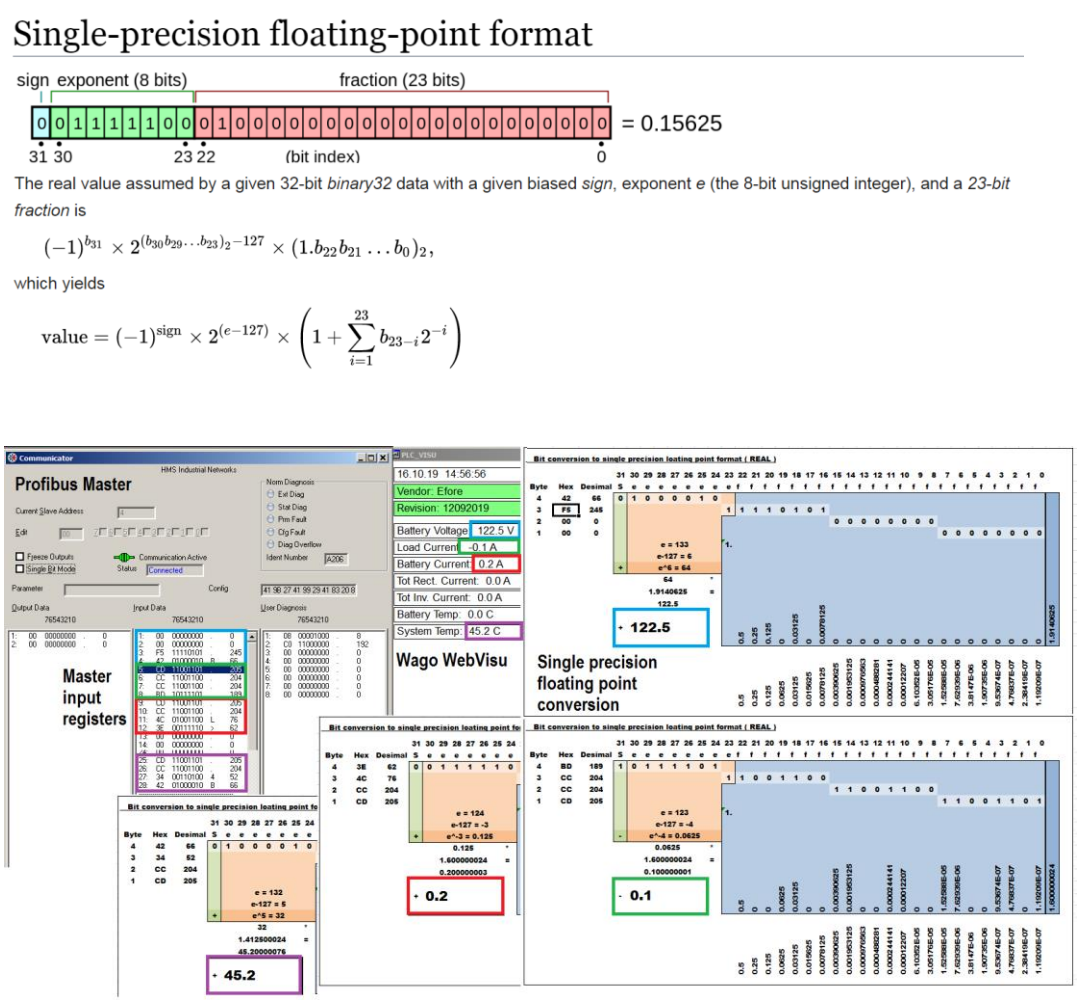


7.5 In CLIENT or SCADA programming, check that all variables come properly

Profibus handles the registers in bytes and GSD file defines the modules which define the byte formats. There is a possibility that the bytes have wrong offset or wrong order. In the Profibus converter software there is three types of variables which are input and output registers in master side: 16 bits words, 32 bits single precision floating point (real) and byte array/bits.

- Words are that the most significant (>255) byte is first (smaller order) and the last significant byte (<256) is the last (next).
- Reals are in 4 bytes format. The first byte is sign and exponent, the next three bytes contain a fraction
- In a byte array the first alarm is in the first byte etc.

Figure 17 Example of a Real type variable



Testing real type of variables.

8 Configure the Client device

Find correct data points

The following list contains all registers and signals that are defined in the Profibus converter program.

