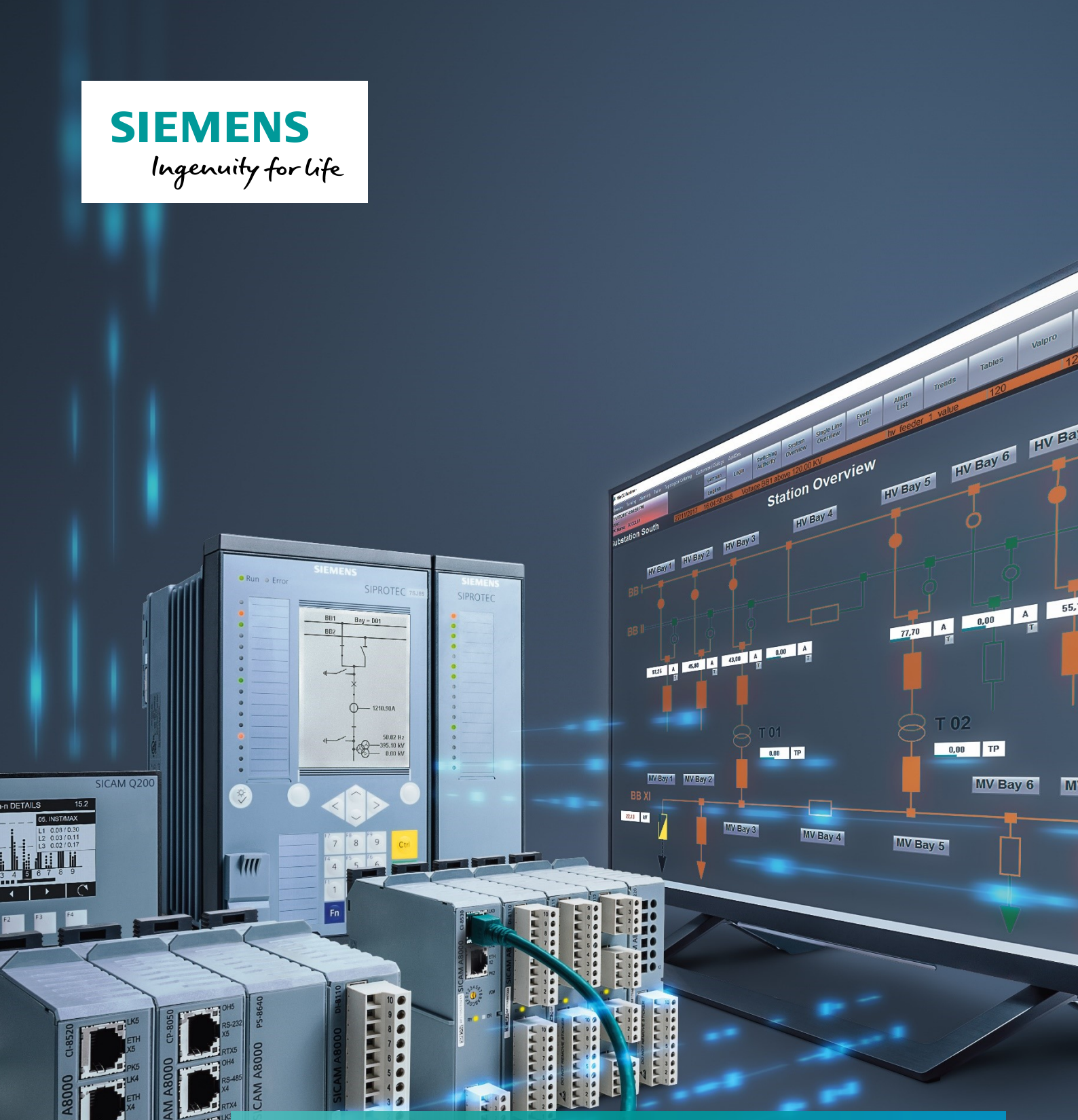
SIEMENS

Ingenuity for life



Network Configuration for a 7SS85 CU with up to 45 Measuring Points

www.siemens.com/siprotec

SIPROTEC 5 Application

Network Configuration for a 7SS85 CU with up to 45 Measuring Points

APN-088, Edition 1

Content

1 Network Configuration for a 7SS85 CU with up to 45 Measuring Points

1.1 Introduction

This application note describes the network configuration for a busbar protection central unit 7SS85 CU when more than one ethernet switch is required. This configuration doesn't foresee any seamless communication redundancy and uses one of the switches as IEEE 1588 PTP grandmaster clock at the same time.

The switch and grand master clock functionalities are covered by a Ruggedcom RSG2488 and for additional switches the Ruggedcom RST2228 is recommended. Redundant interswitch communication forming an RSTP ring is also preferred.

The Ruggedcom RSG2488 when using PTP module has a maximum of 24 ports available. Two ports are dedicated to the interlink communication, which left 22 ports available and all of them can be used for the connection of SIPROTEC 5 devices (ports for 100Mbit/s with PTP support).

The Ruggedcom RST2228 has a maximum of 28 ports available but only 24 are usable for the connection of SIPROTEC 5 devices (ports for 100Mbit/s with PTP support), as the other four ports are for SFP/SFP+ transceivers, which are not recommended for IEEE 1588, unless they utilize 1 Gbit/s optical SFPs. Two of those GB ports can be used for the interlink communication though. Hence, for the connection of SIPROTEC 5 devices 22 ports in the RSG2488 and 24 in the RST2228 will be available, which means that a maximum of 43 merging units plus 3x ETH-BD-2FO from the central unit can be connected when using only two switches (46 ports available in total for SIPROTEC 5 devices).

