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SIPROTEC 5 Application Note

SIP5-APN-003:
Tapped Line Application

Answers for infrastructure and cities.

SIPROTEC 5 - Application: SIP5-APN-003 Tapped Line Application

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1 Tapped Line Application

1.1 Summary

In order to supply small communities or facilities in sparsely populated, remote rural areas, tapped transmission lines provide an attractive solution to the challenge to provide connections at minimum cost. Using a tapped line saves the costs of building a sub-station at the point of connection together with those associated with the need to break the line.

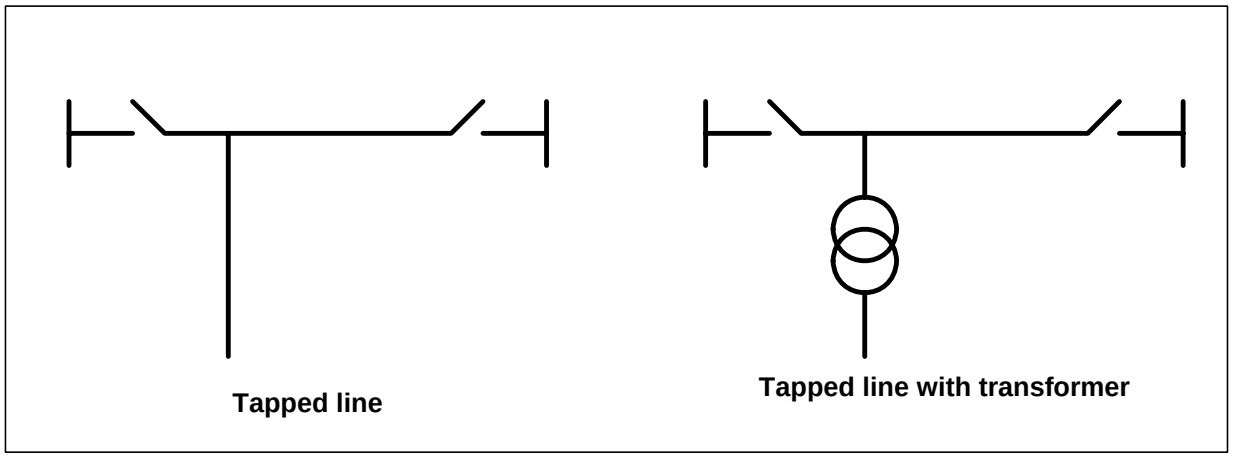

Figure 1: Tapped lines (standard and with transfomer

Unfortunately a tap in the line greatly complicates the protection. Classical protection methods are less sensitive and less selective. Distance protection cannot cover 100% of the line by zone adaptation. Even underreach teleprotection schemes can initiate fast tripping for parts of the line.

Differential protection covers 100% of the line but is less sensitive because of tap load.

The situation is further complicated by the increasing use of distributed generation which can be connected to the system.

New protection technologies as well as advanced communication features provide intelligent solutions for this kind of application. Full selectivity, a maximum of sensitivity, fast tripping and dissimilar redundancy are guaranteed.

1.2 Solution

Communication and local measurement

The key for an intelligent solution to protect a tapped line is communication between all corresponding line ends and local measurement at the tapped line end.

- SIPROTEC 5 devices support protection data interfaces which can be applied for differential protection and distance protection as well.
- Various Plug In modules and external converters offer communication via all kind of media (fiber optic, communication networks, pilot wires).
- Secure communication is ensured on all kind of media by various supervision features.
- Ring topologies offer communication redundancy for higher availability

