APPLICATION NOTE

Capabilities of the 7SX85 as a CPC in small substations

APN-102, Edition 1

unrestricted

SIEMENS

SIPROTEC Application

Capabilities of the 7SX85 as a CPC in small substations

APN-102, Edition 1

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1 Capabilities of the 7SX85 as a CPC for small substations

1.1 Introduction

Among the many possible applications for the SIPROTEC 5 Universal Device Protection 7SX85 is the use of it as Centralized Control and Protection equipment or commonly called **CPC** for small substations. 7SX85 as a CPC has the property of protecting and controlling several fields with the concept of bays (**FW > 09.50**), additionally the use of **Mod/Beh** attributes per bay according with Standard IEC61850 **(FW >09.7x**). This APN will show in various small substation configurations the capabilities of the 7SX85 as a CPC Light, i.e., the maximum number of bays it can control and protect at the same time. Configurations for a centralized and decentralized 7SX85 (via bay units / Merging units) will be shown.

It is not part of the document to describe different communications architectures, redundancies, clock types, GOOSE/MMS abilities per port, for this please review what is written down in the applications or manuals intended for this.

The user will finally be able to reference these different configurations for their specific application.

1.2 Considerations per bay.

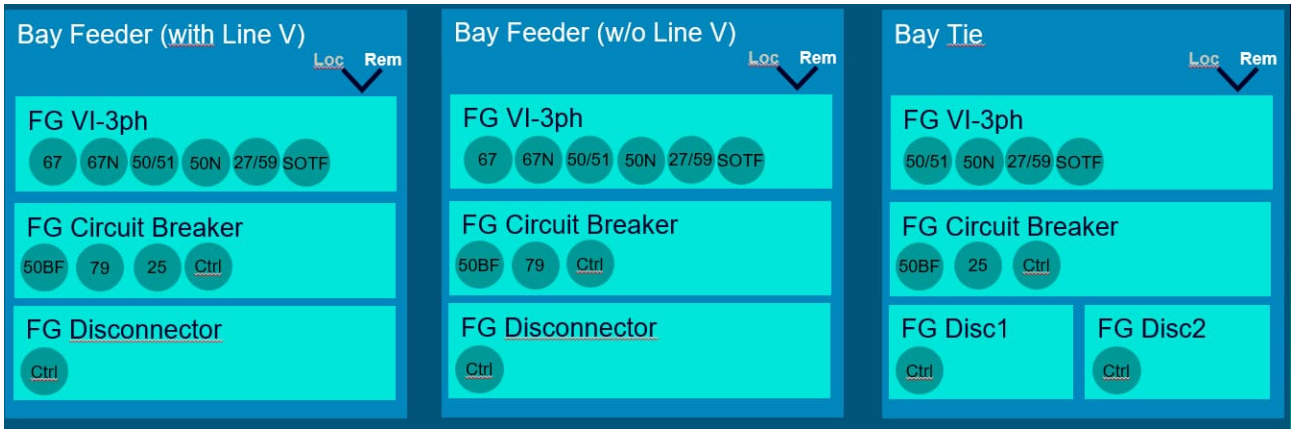
Each substation configuration shown in this APN consists of several bays of several types, additionally each bay requires CFC logic for control and interlocks. This section will only show the considerations for the configuration of protection functions for each bay.

1.2.1 Typical bays used.

There are 6 types of bays with independent **FG** like **Circuit Breaker**, **Disconnector** and **Protection**:

- **Bay Type 1:** Feeder **with** line VT
- **Bay Type 2:** Feeder **without** line VT
- **Bay Type 3:** Tie with 2 busbar VT
- **Bay Type 4:** Line with 21 as a main protection, including teleprotection schemes (POTT and Dir. Comp.).
- **Bay Type 5:** Line with 87 and 21 as main protection, including teleprotection schemes (POTT and Dir. Comp.).
- **Bay Type 6:** Two-winding transformer.

In the following figure you can see a schematic of the several types of bays with their functional groups.



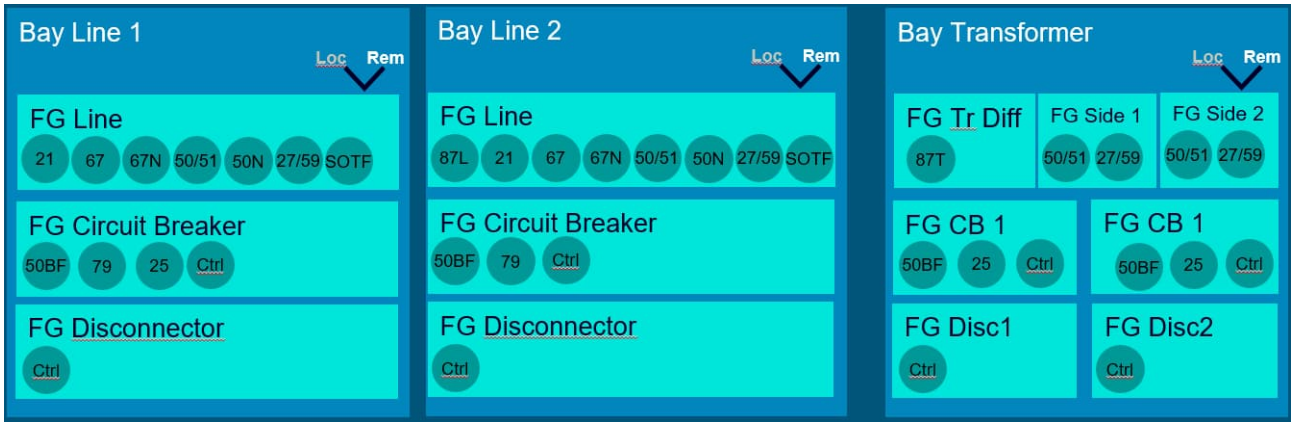


Fig 1. Bay types used in this Application note.

1.2.2 CFC logics used in each bay typical.

Each bay configured on 7SX85 has the following CFC logics:

Interlocking:

Simple interlocks for Circuit Breaker and disconnector considering the position of the device, the user can add more conditions.

