Application of Instantaneous High Current Tripping

www.siemens.com/siprotec

SIPROTEC 5 Application

Application of Instantaneous High Current Tripping

APN-079, Edition 2

Content

1 Application of Instantaneous High Current Tripping

1.1 Introduction

The function „Instantaneous High-Current Tripping" in the SIPROTEC5 devices can be applied for switch on to fault conditions or in general for extremely high fault currents.

The function must be set with an activation method depending on the application:

1. On CB closure = Switch on to fault application.

2. Always active = standard high current instantaneous element.

3. Only with binary signal = user defined activation method.

To achieve the high-speed operation the measurement is with two methods:

1. A filtered fundamental current method that responds accurately but with normal response time of approx. 1 cycle.

2. A fast delta-based method that responds in approx. ¼ cycle.

The description below will focus on the fast delta-based method to provide a setting guideline for the threshold.

1.2 Description of fast delta method

At the center of the fast delta method is a ¼ cycle filter that responds to the delta between samples exactly 5ms apart (at 50 Hz).

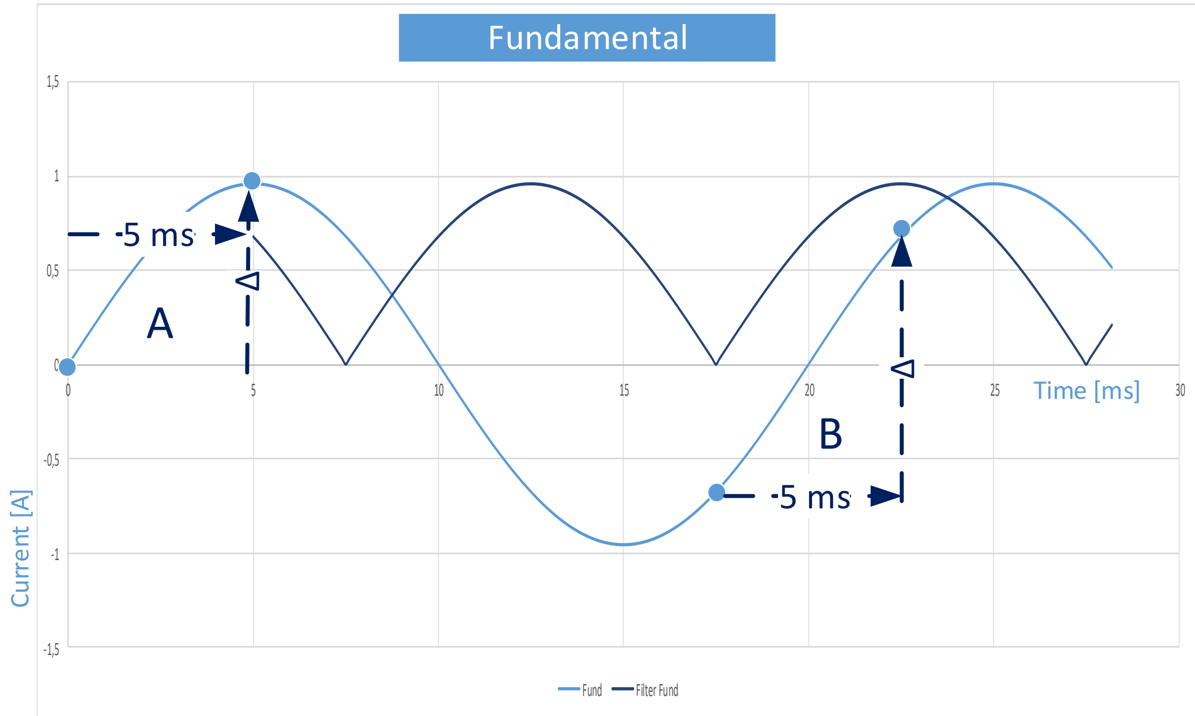

Figure 1: Fundamental with no offset – ¼ cycle delta

At the instance A, the delta from 0 to peak in ¼ cycle is measured as 1/sqrt(2) of the peak by the filter. The factor (1/sqrt(2)) is introduced so that the peak of the filter and fundamental are equal.

At the instance B, the delta on both sides of the zero crossing is measured as equal to the peak by the ¼ cycle delta filter.

