Matlab Simulation of Short-circuit in Power System

Xiao-quan Li*, Geng CHEN and Jiang-jiang HE

Air Force Engineering University Air and Missile Defense College, Shaanxi Xi’an, 710051, China

*Corresponding author

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Abstract. In this paper, MATLAB software is used to build a simulation model for an infinite power supply system, and the short-circuit faults under four different conditions are analyzed. The practice shows that the simulation results are consistent with the theoretical analysis results. It has important practical significance for the research, planning and operation of power supply system, indicates that MATLAB simulation of the power system is feasible, can realize the simulation and data analysis of power supply system faults quickly and accurately, greatly improving the working efficiency.

Introduction

MATLAB is a large software developed by MathWorks in 1984 for mathematical calculation and application simulation. Through development, it gradually becomes a digital application software, which integrates data operation, picture synthesis, mathematical modeling, real-time control, dynamic simulation, signal processing and other functions. Its superior mathematical modeling and dynamic simulation capability make it play more and more important role in power system. Simulink, as a tool library on MATLAB, is equivalent to a software attached to it. It provides users with modeling methods of discrete, continuous and other systems. Simpowersystems(SPS) is under the Simulink module library, can be used to simulate the different systems of power system model, the result compared with the actual result has high reliability, real-time accurate simulation of short-circuit can be set up and running. It mainly includes the following module power supply, components, power electronics, machinery, measurement and application library, additional components library and Powergui (graphical user interface)[1].

In this paper, an infinite power supply system model is selected to explain the construction and function of the model by analyzing its situation under different short-circuit faults.

The Establishment of Simulation Model of Infinite Power System

In the faults of power system, short-circuit fault is very harmful to the power system. Therefore, an infinite power supply system is selected in this paper, and its short-circuit current under several kinds of short-circuit faults is compared and analyzed.

Infinite Power Supply System Simulation

Suppose the infinite power system is shown in Figure 1.

![Figure 1. Power supply system with infinite power.](image)

At 0.02s, a three phase short-circuit fault occurred in the low-voltage denominator line of the transformer. Line parameter is: \( L = 50 \text{KM} \), \( x_1 = 0.4 \Omega / \text{KM} \), \( r_1 = 0.17 \Omega / \text{KM} \); the rated capacity of the transformer is \( S_N = 20 \text{MV} \cdot \text{A} \). Short voltage \( U, \% = 10.5 \), short loss \( \Delta P = 135 \text{KW} \), no-load
loss $\Delta P = 22\text{kw}$, no-load current $I_{\%} = 0.8$, variable ratio $k_p = 110/11$, load $S = 5\text{mw}$, high and low voltage winding are all Y-shaped connections. And let the power point voltage be $110\text{kV}[2]$.  

**Parameter Settings**  
The transformer adopts the module shown in Figure 2, and can be calculated according to the given data. Include: The transformer resistance, The transformer reactance, The leakage inductance of transformer, The transformer excitation resistance, The transformer excitation reactance, The transformer excitation inductance, The primary side reference value, The quadratic side reference value, the leakage inductance and resistivity of the primary winding, and so on.  

![Figure 2. Simulation diagram of infinite power supply system.](image)

The transmission line adopts model shown in Figure 2 and can be calculated according to the given parameters[3].  

$$R_L = r_1 \times l = 0.17 \times 4.08 \Omega = 8.5 \Omega \quad X_L = X_1 \times l = 0.4 \times 50 \Omega = 20 \Omega \quad L_t = \frac{X_L}{2\pi f} = \frac{20}{2 \times 3.14 \times 50} = 0.064H$$  

(1)

The voltage and current signal at the low voltage side of the transformer is converted into Simulink signal by using the voltage and current measurement module. Three phase line fault module is used to set the fault type of the fault point.  
The initial data of the simulation parameter running is 0, the data of the termination running is maintained as 0.2s, and the rest data remains unchanged.

**Analysis of the Simulation Results**

**The Calculation of Theoretical Values**

Because the three phase short-circuit fault is very harmful, this paper selects the three phase short-circuit fault for theoretical calculation.  
The amplitude of short-circuit current periodic component is:

$$I_n = \frac{U_{\%} k_p}{\sqrt{(R_f + R_t)^2 + (X_f + X_L)^2}} = 10.63\text{KA}$$  

(2)

Time constant $T_a$ is:

$$T_a = \frac{L_t + L_f}{R_f + R_t} = \frac{0.202 + 0.064}{4.08 + 8.5} = 0.0211s$$  

(3)

The impact current of the shorts is:
When the system is working normally, the system is simulated, and the current and voltage waveforms of the system can be obtained. When there is no fault in the system, the current is very small, almost zero, because the transformer’s low-voltage side is not connected with the load. At this point the circuit is working normally, the voltage is stable and working normally[4].