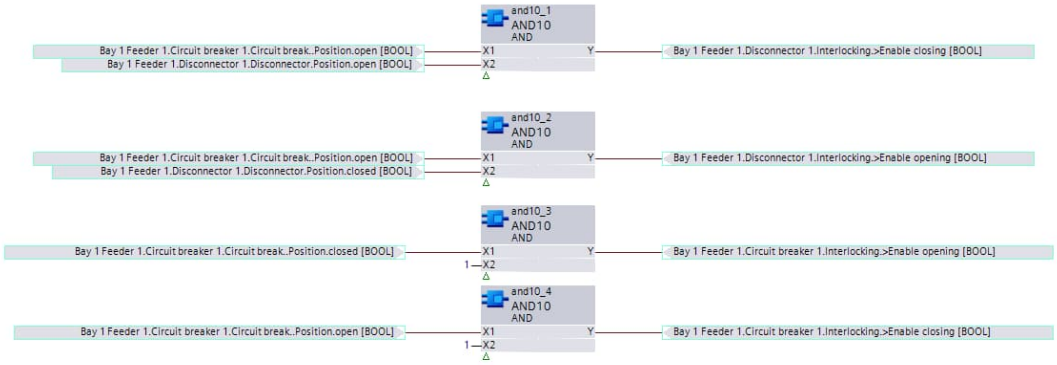


Fig 2. Interlocks for Close/Open CB and Disc.

Open and Close command for CB

This CFC defines the closing and opening of the C.B. only by manual command and not those executed by protection functions. It applies when the CPC publishes via **GOOS**E those commands to the **Bay Unit**.

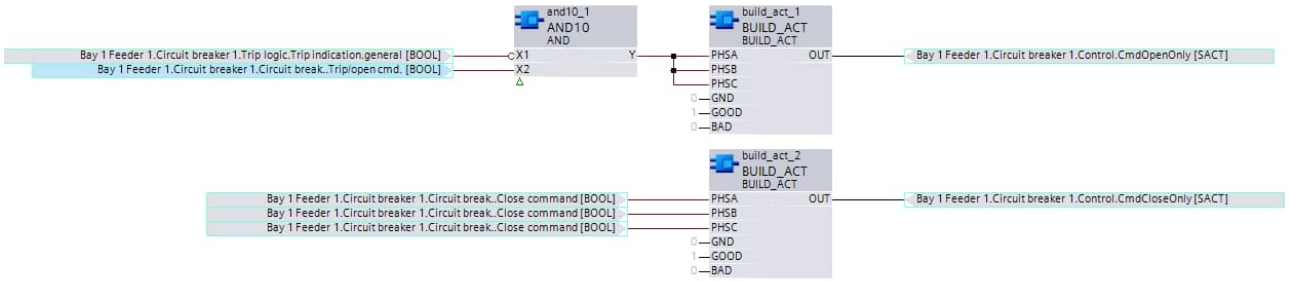


Fig. 3. CFC for CB open/close command.

Ctrl Authority per bay

From FW 09.60, each bay has its own control authority functionality, this CFC shows an example of how to make this change using a user-signal command, the signals to change the Ctrl Auth per bay are **Bay_Name.General>Sw.authority remote [BOOL]** and **Bay_Name.General>Sw.authority local [BOOL].**

Additionally, it considers the General switching position of the device. The user can define their own logic for Ctrl Authority commands.

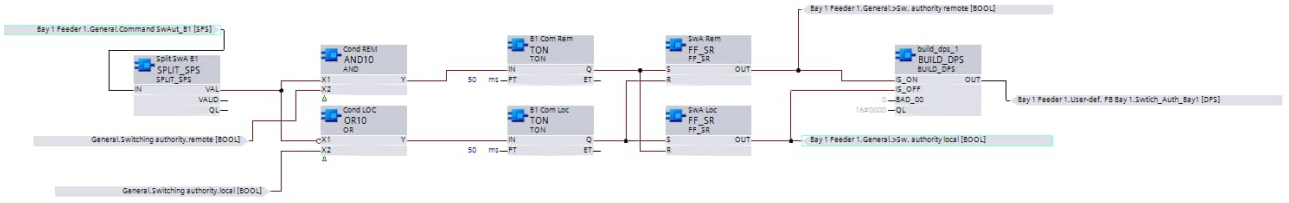


Fig 4. Ctrl Authority commands per bay.

Interlocking OFF/Normal per bay

Similar CFC as the shown previously but now controlling the signals **Bay_Name.General>Sw.mode interlocked [BOOL]** and **Bay_Name.General> Sw.mode non-interl [BOOL]**

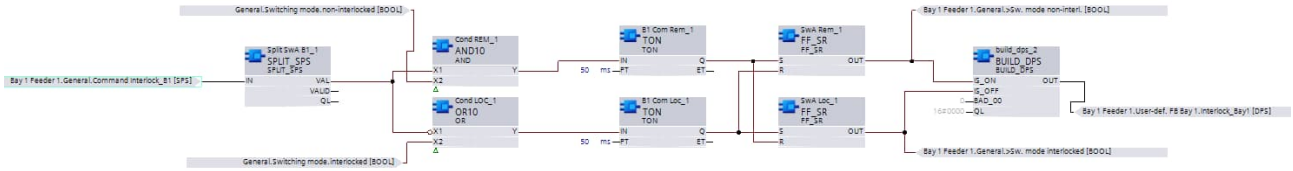


Fig 5. Interlocking OFF/Normal commands per bay

Please refer to the document **SIP5_7SX82_85_V09.60_Manual_C607-A_enz, Chapter 14. Control Functions**
→ **Control Functionality** for a better understanding of this bay functionality.

The user could then group the CFCs by bay as shown in the figure below:

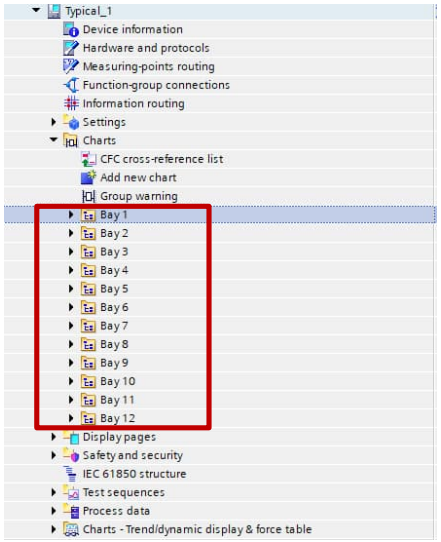


Fig. 6. CFC grouped per bay.

1.2.3. Displays per bay.

Additionally, each bay has two displays, one for control and the other for bay measurements.