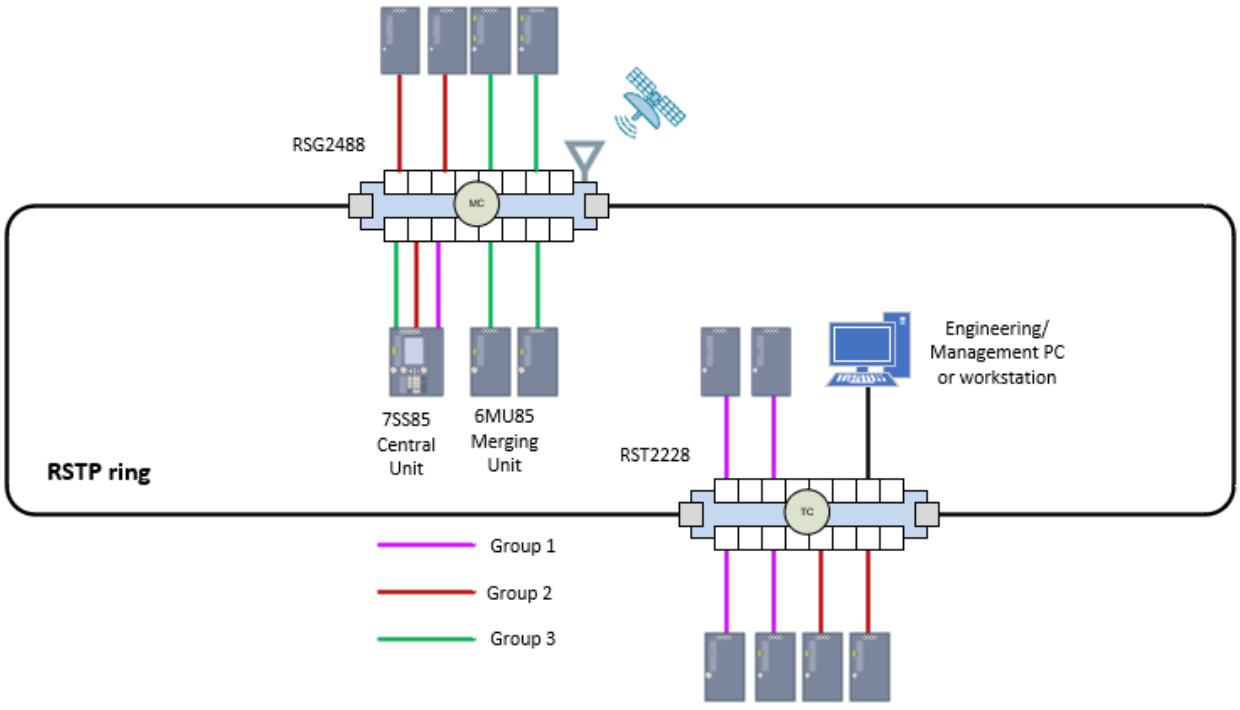


Figure 1. Configuration overview

The 45 measuring points can be still be reached if a couple of merging units publish 2x 3-phase currents, which is especially practicable for coupler bays with two current transformers. As this is an optimized configuration, it is the one described in this application note. In case that more than 43 merging units are required, an additional RST2228 switch must be integrated.

1.2 Preconditions

- Two ethernet switches, at minimum one RSG2488 in the role of an IEEE 1588 PTP grandmaster clock and one RST2228 in the role of an IEEE 1588 PTP peer-to-peer transparent clock.
- Distributed busbar protection with a central unit (CU) 7SS85 and up to 43 Bays / merging units (MU) 6MU85. To achieve the 45 measuring points, it is proposed to connect 2 x 3-ph currents to the same merging unit for two devices.
- 7SS85 CU equipped with 3 x ETH-BD-2FO-Modules
- MUs equipped with 1 x ETH-BD-2FO-Module.
- One Engineering / Management PC for configuration and monitoring of all protection devices and switches. It will be connected to one of the two ports for SFP/SFP+ transceivers available in the RST2228, equipped with a 1 Gbit/s copper SFP transceiver.
- Optionally, one Diagnosis PC for diagnosis / testing tools such as Wireshark. It would be connected to one of the two ports for SFP/SFP+ transceivers available in the RST2228. Keep in mind that if PTP synchronization is required (for use with DANEO or Omicron simulation, for example) a 1 Gbit/s optical SFP and the conversion to the appropriate PC interface (normally RJ45) will be required.

1.3 Design

The process bus client in each ETH-BD-2FO module in the 7SS85 CU will subscribe to up to 15 merging units. Thus, three communication groups will be created, each for one ETH-BD-2FO module of the 7SS85 CU and its corresponding merging units. The transmission of measurements and binary information takes place within the same group and not with devices of other groups. The separation will be achieved with the use of VLANs.

There is no limitation or precondition with regard to the connection of the devices to the switches. The shortest path would be preferred in case the switches are installed in different locations.

The standard SFPs of the ETH-BD-2FO modules of the SIPROTEC 5 devices can be connected to any port with the following characteristics:

- Port type: LC
- Mode: MM (Multi-Mode)
- Speed: 100 Mbps,
- Interface: FX
- Wavelength: 1310 nm

The use of switchports for SFP/SFP+ Transceivers is not possible as the versions for 100Mbit/s are not recommended for use with IEEE 1588 (see additional information in the SIMATIC NET, Networking Components, RUGGEDCOM SFP Transceivers, Catalog C79000-G8976-1251-24).

Therefore, following port assignment is proposed:

Swith	Port	Connected Device	Port Type	Description
RST 2228	0/1	RSG 2488	SFP/SFP+ Transceivers RUGGEDCOM SFP1122-1SX	1000Base-SX SFP – MM, 850 nm, LC, 0.5 km
	0/2	RSG 2488	SFP/SFP+ Transceivers RUGGEDCOM SFP1122-1SX	1000Base-SX SFP – MM, 850 nm, LC, 0.5 km
	0/3	PC Engineering	SFP/SFP+ Transceivers RUGGEDCOM SFP1112-1	1000Base-T SFP – RJ45, 100 m not recommended for IEEE 1588
	0/4	PC Diagnosis	SFP/SFP+ Transceivers RUGGEDCOM SFP1112-1	1000Base-T SFP – RJ45, 100 m not recommended for IEEE 1588
	1/1	MU01	RUGGEDCOM RMM2942-4LC2	100Base-FX, MM, 1310 nm, LC, 2 km
	1/2	MU02		
	1/3	MU03		
	1/4	MU04		
	2/1	MU05	RUGGEDCOM RMM2942-4LC2	100Base-FX, MM, 1310 nm, LC, 2 km
	2/2	MU06		
	2/3	MU07		
	2/4	MU08		
	3/1	MU09	RUGGEDCOM RMM2942-4LC2	100Base-FX, MM, 1310 nm, LC, 2 km
	3/2	MU10		
	3/3	MU11		
	3/4	MU12		
	4/1	MU13	RUGGEDCOM RMM2942-4LC2	100Base-FX, MM, 1310 nm, LC, 2 km
	4/2	MU14		
	4/3	MU15		
	4/4	MU16		
	5/1	MU17	RUGGEDCOM RMM2942-4LC2	100Base-FX, MM, 1310 nm, LC, 2 km
	5/2	MU18		
	5/3	MU19		
	5/4	MU20		
	6/1	MU21	RUGGEDCOM RMM2942-4LC2	100Base-FX, MM, 1310 nm, LC, 2 km
	6/2	MU22		
	6/3	MU23		
	6/4	MU24		

Figure 2. RST2228 Port assignment

Swith	Port	Connected Device	Port Type	Description
RSG 2488	1/1	PTP Module	RUGGEDCOM RMM2431-5PTP	Protocols: PTP and NTP Synchronization Sources: NTP, IEEE 1588 v2, IRIG-B PWM, GPS Port Type: BNC
	1/2			
	1/3			
	1/4			
	2/1	7SS85 CU Port E	RUGGEDCOM RMM2464-4LC2	100Base-FX, MM, 1310 nm, LC, 2 km
	2/2	7SS85 CU Port F		
	2/3	7SS85 CU Port N		
	2/4	MU25		
	3/1	MU26	RUGGEDCOM RMM2464-4LC2	100Base-FX, MM, 1310 nm, LC, 2 km
	3/2	MU27		
	3/3	MU28		
	3/4	MU29		
	4/1	MU30	RUGGEDCOM RMM2464-4LC2	100Base-FX, MM, 1310 nm, LC, 2 km
	4/2	MU31		
	4/3	MU32		
	4/4	MU33		
	5/1	MU34 (2x MP)	RUGGEDCOM RMM2464-4LC2	100Base-FX, MM, 1310 nm, LC, 2 km
	5/2	MU35		
	5/3	MU36		
	5/4	MU37		
	6/1	MU38 (2x MP)	RUGGEDCOM RMM2464-4LC2	100Base-FX, MM, 1310 nm, LC, 2 km
	6/2	MU39		
	6/3	MU40		
	6/4	MU41		
	7/1	MU42	RUGGEDCOM RMM2464-2SFP2 SFP Included:	100Base-FX SFP – MM, 1310 nm, LC, 2 km
	7/2	MU43		
	8/1	RST 2228	SFP Transceivers RUGGEDCOM SFP1122-1SX	1000Base-SX SFP – MM, 850 nm, LC, 0.5 km*
	8/2	RST 2228	SFP Transceivers RUGGEDCOM SFP1122-1SX	

* ports must be compatible with type in RST2228

Figure 3. RSG2488 Port assignment

In this example, we will use 6 VLANs for the three mentioned groups as follows:

Group 1: ETH-BD-2FO in the port E of the CU and the merging units 01 to 15

VLAN 11→ for the transmission of binary information.

