



EXPERT WORKSHOP SERIES

Line Differential Protection webinar series

Bonus Live Q&A Session

Tutorial series overview

1. Line differential protection basics
2. Line differential protection interfaces
3. Line differential protection: configuration and testing
4. Line differential compatibility of SIPROTEC 4 and SIPROTEC 5



Thematic blocks of Questions

- General questions
- Line differential protection compatibility
- Protection communication
- CT questions
- Webinar organization

Line Differential Protection - Part 4

Thank you for attending our webinar

Thank you so much for joining our webinar.
We hope you enjoyed it and got the most out of it.

Our webinar is now on-demand, should you like to view it again click the button to enter the recorded webcast at any time.

If you are interested in our upcoming or as well past webinars register for free here: [Electrification and Automation Webinars](#).

Best regards your
Siemens - Electrification and Automation Team

Thank you and enjoy! Hope to see you soon.

[Go to the recording](#)

Differential vs. Distance Protection

Is there a line length where Line Diff. is preferred over distance protection, or vice versa?

Line Differential Protection Principle

Advantages

- No voltage transformer (VT) needed – only CT's
- 100% of line protected without time delays
- Suitable for:
 - (Short) cables and overhead lines
 - Multi-ended lines (tapped lines)
 - In-zone transformer applications
 - Series compensated lines
- No impact of parallel lines
- No impact of power swings
- All kinds of network grounding
- Sensitive for high resistive and arcing faults
- Simple relay settings

Disadvantages

- Communication channel required
 - Fast
 - Reliable
 - Supervision of communication channel
- No backup protection for external equipment
 - Following lines, transformers, ...
 - Only „in-zone“, defined by CT locations

Distance protection

Short lines

Measurement errors

- CT 10P20 → 10 % error @ $20 \cdot I_r$ → e.g. 600 A / 1 A → 10 % @ 12 kA = 1200 A
- CT error e.g. 3 % @ $I_{fault} = 5 \text{ kA}$
- VT error e.g. 3 % for class 3P @ (5% ... 120%) U_r
- Impedance error approx. 6 %

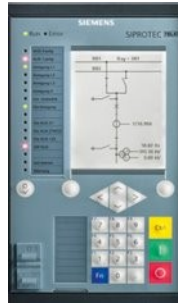
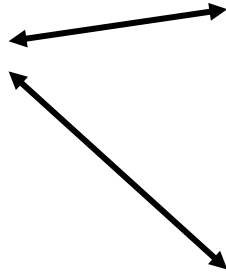
Relay settings

- Lowest relay impedance setting @ $I_n = 1 \text{ A}$: 0,05 Ohm (secondary) (measurement accuracy)
- Min. measuring voltage for accuracy claims → e.g. 1 V (secondary)
- “Short” depends on SIR (source to line impedance ratio)
- Strong network → low voltage drop at relay → “short” = few kilometer
- Weak network → high voltage drop at relay → “short” = few hundred meters

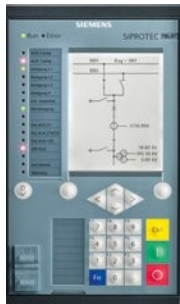
Interoperability

Can we mix line differential protection devices of different manufacturer?

Line Differential Protection Interoperability



- Interoperability between SIPROTEC 4 & SIPROTEC 5 (compatibility modes)
- Interoperability between SIPROTEC 5 devices with different firmware versions (down to FW V04.00)
- Interoperability between different SIPROTEC 5 devices (7SD82, 7SL87, 7UT8, 7SX85, ...)



- Not compatible with other manufactures (proprietary communication protocols)

87L algorithm

Why there is no slope setting for line differential relay?