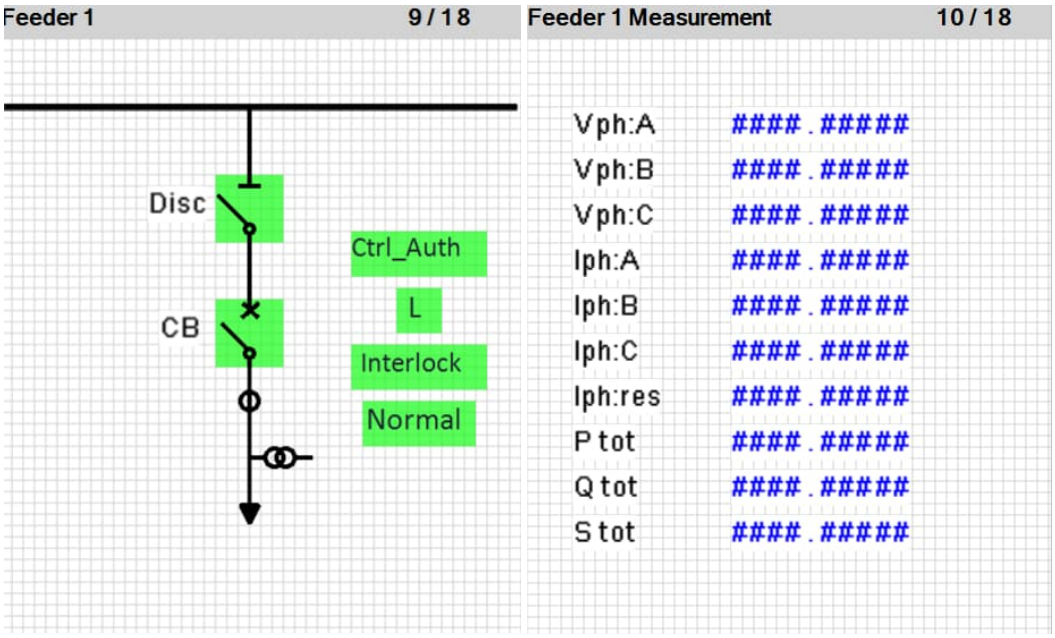


Fig. 7. Bay displays.

The Control Display additionally has the option of local commands so that the user can switch only for one bay if the controls are local or remote, additionally for the Interlocks if they will be Normal or off.

1.3 Capabilities for a 7SX85 as a small CPC.

1.3.1 Distributed CPC Light.

This section will show different typical substations in a distributed CPC configuration, including the bay units/Merging units located close to the primary equipment. The user can define the amount of Binay I/O per bay unit.

The components for a distributed CPC include:

- Universal SIPROTEC device 7SX85 with communication module **ETH-BD-2FO** for process bus and **ETH-BX-XXX** for Station Bus.
- Bay Units (Merging Units), interface between the instrument transformers, primary equipment and 7SX85.
- Additional components like switches, clocks according to IEEE 1588, IEC 61850-9-3.
- A proper redundancy according to the solution (Line mode, PRP, HSR).
- In general, compliance with standards such as IEC61850, IEC61869 and technical recommendations for digital substations.

- **Typical 1. Only feeders with Tie.**

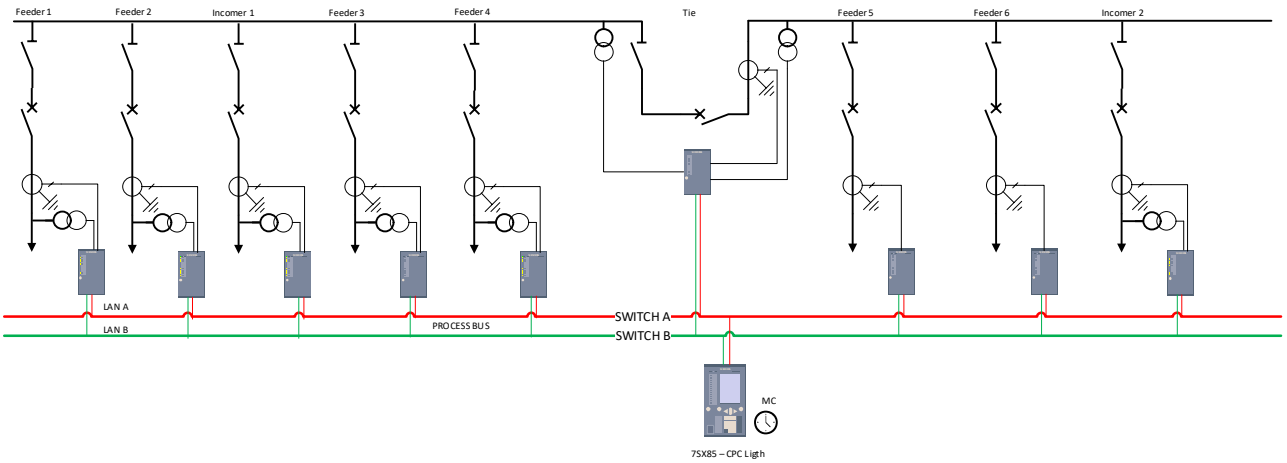


Fig. 8. Distributed CPC Light Typical Nr. 1.

For this typical, the following summary table applies:

Bays Qty	MP 3Iph	MP 3Vph	Typical Bay						Protection functions included										Total F.P.*
			Feeder with line VT	Feeder w/o line VT	Tie	Line Type 1	Line Type 2	Trf	87T	87L	21	85 21 & 85 67N	67/ 67N	50 (N) 51 (N)	59/ 27	25	79	50BF	
9	9	8	6	2	1	0	0	0	0	0	0	0	8	9	9	7	8	9	1672

Table 1. Summary table for Typical 1.

NOTE (*):

The Total function points are given by the number of protection functions, but additionally by the number of controllable disconnectors, Circuit breakers, process bus client functionality and 1588 Master Clock property, among others.

The resource consumption due to CFC is given in the following figure.

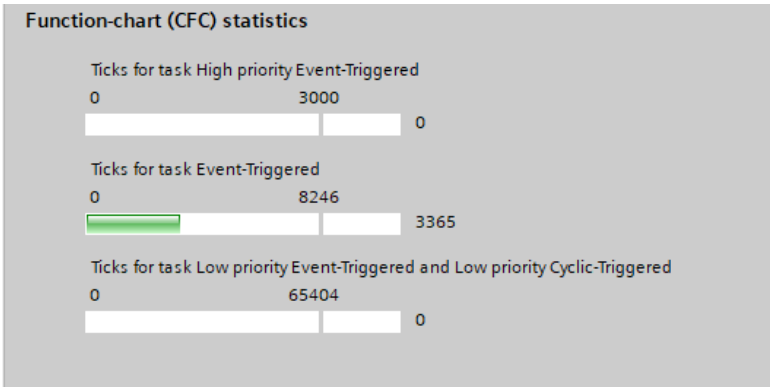


Fig. 9. Resource consumption per CFC logics.

