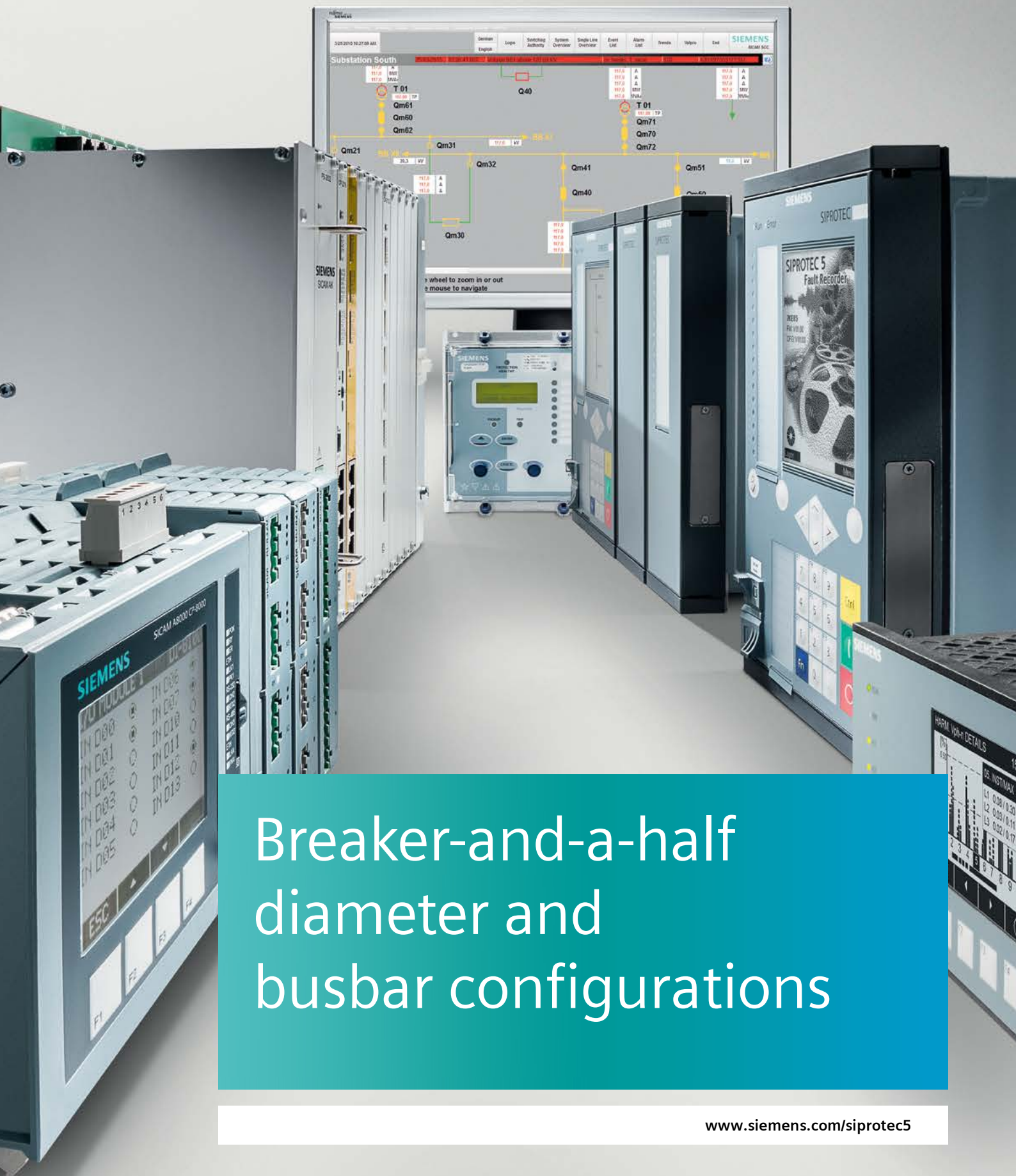


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Breaker-and-a-half  
diameter and  
busbar configurations

# SIPROTEC 5 Application

Control of Breaker-and-a-half diameter and double busbar configurations and use of Phasor Measurement Unit (PMU)

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## SIPROTEC 5 Application

# Control of Breaker-and-a-half diameter and double busbar configurations and use of Phasor Measurement Unit (PMU)

APN-012, Edition 1

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# 1 Control of Breaker-and-a-half diameter and double busbar configurations and use of Phasor Measurement Unit (PMU)

## 1.1 Summary

This application description explains the use of SIPROTEC 5 bay controllers in breaker-and-a-half applications and in double busbar systems. It illustrates the basic principles and possible uses of the bay controllers and their integrated functions e.g PMU.