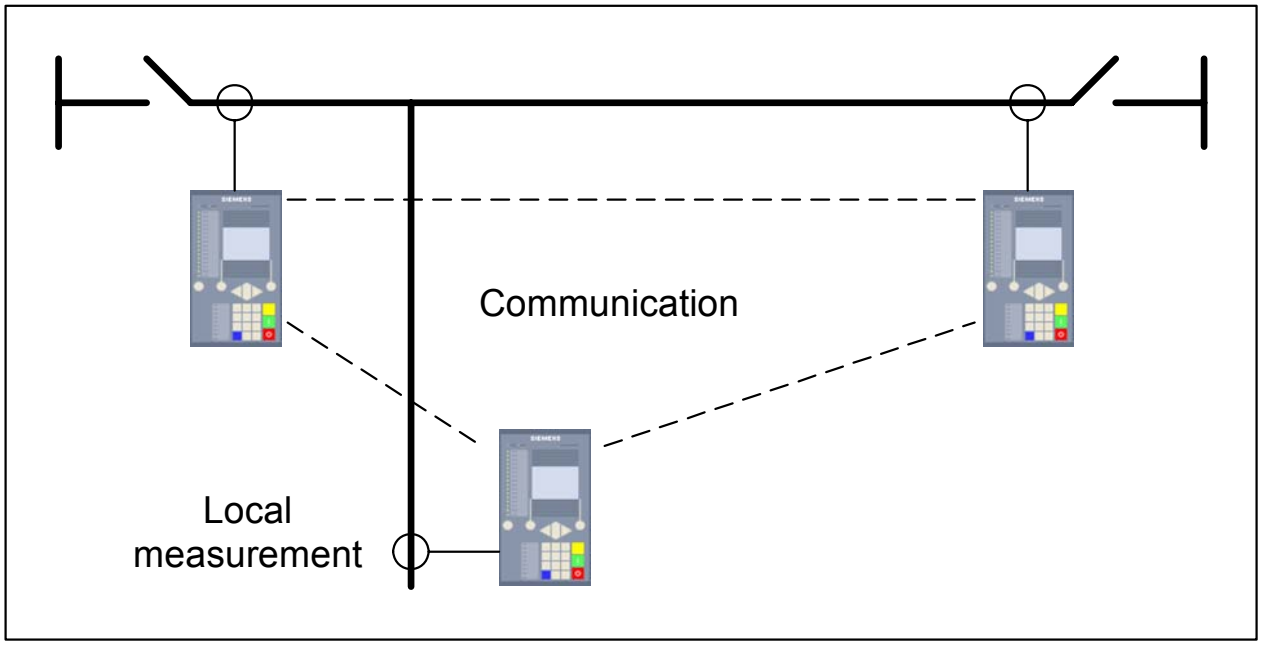

Figure 2: Tapped lines with communication and local measurement

Reduced investment

A tapped line has to be covered by 3 measuring points. The number of line ends and therefore the number of required protection devices depends on the distances between the measuring points. Two measuring points can be covered by one SIPROTEC 5 device if the distance between both is below 500 meter. Thus only two SIPROTEC 5 devices are needed to cover the protected area. The cost reduction is achieved by the integrated measurement of two 3-phase current inputs in one device. Local current summation by internal measurement knots (see fig.) simplifies measurement of the differential and summation currents for both protection principles (differential, distance)