- **Typical 2. Lines (with distance protection) and Feeders.**

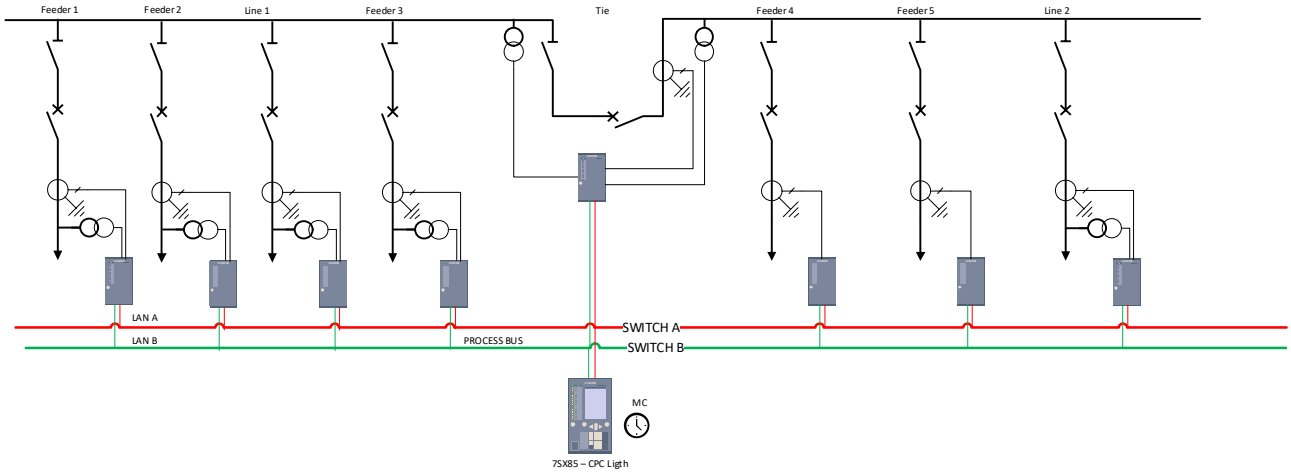


Fig. 10. Distributed CPC Light Typical Nr. 2.

For this typical, the following summary table applies:

Bays Qty	MP 3Iph	MP 3Vph	Typical Bay						Protection functions included										Total F.P.*
			Feeder with line VT	Feeder w/o line VT	Tie	Line Type 1	Line Type 2	Trf	87T	87L	21	85 21 & 85 67N	67/ 67N	50 (N) 51 (N)	59/ 27	25	79	50BF	
8	8	7	3	2	1	2	0	0	0	0	2	2	7	8	8	6	7	8	2216

Table 2. Summary table for Typical 2.

The resource consumption due to CFC is given in the following figure.

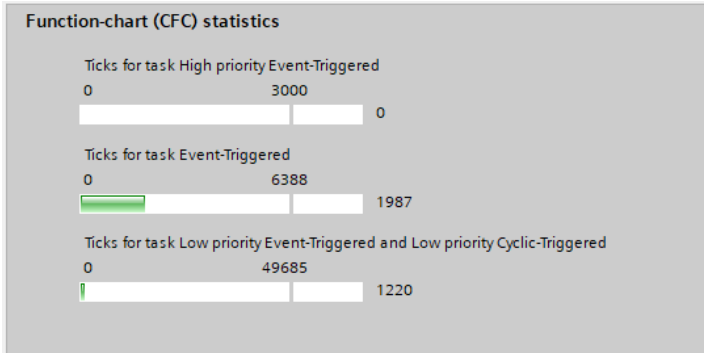


Fig. 11. Resource consumption per CFC logics.

- **Typical 3. Two Lines (with differential and distance protection) and Feeders.**

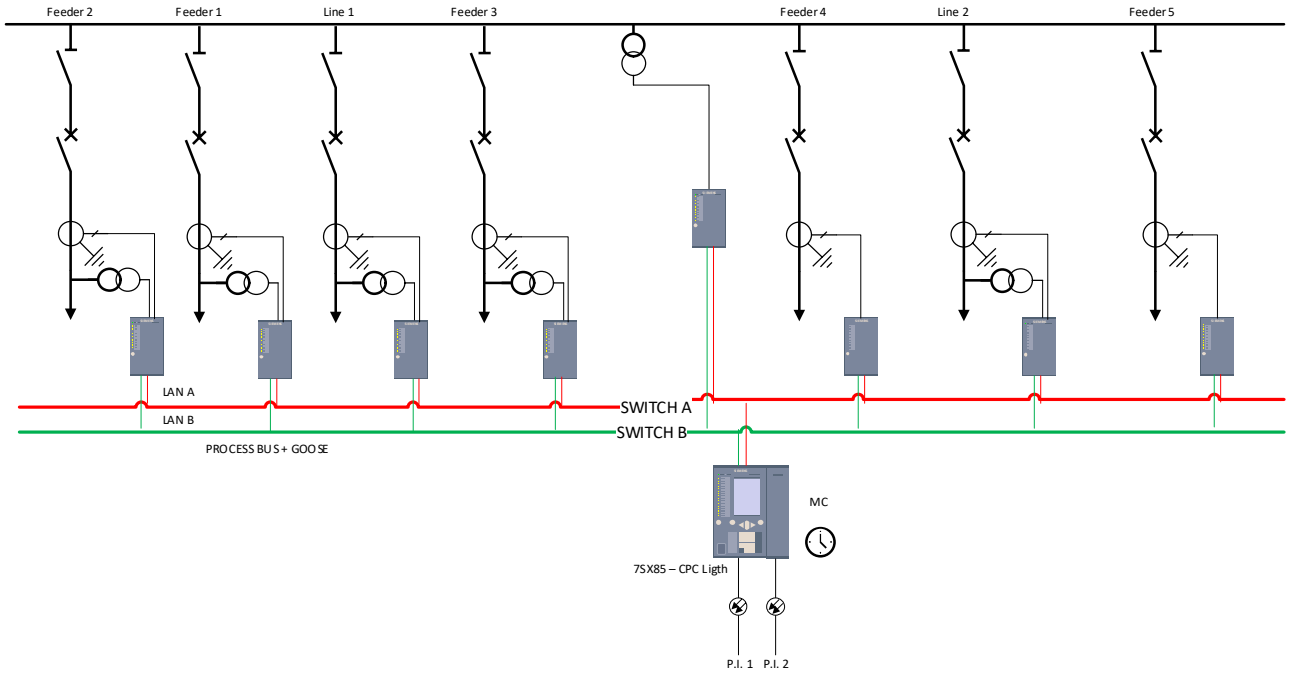


Fig. 12. Distributed CPC Light Typical Nr. 3.