## 1.2 Introduction to the application

This application note describes the following application examples:

### **Breaker-and-a-half application:**

For control of breaker-and-a-half diameters there are in principal two methods:

- Controlling the entire diameter with 1 bay controller. This is possible with the modular and flexible SIPROTEC 5 bay controllers.
- Controlling the diameter with 3 bay controllers. This preserves the redundancy that exists in the primary equipment (1 ½ circuit breakers per feeder) also in the secondary equipment.

### **Double busbar configurations**

- Control and interlocking of a double busbar feeder with query of the coupling via GOOSE

### **Phasor Measurement Unit with interface as per IEEE C37.118**

## 1.3 Solutions

### 1.3.1 Breaker-and-a-half application

Figure 1 shows a breaker-and-a-half configuration. The two lines 1 and 2 can be connected to busbar 1 or 2 via the 3 circuit breakers QA1, QA2 and QA3 in the three sections A, B and C. This implies a certain degree of redundancy in the primary equipment, because both lines can still be supplied reliably in any case even if one circuit breaker is faulted.

A total of 17 switching devices (circuit breakers, disconnectors and grounding switches) exist in a breaker-and-a-half diameter, as shown in Figure 1.

Depending on the philosophy, the diameter can be controlled by one 6MD86 bay controller or by three bay controllers. The solution in the first case is cost-efficient and uses the full flexibility of the device when connecting multiple voltage transformers. In the second case, hardware redundancy is also ensured on the secondary side. In this application, we will concentrate on the first solution.

We select a bay controller with 2 x IO202 and 3 x IO207 (available as standard variant). We thus obtain a quantity structure of 67 binary inputs, 39 binary outputs (incl. life contact), 8 current transformers and 8 voltage transformers.

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Figure 2 shows the assignment of the voltage transformer connections of the bay controller to the breaker-and-a-half diameter. The voltages of the feeders and busbars are used for the synchrocheck of the circuit breakers. Based on the disconnector positions, it is decided which of the two voltages the synchrocheck functions use for their decision. The voltage selection logic is created in CFC.

