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FINDING SHORT-CIRCUIT CURRENT TIME BASED ON RAW DATA

Series of tests were conducted in which short-circuit current was registered. Four different overcurrent protection devices were used for a set value of prospective current. Based on obtained data the short-circuit time was calculated. In order to obtain this information a procedure was developed. Later it was implemented with the help of numerical computation software Scilab. In this paper results of calculations, the procedure itself and its implementation are presented.

KEYWORDS: overcurrent, Scilab, histogram, short-circuit time

1. TEST SET-UP

Break time for four different overcurrent protection devices was tested. They operate under different electrical conditions and are exposed to many hazardous phenomenons. These phenomenons include normal current flow, overcurrents and short-circuit currents. These events may have a significant impact on the expected lifetime and reliability of electrical equipment and installation protected by them [1]. The experimental test set-up is shown in Figure 1.

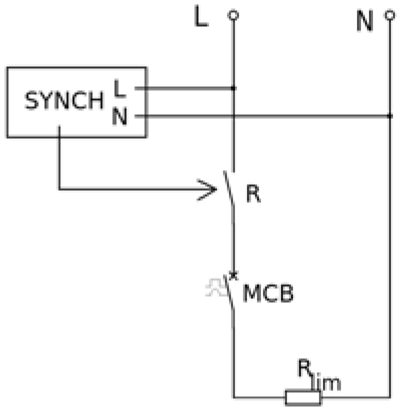

Fig. 1. Experimental test set-up: SYNCH – synchronization device, R – electromechanical relay, MCB – miniature circuit breaker, R_{lim} – limiting resistor

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The circuit is composed of miniature circuit breaker *MCB*, resistor used to set desired value of prospective current R_{lim}, electromechanical relay *R* and a synchronization device *SYNCH*, which lets set the desired current phase at which the test should start. Each attempt was recorded. One task in analysing the results was to calculate the breaking time t_z. Although other methods are useful [2], a method that can calculate the breaking time based only on time-current oscillogram can be potentially helpful. Normally just by looking on current-time graph the time frame can be estimated. But when digital data is in use this is not acceptable.

2. OBTAINING SHORT-CIRCUIT TIME BASED ON HISTOGRAMS

A hypothesis was made that breaking time t_z could be calculated with the use of a histogram [3, 4]. An important notice is that, based on digital data, the created program will not calculate breaking time directly, instead it will calculate number of data points in record and later based on this number the breaking time will be estimated.

First step in creating this program was to develop a test signal data (Fig. 2) that could resemble real input data. This test data was composed of two signals. The first one was a randomly generated noise, with the amplitude set to one, the second signal was a sample partial sine wave, that represented short-circuit current, with amplitude set to 10. This two signals were added, the maximum amplitude could reach the value of eleven (no unit presumed). Test data had one thousand data points, where 200 were set to be sine wave.

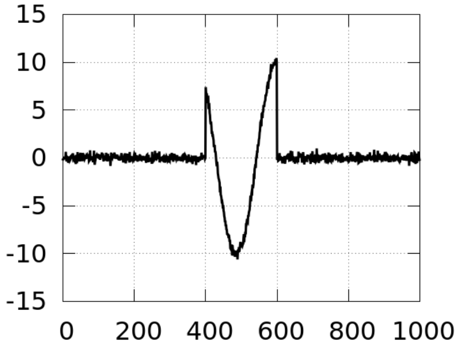

Fig. 2. Procedure test data

Second step was to test how many class intervals (bins) of histogram would generate the best results in calculating the breaking time. Three different number of class intervals where tested, and they were sets according to (n = 1000):

$$k_1 = 1 + 3{,}3\log(n) = 10 \tag{1}$$

$$k_2 = 5\log(n) = 14 \tag{2}$$

$$k_3 = 5 \tag{3}$$

Later the input data was sorted descending and the final histogram was created. Obtained histograms for three class intervals are presented on Figure 3. Finally, the first class is rejected (with the largest number of points). Sum of other classes values is the result.

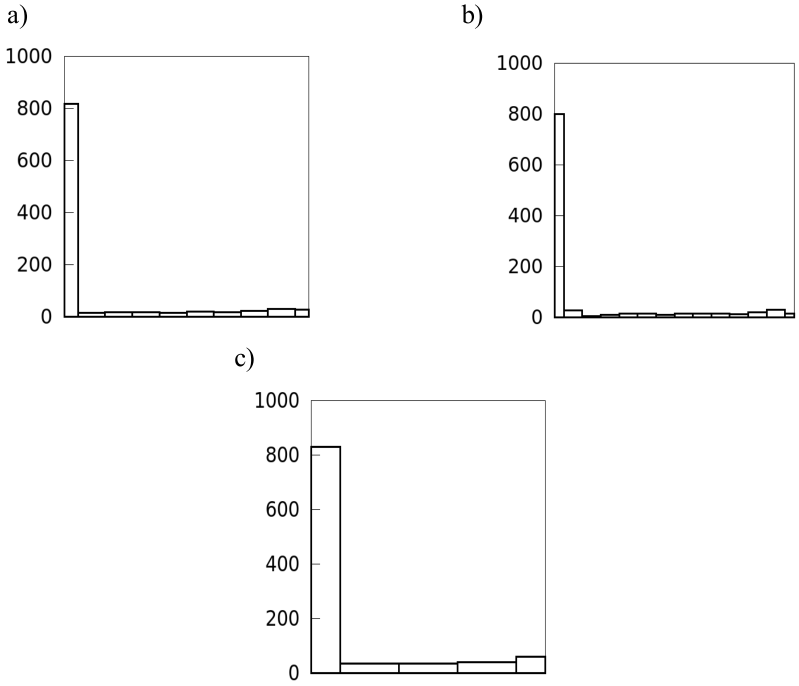

Fig. 3. Obtain histograms for class intervals: a) $k_1 = 10$, b) $k_2 = 14$, c) $k_3 = 5$