Introduce a DC offset. The next diagram will show the filter response when the fundamental has a full DC offset:

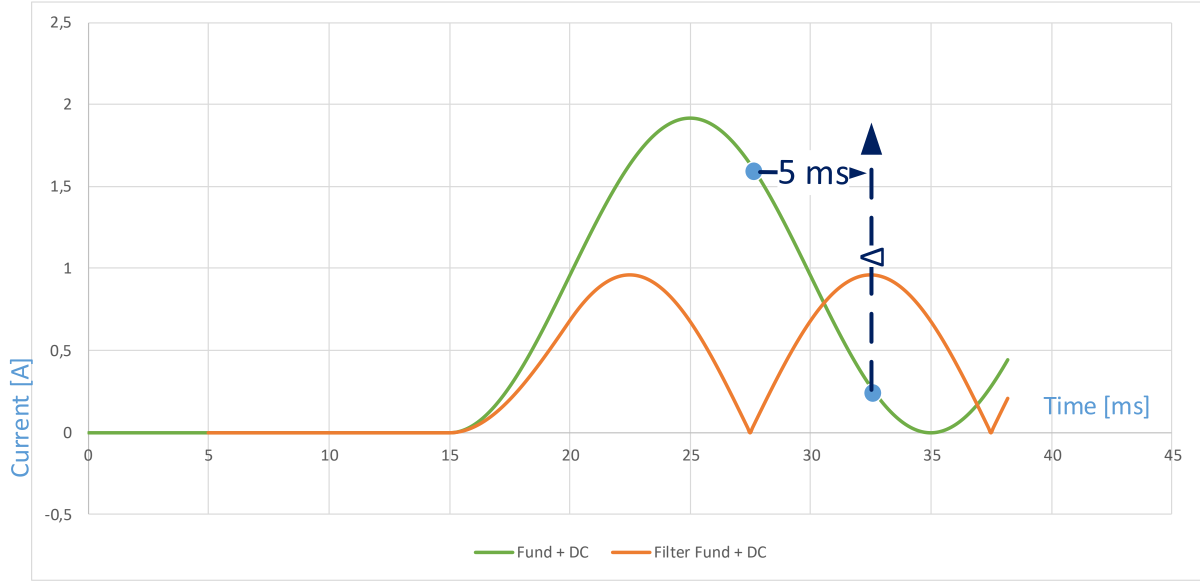

Figure 2: Fundamental with full DC offset – ¼ cycle delta

The filtered value in Figure 2 measures the same result as in Figure 1, indicating that a fully offset waveform causes no overreach. This is not realistic; the DC will be transient as shown below.

In the next diagram the DC offset is done with a decay corresponding to a time constant of 50 ms. Again, the current is fully offset at fault inception.