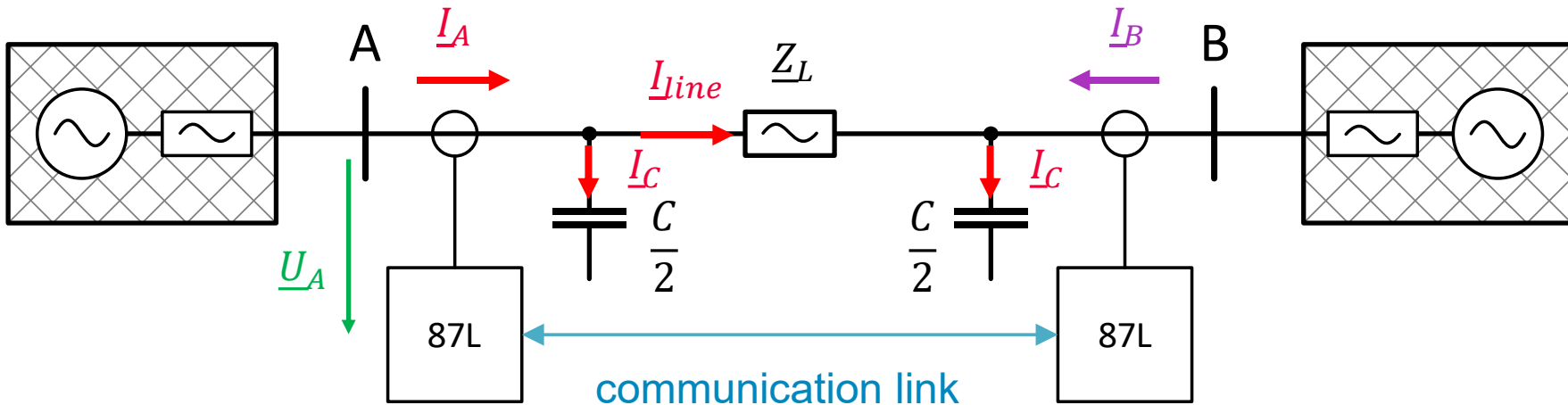
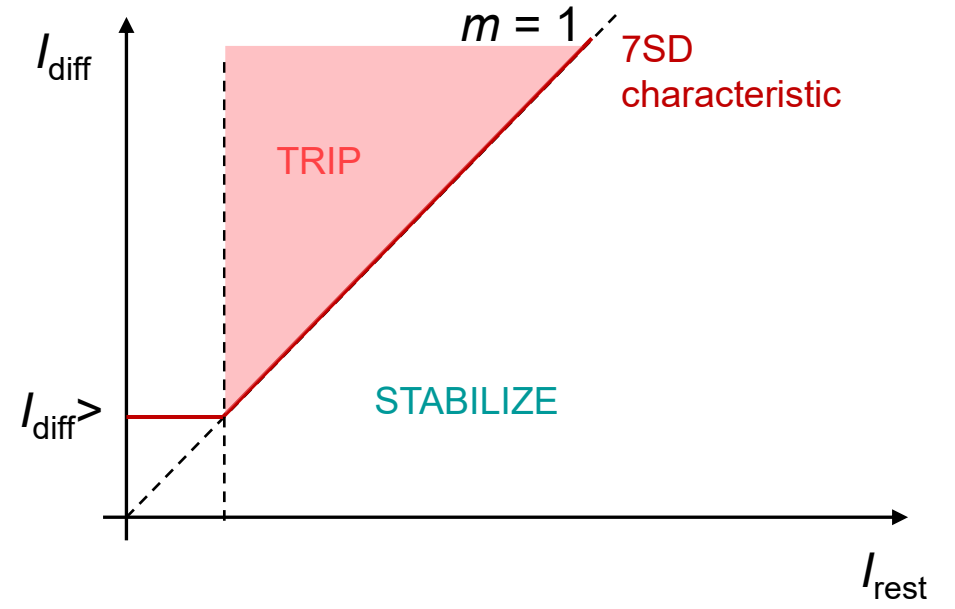
Line differential protection principle

Adaptive restrained differential characteristic – 7SD5/6/8

- Single slope characteristic
 - Fixed 45° slope
 - Adaptive restraining current (incl. measuring errors, signal distortion)

$$I_{diff,ph} = |I_{A,ph} + I_{B,ph}|$$

$$I_{rest,ph} = I_{thr} + \sum_n I_{ph,CTerr} + \sum_n I_{ph,SigDist} + I_{sync}$$



CT saturation & Inrush

How is CT saturation handled in the Line Diff. algorithm?

