SIEMENS

Ingenuity for life

Line differential protection and TPZ class CT at one terminal

www.siemens.com/siprotec5

SIPROTEC 5 Application

Line differential protection and TPZ class CT at one terminal

APN-047, Edition 1

Content

1 Line differential protection with different CT classes at each terminal 3
1.1 Introduction 3
1.2 Comparison of TPZ class CT with an ideal CT 3
1.3 Current transformers with different characteristics at two line terminals 3
1.4 Conclusion 5

1 Line differential protection with different CT classes at each terminal

1.1 Introduction

Most power system protection functions are designed to operate with a single set of instrument transformers. However, differential protection functions must rely on the secondary currents of several current transformers.

In order to get comparable secondary currents, CTs are classified according to their responding characteristic in IEC standards.

Especially line differential protection often faces the difficulty of different CT ratios and/or classes installed at each terminal. SIPROTEC 4 and SIPROTEC 5 devices are capable of working with different CT ratios and classes, as different error types can be considered within the device settings.

1.2 Comparison of TPZ class CT with an ideal CT

Short circuit currents might contain a decreasing DC component. CTs of TPZ class are especially designed to suppress this DC component in their secondary current. A *differential current* is calculated as the sum of secondary currents of TPZ class CT and an ideal CT according to Figure 1. Other than the transformation errors that originate from the current magnitude and angle, an additional DC component in the *differential current IDiff* is also present, due to the different response characteristics.

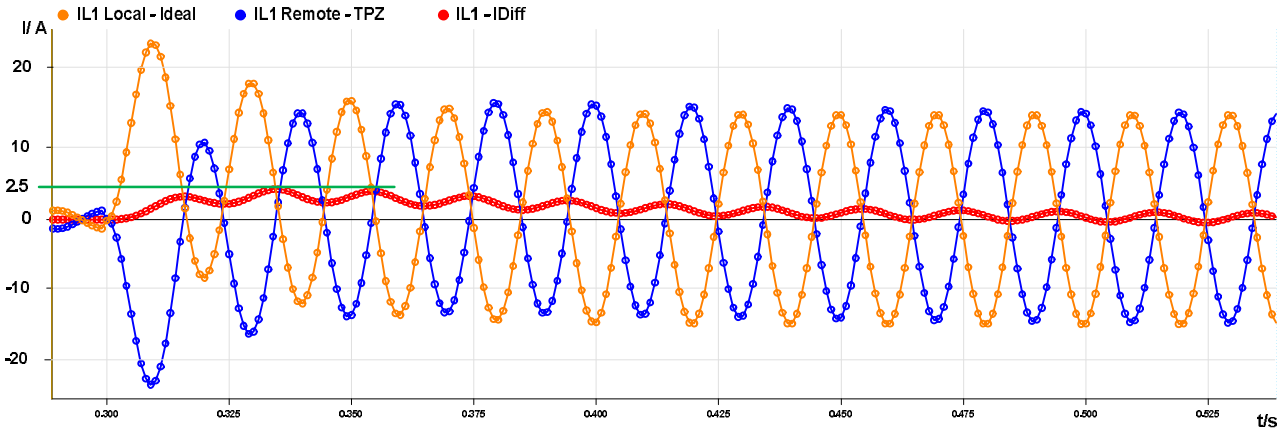

Figure 1: Secondary currents of TPZ class CT and ideal CT and resulting differential current IDiff for an external fault.

1.3 Current transformers with different characteristics at two line terminals

SIPROTEC 4 and SIPROTEC 5 line differential protection devices consider the different CT ratios at each terminal. Specifying the CT ratios is part of the planning work, which needs to be done in advance. This also includes the correct dimensioning of the CTs. The actual CT ratio must be set in the device and needs to be double checked during commissioning. As different CTs might have different transformation errors, these errors must also be set in the devices. The manuals for SIPROTEC devices contain typical settings for the different CT classes.

Transformer Class	Standard	Rated-Current Error		Rated-Overcur-rent Factor Error	Setting Recommendations for Settings		
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 BS: Class X				1.50	3.0 %	10.0 %
C100 to C800	ANSI				1.50	5.0 %	15.0 %

Figure 2: Extract of actual SIPROTEC 7SL87 device manual: Setting recommendations for CT errors.

1.3.1 Example for TPZ class CT at one terminal

SIPROTEC 4 and SIPROTEC 5 devices take the CT errors into account according to their settings. The following calculation example is made for a two-terminal configuration of SIPROTEC 5 devices with TPZ class CTs at one terminal and an ideal CT at the other terminal. Assuming that both devices are correctly parameterized: the CT error at the terminal with TPZ class CT is set to 6% / 20% and the terminal with an ideal CT is set to 3% / 10% (lowest setting according to manual). To make calculation easier, the CT ratio on both terminals is identical and the secondary current is assumed to be 10 times the nominal current of the CTs. For that reason, the greater CT error values of 10% and 20% are used.

I-DIFF stage (Idiff> at SIPROTEC 4) and I-DIFF fast (2) stage (Idiff>> at SIPROTEC 4) are working in parallel with different algorithms and need to be considered separately.

I-DIFF Stage:

The restraint current of I-DIFF stage is the sum of the following components:

- $I_{diffThreshold}$: I-DIFF-threshold value
  with $I_{diffThreshold} = 0.3A$
- $I_{CTerror}$: Measured local current · local CT error + Measured remote current · remote CT error
  with Measured local current = 10A
  local CT error = 20% = 0.2
  remote CT error = 10% = 0.1
- $I_{synchronization}$: Component of the time synchronization error
- $I_{distortion}$: Component to compensate the deviation from sin wave form and DC offset

If we assume that there is no CT saturation or other harmonics in the currents, and there is a direct fiber connection between the protection interfaces, the components $I_{synchronization}$ and $I_{distortion}$ (except the DC component) can be neglected à $I_{synchronization} = I_{distortion} = 0$. This leads to a simplified calculation of the restraint current $I_{restraint}$.

