

# SIEMENS



SIPROTEC 5 Application Note

## Breaker-and-a-half solutions

SIP5-APN-002, Edition 2

## SIPROTEC 5 – Application Note

### Breaker-and-a half solutions

SIP5-APN-002, Edition 2

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## 1 Breaker-and-a-half solutions

### 1.1 Introduction

This application describes the requirements for the protection and control of breaker-and-a-half systems and introduces an efficient and innovative solution concept with SIPROTEC 5.

### 1.2 Terminology

The following terminology is used in the context of breaker-and-a-half:

- **Breaker-and-a-half:**  
This is the term used for the plant configuration shown in the single line diagram below.
- **Diameter:**  
This is the term used to describe the three circuit breakers and associated equipment in the diagram below. A number of such "diameters" in parallel are applied to the two busbars.
- **Stub Protection:**  
In this application this is a special protection that covers the zone between the breakers and the line isolator when the line isolator is open.
- **Tie-CB:**  
The central circuit breaker, between the two feeders, in the breaker-and-a-half configuration is referred to as the Tie-CB.
- **Leader/Follower:**  
The Leader/Follower logic is associated with the auto re-close function in the breaker-and-a-half configuration. It determines the sequence of re-closing of the two circuit breakers that trip to clear a fault on the OHL.
- **Function Group:**  
Within SIPROTEC5 the fixed allocation of particular function belongs to a set which is referred to as a Function Group. Not all functions are therefore available for all Function Groups.
- **Application Template** :  
Predefined device configuration in DIGSI (e.g DIS overhead line, grounded systems). The application templates contain the basic configurations, required functions groups and function as well as default settings.

### 1.3 Properties of a breaker-and-a-half application

- Each line is delimited by two circuit breakers and the associated current transformers. These currents have to be supersized and processed.
- Each diameter contains two feeders (two lines or line and transformer). The center circuit breaker is used jointly by both feeders. Only 3 circuit breakers are consequently available for 2 feeders. Hence the designation breaker-and-a-half application.
- Different voltages have to be selected for synchronizing the switching command depending on the switch position.

Requirements for the system solution

- Feeder protection (main protection and backup protection)
- Circuit-breaker failure protection
- AR for each circuit breaker of a feeder
- Controlling the diameter

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- Synchronization of each circuit breaker
- Sufficient number of inputs and outputs for controlling and detecting the switching elements and signal

### 1.4 Solution concept with SIPROTEC 5 for two feeders

- Main protection and backup protection devices for each line
- 1 central control unit for the entire diameter/bay
- All devices of a diameter are connected by means of a diameter bus.
- Distribution of the functions between the devices using the flexibility of SIPROTEC function structure:
  - Control unit: control, synchrocheck
  - Protection devices: protection, tripping, AR, circuit-breaker failure protection
- Flexible expansion of IOs using the modular quantity structure or connected IO units (diameter bus)