Why 5th Harmonics blocking is not available in 7SL87 relay in 87L function?

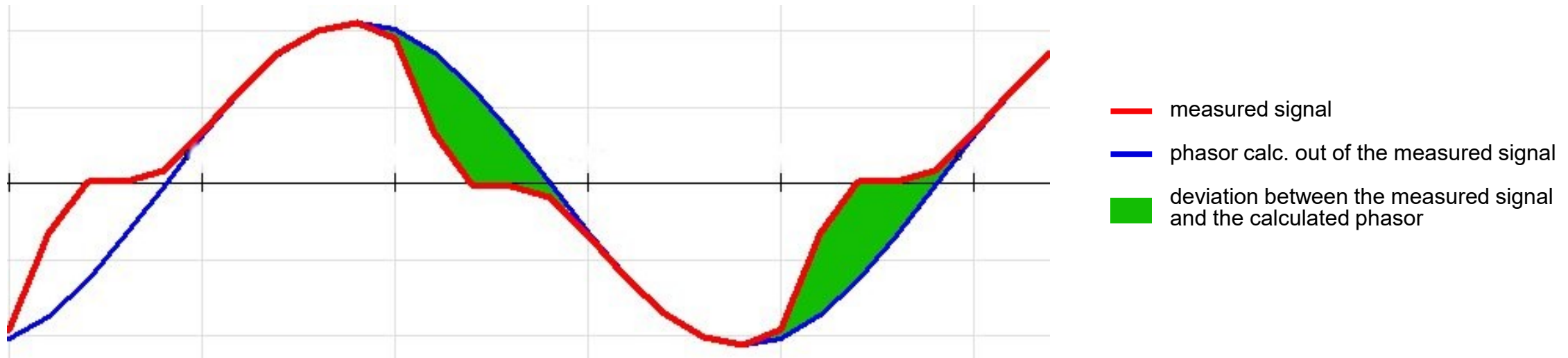
7SD8 Line Differential Protection Restraining Current: Signal Distortion

$$I_{rest} = I_{thr} + \sum_n I_{ph,CTerr} + \sum_n I_{ph,SigDist} + I_{sync}$$

- Differential currents due to CT saturation and signal distortion (e.g. current harmonics)
 - Transient errors

→ Deviation of measured signal compared to fundamental frequency component

→ Adaptive stabilization



Rated values – Setting clarification

Rated current in the 'Line/ General' settings must be the same in both devices.

Should the rated current be the same as CT ratio?

What about Rated normal current in 'Circuit breaker/ General' settings?

Rated values in DIGSI 5

CT nominal data:

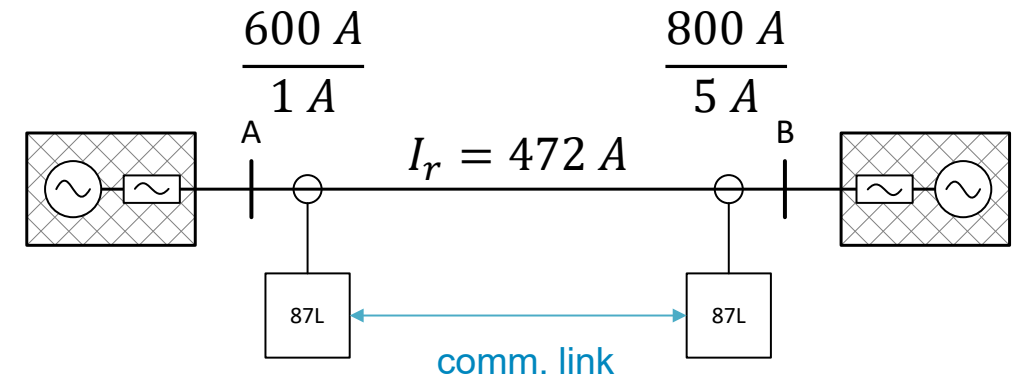
CT phases	
11.931.8881.101	Rated primary current: <input type="text" value="600.0"/> A
11.931.8881.102	Rated secondary current: <input type="text" value="1 A"/>

Nominal data of the protection object:

General	
Rated values	
21.9001.101	Rated current: <input type="text" value="472"/> A
21.9001.102	Rated voltage: <input type="text" value="220.00"/> kV
21.9001.103	Rated apparent power: <input type="text" value="179.9"/> MVA

Nominal data of the circuit breaker:

General	
Ref. for %-values	
301.2311.101	Rated normal current: <input type="text" value="1000.00"/> A
301.2311.102	Rated voltage: <input type="text" value="400.00"/> kV



CT ratio

How the relay handles different CTs at the substations? If CT ratio or CT class is different. How about another difference between CTs?

