Simulation Study on Internal Fault of Transformer

Article *in* Physics Procedia · December 2012

DOI: 10.1016/j.phpro.2012.03.111

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Available online at www.sciencedirect.com

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Physics Procedia 25 (2012) 459 – 464

Physics Procedia

2012 International Conference on Solid State Devices and Materials Science

Simulation Study on Internal Fault of Transformer

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Abstract

The paper studies internal fault of transformer. We established the primary system model of transformer based on MATLAB/Simulink, and setted calculation combined with actual differential protection for a given parameter transformer. Using simulink to simulate test of short-circuit. By the simulation study, we investigated and improved the performance of transformer protection.

Keywords: Transformer; internal fault; simulation; short-circuit.

1. Introduction

Transformer differential protection improves and perfects the realization of traditional protection techniques with computer's technical advantages. It is necessary to study the fault of transformer to explore new protection principle, and improve the transformer protection performance. But there are many drawbacks on test, for example: testing environment, testing conditions, safety and so on. To overcome these shortcomings, we used the system based on simulink technology,and complete a compreh-ensive simulation test of real units and operating environment. It can significantly reduce the development and testing costs, and it can shorten the development cycle too.

2. Transformer protection setting

2.1 Transformers on both sides of transformer ratio

Current of high-voltage side:

$$I_{N1} = \frac{S_N}{\sqrt{3}U_{N1}} = \frac{63000}{\sqrt{3}\times 110} = 330.66(A)$$

Supported by Leading Academic Discipline Project of Shanghai Municipal Education Commission (No.J51801) and the National Natural Science Foundation of China (No. 60802058)

 doi:10.1016/j.phpro.2012.03.111

Current of low-voltage side:

$$I_{N2} = \frac{S_N}{\sqrt{3}U_{N2}} = \frac{63000}{\sqrt{3}\times 10.5} = 34646.1(A)$$

$$n_{TA1} = \frac{400}{5} = 80$$

$$n_{TA2} = \frac{4000}{5} = 800$$

The transformer ratio is 800/80.

2.2 *Secondary current of the current transformer*

$$I_{1c2} = \frac{330.7}{80} = 4.13(A)$$

$$I_{2c2} = \frac{3464.1}{800} = 4.33(A)$$

Taken I_{1c2} as the reference value

2.3 *Current balance adjustment factor*

$$k_b = \frac{I_{1c2}}{I_{1c1}} = \frac{4.13}{4.33} = 0.954$$

Minimum differential current:

When $I_r \le I_{r.\min}$, the operating conditions for the differential protection is $I_d \ge I_{d.\min}$: $I_d = I_{d.\min} = (0.2 \sim 0.5)\,I_n = 0.4\times 4.13 = 1.652(A)$

the braking current at inflection point：

$$I_{r.\min} = (0.5 \sim 1.2)\,I_n = 1\times 4.13 = 4.13(A)$$

When $I_r \le I_{r.\min}$, the operating conditions for the differential protection is：

$$I_d \succ I_{d.\min} + K(I_r - I_{r.\min})\,:$$

K is the ratio braking coefficient，and is taken 0.4 here.

2.4 *Action current of differential interruption*

$$I_{d.set} \ge (5 \sim 6)\,I_n = 5\times 4.13 = 20.65(A)$$

3. Transformer primary system modeling

3.1 *Primary system modeling*

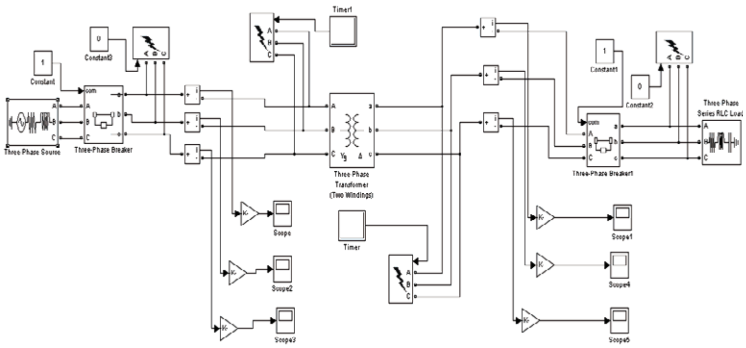

Figure 1. primary system modeling

Using MATLAB/Simulink to establish the mathematical model of transformer, the primary system modeling is shown in figure 1.