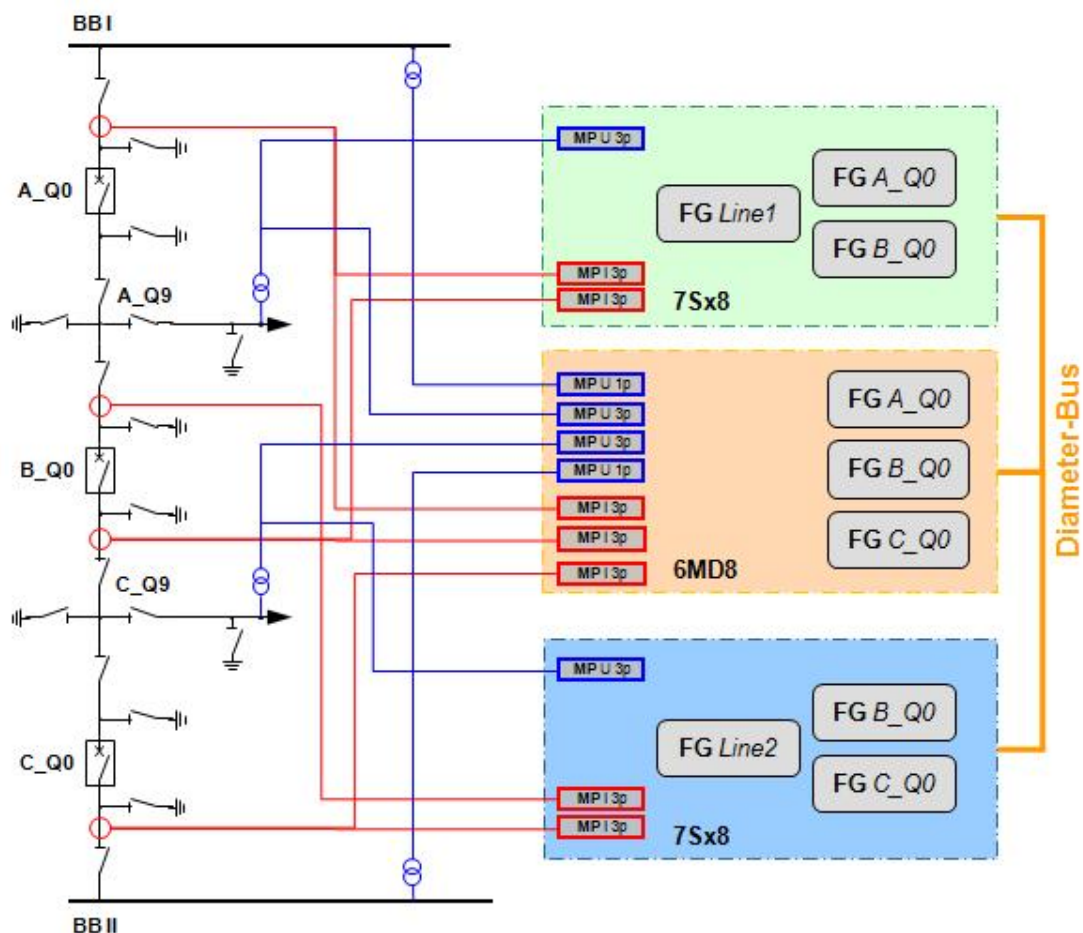


Figure 1: Overall concept for protection and control of breaker-and-a-half systems

### 1.5 Description of the individual system concepts

#### Diameter bus

The diameter bus is implemented in order to ensure the proper data exchange among the devices belonging to the diameter. This provides the following system benefits:

- fast data exchange between the devices
- isolated signal exchange (optical fiber)
- enhanced security compared to wire connections through monitoring of the signal links
- easy implementation of group indications and additional automation functions via SW (e.g. common start of fault records, coordination of protection functions that run parallel)
- It is possible to implement communication and function redundancy.
- easy integration of redundant devices and additional devices
- reduced wiring and engineering effort
- more flexibility for future modifications
- less space required

There is several options for such a diameter bus:

1. Using Protection Data Interfaces (PDI) - Modules USART-xx-yFO
2. Using a dedicated IEC61850 GOOSE Network by adding an ETH-xx-2FO Module, preferably using HSR configuration.

#### Controlling equipment

The switching equipment, circuit breakers and disconnector, is operated from a central bay controller.

- clearly arranged operation owing to representation on the device display
- The diameter bus provides the central bay controller with all the information that is relevant to assume the control task. (e.g. interlocking)
- It is possible to activate backup protection functions in the central bay controller if no line backup protection is used.

#### Synchrocheck

The synchrocheck is realized centrally in the bay controller for the entire diameter. All voltages are acquired directly and independently by the bay controller and applied to the synchrocheck function depending on the diameter current configuration.

- enhanced security and reduced wiring effort because no external coupling relays are needed to select the voltage
- monitoring of all voltage transformers (fuse failure monitor)

#### Line protection

The protection scheme can be implemented with a single device. Redundancy can be achieved by using the protection device of one feeder as the backup protection of the other.

- Line differential protection and distance protection in one device (7SL8). Alternatively, can be also distributed on two devices (7SD8 and 7SA8)
- integrated stub protection (87Stub) when line disconnectors are open
- increased sensitivity of the line differential protection through separate transformer acquisition

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- additional stability of the direction determination for the distance protection
- saturation detection for each transformer

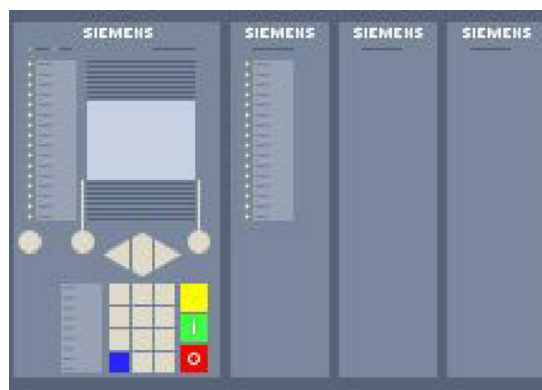
### 1.6 Description of the device hardware configuration

For this solution the following devices are selected:

- 7SL8 Line Differential and Distance Protection (Line 1 Main 1)
- 7SL8 Line Differential and Distance Protection (Line 2 Main 1)
- 6MD8 Bay Controller (Control of switching devices of the diameter)

2 x 7SL87 for Line 1 and 2:

Product code P1C107747 \*



7Sx8	I	U	BI	BO
PS 201			3	2
I/O 202	4	4	8	6
I/O 208	4	4	4	11
I/O 207	-	-	16	8
I/O 207	-	-	16	8
CB 202	Optional – not included			
<b>Total</b>			47	35
<b>used</b>			32	27
<b>spare:</b>			15	8
<b>Line 1</b>				

7Sx8	I	U	BI	BO
PS 201			3	2
I/O 202	4	4	8	6
I/O 208	4	4	4	11
I/O 207	-	-	16	8
I/O 207	-	-	16	8
CB 202	Optional – not included			
<b>Total</b>			47	35
<b>used:</b>			32	27
<b>spare:</b>			15	8
<b>Line 2</b>				

\* Diameter Bus with PDI

- Housing width: 5/6 x 19"
- Housing type: Flush mounting
- Binary inputs: 47\*\*
- Binary outputs: 36 Relays (22 Standard, 14 Fast, 0 High-Speed, 0 Power)\*\*
- Current transformers: 8 for protection, 0 for measurement and sensitive ground-current detection\*\*

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- Voltage transformers: 8\*\*
- Modules in 19" row 1: IO202 , PS201 , IO208 , IO207 , IO207
- Number of LEDs: 32
- Display type: Small display
- Power Supply: DC 60 V-250 V, AC 100 V-230 V

## Communication:

- Communications encryption: Normal
- Integrated Ethernet port: for DIGSI 5
- Plug-in module position E:  
USART-AE-2FO: 2 x optic 1.5 km, 820 nm, ST connector, for serial protocols, e.g. IEC60870-5-103, DNP3.0 etc. and protection interface
- Plug-in module position F:  
ETH-BB-2FO: 2 x optic Ethernet, Ethernet 100 Mbit/s, 1300 nm, LC-Duplex connector, 2 km over 50/125  $\mu$ m or 62,5/125  $\mu$ m multimode - fiber

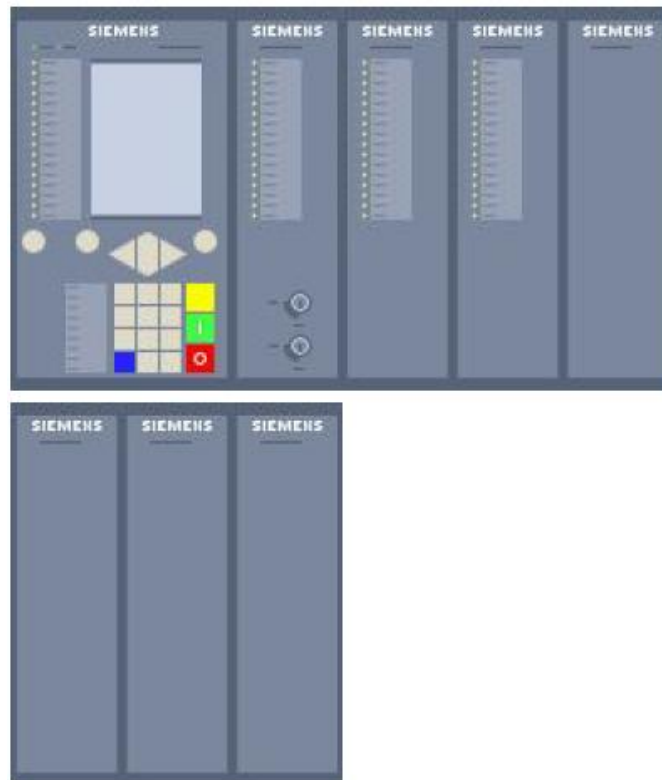
## Functions:

Function points class: Base + 425 function points

\*\* The amount of binary/analog inputs and outputs can be adjusted by adding, reducing, changing the IO Modules.

1 x 6MD86 for Control of switching equipment of the diameter:

Product code P1G93301\*



# Breaker-and-a-half solutions

## SIPROTEC 5 Application Note

<b>6MD8</b>	<b>I</b>	<b>U</b>	<b>BI</b>	<b>BO</b>
<b>PS 201</b>			3	2
<b>I/O 202</b>	4	4	8	6
<b>I/O 202</b>	4	4	8	6
<b>I/O 231</b>	-	-	24	24
<b>I/O 231</b>	-	-	24	24
<b>I/O 231</b>	-	-	24	24
<b>PS 203</b>			-	1
<b>I/O 231</b>	-	-	24	24
<b>I/O 230</b>	-	-	48	0
<b>CB 202</b>	Optional – not included			
			147	93
<b>used:</b>			47	36
<b>Spare (add. Indications: e.g. MCB trip)</b>			100	57

- Housing width: 9/6 x 19"
- Housing type: Flush mounting
- Binary inputs: 147\*\*
- Binary outputs: 93 Relays (75 Standard, 18 Fast, 0 High-Speed, 0 Power)\*\*
- Current transformers: 0 for protection, 12 for measurement and sensitive ground-current detection\*\*
- Voltage transformers: 8\*\*

\* Diameter Bus with PDI

\*\* The amount of binary/analog inputs and outputs can be adjusted by adding, reducing, changing the IO Modules.