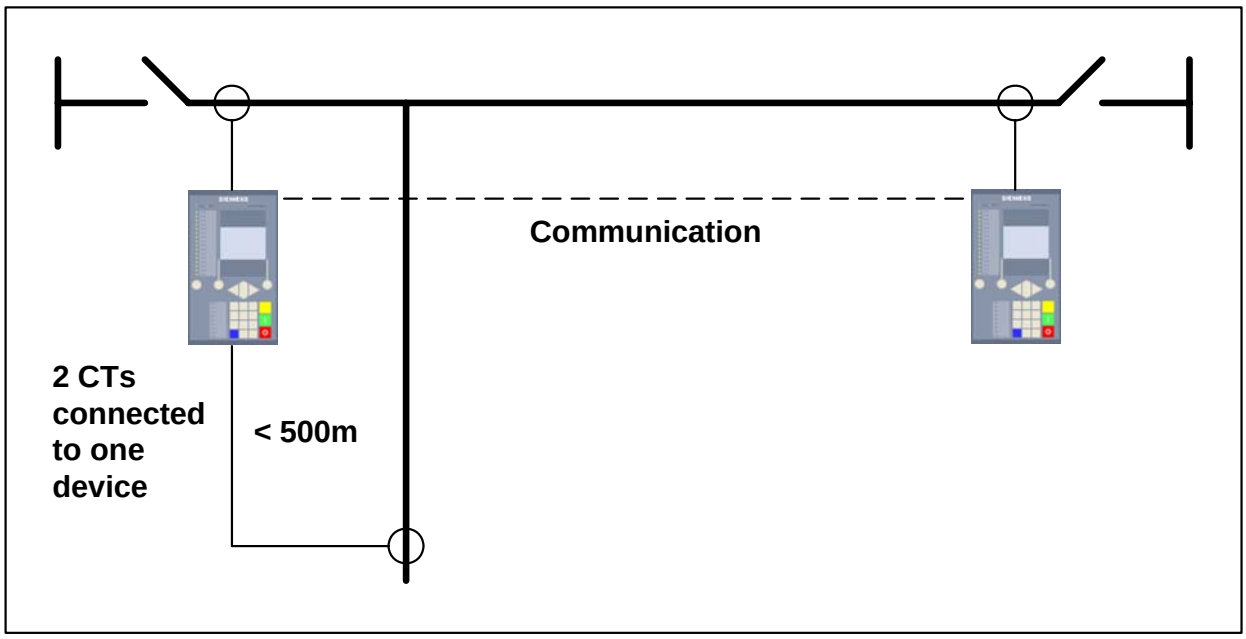

Figure 3: Local measurement of two line ends with one device

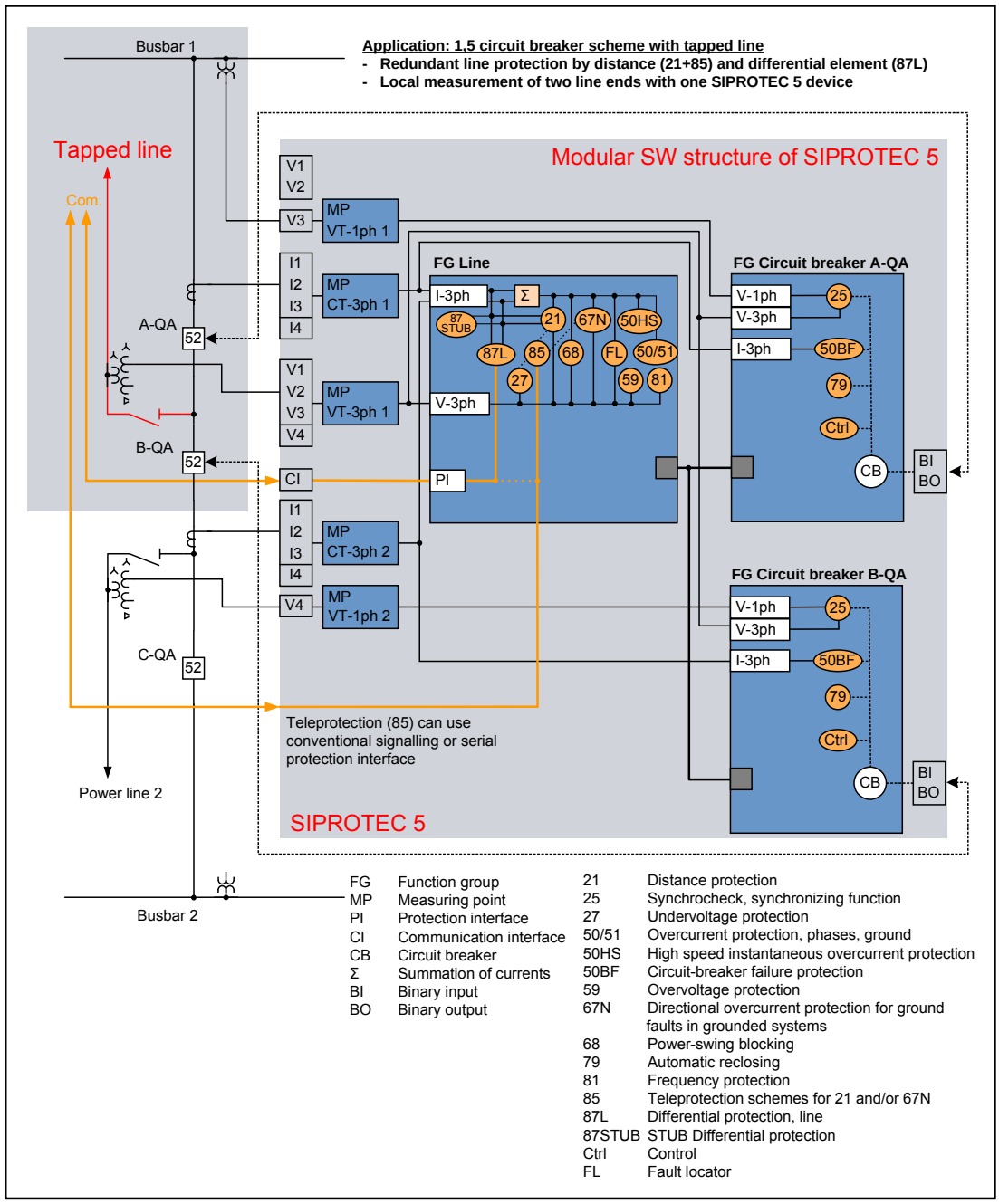

Figure 4: Application template of SIPROTEC 5 for breaker-and-a-half schemes with tapped line

Tapped line protected by differential protection (87)

Applying differential protection an 100% line coverage is ensured by the protection principle which needs CTs only (Fig.2 and Fig.3). The protected area is defined by the position of the CTs. The principle is stable under all kind of in-feed conditions at the line ends. Clear decisions regarding external and internal faults are guaranteed even if faults occur close to the CTs.

High speed tripping

The SIPROTEC 5 differential protection provides high speed tripping down to 9ms (50Hz) using high speed contacts (option). Line faults can be cleared by 1-pole or 3-pole tripping (depends on device type).

Maximum of sensitivity and stability

The maximum of sensitivity is kept by the "Adaptive Algorithm" which compensates CT errors and influences caused by the communication. Even with integrated measurement of two 3-phase current inputs in one device the maximum of stability is achieved by compensation of errors for each CT separately.

High capacitive charging currents on long lines and cables (option, VTs needed) can be compensated by the "Capacitive Charging Current Compensation". This optional sub function of the differential protection can be selected within the function library in DIGSI. Note: This option will be charged by function points.

Tapped line with transformer