3.2 System module parameters setting

1) Three-phase power components

Setting the phase voltage, phase angle, frequency, internal connections, short-circuit impedance values and three-phase power.

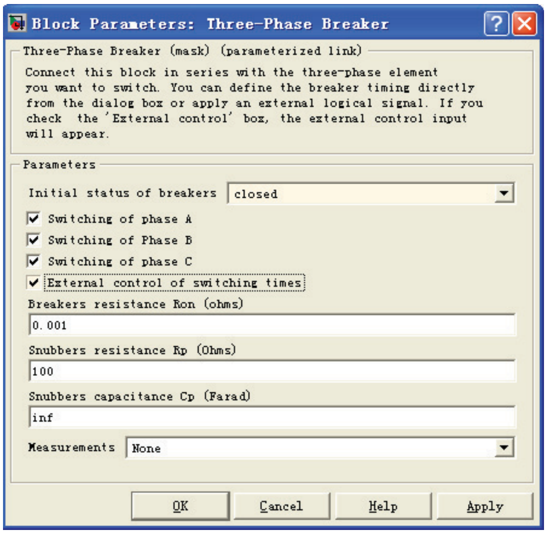

Figure 2. parameter setting for three-phase power

2) Three-phase circuit breaker components

Setting resistors, the initial state, hysteresis resistance, hysteresis capacitance, switching time, the internal timer sampling time, external control and measurement conversion time.

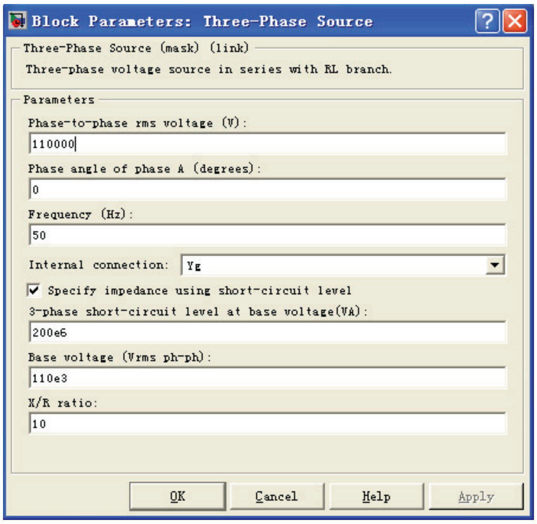

Figure 3. parameter setting for three-phase circuit breaker

3) Three-phase transformer components

Setting the rated power, frequency, parameters of winding 1, and winding 2, three-winding transformer options and measu-rement options.

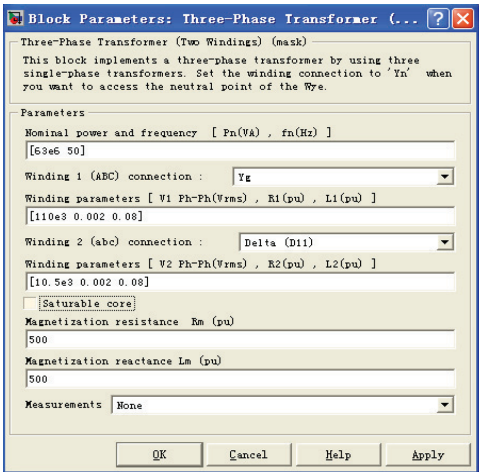

Figure 4. parameter setting for three-winding transformer

4. Simulation of Transformer Internal Fault

4.1 Normal operation

When the transformer is operating normally, the each phase current of high and low voltage side is shown in figure 5and 6.

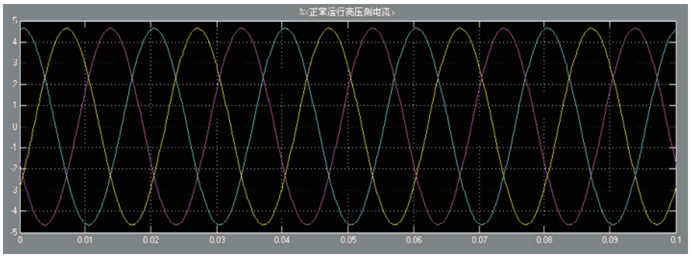

Figure 5. the each phase current of high voltage side

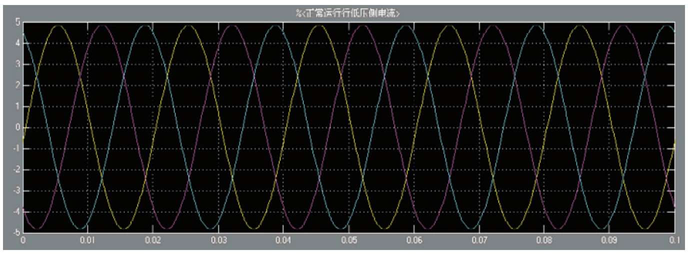

Figure 6. the each phase current of low voltage side

By analysis and comparison the figures 5 and 6, we can get the following conclusions: when the transformer is operating normally, each three-phase current difference of 120 degrees, the current of low voltage side advances the current of high voltage side 30 degrees, it is normal.