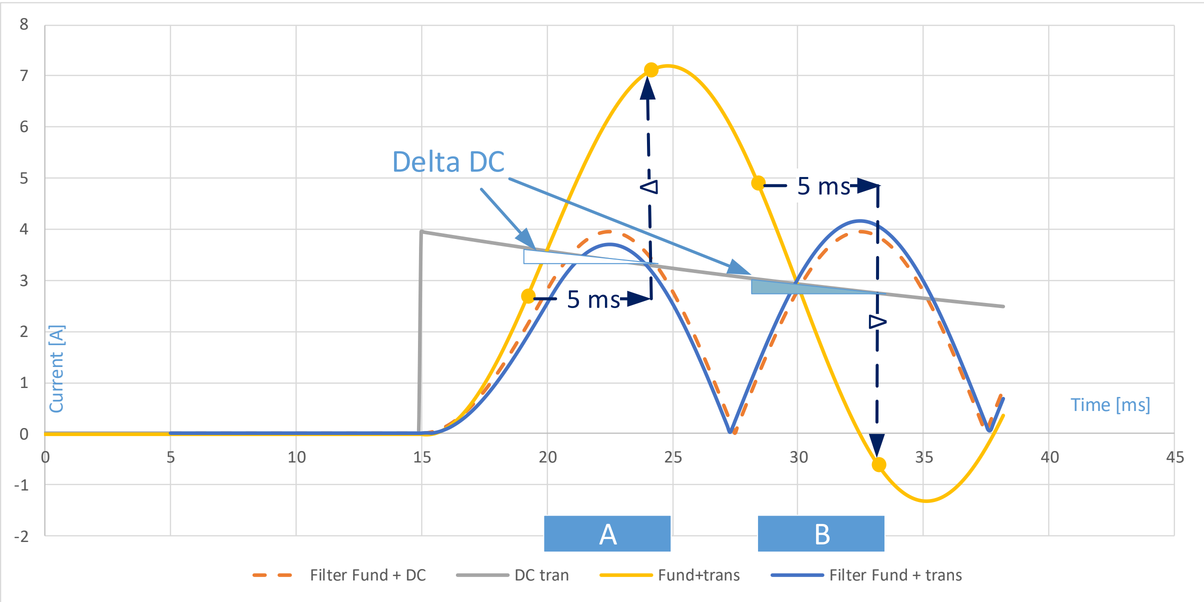

Figure 3 Fundamental with DC offset (50ms time constant) – ¼ cycle delta

The measurement at "A" is below the expected value (dashed curve) while at "B" the measured result is above the dashed curve. This is caused by the "delta DC". The DC component is decaying and introduces (in this case negative) superimposed value on the filtered result. This negative value results in smaller filtered result during rising current and larger result during falling current. An offset in the negative direction would have the opposite effect.

1.3 Setting security margin

To prevent pick-up by the fast filtered current an additional security margin can be introduced. This additional margin can be determined by deriving the maximum “delta DC”. The DC transient will have the largest change at the start, and this will decrease over time. For the calculation the theoretical worst case, from time “0” at fault inception up to time (0+5ms), is assumed.

A further factor that will affect the “delta DC” is the time constant. In this case a shorter time constant will be the worst case.

$$\Delta DC_{t1\_t2} = I_{Set} \cdot \left(e^{-\frac{t1}{\tau}} - e^{-\frac{t2}{\tau}}\right) \cdot \sqrt{2} \qquad \text{Equation 1}$$

Where ΔDC_{t1_t2} is the difference between the two sampled current values at t1 and t2.

As the set value would have to be increased by the determined ΔDC, the above equation can be modified as follows:

$$I_{Set\_mod} = I_{Set} + \frac{\Delta DC_{ti\_t2}}{\sqrt{2}} = I_{Set}\left[1 + \left(e^{-\frac{t1}{\tau}} - e^{-\frac{t2}{\tau}}\right)\right] \qquad \text{Equation 2}$$

Alternatively, the factor by which the original setting is multiplied can be obtained as follows:

$$I\_Set_{safety\_factor} = \frac{I_{Set\_mod}}{I_{Set}} = \left[1 + \left(e^{-\frac{t1}{\tau}} - e^{-\frac{t2}{\tau}}\right)\right] \qquad \text{Equation 3}$$

The following table gives some numerical examples.

Time Constant	Setting safety factor for interval:	
t [ms]	**0 - 5 ms**	**10 - 15 ms**
30	1,154	1,110
50	1,095	1,078
100	1,049	1,044

As the ΔDC is negative for positive offset current (Figure 3), or alternatively positive for negative offset current, during the initial ½ cycle, the influence of the ΔDC must be considered after the initial ½ cycle.

For an assumed worst case time constant (τ) of 30 ms and measurement after the initial ½ cycle (10-15 ms) with fully offset current, the factor 1.11 (Table above) is required to prevent pickup for currents with fundamental component below the determined threshold (I_set).

1.4 Test Example

The diagram below shows a test case with the following parameters:

Set threshold	3 A
I Test	2.8 A fundamental
Time const (τ)	30 ms

Safety factor is: $\frac{3A}{2.8A} = 1.07$ which is less than the required 1.11.