CT ratio & CT error

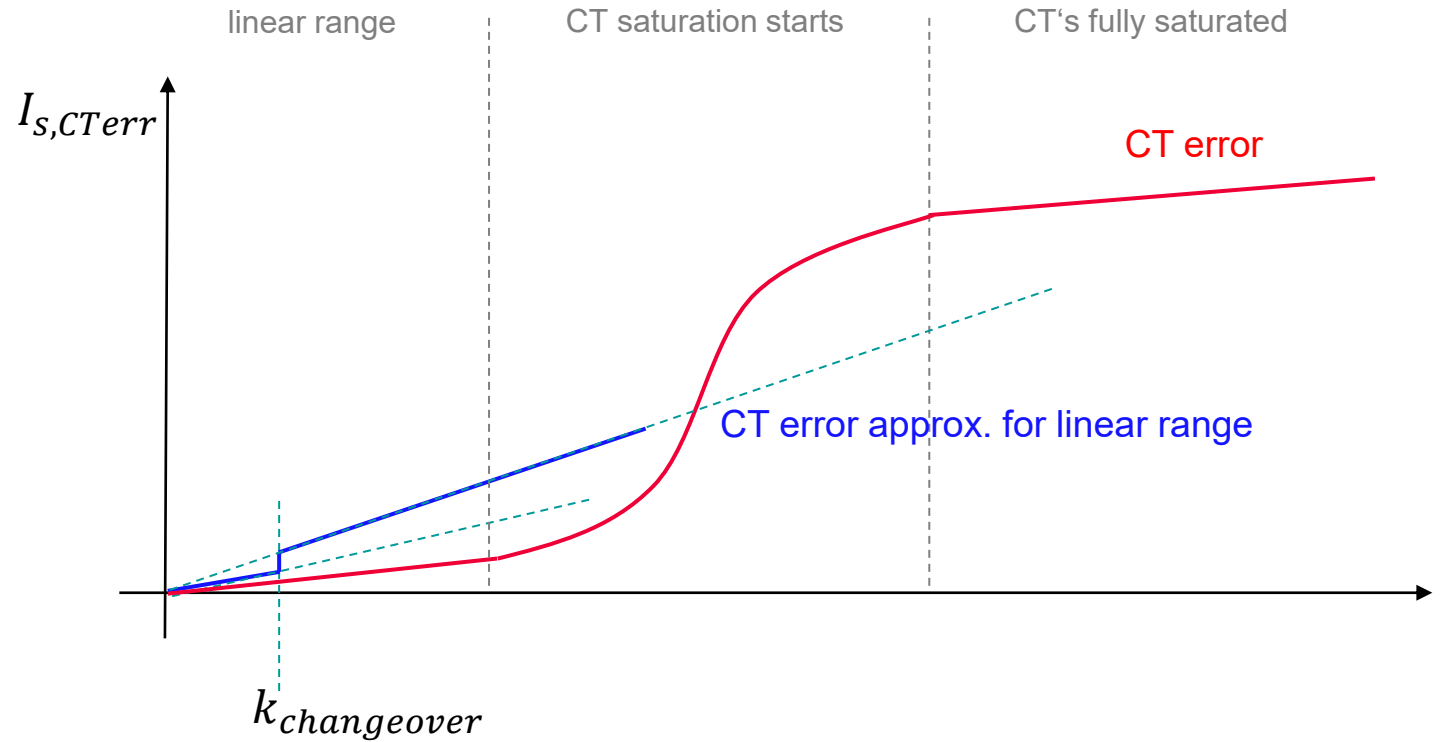
$$I_{rest} = I_{thr} + \sum_n I_{ph,CTerr} + \sum_n I_{ph,SigDist} + I_{sync}$$