For this typical, the following summary table applies:

Bays Qty	MP 3Iph	MP 3Vph	Typical Bay						Protection functions included										Total F.P.*
			Feeder with line VT	Feeder w/o line VT	Tie	Line Type 1	Line Type 2	Trf	87T	87L	21	85 21 & 85 67N	67/ 67N	50 (N) 51 (N)	59/ 27	25	79	50BF	
7	7	6	3	2	0	0	2	0	0	2	2	2	7	7	7	5	7	7	2732

Table 3. Summary table for Typical 3.

The resource consumption due to CFC is given in the following figure.

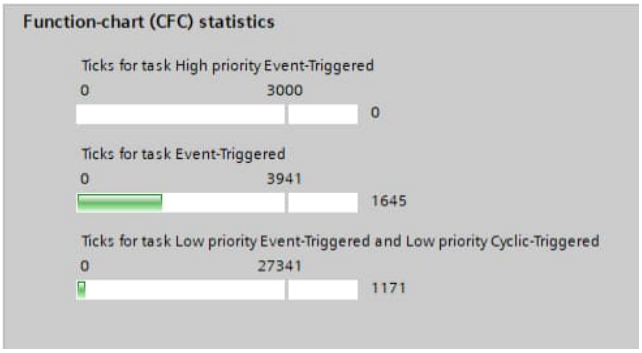


Fig. 13. Resource consumption due to CFC logics.

Note that for the dual functionality of 87L in a device, it is necessary to add the functional group **Prot. com. (type 1),** as is shown in the manual **SIP5_7SA-SD-SL-VK-87_V09.60_Manual_C011-M, Chapter 3.6.6 Advanced protection communication.** Also, it is necessary that communication module **USART-XX-XXX** must be configured with the **Adv. Prot. Intrf** option.

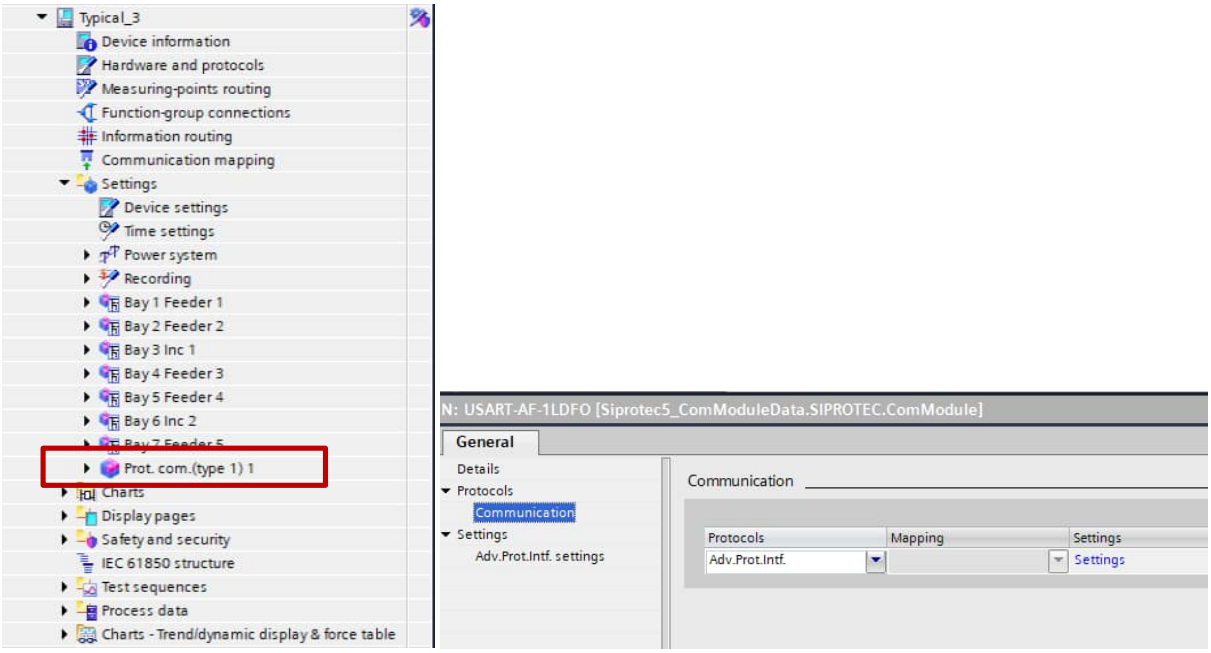


Fig. 14. Necessary settings for double 87L functionality in one device.

- **Typical 4. Lines (with differential and distance protection) and Feeder.**

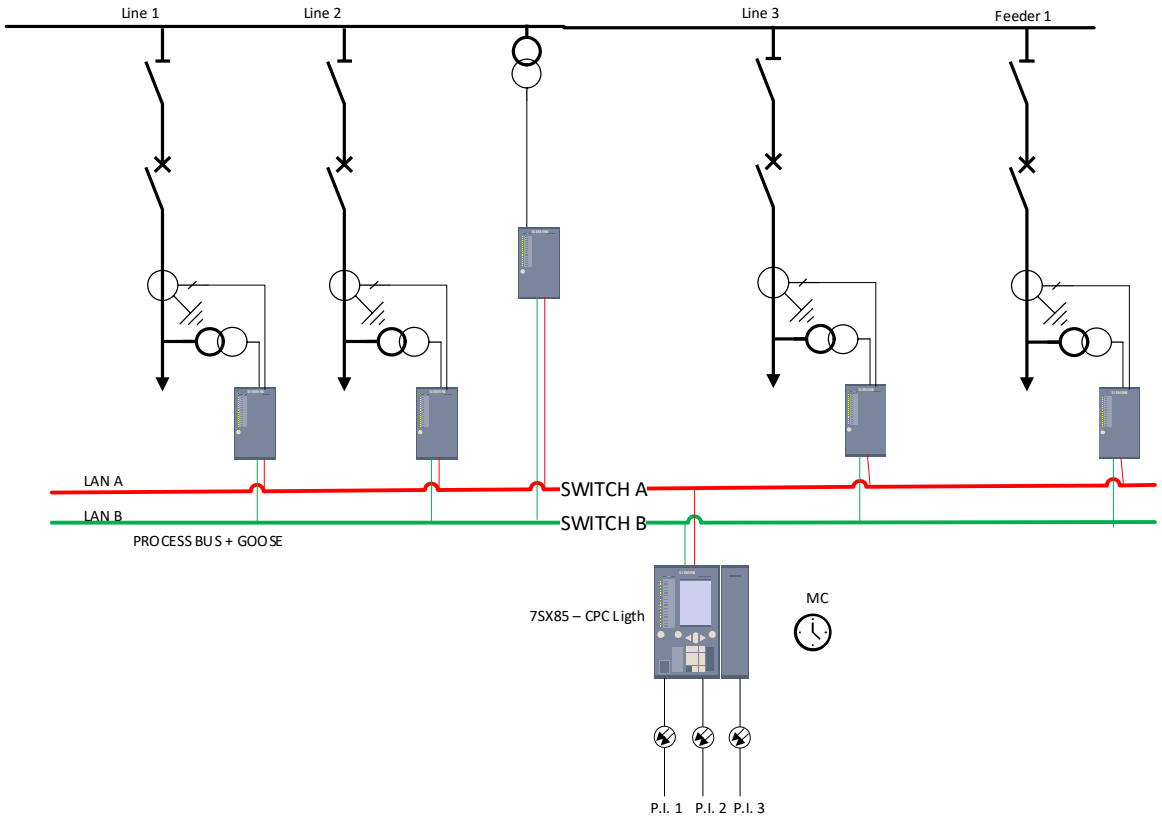


Fig. 15. Distributed CPC Light Typical Nr. 4.