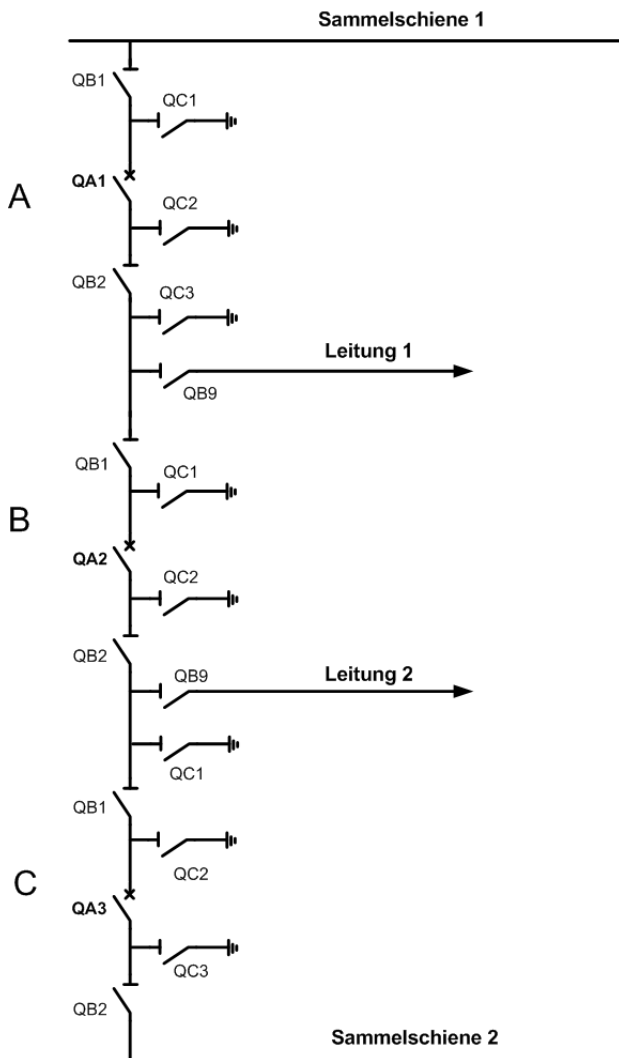


Figure 1: Schema of a breaker-and-a-half diameter

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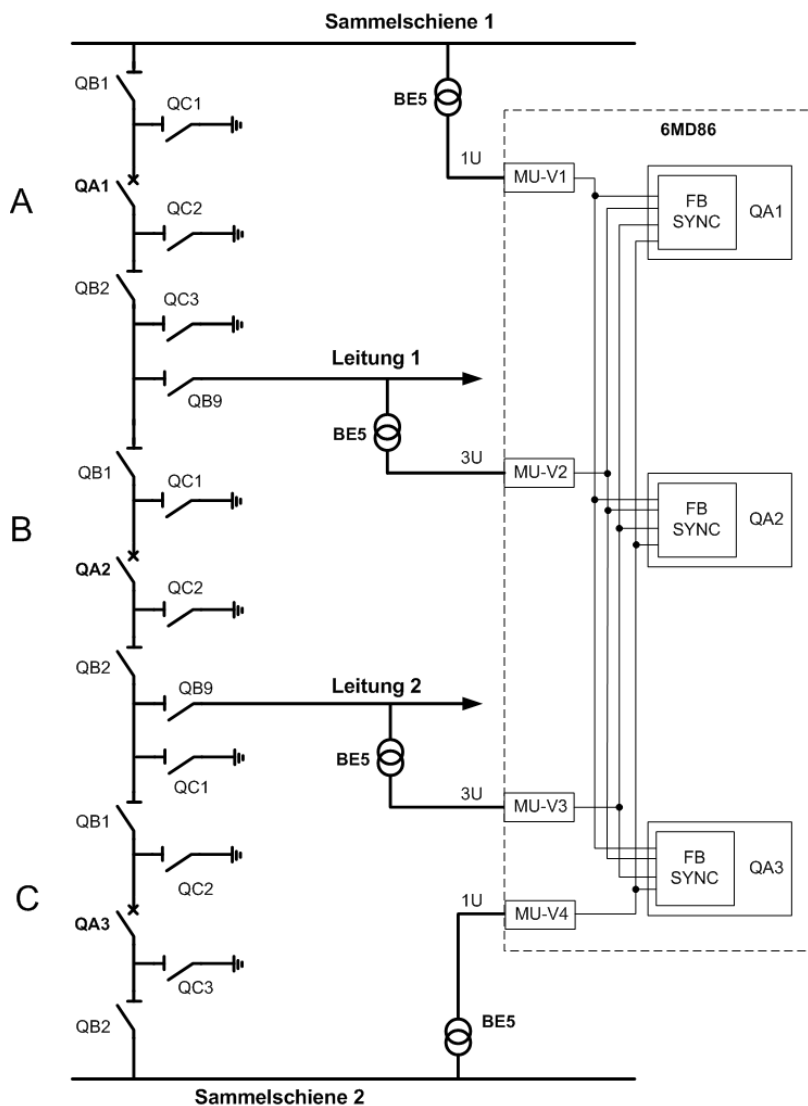


Figure 2: Controlling of a diameter with one 6MD86 bay controlle

Figure 2 shows that a "2 out of 4" decision for the synchronization voltages must be created at each circuit breaker. This decision depends on the switch position. To this end, CFC charts evaluate the positions of the circuit breakers and disconnectors and derive the valid transformer combination for the corresponding situation.

Figure 3 shows the entire diameter with protection devices and bay controllers. The current transformers are also depicted. The tasks are distributed as follows: The combined 7SL87 distance and differential protection devices assume the line protection with the backup protection function being configured for the other line respectively. They also assume the functions "circuit-breaker failure protection" and "automatic reclosing" for two circuit breakers respectively (the center breaker QA2 is operated twice). The bay controllers are responsible for controlling all 17 switching devices, synchrocheck of the circuit breakers and the measured values (e.g. power measurement in the line feeders).