VLAN 21→ for the transmission of measurements (SMV).

Group 2: ETH-BD-2FO in the port F of the CU and the merging units 16 to 30

VLAN 12→ for the transmission of binary information.

VLAN 22→ for the transmission of measurements (SMV).

Group 3: ETH-BD-2FO in the port N of the CU and the merging units 31 to 43

VLAN 13→ for the transmission of binary information.

VLAN 23→ for the transmission of measurements (SMV).

IEEE 1588 PTP Announce, Sync and Follow-Up telegrams (layer 2 multicast, without VLAN- or priority-tag) will be send from the switchports to the connected CU and MU ETH-BD-2FO modules. IEEE 1588 PTP Peer Delay Request / Response / Follow-Up telegrams (layer 2 multicast, without VLAN- or priority-tag) will be exchanged between switchport and each connected CU or MU ETH-BD-2FO module.

DIGSI, HTTP(S), SSH, Telnet and others are IP-based protocols are transmitted and received without VLAN-Tag or Priority-Tag by the Engineering / Management PC. These packets are sent with VLAN-Tag and VLAN-ID = 4 over the network. The switchport, where the PC is connected to, perform the assignment of the received untagged packets to VLAN 4 by help of a corresponding Port VLAN-ID (PVID) configuration. The switch-internal management IP interfaces of the two switches must be assigned to VLAN 4 instead of preconfigured VLAN 1, to be reached using SSH, Telnet and HTTP(S). This requires a specific VLAN configuration of the IP interfaces of the ETH-BD-2FO modules as well.

A diagnosis PC different to the PC for engineering and monitoring is proposed, as it should receive the complete layer 2 traffic. The SMV are cyclically transmitted and have high bandwidth requirements (more than 200 Mbit/s in case of more than 40 merging units). In addition, GOOSE messages are also present in the network. This constant high traffic load is a challenge for a normal computer and its management running in parallel with the DIGSI communication could overreach the performance limits of the PC. Also keep in mind, that for an accurate performance evaluation of the network other hardware tools as DANEO may be required.

In case, a single PC is used as engineering and diagnosis PC, the switchport configuration shown for the diagnosis PC shall be used. Keep in mind this could affect the performance of the DIGSI communication.

The two switches are connected via interswitch links forming an RSTP ring. The interswitch ports are optical with a bandwidth of 1 Gbit/s. For the connection of CU and MU ETH-BD-2FO modules, the two switches are equipped with optical ports with a bandwidth of 100 Mbit/s. See Figures 2. and 3.

The RSG2488 switch can be equipped optionally with a PTP-Module for synchronization via GPS or IRIG-B. This is not compulsory. The internal oscillator of the RSG2488 can also be used as a PTP time source because the CU und MUs require only a relative and not absolute synchronization. The advantage of an IRIG-B or GPS time source is to get correct timestamps in the logs of the protection devices which is not given when using the internal oscillator because of the drift.

VLAN Configuration premises:

The binary information (Layer 2, with or without priority tag) will be send out by either the CU or the MUs and received by the communication modules of the devices belonging to the same group. The telegrams will be exchanged using the VLAN 11, 12 or 13. The assignment to the corresponding VLAN is achieved using the Port-VLAN-ID (PVID) of the switchports, where the devices are connected to.

The SMV (Layer 2, multicast) will be send out by the MUs with a VLAN-Tag (VLAN-ID = 21, 22 or 23) and forwarded only to the corresponding interface of the 7SS85 CU. The streams won't be forwarded to the other MUs because it would occupy unnecessarily the bandwidth of their communication interface.

Note: the switchports where merging units are connected behave asymmetric from the communication point of view, as they receive SMV streams but don't forward them. This behavior will be reached with a special configuration using forbidden ports. A forbidden port is a port not allowed to be member of a specific VLAN. The switchports where the merging units are connected are neither member of VLAN 21, 22 nor 23 (they are forbidden ports for those VLANs) and thereby they don't send SMVs to the MUs. Nevertheless, the switchports receive SMVs of those VLANs from the MUs and transfer them because the feature "Ingress Filtering" of the switches is deactivated.

It means, that only the ports connected to the ETH-BD-2FO modules of the 7SS85 CU central unit belong to the VLANs transmitting SMV.
In our example the ETH-BD-2FO modules of the 7SS85 CU are connected to the following ports:

ETH-BD-2FO module in port E is connected to Port 2/1 of RSG2488 → member of VLAN 21
ETH-BD-2FO module in port F is connected to Port 2/2 of RSG2488 → member of VLAN 22
ETH-BD-2FO module in port N is connected to Port 2/3 of RSG2488 → member of VLAN 23

The Diagnosis PC port will be member of all VLANs to allow transmission of SMV, PTP and binary information to tools as Wireshark.

To achieve this, a table with Static VLANs must be created in the configuration of the switches, where the corresponding VLANs and forbidden ports are specified. VLANs not existing in the static table are by default allowed at all ports.

In addition, the configuration of the VLANs in the switches is completed with the configuration of the parameter *Port-VLAN-ID* (PVID) in the switchports. Each port is assigned to a native VLAN number, the Port VLAN ID (PVID). When an untagged frame enters a port, it is associated with the port's native VLAN. (see 1.4 Configuration).

Summary of the communication protocols/services of devices (IEDs/PC) and their characteristic regarding VLAN in send direction:

Type of Data	Group 1		Group 2		Group 3		Engineering PC	Diagnosis PC
	MUs	CU	MUs	CU	MUs	CU		
SMV	VLAN 21, Tagged		VLAN 22, Tagged		VLAN 23, Tagged			VLAN 21,22,23 Tagged
Binary Information	VLAN 11, Untagged or Tagged	VLAN 11, Untagged or Tagged	VLAN 12, Untagged or Tagged	VLAN 12, Untagged or Tagged	VLAN 13, Untagged or Tagged	VLAN 13, Untagged or Tagged		VLAN 11,12,13 Tagged
DIGSI, HTTPS	VLAN 4, Tagged	VLAN 4, Tagged	VLAN 4, Tagged	VLAN 4, Tagged	VLAN 4, Tagged	VLAN 4, Tagged	VLAN 4, Untagged	
PTP	Untagged	Untagged	Untagged	Untagged	Untagged	Untagged		

Figure 4. VLAN features per protocol in IEDs and PCs in send direction

Summary of configuration of the switchports according to their connectivity to the protection devices / PC / Interswitch link:

	Group 1		Group 2		Group 3		Engineering PC	Diagnosis PC	Interswitch Link
	MUs	CU	MUs	CU	MUs	CU			
Type	Trunk	Trunk	Trunk	Trunk	Trunk	Trunk	Edge	Trunk	Trunk
Port VLAN-ID	11	11	12	12	13	13	4	4	1
Member of VLAN Untagged	11	11	12	12	13	13	4	1,4,11,12,13	1
Member of VLAN Tagged	4	4, 21	4	4, 22	4	4, 23	NA	4, 11,12,13, 21,22,23,	All
Forbidden for VLAN	12,13, 21,22,23	12,13, 22,23	11,13, 21,22,23	11,13, 21,23	11,12, 21,22,23	11,12, 21,22	NA	None	None

Figure 5. VLAN features in switchports

1.4 Configuration

The VLAN configuration needs to be adapted in the switches and also in the devices participating in the network. For the devices, the parameterization will take place in DIGSI 5 if the VLAN should act on the TPC/IP level and in the IEC 61850 System Configurator if the VLAN is associated to a layer 2 service, as in the case of the sampled measured values.