For this typical, the following summary table applies:

Bays Qty	MP 3Iph	MP 3Vph	Typical Bay						Protection functions included										Total F.P.*
			Feeder with line VT	Feeder w/o line VT	Tie	Line Type 1	Line Type 2	Trf	87T	87L	21	85 21 & 85 67N	67/ 67N	50 (N) 51 (N)	59/ 27	25	79	50BF	
4	4	5	1	0	0	0	3	0	0	3	3	3	4	4	4	4	4	4	2654

Table 4. Summary table for Typical 4.

As this typical include 3 x line differential protection schemes, note that it would not be possible to add an exclusive port for the station bus, if the application does not require communication redundancy the user can use the J port, or use the process bus port also for station bus (please follow the recommendations for this cases).

The following figure shows in a red box highlighted the ports used for 87L functionality.

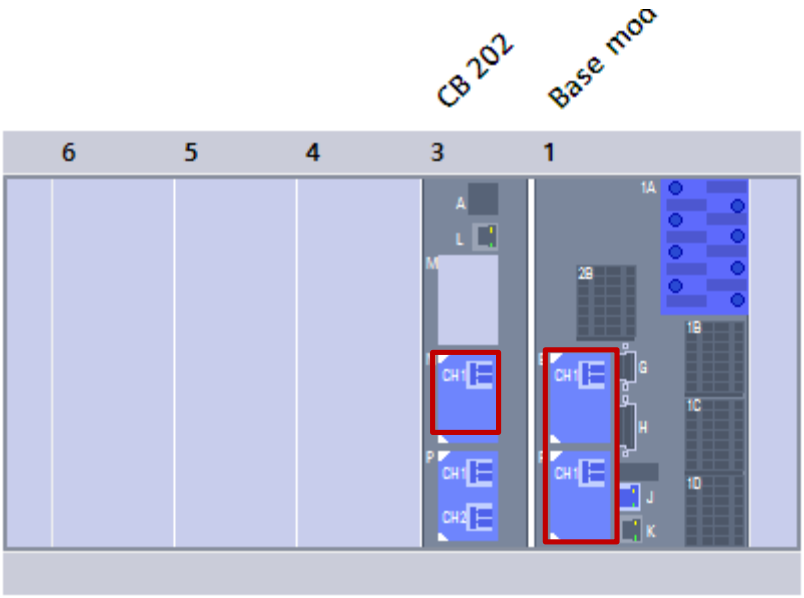


Fig 16. Comm Ports used for 87L protection function.

The resource consumption due to CFC is given in the following figure.

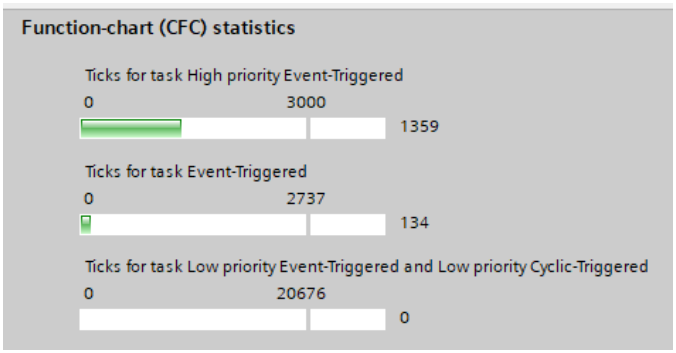


Fig. 17. Resource consumption due to CFC logics.