Transformer Class	STANDARD	Ratio Error at Rated Current	Angle Error at Rated Current	Fault at Rated Overcurrent Factor	Fault Transition ³⁰	CT error A ³⁰	CT error B ³⁰
5P	IEC 60044-1	1.0 %	± 60 min	≤ 5 %	1.50	3.0 %	10.0 %
10P		3.0 %	–	≤ 10 %	1.50	5.0 %	15.0 %
TPX		0.5 %	± 30 min	ε ≤ 10 %	1.50	1.0 %	15.0 %
TPY		1.0 %	± 30 min	ε ≤ 10 %	1.50	3.0 %	15.0 %
TPZ		1.0 %	180 min ± 18 min	ε ≤ 10 % (only I ≈)	1.50	6.0 %	20.0 %
PX	IEC 60044-1 OV: Class X				1.50	3.0 %	10.0 %
C100 to C800	ANSI				1.50	5.0 %	15.0 %
5TPE	IEC 61869-10	1.0 %	± 60 min	≤ 5 %	1.50	5.0 %	15.0 %

CT ratio & CT error

$$I_{rest} = I_{thr} + \sum_n I_{ph,CTerr} + \sum_n I_{ph,SigDist} + I_{sync}$$

Rated primary current:	<input type="text" value="1000.0"/>	A
Rated secondary current:	<input type="text" value="1 A"/>	
Current range:	<input type="text" value="100 x IR"/>	
Internal CT type:	<input type="text" value="CT protection"/>	
Neutr.point in dir.of ref.obj:	<input type="text" value="yes"/>	
Inverted phases:	<input type="text" value="none"/>	
CT error changeover:	<input type="text" value="1.50"/>	
CT error A:	<input type="text" value="5.0"/>	%
CT error B:	<input type="text" value="15.0"/>	%



The relays exchange percentage values in relation to the nominal line current.

Max. & min. line length for 87L

What is the maximum and minimum distance for a SIPROTEC 5 Line differential protection topology?

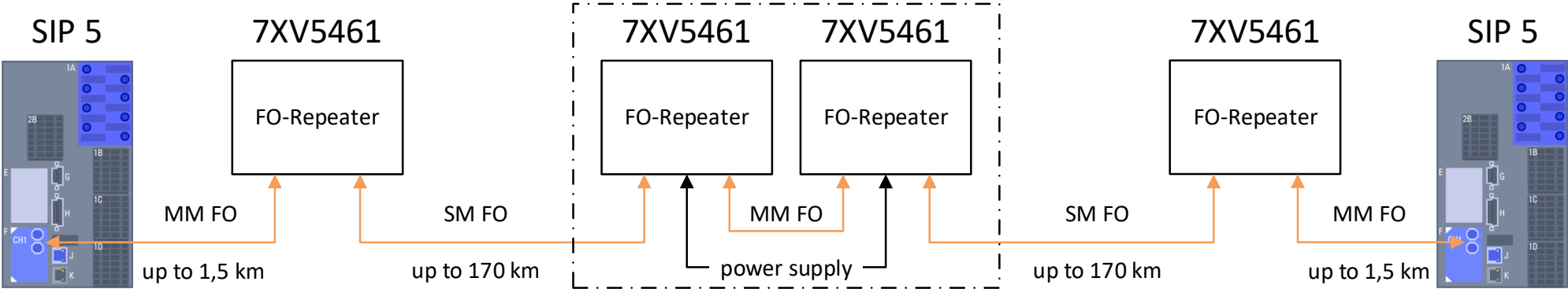
For a transmission lines do you think that is technical defendable to do a differential protection?

Maximum / minimum line length for 87L

There is no definite value for a maximum or a minimum distance between two devices of an 87L topology.