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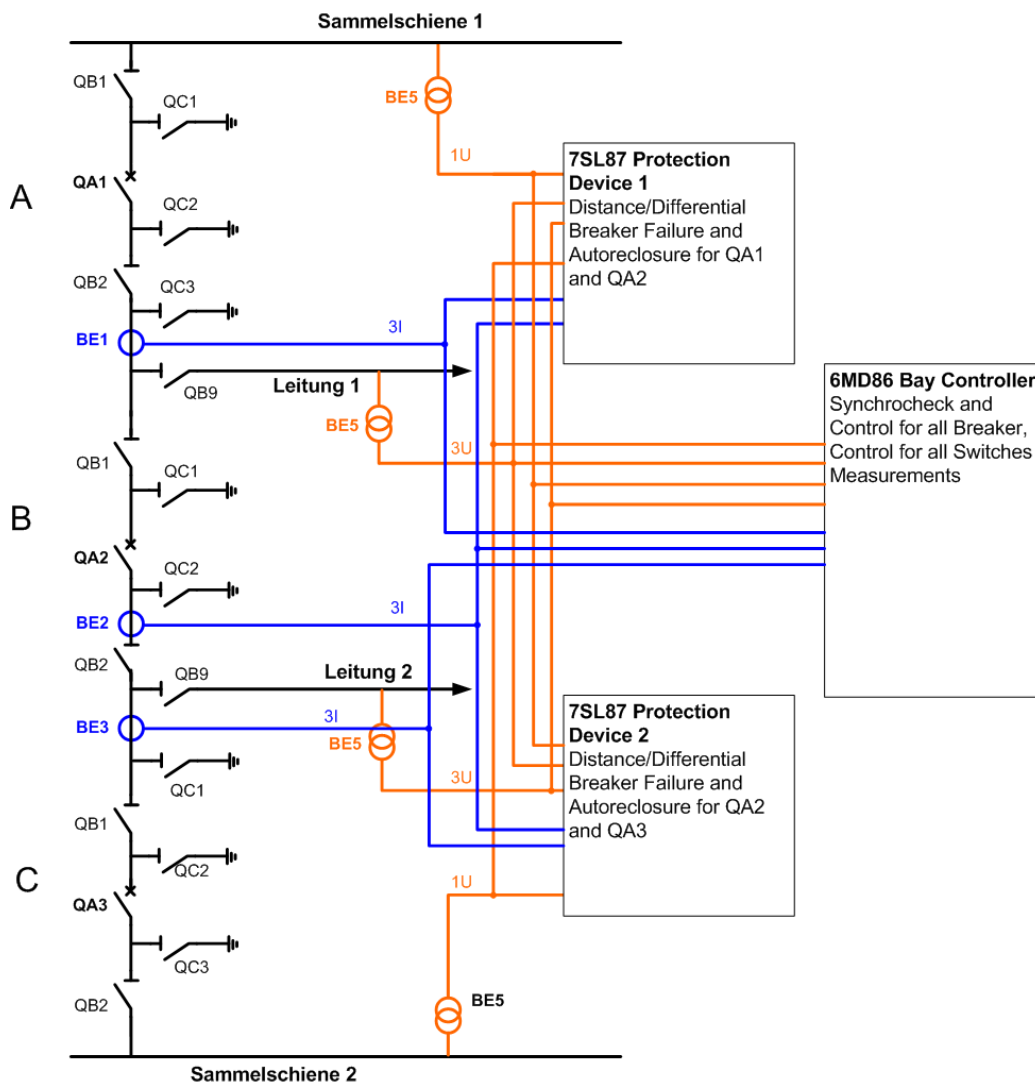


Figure 3: Breaker-and-a-half diameter with protection and control

In the following, we will look at the voltage selection for the synchrocheck in the 6MD86 bay controller. This selection is based on the position of the switching devices which are evaluated using the CFC chart. Figure 4 shows the configuration of the voltages to the inputs of the function group "circuit breakers" and Figure 5 shows an example of a CFC chart for selecting the voltage.

▼ Connect measuring points to function group		
Measuring point	A_Circuit brk.QA1	
	V sync1	V sync2
(All...)	(All...)	(All...)
Meas.point I-3ph 1[ID 1]		
Meas.point V-3ph 1[ID 2]		X
Meas.point V-3ph 2[ID 3]		X
Meas.point V-1ph 1[ID 4]	X	
Meas.point V-1ph 2[ID 5]		X

Figure 4: Assigning the voltage inputs to the function groups

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▼ A_Circuit brk.QA1	401	
▶ Control	401.4201	
▶ Circuit break.	401.4261	
▶ Interlocking	401.4231	
▼ V sync select.	401.10711	
◆ V sync1	401.10711.5...	INS
◆ V sync2	401.10711.5...	INS
▶ Health	401.10711.53	ENS
◆ Sel. V sync1 invalid	401.10711.3...	SPS
◆ Sel. V sync2 invalid	401.10711.3...	SPS