- Modules in 19" row 1: IO202 , PS201 , IO202 , IO201 , IO231 , IO231
- Modules in 19" row 2: PS203, IO231 , IO230
- Number of LEDs: 64
- Key switch: With
- Display type: Large display
- Power Supply: DC 60 V-250 V, AC 100 V-230 V

Communication:

- Communications encryption: Normal
- Integrated Ethernet port: for DIGSI 5
- Plug-in module position E:  
ETH-BA-2EL: 2 x electric Ethernet, RJ45, applicable for DIGSI, IEC61850, DNP, etc.

Plug-in module position F:

USART-AD-1FO: 1 x optic 1.5 km, 820 nm, ST connector, for serial protocols, e.g. IEC60870-5-103, DNP3.0 etc. and protection interface

Functions:

- Function points class: Base



### 1.7 SIPROTEC 5 Function Groups for Breaker-and-a-half

In the SIPROTEC 5 platform was introduced the "Function Group" concept. A "Function group", FG, is the representation of a primary object like a line, circuit breaker, transformer, disconnector, or generic V-I groups, among others. The protection functions are assigned to the corresponding Function Groups where the protection functionality is to operate, providing a clear interface and separation of tasks between the various functions in a complex application. The following example shows the allocation of the required Function Groups and Protection Functions for this application:

Distribution of Protection Functions in the corresponding Function Groups:

	Protection Devices						Control Device		
	7SL87 Line 1 Main 1			7SL87 Line 2 Main 1			6MD86		
	FG Line	FG Circuit Breaker A_Q0	FG Circuit Breaker B_Q0	FG Line	FG Circuit Breaker C_Q0	FG Circuit Breaker B_Q0	FG Circuit Breaker A_Q0	FG Circuit Breaker B_Q0	FG Circuit Breaker C_Q0
Distance Protection	x			x					
Line Differential	x			x					
Over Current	x			x					
Over Voltage	x			x					
Auto Reclose		x	x		x	x			
Sync Check							x	x	x
Breaker Failure		x	x		x	x			

Figure 2: Functional allocation

### 1.8 Protection Functions (Optional Control Functions)

Several protection functions shall be normally enabled in a diameter in order to cover all possible fault scenarios. The table below shows an example for overhead lines OHL, indicating the type of IED that can be used with information about the applicable Function group and Protection functions, as well as the corresponding SIPROTEC 5 Application Note if available:

Function	Function Group	Description	Protection IED	Detailed App Instr.
Distance Protection	Line	Main and / or back up protection in OHL	7SA86, 7SA87, 7SL86 and 7SL87	SIP5-APN0016
Differential protection	Line	Main and / or back up protection in OHL	7SD86, 7SD87, 7SL86 and 7SL87	
Earth Fault Protection	Line	Back up protection in OHL	7SA86, 7SA87, 7SD86, 7SD87, 7SL86 and 7SL87	
Voltage / frequency Protection	Line	Additional protection in OHL	7SA86, 7SA87, 7SD86, 7SD87, 7SL86 and 7SL87	
Stub	Line	Protection to cover the zone	7SA86, 7SA87,	SIP5-APN017

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protection		between circuit breakers and line isolator	7SD86, 7SD87, 7SL86 and 7SL87	
Busbar protection	Busbar	Protection to the busbar and zone between CB and Busbar	7SS85	
Breaker failure protection	Circuit Breaker	Local back-up protection for breaker fail scenarios after a protection trip	7SA86, 7SA87, 7SD86, 7SD87, 7SL86 and 7SL87  7VK86 7VK87 and 6MD8x	
Auto reclose Incl. leader follower function	Circuit Breaker	Together with the OHL protection provides for reclose of CB after OHL fault clearance	7SA86, 7SA87, 7SD86, 7SD87, 7SL86 7SL87,  7VK86 7VK87 and 6MD8x	SIP5-APN-018
Sync Check	Circuit Breaker	Provides sync check prior to closing of CB (after AR or control command)	7SA86, 7SA87, 7SD86, 7SD87, 7SL86 and 7SL87  7VK86 7VK87 and 6MD8x	SIP5-APN-004

Figure 3: Function overview

## 1.9 Summary

The solution concept introduced above uses the multiple features of the SIPROTEC 5 series. It is based on a distributed system solution approach whose components are merged to a total solution using highly efficient and reliable communication options. The individual functions can be adjusted flexibly to customer requirements and to the individual device within the overall solution.

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