Long lines:

Example: Very long FO distance application



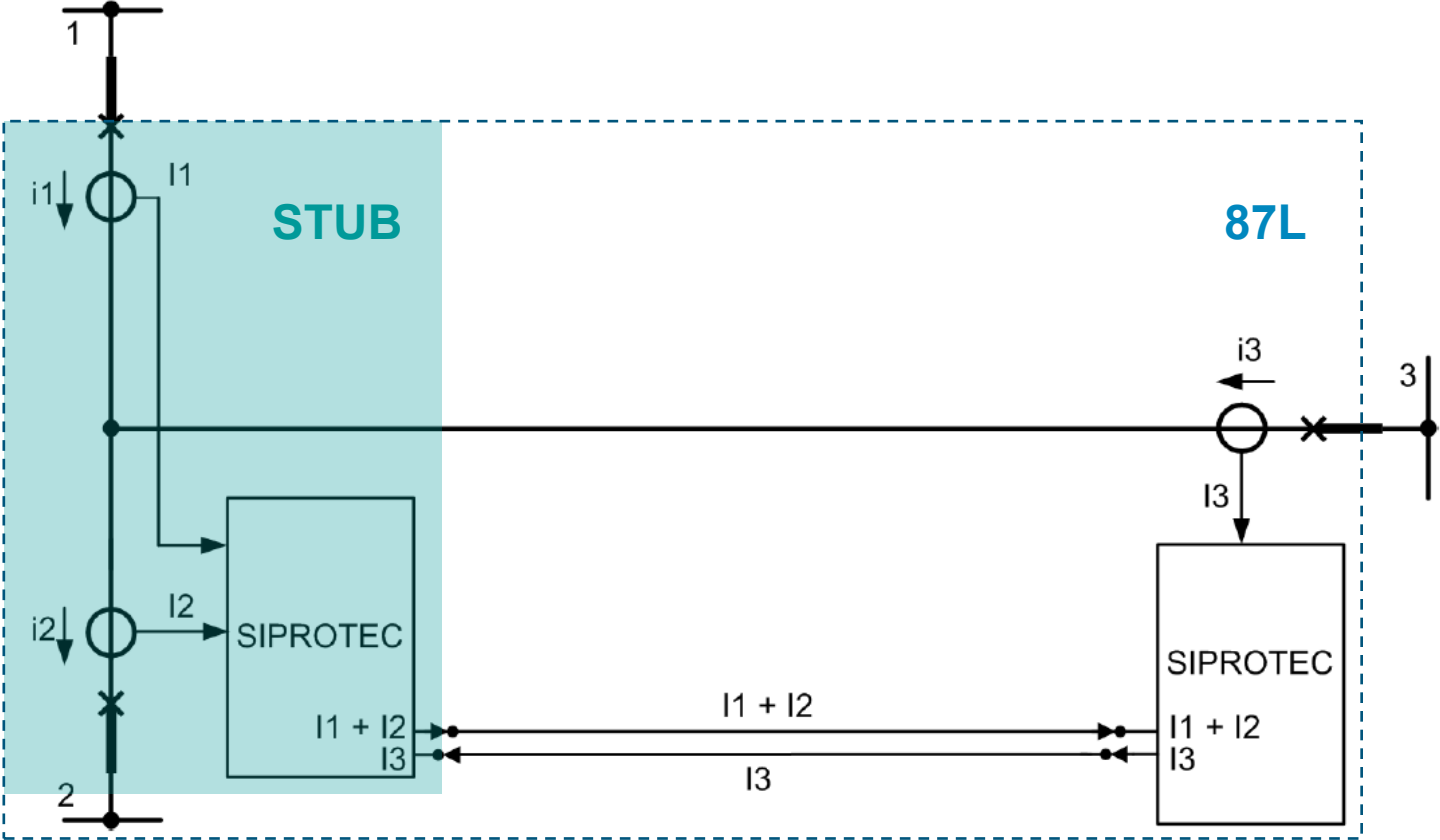
Short lines:

For short distances, the usage of the 87STUB can make sense, because then you only need 1 device

Stub Differential Protection

Can we use Stub Differential in between 1st and 2nd CT(1st zone) and Line Differential in between 1st and 3rd CT (Zone-2) ?