Figure 5: Voltage selection in the "circuit breaker" function group

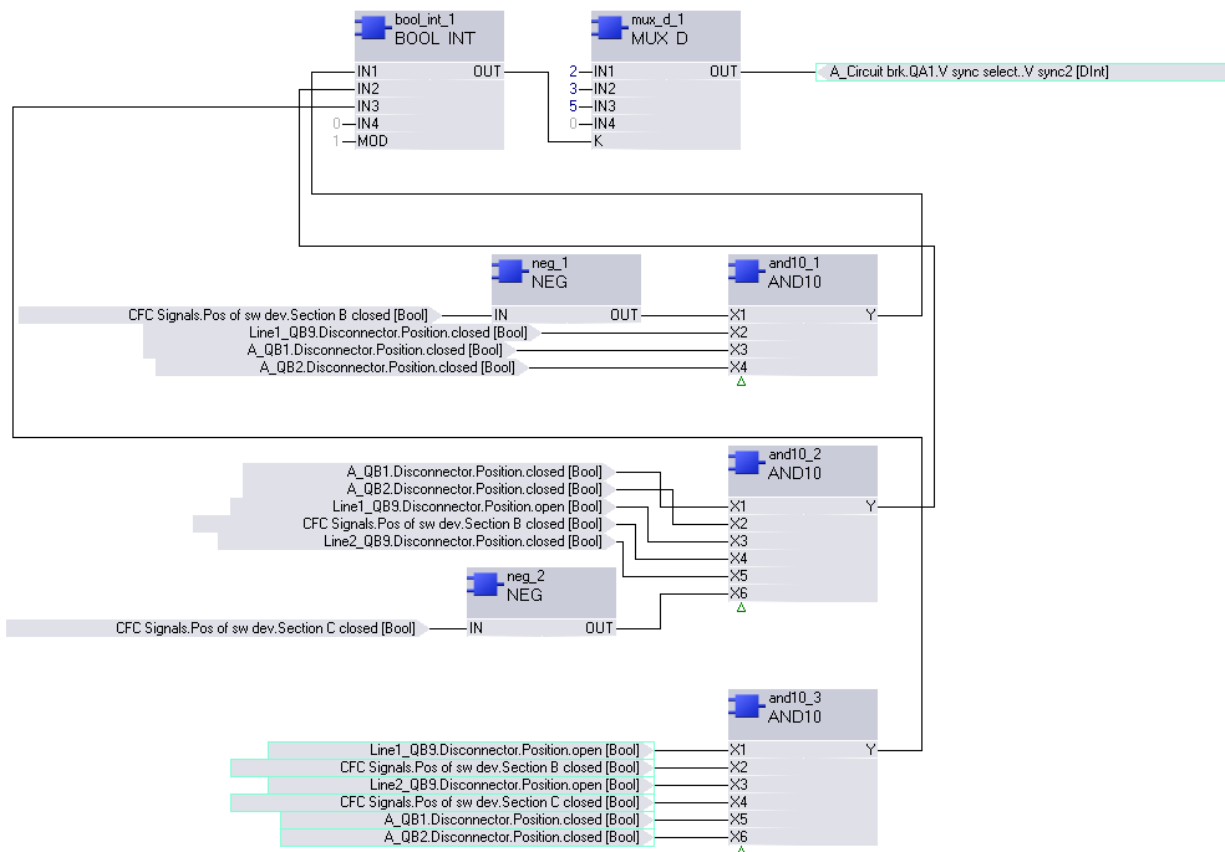


Figure 6: CFC chart for voltage selection

The voltage inputs are numbered consecutively in the device (see Figure 4: ID2-5). In the CFC chart, this number is assigned to the corresponding inputs (see Figure 5) depending on the switch positions. In the example of the breaker-and-a-half application, the input Vsync1 is always permanently connected to the voltage of ID4, while the CFC chart makes the selection for the input Vsync 2 based on the switch position. The voltages with the IDs 2, 3 and 5 are available for this purpose.

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### 1.3.2 Double busbar with switchgear interlocking protection

The double busbar shown in Figure 6 is controlled by one 6MD85 bay controller. The device additionally operates as Phasor Measurement Unit (PMU).