Extended investment in separate transformer protection devices can be saved just by selecting the sub function "Transformer in the protection zone" (option of differential protection) within the function library in DIGSI. Only a few additional transformer settings are necessary (vector group, power, voltage levels). Note: This option will be charged by function points.

1.2.1 Tapped line protected by differential protection (87)

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The SIPROTEC 5 differential protection provides high speed tripping down to 9ms (50Hz) using high speed contacts (option). Line faults can be cleared by 1-pole or 3-pole tripping (depends on device type).

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1.2.2 Tapped line protected by distance protection

Applying distance protection for tapped lines an 100% line coverage can be achieved by using distance teleprotection functions. Please note that VTs are needed for applying distance protection. In most cases a weak in-feed is present at one line end. Thus weak in-feed elements are needed additionally. Note: Additional weak in-feed elements will be charged by function points separately.

High speed tripping

The SIPROTEC 5 distance protection provides high speed tripping down to 10ms (50Hz) using high speed contacts (option). Line faults can be cleared by 1-pole or 3-pole tripping (depends on device type).

Applicable teleprotection functions

Two different function principles are recommended. Communication can be applied using the protection data interfaces as well as power line carrier. If a differential protection is used in parallel please do not use the same protection data interfaces for the teleprotection to ensure communication redundancy.