**Three Phase Short-circuit**

Select the corresponding A, B and C phases in the “three phase fault ” module, and keep other parameters unchanged. After debugging, the simulation is running. Three phase short-circuit current waveform is obtained by oscillograph, as shown in Figure 3.

![Figure 3. Three phase short-circuit current waveform.](image)

At 0.02s, A, B and C phase grounding fault occurred, A, B and C phase currents gave rise to strong shaking, and the short-circuit current’s periodic component amplitude was 10.63KA, and the impact current was 17.3KA.Compared with the actual calculation results, it is basically consistent, mainly because there is a different between the parameter setting of the power supply and the actual parameters, which verifies the correctness of the simulation model. Comparing with the current of other kinds of short-circuit faults, it can be seen that the short-circuit current of this kind of fault is the largest and damage is the greatest. By studying its voltage waveform, it can be found form Figure 4 that when the short-circuit fault occurs, the voltage rapidly becomes 0, while at this time, when the fault is removed, a large degree of voltage jump occurs. Form Figure 4, it can be found that the jump voltage at the time of 0.1s reaches 100000 voltages, which is very large[5].

![Figure 4. Three phase short-circuit voltage waveform.](image)
Two Phase Ground Short-circuit

Select any two phases of Fault phase in the “three phase fault” module. Select A and B phases here. Select “Ground Fault” item. After debugging, run the simulation, and get the short-circuit current waveform when two phase ground short-circuit through oscilloscope as shown in Figure 5. System before failure, the original system and stable operation, after 0.02s failure, A,B two phase current rapidly changing, C phase current remain unchanged, in 0.1s failure after resection, A,B two phase current decay to zero quickly. C phase current is kept constant. Compared with three phase short-circuit fault, two phase ground fault is only A, B two phase short-circuit fault, so A, B two phase current mutation, C phase current to maintain the original level, which is not greatly affected. When A short-circuit occurs, the voltage of the A and B the phases becomes zero due to grounding. The voltage of the C phase changes from the phase voltage to the line voltage, so it becomes larger. As shown in Figure 6.

Single Phase Ground Short-circuit

Select any Phase of Fault Phase in the “three phase Fault” module, select Phase A here, and select the “Ground Fault” item. The setting of other parameters remains unchanged. After debugging, run the simulation, and get the short-circuit current waveform when two phase ground short-circuit through oscilloscope as shown in Figure 7. After 0.02s failure, A is connected to the ground. At this time, the amplitude of current of fault phase A changes, but its values is not large due to the connected load. The current of non-fault phase B and C basically remains unchanged. Due to the internal resistance of the wire, the current will have a small value. After the fault is removed, the system parameters return stability. When A short-circuit occurs, the voltage of phase A becomes zero to grounding. At this time, the voltage of phase B and C changes from phase voltage to line voltage, so the amplitude of voltage increases. As shown in Figure 8[6].

Figure 5. Two phase ground short-circuit current waveform. Figure 6. Two phase ground short-circuit voltage waveform.

Figure 7. Single phase short-circuit current waveform. Figure 8. Single phase short-circuit voltage waveform.
Two Phase Short-circuit

Select any two phases of the fault phase in the “three phase fault” module. Select A and B phases here. After debugging, run the simulation, and get the short-circuit current waveform when two phase ground short-circuit through oscilloscope as shown in Figure 9. After 0.02s failure, the current of A and B fault phases changes dramatically, and the current of C non-fault phase remains unchanged at original level. When the fault is over, the phase A and B currents are rapidly reduced to zero, the phase C current remains unchanged, and the system current remains stable. When A short-circuit occurs, the voltage of the A and B phases becomes zero, and the voltage of the C phase becomes larger. As shown in Figure 10.

Figure 9. Two phase short-circuit current waveform.          Figure 10. Two phase short-circuit voltage waveform.

Conclusion

In this paper, an infinite power supply system is used to build a power system simulation model in MATLAB, and the short-circuit current of several short-circuit faults is simulated and analyzed. The results are shown that the powerful MATLAB simulation system provides an effective experimental research method for power system analysis and greatly simplifies the workload of calculation and analysis.

References