4.2 A and B phase short-circuit at the high voltage side

When A and B phase short-circuit at the high voltage side, the changes of each phase current at high and low voltage side is shown in figure 7 and 8.

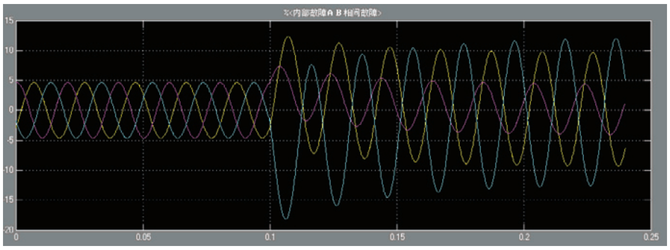

Figure 7. the each phase current of high voltage side

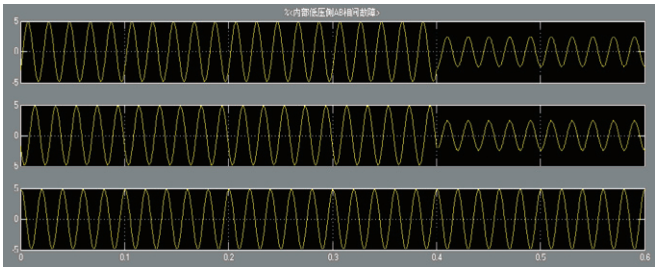

Figure 8. the each phase current of low voltage side

From the two chart analysis above, we know that AB phase short circuit fault occurs, the high current AB side of the current increase in 0.4 seconds 4 times the rated current, non-fault phase C current normal; from the low pressure side of the plot shows that in 0.4 seconds after a fault current occurs AB.

4.3 Internal three-phase short circuit

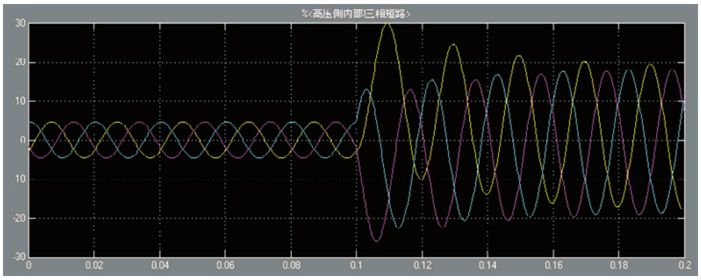

Figure 9. the each phase current of high voltage side

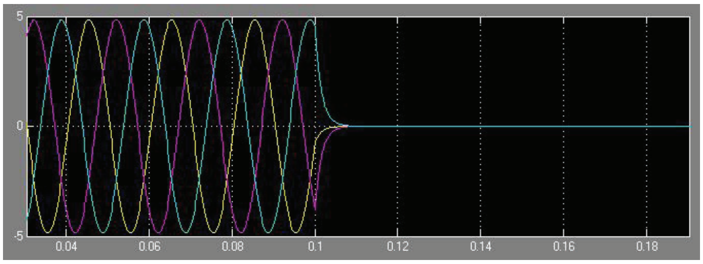

Figure 10. the each phase current of low voltage side

According the figures 9 and 10, we can get the following conclusions: when it occurs that A phase contacts to ground, the current will increase to 10A in the 0.1s at A phase, and the current is normal at non-fault phase. Single-phase ground fault is a common fault. In large grounding system, It can be set to zero protection in order to increaseing the sensitivity.

5. Conclusion

In this paper, we established the primary system model of transformer based on MATLAB/Simulink, and setted calcula-tion combined with actual differential protection for a given parameter transformer. Using simulink to simulate different states of transformer: normal operation, A and B phase short-circuit at the high voltage side and internal three-phase short circuit. By the simulation study, we investigated and improved the performance of transformer protection.

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