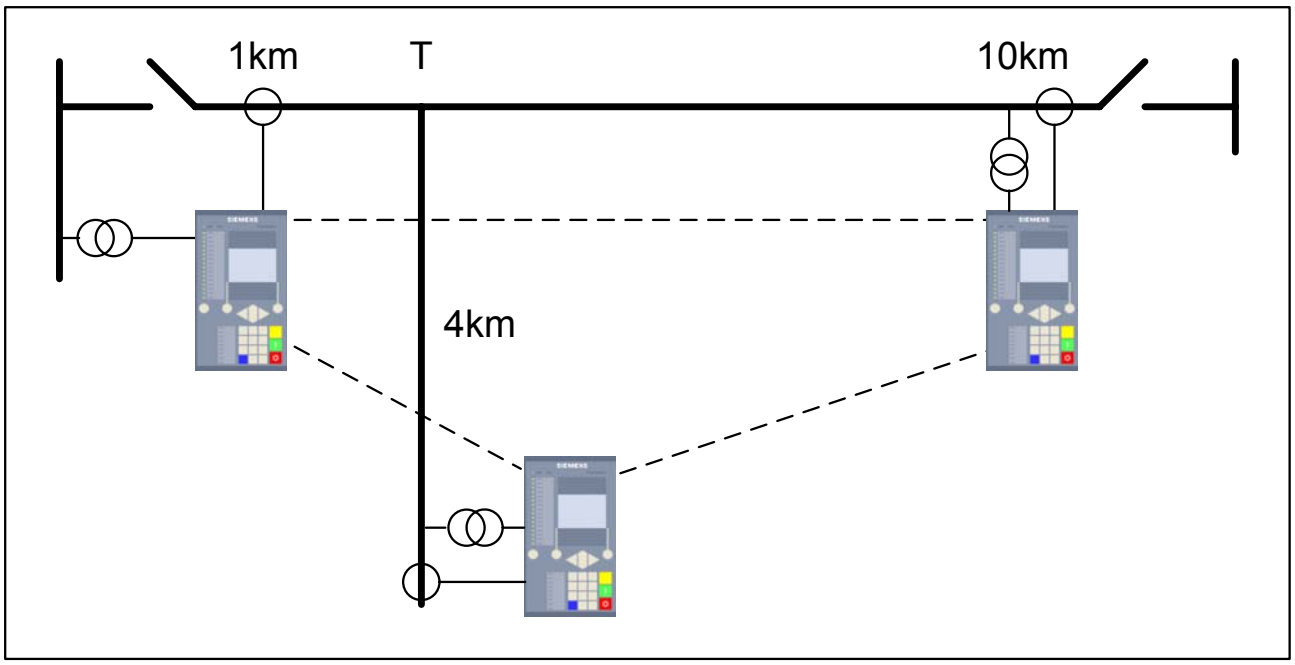

Figure 5: Example: Tapped line protected by distance protection

Blocking

The local trip is initiated by pickup in Z1B (overreach forward zone) when no remote line end detects a reverse failure. The blocking channel prevents tripping at the remote line end in case of reverse failures.

Tripping at the weak in-feed end can be initiated via receiving a distance protection trip signal from one remote end. This can be applied by a “weak in-feed trip element” or a “direct trip initiation”. Therefore a second communication channel is needed.

Permissive Overreach Transfer Trip (POTT)

The local trip is initiated by pickup in Z1B (overreach forward zone) at all line ends. Therefore both remote pickups in Z1B have to be received to release the local trip (logical AND).

A weak in-feed line end has to apply an “weak in-feed echo element” to release tripping at the remote line ends. If tripping at the weak in-feed line end is required a “weak in-feed trip element” has to be applied.

Zone settings

The fast tripping zones Z1 and Z1B have to be configured according to the line and its tapped end.

Z1 is the independent tripping zone and has to avoid overreaching.

Recommendation: Z1 = 80% of the shortest remote end.