1.4.1 Configuration in DIGSI 5

The VLAN settings in DIGSI must be activated and properly parametrized to the VLAN 4 as defined during the design. This VLAN can be assigned as shown below.

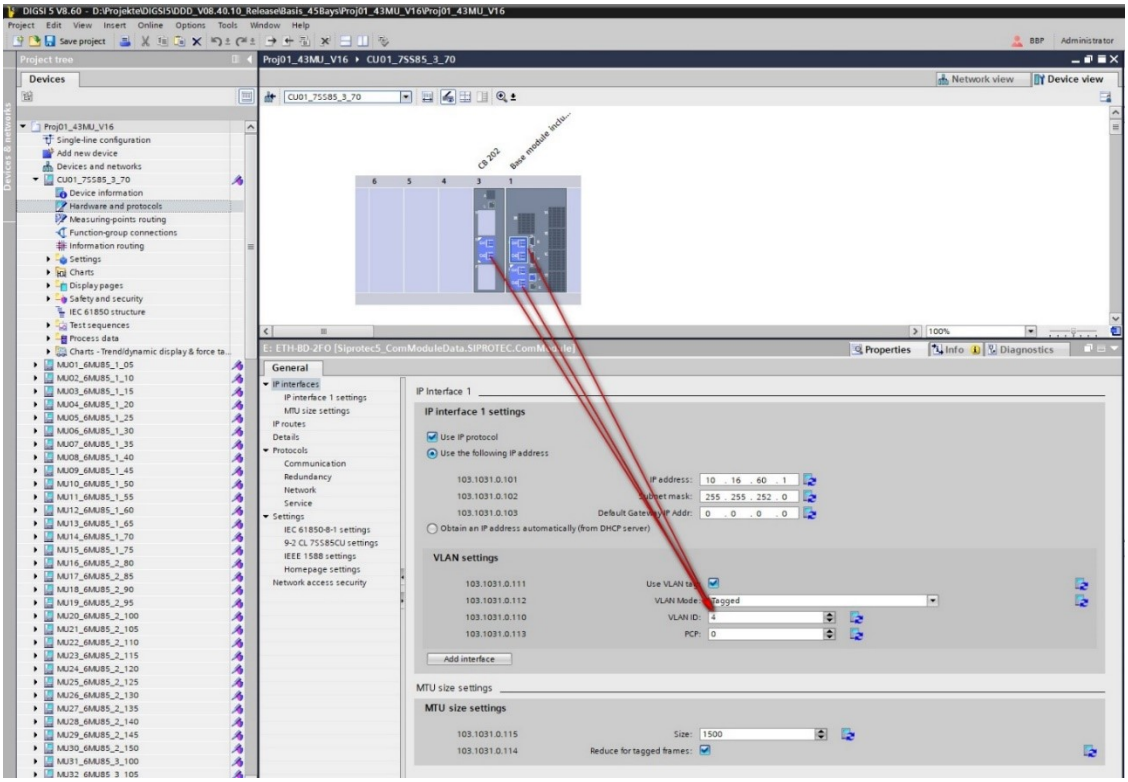


Figure 6. VLAN parameterization for ports E, F and N in 7SS85 CU

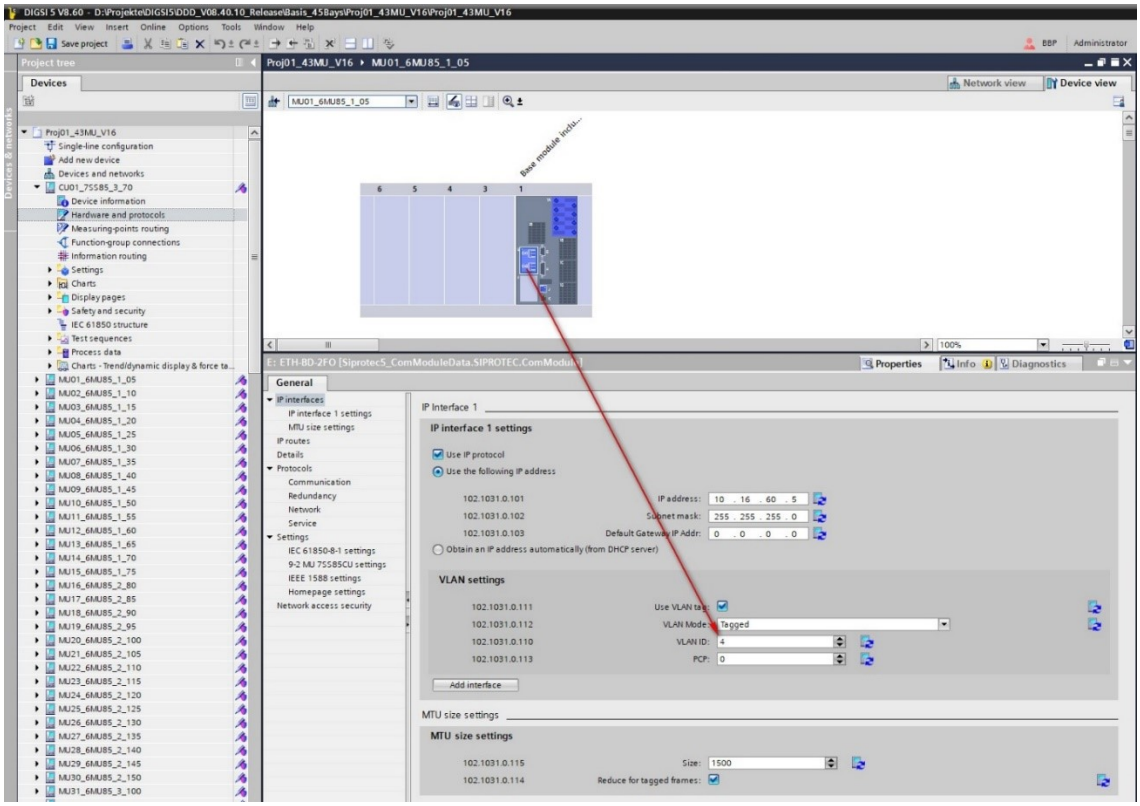


Figure 7. VLAN parameterization in the merging units

1.4.2 Configuration in IEC 61850 System Configurator

In the IEC 61850 System Configurator we must parameterize the VLAN-IDs for the SMV streams according to the design (see chapter 1.3 Design).

In the IEC 61850 System Configurator go to the editor “SMV”, select the dataset from the first merging unit and click on the properties of the “SMV Control Block” at the right side of the screen, or right-click on the dataset and select from the menu the option “Configure SMV”. There, the respective VLAN-ID can be assigned.