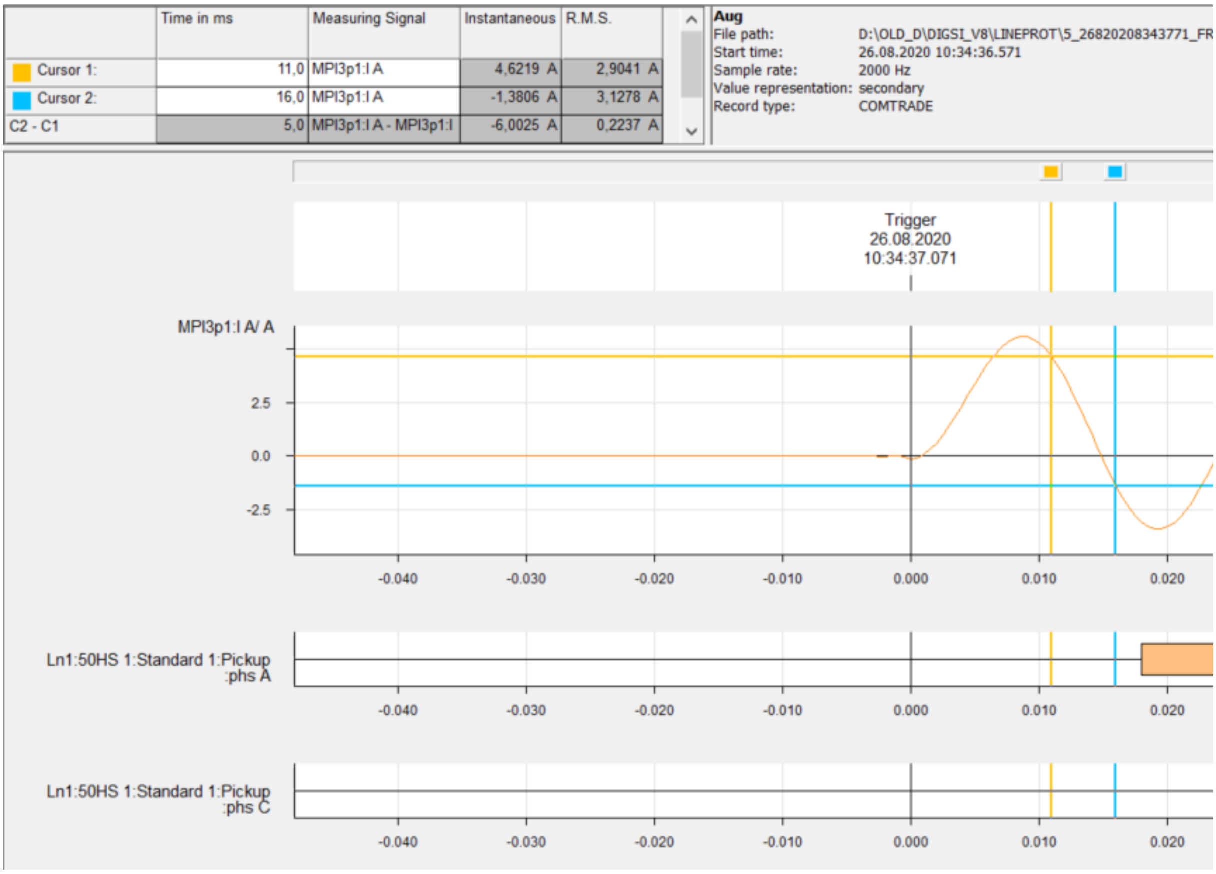

Figure 4: Test case with 2.8 A fault current and DC transient and set threshold = 3 A

Time stamp	Time stamp	Sampled current	Sampled current	Delta I t1 – t2	Filter response
t1 [ms]	**t2 [ms]**	**I1 [A]**	**I2 [A]**	**Delta [A]**	**I filter [A]**
10	15	5,2696	-0,1676	5,4372	2,7186
11	16	4,6219	-1,3806	6,0025	**3,00125**
12	17	3,6626	-2,3731	6,0357	**3,01785**
13	18	2,4728	-3,0733	5,5461	2,77305
14	19	1,1568	-3,3714	4,5282	2,2641

Only in the interval between 11-16 and 12-17 ms is the filtered current minimally above the set threshold of 3 A (safety factor set, 1.07 was too small). This is the expected behavior where the ΔDC introduces the measuring deviation after the 1st ½ cycle.

Based on the above the correct safety factor should be 1.11. Therefore, to have no pickup with the test current of 2.8A, the setting should be:

$$I_{Set\_mod} = I_{Set} \cdot I\_Set_{safety\_factor}$$

$$I_{Set\_mod} = 2.8\,A \cdot 1.11 = 3.11\,A$$

With the modified setting there is no pick-up.

1.5 Conclusion

The function „Instantaneous High-Current Tripping" in the SIPROTEC5 devices provides very fast operation on over current conditions. It must however be considered that due to the short filters the influence of DC change "delta DC" is not eliminated fully.

This document describes the principal and gives a setting recommendation for this aspect.

Published by
Siemens AG

Smart Infrastructure
Digital Grid
Humboldtstrasse 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)

Customer Support: www.siemens.com/csc

For the U.S. published by
Siemens Industry Inc.

100 Technology Drive
Alpharetta, GA 30005
United States