A:	0,8 x (1 + 4) km	= 4,0 km
B:	0,8 x (10 + 1) km	= 8,8 km
C:	0,8 x (4 + 1) km	= 4,0 km

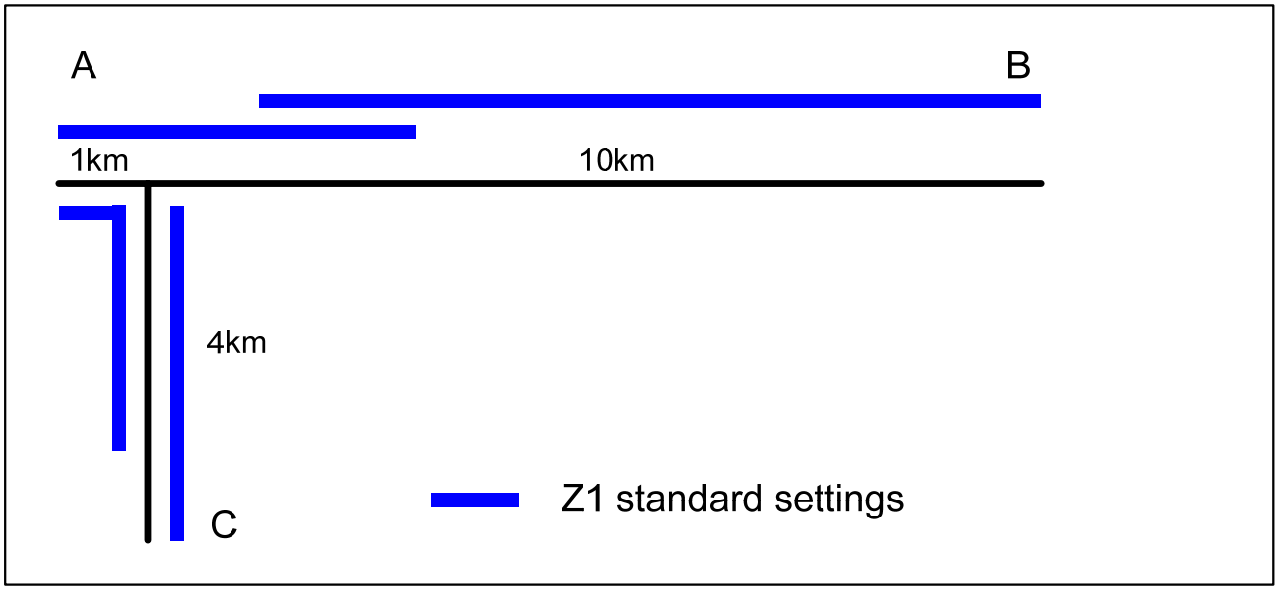

Figure 6: Standard settings example for zone Z1 (line partly covered)

Z1B is the fast tripping overreaching zone and has to cover the line including the tapped end.

Recommendation: Z1B = 120% of the most far remote end.