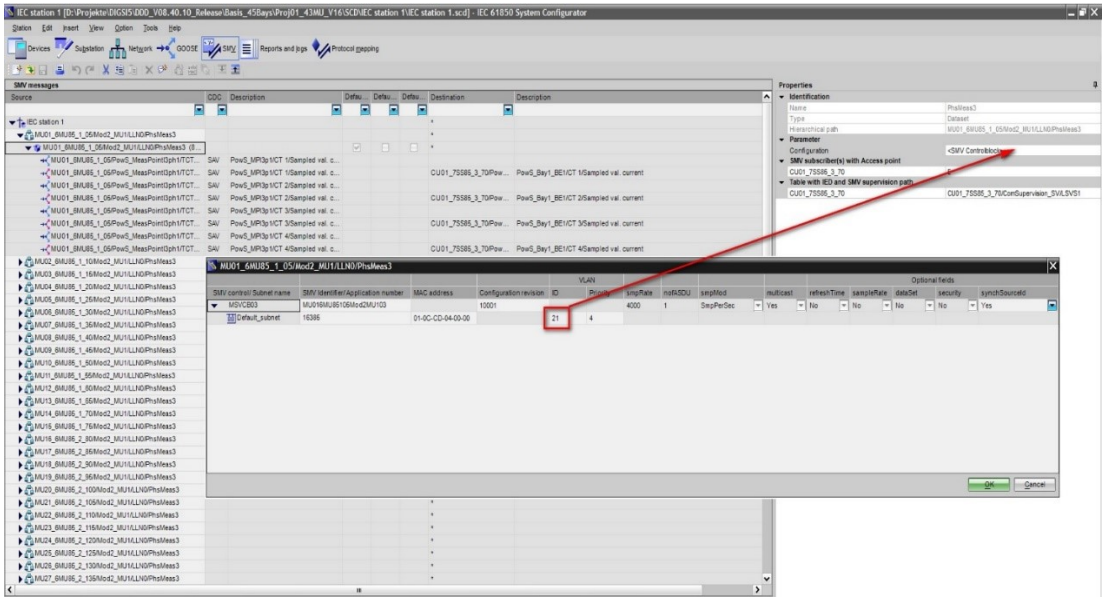


Figure 8. VLAN parameterization for the SMV

Repeat the procedure for each stream of each merging unit assigning the VLAN 21 for Group 1, 22 for Group 2 and 23 for Group 3.

1.4.3 Configuration of the switches

Get access to the switch by typing on the web browser its IP address (for example https:// 192.168.0.1). Upon connecting to the device, some web browsers may report the web server's certificate cannot be verified against any known certificates. This is expected behavior, and it is safe to instruct the browser to accept the certificate. Once the certificate is accepted, all communications with the Web server through that browser will be secure. Once the connection is established the login box appears. Below the default values.

Username	Password
admin	admin

Keep in mind that if the switch has been previously configured you must know the IP address used as well as the enabled username and password.

1.4.3.1 Configuration of the Ruggedcom RST2228

Navigate to the menu “System Time Manager” and select “Configure Time source”.

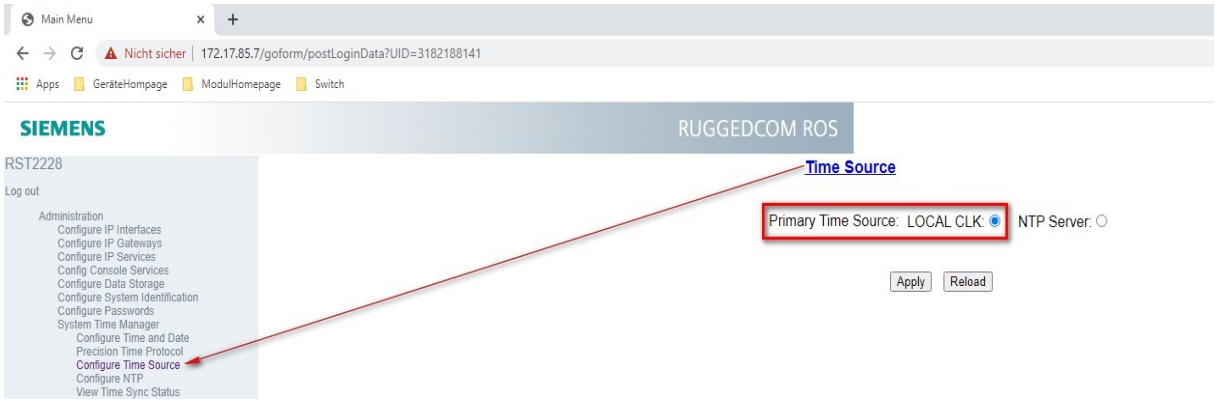


Figure 9. Time source configuration

Check under “System time Manager -> Precision time Protocol” the clock Parameters.

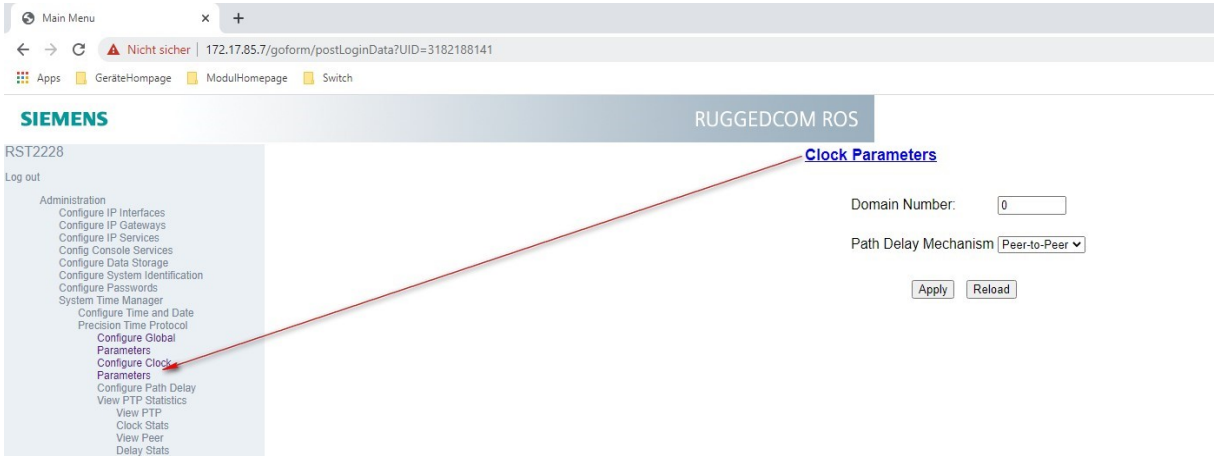


Figure 10. PTP – Clock parameters

Navigate to “Configure Global Parameters” and check if PTP is enabled and if the clock type is selected as P2P Transparent clock. The Utility Profile Level 1, which corresponds to the IEC 61850-9-3, and the transport protocol to “Layer 2 multicast” must be set.

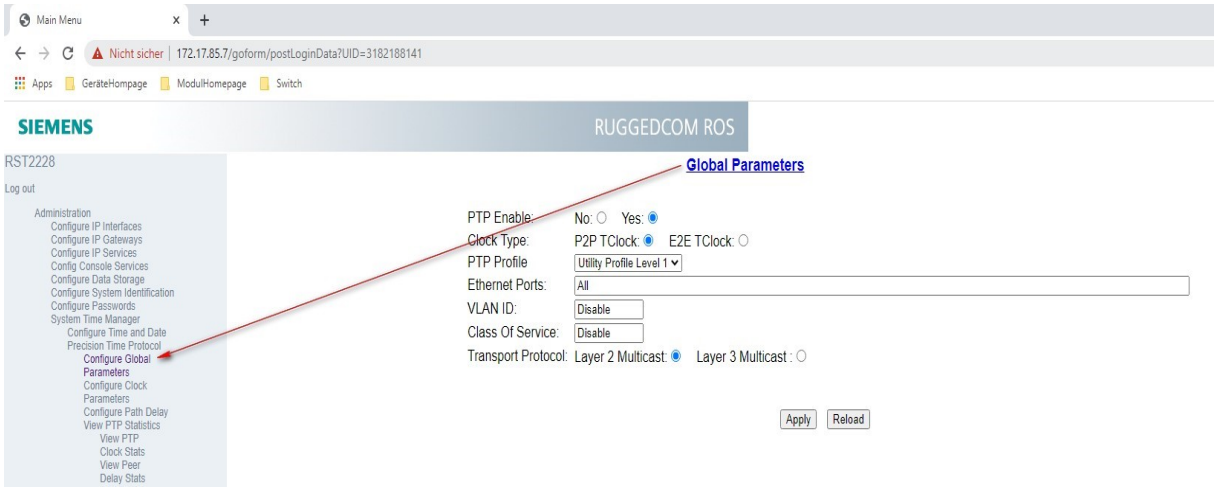


Figure 11. PTP – Global parameters

An essential part of the configuration is the correct parameterization of the virtual LANs.
Start under “Virtual LANs” with the item “Configure Global VLAN Parameters” and check if the VLAN- Awareness is given and the “Ingress Filtering” is disabled.