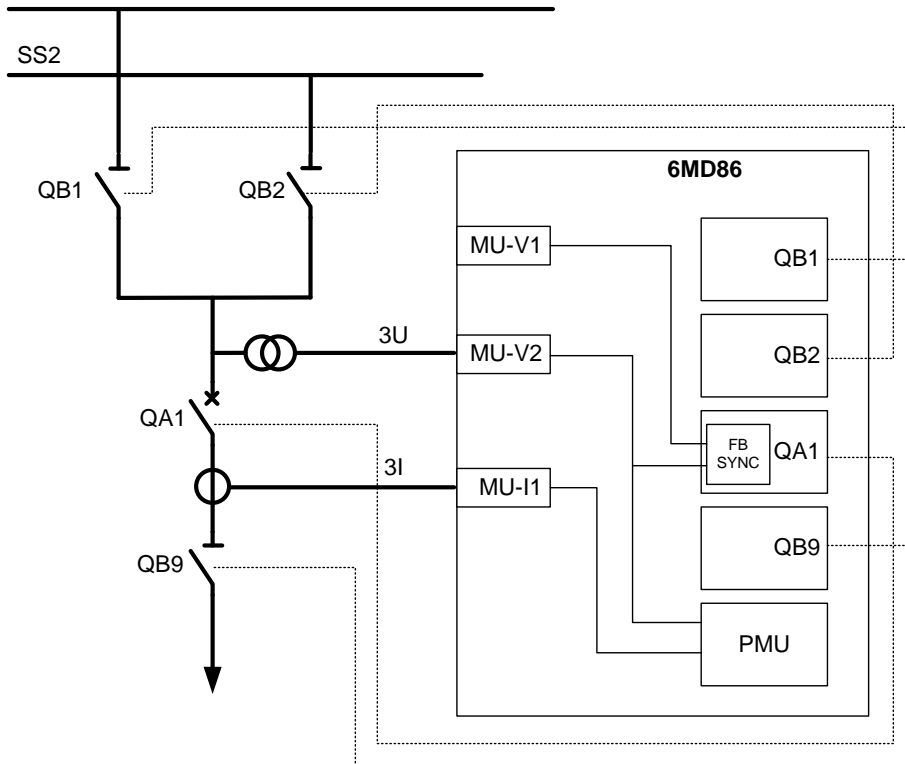


Figure 7: Double busbar with bay controller

This paragraph describes the switchgear interlocking protection of the bay. Moreover, the configuration of the Phasor Measurement unit in the bay controller is discussed. Other functions such as synchrocheck of the circuit breaker, protection function or measured value processing are possible.

#### Switchgear interlocking protection

The switchgear interlocking protection can be divided into bay-related switchgear interlocking protection and cross-bay switchgear interlocking protection. The bay-related switchgear interlocking protection only requires information that is available in the bay controller itself. The cross-bay switchgear interlocking protection also requires information from adjacent bays, for example concerning the switching status of the bus coupler. Such information is exchanged between the devices using the IEC 61850-GOOSE communication link (Figure 8).



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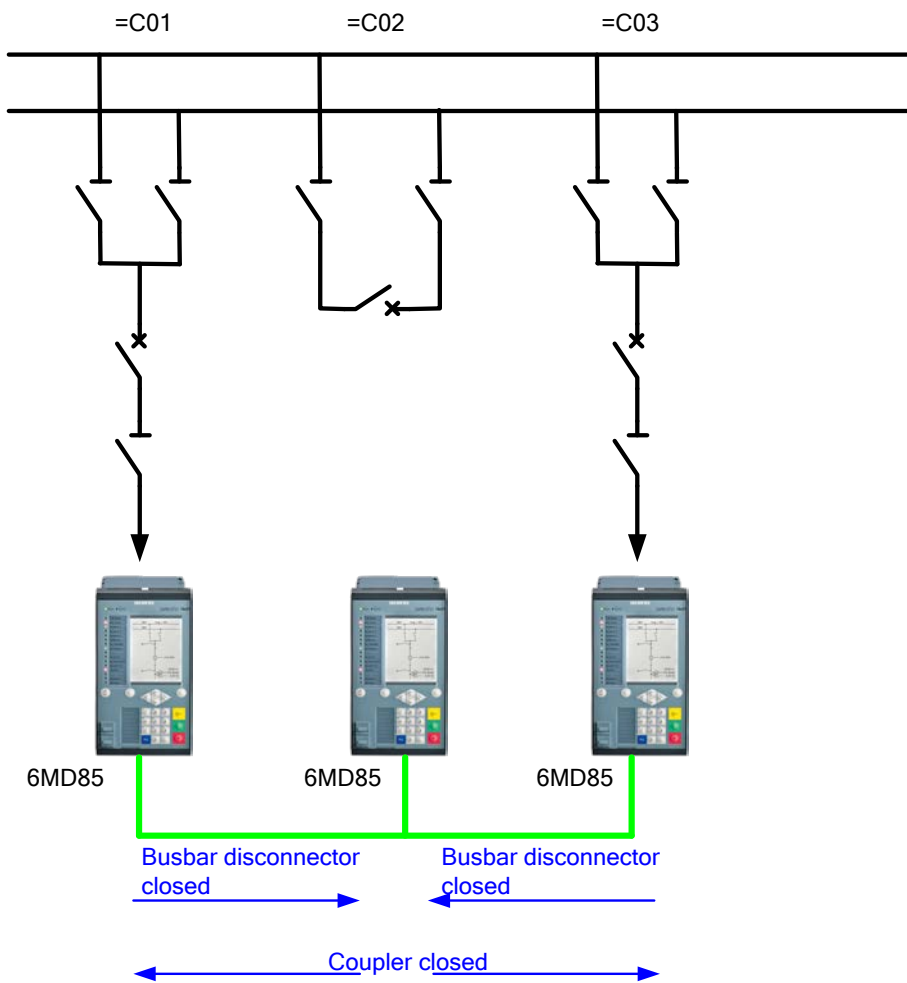