To estimate obtain result an error criteria was proposed:

$$e = \left(\frac{(d_s - d)}{d_s} \right) \cdot [\%] \tag{4}$$

where: d_s – true value of sine wave data points, d – obtained value form calculations. Value of error e closer to zero means better result. Ten trials with different random noise were done and results, with corresponding error values, are presented in Table 1. Statistical analysis of the results is shown in Table 2.

Table 1. Results of calculations for different number of classes: d_1,d_2, d_3 – obtained value, e_{d1}, e_{d2}, e_{d3} – relative error

Lp.	k_1		k_2		k_3	
	d_1	e_{d1}	d_2	e_{d2}	d_3	e_{d3}
	[n]	[%]	[n]	[%]	[n]	[%]
1	187	7	205	-2,5	169	15,5
2	185	7,5	202	-1	170	15
3	184	8	210	-5	169	15,5
4	187	7	205	-2,5	167	16,5
5	187	6,5	193	3,5	170	15
6	185	7,5	199	0,5	172	14
7	185	7,5	200	0	168	16
8	184	8	205	-2,5	168	16
9	185	7,5	218	-9	170	15
10	186	7	201	-0,5	173	13,5

Table 2. Statistical results of calculations for different number of classes: d_1, d_2, d_3 – obtained time

	Average	Standard deviation	Relative error
	[n]	[n]	[%]
d_1	185,5	1,18	7,25
d_2	203,8	6,75	-1,9
d_3	169,6	1,84	15,2

For each bin k_1, k_2 and k_3 there were little differences between each trail run. Relative error was lest for 14 intervals. However standard deviation was largest for it, and smaller values were obtained for 10 bins. The third test had the largest relative error value.

3. APPLYING PROCEDURE TO REAL DATA

Proposed procedure for calculation of breaking time of a circuit breaker was used to calculate the time t_z based on 34 different oscillograms obtained from presented test set-up. An example oscillogram is presented on Figure 4.

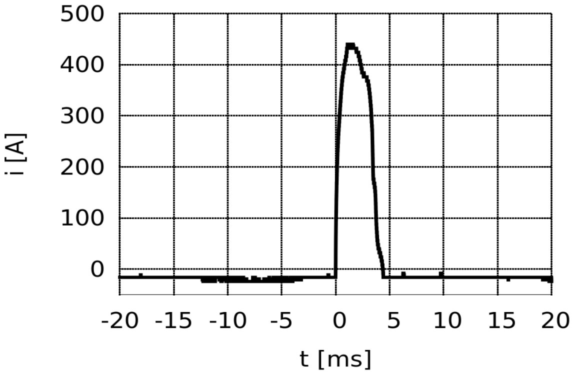

Fig. 4. Example current-time oscillogram of short-circuit current

Table 3. Results of calculating breaking time t_z for two different class intervals: t_{z1} – for 10 bins, t_{z2} – for 14 bins

Lp.	t_{z1}	t_{z2}	Lp.	t_{z1}	t_{z2}	Lp.	t_{z1}	t_{z2}
1	6,66	6,82	13	3,58	3,77	25	6,25	6,42
2	6,35	6,67	14	6,50	6,71	26	6,48	6,62
3	6,60	6,82	15	6,67	6,84	27	5,59	5,65
4	6,04	6,13	16	5,71	5,79	28	5,61	6,00
5	6,28	6,47	17	4,09	4,13	29	6,10	37,26
6	6,59	6,76	18	3,82	3,84	30	5,77	16,80
7	5,71	5,77	19	3,29	3,51	31	3,92	4,07
8	6,63	6,77	20	4,14	15,08	32	3,17	4,78
9	6,11	6,67	21	6,86	46,14	33	3,25	3,27
10	4,10	4,16	22	6,40	46,40	34	2,76	2,77
11	5,66	5,72	23	6,09	57,72			
12	3,88	3,89	24	5,44	46,88			

It can be seen that the breaking time in question would only be a small part of the whole data collected. Looking inside the file containing raw data a lot of noise can be observed. These noise makes estimating the time problematic. Based on test results presented in Tables 1 and 2 two class intervals, for 10 and 14 bins, were selected to test the procedure on real data. Results of calculations are presented in Table 3. For most of them there is little difference between the two class intervals used. There are however few results that are very different from each over. Comparing these results to the input data it can be concluded that the second result t_{z2} is incorrect. Based on this information it is presumed that the breaking time t_{z1} is the proper one, and this results can be used in further studies.

4. CONCLUSION

Analysing experimental data, especially one with lots of noise, could pose a problem. A solution to this problem may be the use of special scientific software, like Scilab, that is capable of processing all kinds of experimental research data. Solution for a specific problem was presented, tested and the results show promise. Proposed procedure is effective and simple yet it allows gathering necessary information from raw data obtained from experiments.

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