$I_{restraint} = I_{diffThreshold} + I_{CTerror} = 0.3A + (10A \cdot 0.2) + (10A \cdot 0.1) = 3.3A \triangleq 330\%$

The *differential current* can be taken from the calculation example in figure 1. We only consider the maximum value of 2.5A and neglect the DC component.

$Idiff = 2.5A / \sqrt{2} = 1.77A \triangleq 177\%$

I-DIFF fast (2) stage:

As I-DIFF fast (2) stage uses very short filters, a calculation example is difficult, but the algorithm contains a restraint mechanism which smoothes the signal. Additionally, a restraint mechanism adds a stabilizing effect to the DC component. This stylization starts one period after the detected current jump, as this time is needed for calculating DC-component.

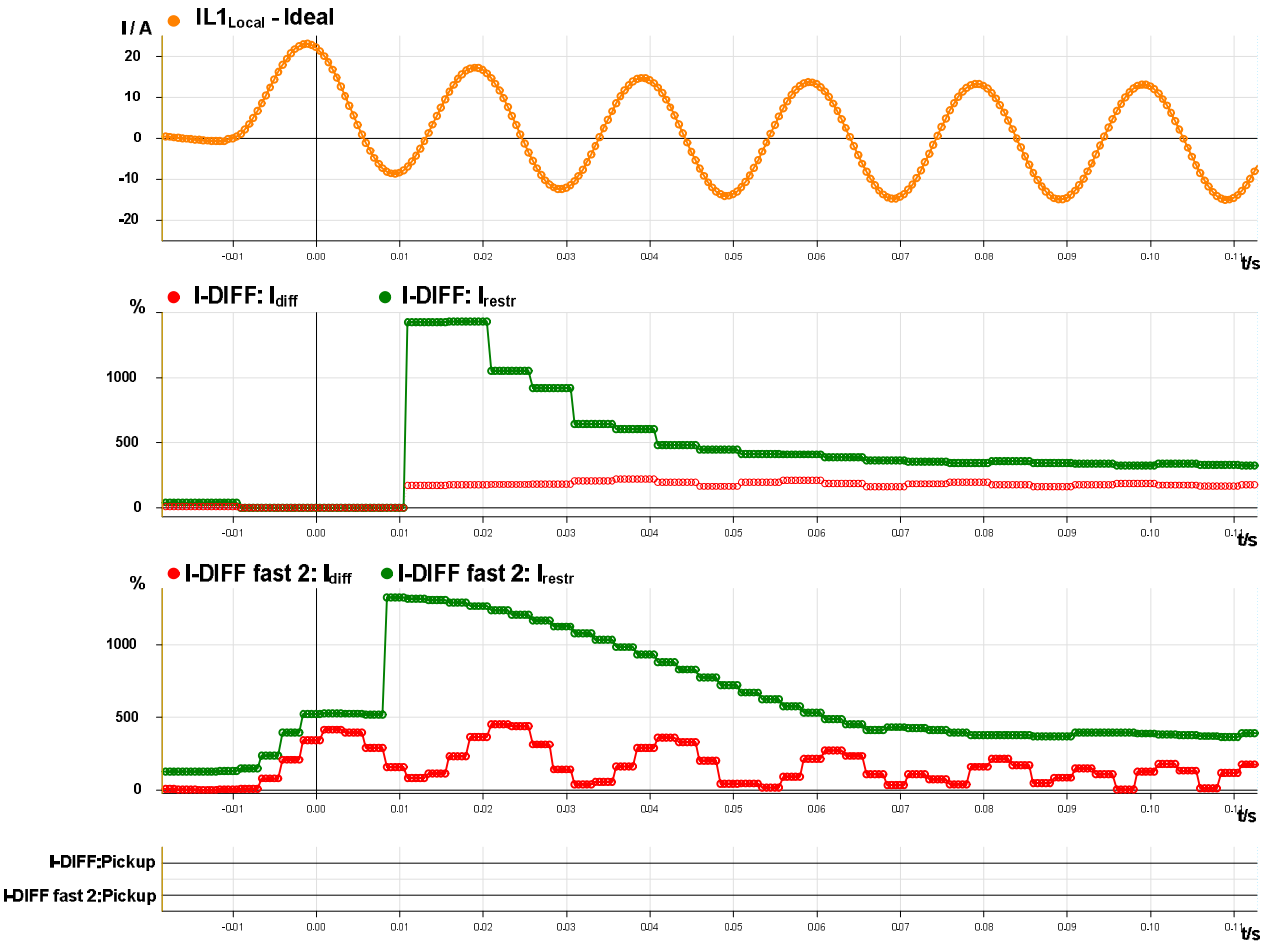

Figure 3: Calculated values from SIPROTEC 5 device (7SL8x V7.50)

1.4 Conclusion

The combination of CTs with TPZ class and other CTs is possible with SIPROTEC 4 and SIPROTEC 5 devices, as long as CT ratios and CT errors are provided to the devices and CTs are correctly dimensioned.

The suppressed DC-component of TPZ class CTs is not critical for SIPROTEC 4 and SIPROTEC 5 devices using line differential protection functions.

Published by
Siemens AG 2017
Energy Management Division
Digital Grid
Automation Products
Humboldtstr. 59

90459 Nuremberg, Germany

www.siemens.com/siprotec

For more information, please
contact our Customer Support
Center.

Tel.: +49 180 524 70 00
Fax: +49 180 524 24 71
(Charges depending on provider)

Email: support.energy@siemens.com