Figure 8: Communication between multiple bays to exchange information regarding the switchgear interlockings

The required interlockings are created in CFC. Figure 8 shows the resulting chart in the device for feeder bay C01. You can see the query of the indication "coupling closed" from device C02 in the coupling as additional release for the busbar disconnector (these can then be opened or closed).

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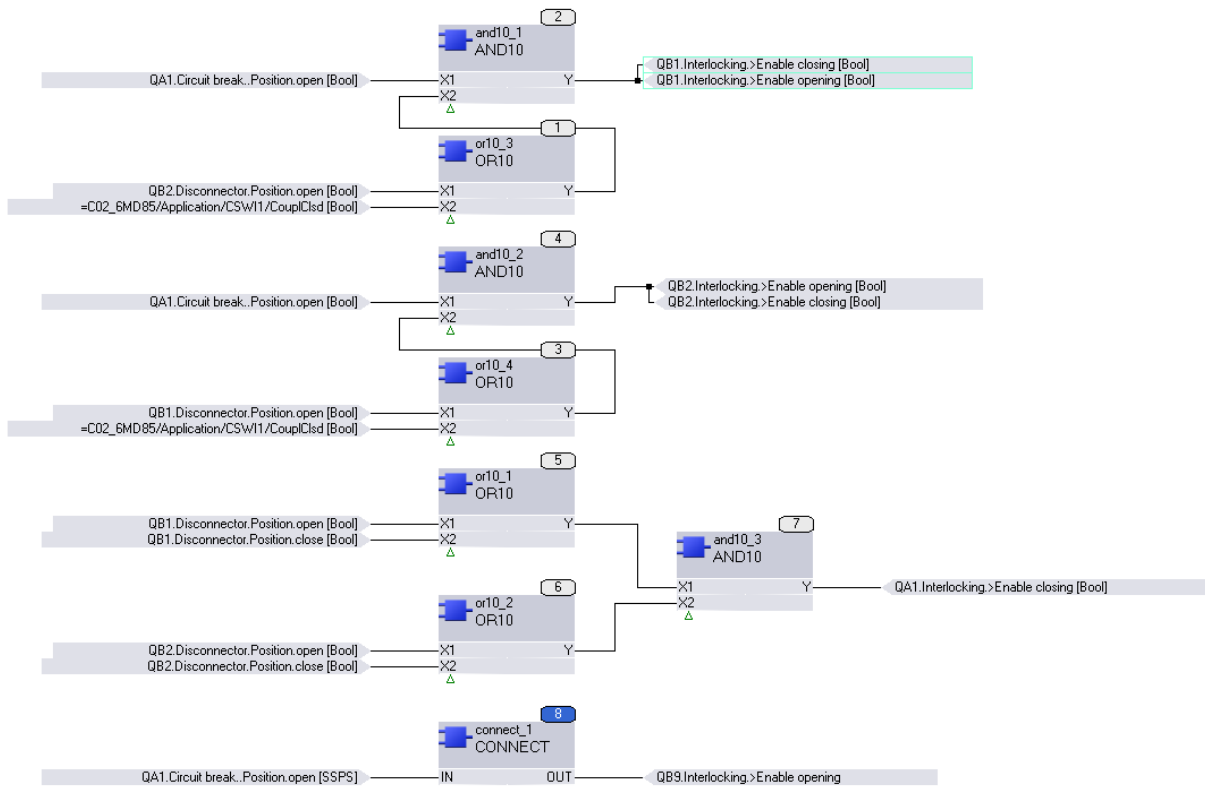