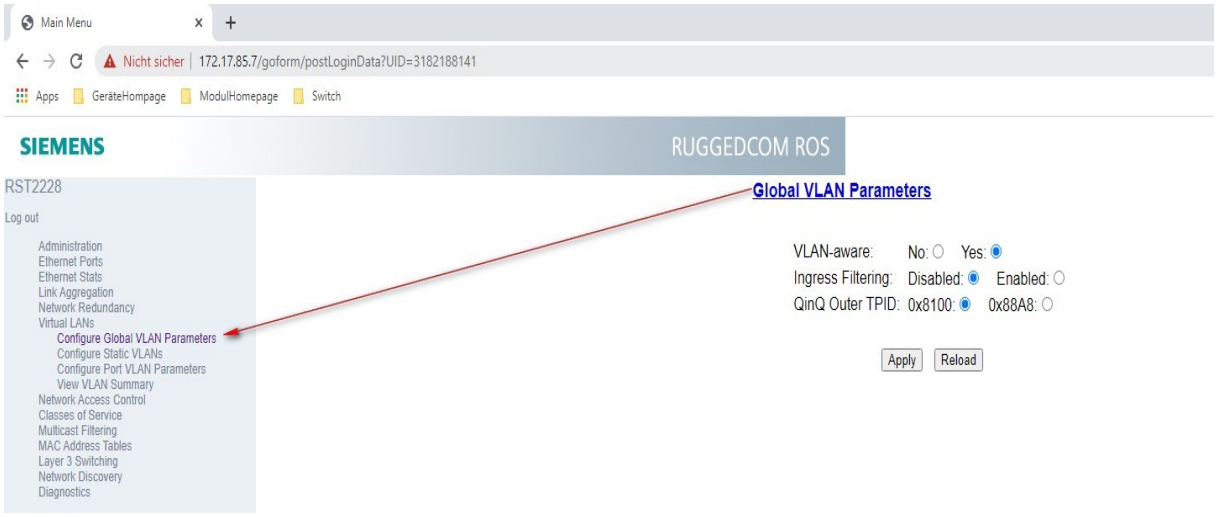


Figure 12. Global VLAN Parameters in Ruggedcom switch

Now move to the item “Configure Static VLANs” and add the respective VLANs such as 1, 4, 11, 12, 13, 21, 22 and 23. It is also important to add the forbidden Ports to the different VLANs, under “Static VLANs”.

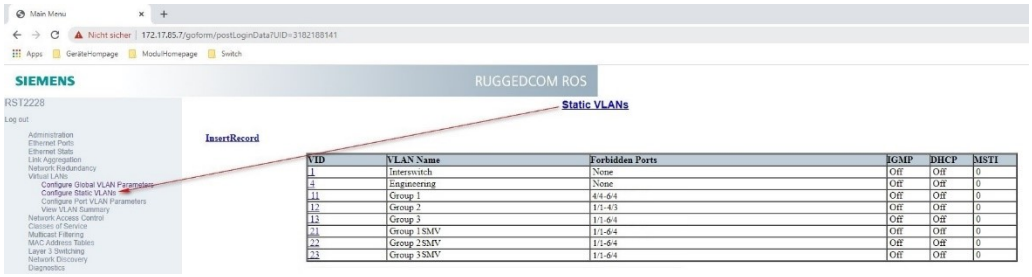


Figure 13. Static VLANs

The next step is the item “Configure Port VLAN Parameters”. For correct functionality of the binary information, it is necessary, that every group gets the correct PVID. 11 for group1, 12 for group 2 and 13 for group 3.

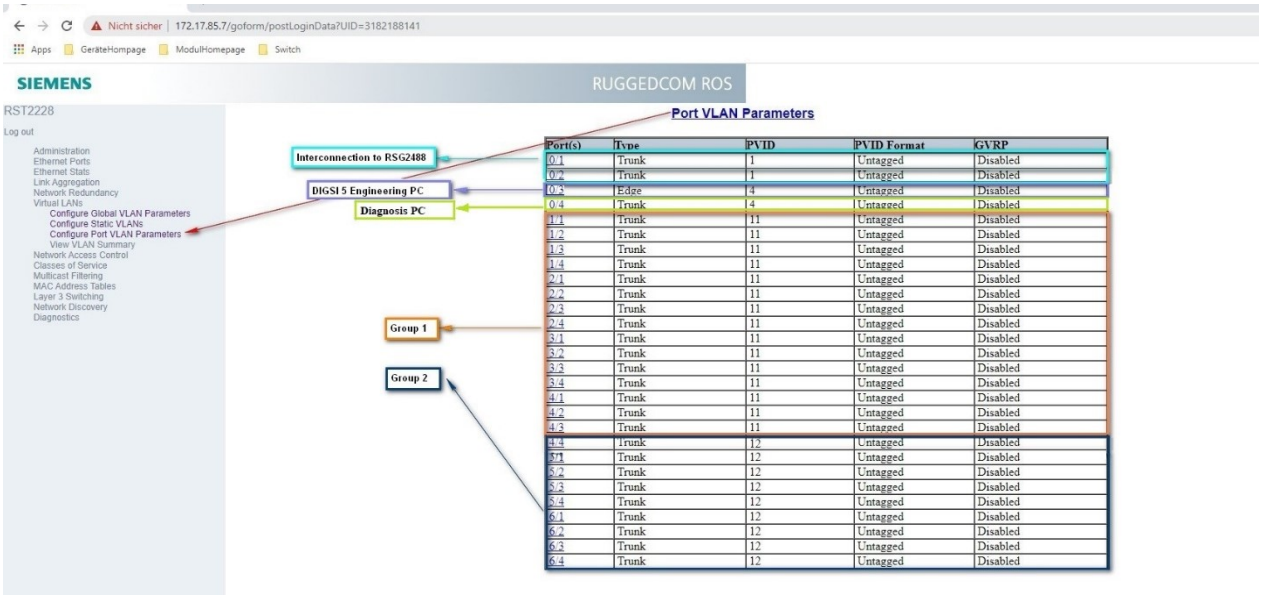


Figure 14. Port VLAN Parameters in Ruggedcom switch

The configuration of the switch RST2228 is finished.

1.4.3.2 Configuration of the Ruggedcom RSG2488

Start with the configuration of the System Time Manager at the item “Configure Time Source”.

The switch has a PTP module, and the primary time source is GPS.