- **Typical 5. Transformer, Line and Feeders**

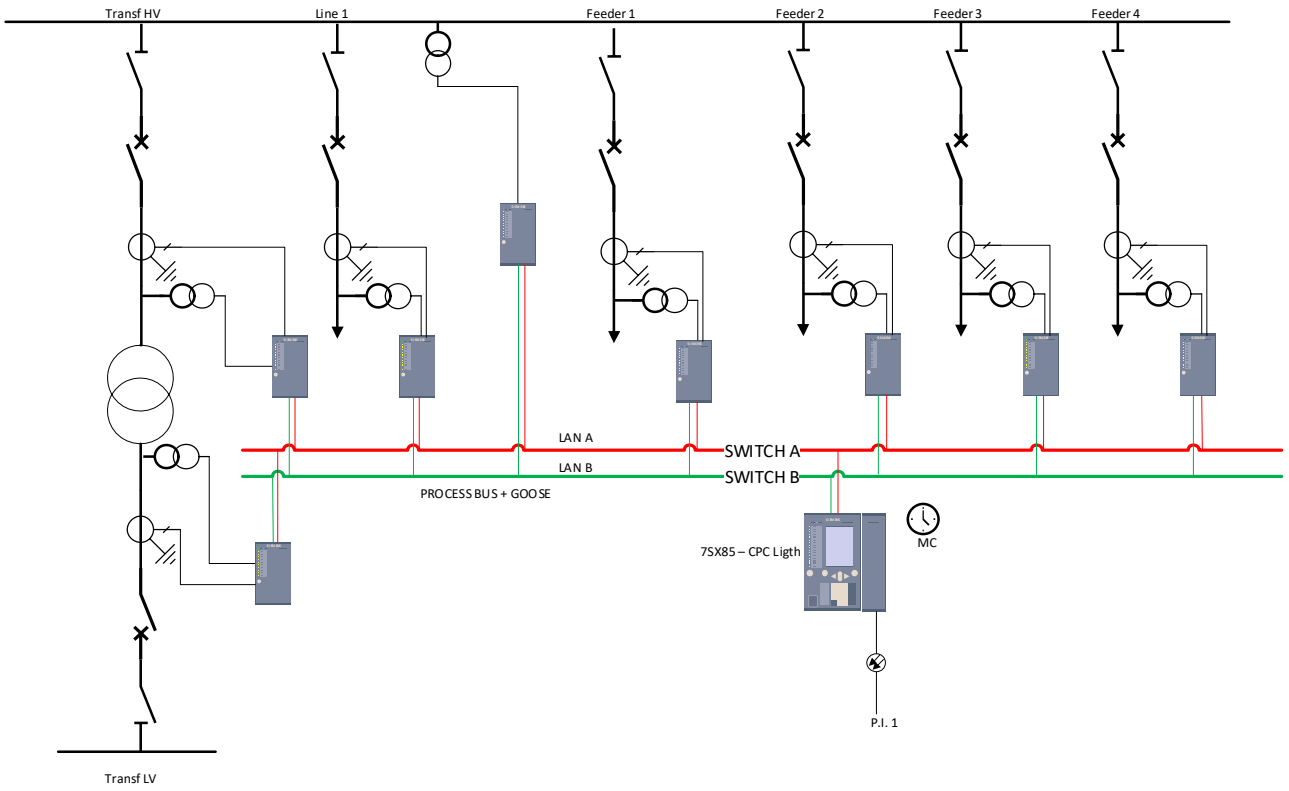


Fig. 18. Distributed CPC Light Typical Nr. 5.

For this typical, the following summary table applies:

Bays Qty	MP 3Iph	MP 3Vph	Typical Bay						Protection functions included										Total F.P.*
			Feeder with line VT	Feeder w/o line VT	Tie	Line Type 1	Line Type 2	Trf	87T	87L	21	85 21 & 85 67 N	67/ 67N	50 (N) 51 (N)	59/ 27	25	79	50BF	
7	7	7	4	0	0	0	1	1	1	1	1	1	3	7	7	7	5	7	1992

Table 5. Summary table for Typical 5.

The Transformer functionality, including the FG **Transformer diff. 1**, **Transformer side 1** and **Transformer side 2**, are associated with two bays, as is indicated in the following figure.

Connect function group to circuit-breaker groups

	Bay 1 Transf HV	Bay 2 Transf LV	Bay 3 Line 1	Bay 4 Feeder 1	Bay 5 Feeder 2
Protection group	Circuit breaker 1	Circuit breaker 1	Circuit breaker 1	Circuit breaker 1	Circuit breaker 1
(All)	(All)	(All)	(All)	(All)	(All)
Transformer diff. 1	X	X			
Transformer side 1	X				
Transformer side 2		X			
Bay 1 Transf HV	X				
Bay 2 Transf LV		X			
Bay 3 Line 1			X		
Bay 4 Feeder 1				X	
Bay 5 Feeder 2					X

Fig 19. Bays connected to FG transformer.

The resource consumption due to CFC is given in the following figure.

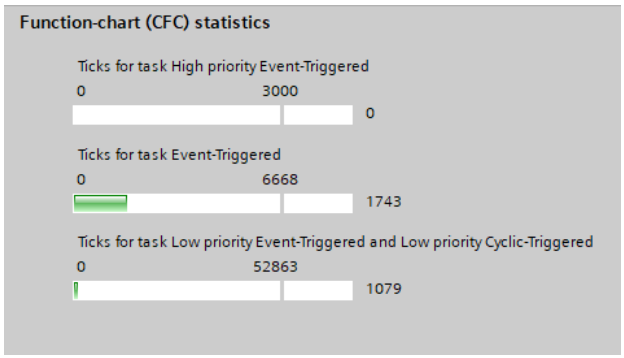


Fig. 20. Resource consumption due to CFC logics.

- **Typical 6. Transformers and Feeders**

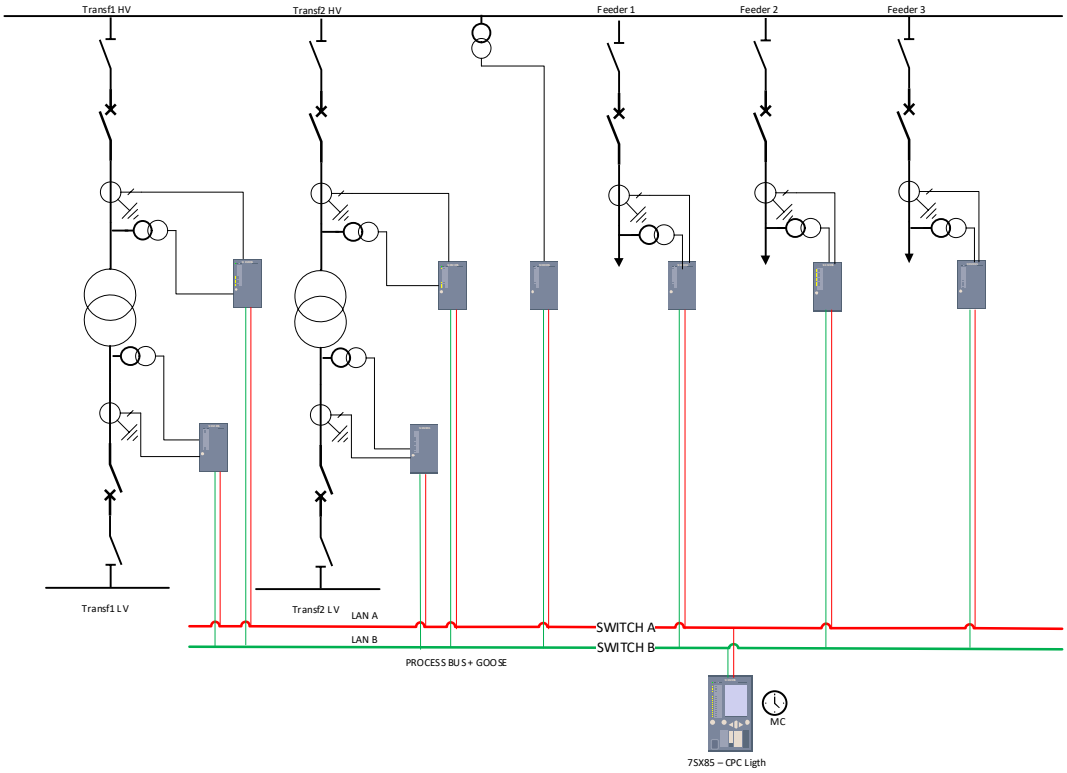


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Fig. 21. Distributed CPC Light Typical Nr.6.

For this typical, the following summary table applies:

Bays Qty	MP 3Iph	MP 3Vph	Typical Bay						Protection functions included										Total F.P.*
			Feeder with line VT	Feeder w/o line VT	Tie	Line Type 1	Line Type 2	Trf	87T	87L	21	85 21 & 85 67 N	67/ 67N	50 (N) 51 (N)	59/ 27	25	79	50BF	
7	7	8	3	0	0	0	0	2	2	0	0	0	3	7	7	7	3	7	1392

Table 6. Summary table for Typical 6.