Possible application for the 87STUB

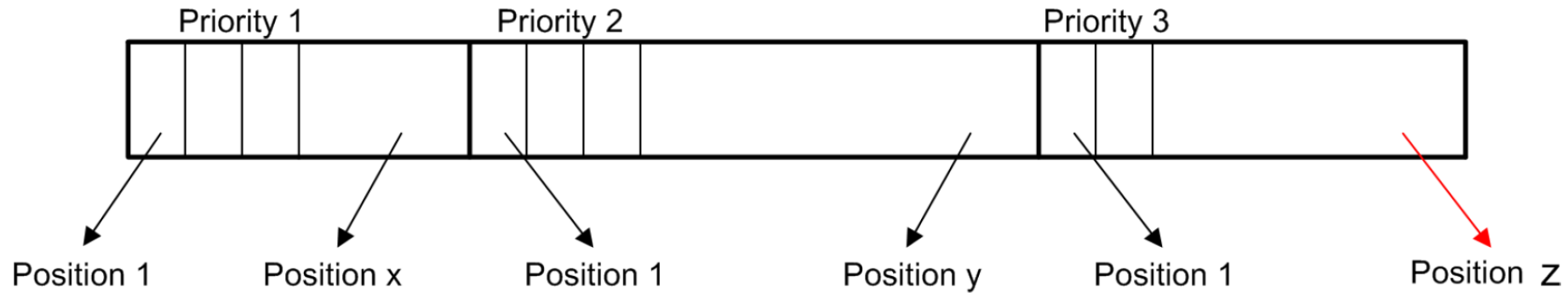


Remote Data

How do I exchange additional information between two devices via Protection Interface and how many binary signals or measured values can be transmitted?

Configuring Remote Data – Signal Priority

Data Bar Exchanged between Devices



Priority 1 signals are sent with every telegram (5 ms / 10 ms),

Priority 2 signals are sent with at least every 2nd telegram,

Priority 3 signals are transmitted at least every 100 ms.

Configuring Remote Data – Available & Required bits

Available Bits – Minimum Constellation Baud Rate 512 / 2048 kBit/s

	Priority 1	Priority 2	Priority 3
Type 1	48 bits	128 bits	384 bits

Requirement in Bits

Signal Type	Size in Bits
SP (single-point indication)	1 bit
DP (double-point indication)	2 bits
IN (metered values)	32 bits
MW (measured values) ¹²	32 bits

Fault Locator

Can we use fault locator in line diff protection?

DIGSI License Model

Can we use the DIGSI license free version on our system?

What is difference DIGSI Professional and Premium ?

DIGSI 5 License Model - excerpt

	Compact	Standard	Premium
Project Editing			
Maximum number of devices per project	O 8/1 ¹	X Unlimited	X Unlimited
Full device configuration including function charts (CFC)	X	X	X
Acquisition of process data from the device	X	X	X
Incorporating new SIPROTEC 5 devices with product code	O 8/1 ¹	X Unrestricted	X Unrestricted
Graphical hardware and network configuration	O Network and device view	X Network and device view	X Network and device view
Support of Editions 1 and 2 of IEC 61850	–	O Basic	X Advanced
Configuration of GOOSE messages	–	X	X
IEC 61850 – Flexible engineering and functional naming	–	–	X

Line Differential Protection webinar series

Links to all webinars of the series

- **Part 1: Line Differential Protection - Basics**
<https://smartinfrastucture.webinar.siemens.com/line-differential-protection-part/b1f36e4f86751bac5b5b>
- **Part 2: Line Differential Protection - Interfaces**
<https://smartinfrastucture.webinar.siemens.com/line-differential-protection-part-1/5101ce29a70e0f2f0c95>
- **Part 3: Line Differential Protection - Configuration and Testing**
<https://smartinfrastucture.webinar.siemens.com/line-differential-protection-part-2/a155d5a3afa6d0d61295>
- **Part 4: Line Differential Protection - Compatibility of SIPROTEC 4 and SIPROTEC 5**
<https://smartinfrastucture.webinar.siemens.com/line-differential-protection-part-3/a582c41832151fbce672>
- **Bonus Live Q&A Session - Line Differential Protection**
<https://smartinfrastucture.webinar.siemens.com/live-qa-session-line-differential/478dbe71dc403bfb8940>

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