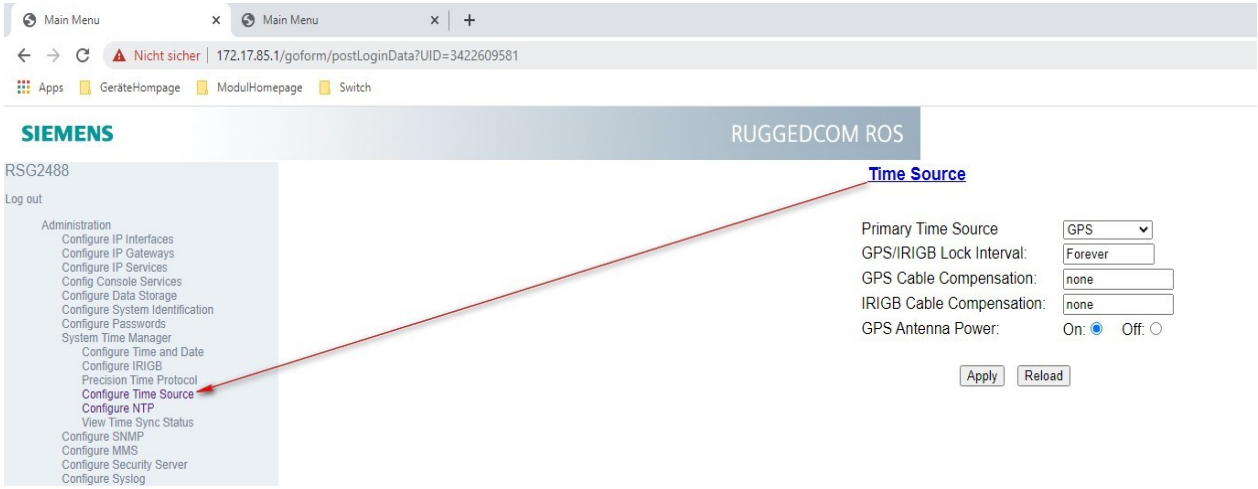


Figure 15. Time source configuration in RSG2488

If the internal oscillator of the RSG2488 is to be used as a PTP time source, the “Primary Time Source” setting must be set to LOCAL CLK. In this case, no PTP module is required but not absolute time will be available.

The next step is the Precision Time Protocol. Here, start with the item “Configure Global Parameters”. It is important to set the clock type to Ordinary Clock, to select the Utility Profile Level 1, which corresponds to the IEC 61850-9-3, and the Network Class to “IEEE1588 network”.

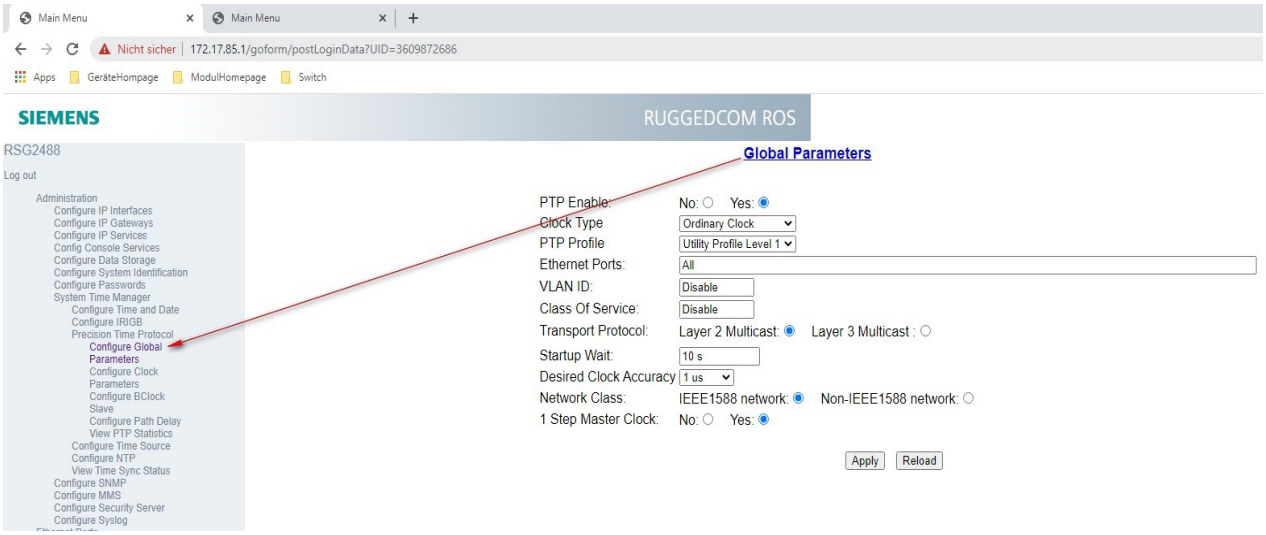


Figure 16. PTP – Global parameters

Afterwards, move to the item “Configure Clock Parameters”

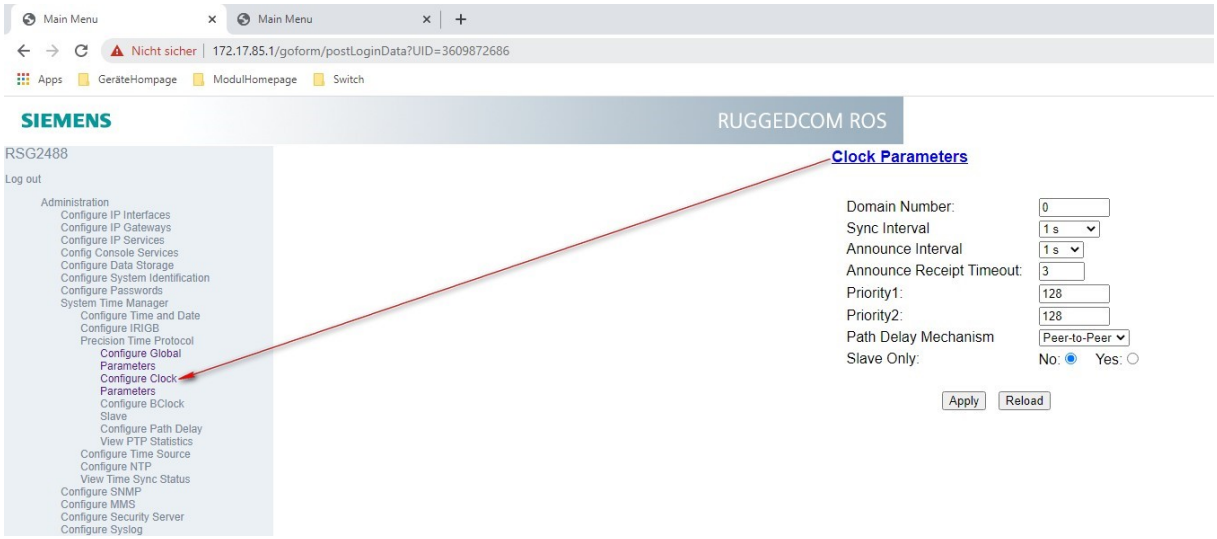


Figure 17. PTP – Clock parameters

Finally, configure the Virtual LANs correctly, similar to the configuration done for the RST2228. Start with “Configure Global VLAN Parameters”.