A: 1,2 x (1 + 10) km = 13,2 km

B: 1,2 x (10 + 4) km = 16,8 km

C: 1,2 x (4 + 10) km = 16,8 km

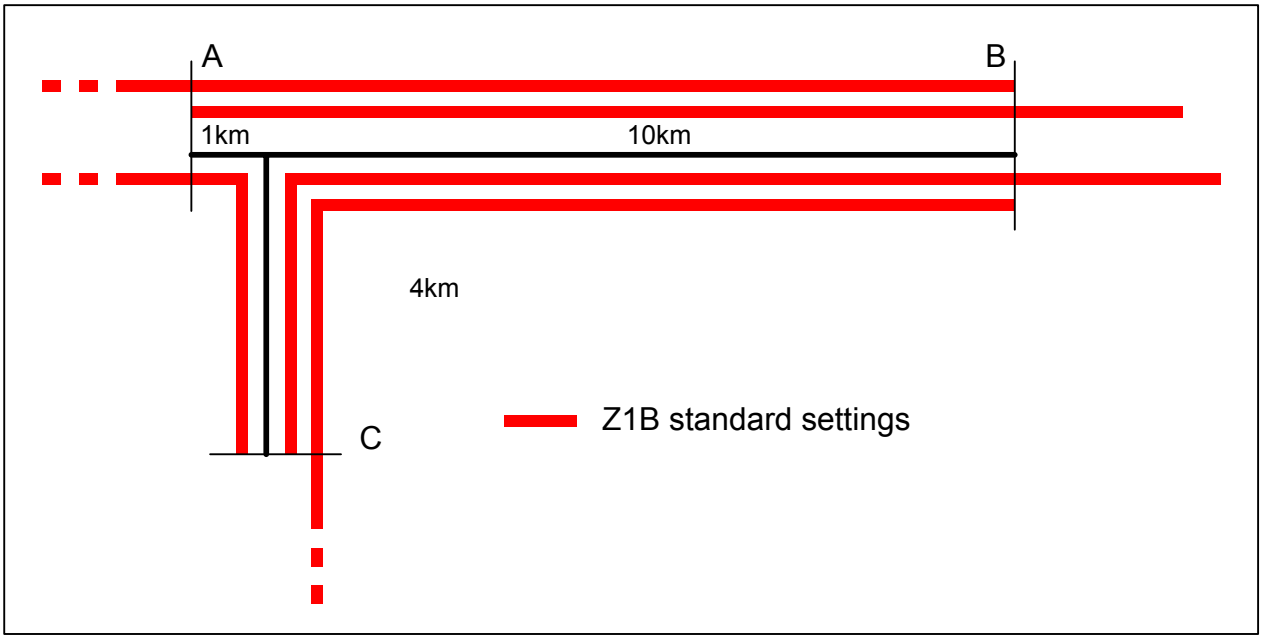

Figure 7: Standard settings example for zone Z1B (line fully covered)

1.2.3 Dissimilar redundancy by the 2in1 principle

A big commercial factor is the high availability of energy support. According to this redundant systems are required to handle disturbances in the primary system and in the protection equipment.

Dissimilar redundancy can be achieved by two main protection functions based on different measurements, different algorithms and different communication media. Both main functions are operating independently like two separate devices. 7SL86 (3-pole tripping) and 7SL87 (1/3-pole tripping) are both 2in1 devices within the SIPROTEC 5 system and support all functions to protect tapped lines with full redundancy.

Main1 / Main2 tripping modes:

- Full parallel operation with concurrent tripping
- Full parallel operation but with different tripping priority (CFC logic)
- 7SL86 (3-pole tripping), 7SL87 (1/3-pole tripping)

High speed tripping (½ power cycle) by Main1 and Main2

100% line coverage by Main1 and Main2

Different algorithms compensate specific weaknesses

- Loss of communication link --> distance protection still active
- Loss of voltage --> differential protection still active

Different communication links guarantee highest availability

- Two different protection data interfaces in one device allow differential protection and distance protection the use of different media in parallel (fiber optic, communication networks, pilot wires).
- The distance protection can also use power line carrier while the differential protection is still using the protection data interface.

1.2.4 High level of functional integration

Another commercial factor is the high level of functional integration.

- Protection and control of the tapped line can be applied without using separate devices for the control functions. All control features are available in each SIPROTEC 5 device.
- Various protection functions from the protection library provide comprehensive emergency and backup protection solutions.

1.2.5 Ordering requirements

Required devices:

- Differential protection only: 3-pole: 7SD84, 7SD86, 1/3-pole: 7SD87
- Distance protection only: 3-pole: 7SA84, 7SA86, 1/3-pole: 7SA87
- 2in1: 3-pole: 7SL86 1/3-pole: 7SL87

Ordering code:

- Significant feature according to the number of line ends --> ordering code 20th position
- Plug In modules for protection data interfaces according to the existing media
- Choose a HW option with 8I / 8U for close line ends (e.g. 100m) to save one device.
  Assumption: A successful dimensioning of CTs, secondary wires and device burden.
- Functional class:
  Choose the functional class according to the expected application template and according to the total scope of required functions.

1.3 Conclusion

SIPROTEC 5 is well suited for tapped line application.

- All kinds of tapped lines (even with transformer) can be applied.
- Extended hardware features and a various functional scope are saving investments.
- Dissimilar redundancy in one device is given by distance and differential protection in parallel.
- High level of functional integration provides a maximum of availability, comprehensive emergency and backup solutions.
- Protection and Control complement each other in parallel.
- Great variety of communication options offer flexibility and allow cost optimized adaption to exisiting communication infrastructure.

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