2) Measurements:

	GSD Configuration:	Module = "REAL Array [7] (DPM-IN)" 0x41,0x9B,0x27			
No:	Definition:	Profibus register (Slave):	Profibus Format:	Modbus Holding Register:	Efore definition:
1	System (Battery) Voltage	Output Data 1-4	Float32	HR10	System voltage
2	Load Current	Output Data 5-8	Float32	HR11	Load current
3	Battery Current	Output Data 9-12	Float32	HR12	Battery current
4	Total Rectifier Current	Output Data 13-16	Float32	HR13	Total rectifier current
5	Total Inverter Current	Output Data 17-20	Float32	HR14	Total inverter current
6	Battery Temperature	Output Data 21-24	Float32	HR15	Battery temperature
7	System Temperature	Output Data 25-28	Float32	HR16	System temperature

3) Word registers:

	GSD Configuration:	Module = "WORD Array [13] (DPM-IN)" 0x41,0x99,0x29			
No:	Definition:	Profibus register (Slave):	Profibus Format:	Modbus Holding Register:	Efore definition:
1	Data Version Counter	Output Data 29-30	Word16	HR1	Data Version Counter
2	Operation Mode	Output Data 31-32	Word16	HR2	Operation Mode
3	Battery Test State	Output Data 33-34	Word16	HR3	Battery Test State
4	Battery Charge State	Output Data 35-36	Word16	HR4	Battery Charge State
5	System Voltage Alarms	Output Data 37-38	Word16	HR30	System voltage alarms
6	System Fault Alarms	Output Data 39-40	Word16	HR31	System fault alarms
7	Miscellaneous System Alarms	Output Data 41-42	Word16	HR32	Miscellaneous system alarms
8	Rectifier Alarms	Output Data 43-44	Word16	HR33	Rectifier alarms
9	Inverter System Alarms	Output Data 45-46	Word16	HR34	Inverter system alarms
10	Other Modules Alarms	Output Data 47-48	Word16	HR35	Other modules alarms
11	Battery Alarms	Output Data 49-50	Word16	HR36	Battery alarms
12	Low Voltage Disconnection Alarms	Output Data 51-52	Word16	HR37	Low voltage disconnection alarms
13	External Alarms	Output Data 53-54	Word16	HR38	External alarms

4) Alarm and State Bytes:

	GSD Configuration:	Module = "BYTE Array [4] (DPM-IN)" 0x41,0x83,0x28			
No:	Definition:	Profibus register (Slave):	Profibus Format:	Modbus Holding Register:	Efore definition:
1	Float Charge Active	Output Data 55.0	Byte8	HR2.0	Float Charge Active
2	Boost Charge Active	Output Data 55.1	Byte8	HR2.2	Boost Charge Active
3	Bottery Test Active	Output Data 55.2	Byte8	HR2.1	Bottery Test Active
4	Battery Test Fault	Output Data 55.3	Byte8	HR36.4	Battery Test Fault
5	Low System Voltage	Output Data 55.4	Byte8	HR30.2	Low System Voltage
6	High System Voltage	Output Data 55.5	Byte8	HR30.3	High System Voltage
7	Mains Fault	Output Data 55.6	Byte8	HR30.0	Mains Fault
8	Earth Fault	Output Data 55.7	Byte8	HR31.0	Earth Fault
9	Load Fuse Fault	Output Data 56.0	Byte8	HR31.1	Load Fuse Fault
10	Battery Fuse Fault	Output Data 56.1	Byte8	HR31.2	Battery Fuse Fault
11	System Over Temperature	Output Data 56.2	Byte8	HR31.7	System Over Temperature
12	Any Boost Charge Active	Output Data 56.3	Byte8	HR32.0	Any Boost Charge Active
13	Rectifier Fault	Output Data 56.4	Byte8	HR33.5	Rectifier Fault
14	Rectifier Over Temperature	Output Data 56.5	Byte8	HR33.7	Rectifier Over Temperature
15	Inverter System Fault	Output Data 56.6	Byte8	HR34.5	Inverter System Fault
16	Battery Over Temperature	Output Data 56.7	Byte8	HR36.5	Battery Over Temperature
17	Battery Temp. Sensor Fault	Output Data 57.0	Byte8	HR36.7	Battery Temp. Sensor Fault
18	Float Charge Deviation	Output Data 57.1	Byte8	HR30.4	Float Charge Deviation
19	Rectifier Overload	Output Data 57.2	Byte8	HR31.3	Rectifier Overload
20	Communication Error	Output Data 57.3	Byte8	HR33.0	Communication Error
21	Ext. Alarm Group 1	Output Data 57.4	Byte8	HR38.0	Ext. Alarm Group 1
22	Ext. Alarm Group 2	Output Data 57.5	Byte8	HR38.1	Ext. Alarm Group 2
23	Ext. Alarm Group 3	Output Data 57.6	Byte8	HR38.2	Ext. Alarm Group 3
24	Ext. Alarm Group 4	Output Data 57.7	Byte8	HR38.3	Ext. Alarm Group 4
25	Other Alarms	Output Data 58.0	Byte8	HR30-HR38	All other alarms are not listed above

1) Master Command Word:

	GSD Configuration:	Module = "WORD (DPM-OUT)" 0x81,0x81,0x30			
No:	Definition:	Profibus register (Slave):	Profibus Format:	Modbus Holding Register:	Definition:
1	Master Command for testing	Input Data 1-2	Word16.0		Only connected to the Web Visu Lamp