Each Transformer Bay includes 2 Bays as was shown in Fig. 17.

The resource consumption due to CFC is given in the following figure.

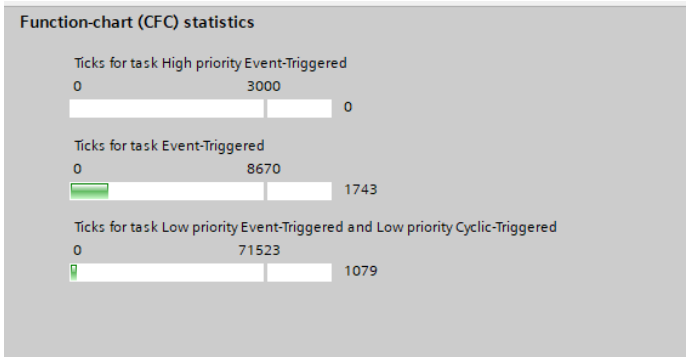

Fig. 22. Resource consumption due to CFC logics.

1.3.2 Centralized CPC Light

This section covers typical configurations for the 7SX85 relay as CPC Light in a centralized architecture. For this type of simulation, a maximum of 10 Binary Inputs and 7 binary outputs per bay was considered.

For more binary inputs or outputs the user might consider what is shown in the **SIP5-APN-040_SIPROTEC7SS85-extension-with-6MD8x Application**.

The first step is the configuration of the device with its analog and binary signals, to obtain an optimization of the hardware the user can custom the SIRPOTEC 5 device using the assistant of the SIPROTEC 5 Configurator, as shown in the following figure.

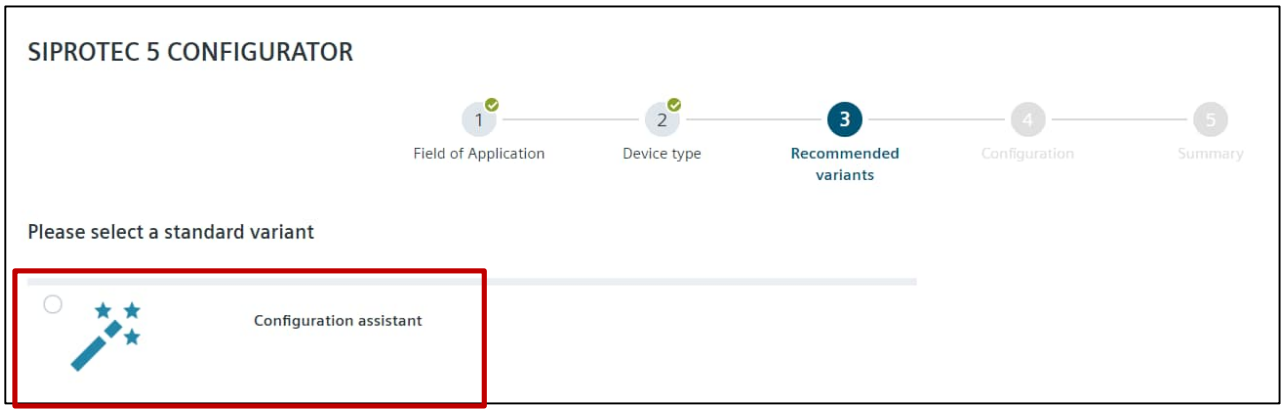

Fig. 23. Configuration assistant.

for example, if the Light CPC has 5 Bays, each with 10 BI, 7 BO, 4 x VT and 4 x CT. The total sum of the required hardware is typed into the configuration assistant:

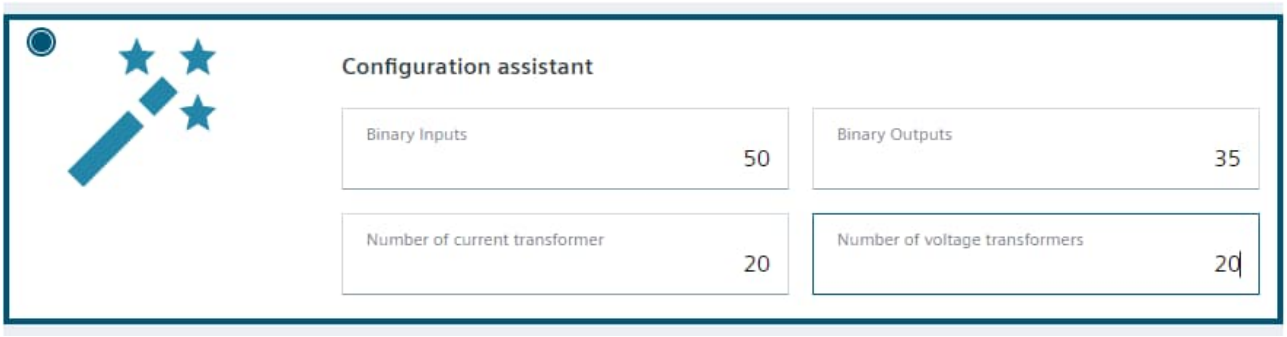

Fig 24. Configuration assistant step 2.

The configurator shows an optimized hardware configuration.

Fig 25. Optimized configuration example.

Review the results and if it fulfills the requirements the user can continue to the next steps of configure the 7SX85 Universal relay.

The following table shows the capabilities of the7SX85 as a centralized CPC, considering the same typical used in 1.3.1.

Typical	Bays Qty	MP 3Iph	MP 3Vph	Typical Bay				Total BI	Total F BO	Total Std BO	Total F.P.*
				Feeder with line VT	Line Type 1	Line Type 2	Trf				
1	9	9	9	9	0	0	0	91	62	5	1934
2	8	8	8	6	2	0	0	83	56	5	2478
3	6	6	6	4	0	2	0	67	44	5	2526
4	4	4	4	1	0	3	0	51	32	5	2754
5	7	7	7	4	0	1	1	75	50	5	2092
6	7	7	7	3	0	0	2	75	50	5	1612

Table 7. Overview of Quantities and Bay Types for Decentralized CPC

1.4 Conclusion

This application provides user support on the capabilities of 7SX85 universal relays with CPC functionality, the user can take these typical examples and use them as a reference for their final solution.

Using the 7SX85 as a CPC allows end users to eliminate the dependency of different device types per bay, due to the use of a single reference of Merging Units and one universal 7SX85 device with enough functional points as required in the solution. This will additionally allow a simplification in the Substation Asset management.

For simplified engineering of the bay units of your CPC solution, please review the contents of the **APN-100 Typical-Based Engineering**.