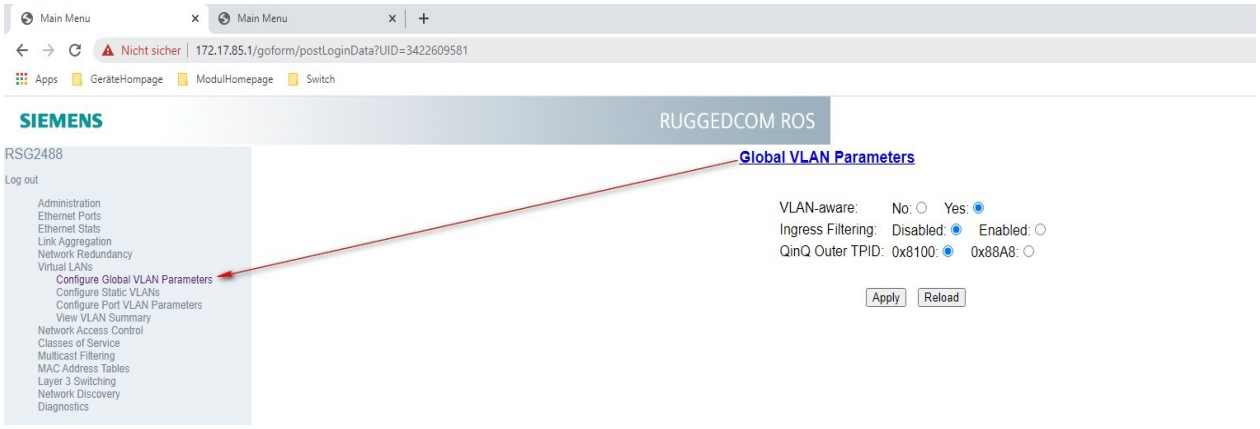


Figure 18. Global VLAN parameters

For a proper traffic separation, parameterize in the next step the static VLANs by selecting the item “Configure Static VLANs”. It is important to add the VLAN-IDs 1, 4, 11, 12, 13, 21,22 and 23 as it was done for the RST2228 switch. Take care that the forbidden ports are entered correctly for each VID/Group.

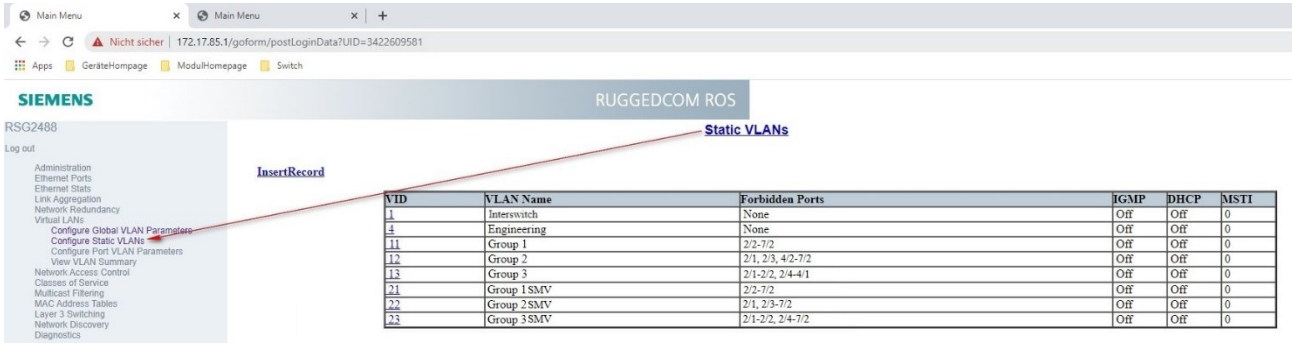


Figure 19. Static VLANs parameters

Now adapt the port VLAN parameters by clicking the item “Configure Port VLAN Parameters”. For correct forwarding of binary information, it is necessary, that every group gets the proper PVID. 11 for group1, 12 for group 2 and 13 for group 3.

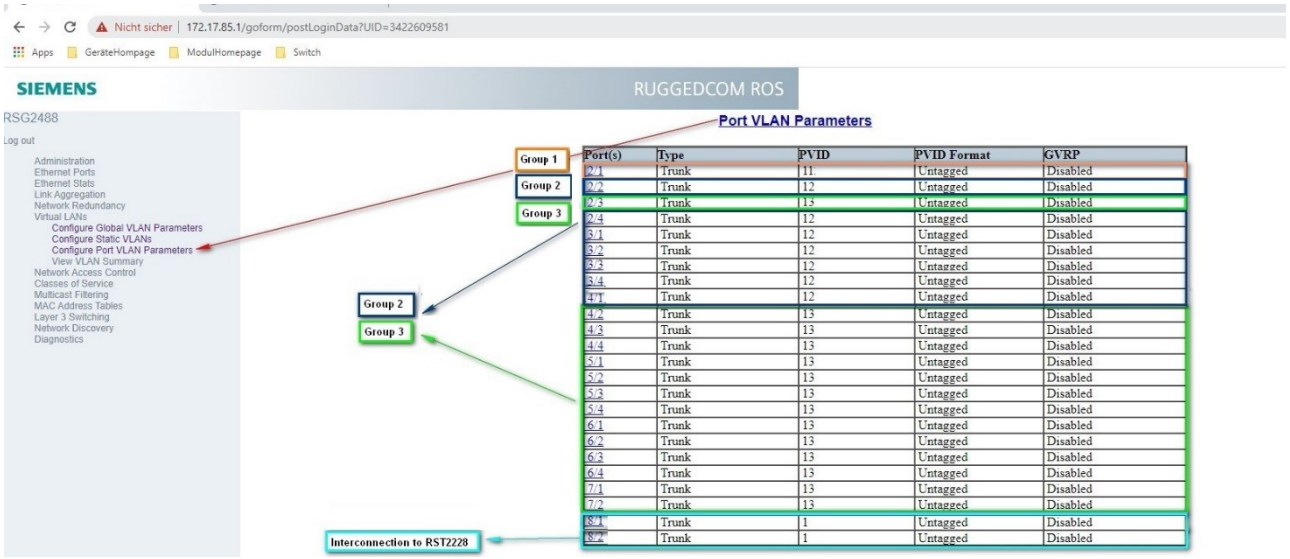


Figure 20. Port VLANs parameters

1.5 Conclusion

A simple network configuration for the busbar protection 7SS85 CU for up to 45 measuring points can be built by using one RSG2488 and one or two RST2228 Ruggedcom switches.

The RSG2488 is responsible for the sampled values synchronization, which can be achieved with or without PTP module in the switch. The PTP module offers the advantage of providing an absolute reference time to synchronize additionally the time of the devices.

The standard SFPs of the ETH-BD-2FO modules of the SIPROTEC 5 devices can be connected to any port with the following characteristics: Port type: LC, Mode: MM (Multi-Mode), Speed: 100 Mbps, Interface: FX, Wavelength: 1310 nm. The use of switchports for SFP/SFP+ Transceivers is not possible as the versions for 100Mbps are not recommended for use with IEEE 1588 (see additional information in the SIMATIC NET, Networking Components, RUGGEDCOM SFP Transceivers, Catalog C79000-G8976-1251-24).

For the interswitch links, it is recommended using 1 Gbit/s optical ports due to the high amount of information to be exchanged among switches. In any case, if using the switchports for SFP/SFP+ Transceivers, 1 Gbit/s optical modules are mandatory to grant the accuracy of the PTP signal; the 1 Gbit/s copper SFP transceiver is not recommended for use with IEEE 1588 neither.

It is possible to reach the maximum of 45 measuring points with only two switches if some merging units publish more than one measuring point, otherwise a third switch will be necessary.

The traffic must be filtered using VLANs in order to respect the limits of the ETH-BD-2FO modules (100Mbit/s). It is recommended to design with a maximum of 60% of the bandwidth for SMV.

Published by
Siemens AG

Smart Infrastructure
Digital Grid
Humboldtstrasse 59
90459 Nuremberg, Germany

www.siemens.com/siprotec

For more information, please contact our Customer Support Center.

Tel.: +49 180 524 70 00
Fax: +49 180 524 24 71
(Charges depending on provider)

Customer Support: www.siemens.com/csc

For the U.S. published by
Siemens Industry Inc.

100 Technology Drive
Alpharetta, GA 30005
United States