Figure 9: Switchgear interlocking for busbar disconnectors and circuit breakers

### 1.3.3 Phasor Measurement Unit (PMU)

Synchrophasors are perfectly suited to monitor the dynamic power system behavior. This function can be activated in the SIPROTEC 5 devices; an Ethernet communication module is required for this purpose. Select the communication protocol "Synchroph./PMU" on this module. For bay controllers this will typically be a second communication module (in addition to the module required for the substation automation system protocol). This module for PMU communication transmits the synchrophasors to a phasor data concentrator such as SIGUARD PDP via the IEEE C37.118 protocol where they are archived and evaluated (Figure 9).

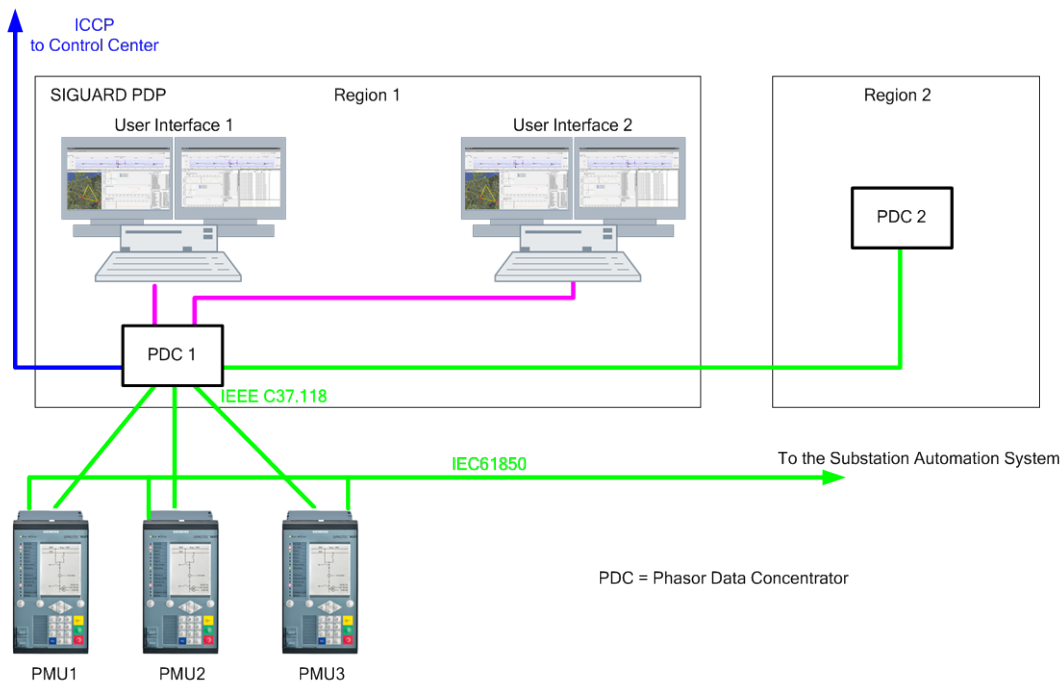


Figure 10: SIPROTEC 5 bay controllers as PMU in a wide area monitoring system

By selecting the protocol "Synchrophasor/PMU", a PMU function group is created in the device which is, however, not displayed in DIGSI. This is due to the fact that all required parameters are available in the channel settings of the protocol (Figure 11).

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**Communication protocols**

Selected protocol: IEEE C37.118 PMU  
Default communication mapping: None

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PMU 1

**Gen. settings**

103.1031.0.105	PMU ID: 1
103.1031.0.106	Station name: PMUx
103.1031.0.107	PMU transport: TCP
103.1031.0.108	IP address PDC1: 0 . 0 . 0 . 0
103.1031.0.109	IP address PDC2: 0 . 0 . 0 . 0
103.1031.0.110	IP address PDC3: 0 . 0 . 0 . 0

**Func. settings**

801.10621.1	Mode: on
801.10621.101	Class: Class P
801.10621.102	Reporting rate: 10 frames/s
801.10621.103	Only positive sequence: no

Figure 11: Configuration of the PMU in DIGSI

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