

Power System Simulation Study Based on MATLAB

Yiting Qian^{1,a,*}

¹Business School, University of Shanghai for Science and Technology, Shanghai, China

^a18019062918@163.com

*Corresponding author

Abstract: This paper discusses in detail the study of power system simulation based on MATLAB, focusing on the establishment and simulation of single-machine-infinity system model. The article firstly introduces the importance of power system simulation and the application of MATLAB/SIMULINK in power electronics. By analyzing the composition and system development of MATLAB, we demonstrate the flexibility and usefulness of these tools in power system simulation. The construction method of the single-machine-infinity system model is detailed in the paper, and corresponding MATLAB code examples are provided to demonstrate the simulation process. The simulation results are also carefully analyzed to assess the stability and performance of the system. By key parameters such as generator speed and system voltage, this study not only verifies the accuracy of the simulation model, but also provides practical guidance for the design and optimization of power systems. Finally, the paper concludes the research results and an outlook on future research directions.

Keywords: Power System Simulation, MATLAB/SIMULINK, Stand-alone-infinity System Modelling, System Stability Analysis, Technology Innovation and Application

1. Introduction

In today's rapidly evolving technological era, the stability and efficiency of the power system is critical as the lifeline of modern society. Power system simulation not only helps to design a more efficient and reliable power grid, but is also critical for responding to emergencies, optimizing energy distribution and integrating emerging renewable energy technologies. With the growth of global energy demand and changes in energy mix, power system simulation has become a key technology to ensure the safe and efficient operation of power grids^[1].

MATLAB and SIMULINK have undergone continuous development and refinement since their introduction. The use of these tools in power system simulation has become an industry standard^[2]. They not only make power system design and analysis more efficient, but also drive innovation across the industry by providing deep insights into complex systems. In particular, MATLAB and SIMULINK play a crucial role in emerging areas such as smart grid technology and renewable energy integration.^[3]

2. Modelling and Simulation of Single-machine-infinity Systems

2.1. System Model and Simulation Diagram

The single-machine-infinity system model is a classical model in the study of power system dynamics. This type of model is commonly used to analyse the dynamic interactions between generators and the infinite power system (i.e., the power grid). This study uses the Simpowersystems toolbox to construct such models. Constructing a single-machine-infinity system model in MATLAB usually involves modelling a generator (representing the single machine) and an equivalent infinity system as Figure 1 shown. After building the model, the basic parameters of the single-machine-infinity system model are defined, including the reference power, reference voltage, inertia constant and reactance values of the generator, and the equivalent reactance of the infinity system. Next, a simplified transfer function model of the system as Figure 2 shown is constructed using these parameters.

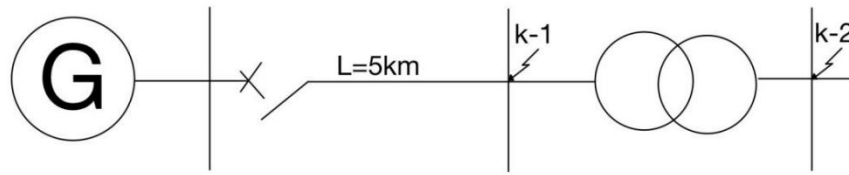


Figure 1: Single-computer-infinity system model.

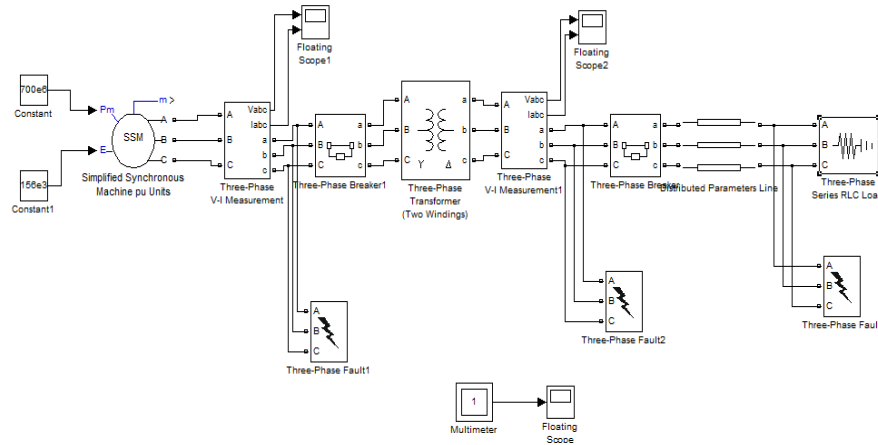


Figure 2: Simulation diagram of single-machine-infinity system.

2.2. Simulation Parameter Setting

When the circuit diagram design is completed, it is simulated in order to observe the stable operation of the system and the state change when a short circuit occurs. In the menu options of simulation, select the Simulation menu and activate the Simulation Parameters command to bring up the Simulation Parameters dialogue box. The parameters of the simulation were first set, including start and end times, solver type, and tolerances. Next, a single machine-infinity system model was created and the simulation was run. Finally, the response curve of the generator speed is plotted to visualize the dynamic behaviour of the system under specific conditions.

3. Fault Point Current Analysis

When simulating a short-circuit fault on a three-phase circuit, you first need to select the fault type in the settings of the short-circuit fault generator. In this paper, a three-phase fault is selected and the option to ensure that the faulted phase is grounded is activated. This is configured to simulate a simultaneous three-phase short-circuit in a circuit, which is an extreme but important test scenario.

Afterwards, make sure that both the circuit diagram and the simulation parameters have been set correctly, and you can start the circuit simulation. This step is achieved by activating the simulation button in SIMULINK. After starting the simulation, the focus of observation is on the waveform variation of the current at the point of fault.

In order to understand in detail the variation of the current in phase A at the point of fault, this paper uses a multimeter element to measure this electrical quantity in the simulation. When the simulation starts, the waveform shape of the current in phase A at the point of fault is shown in Figure 3. This waveform graph provides a wealth of information. When the circuit reaches steady state, the current in phase A at the point of fault remains at 0 A because the short-circuit fault generator of the three-phase circuit is in the disconnected state; however, when the simulation time reaches 0.6 seconds, the short-circuit fault generator closes, resulting in a three-phase short-circuit in the circuit, and at this time, the waveform of the current in phase A at the point of fault undergoes a significant change, with a rise in the value of the current followed by a gradual decrease. When the simulation time reaches 0.7 seconds, the short-circuit fault generator is disconnected again, simulating the elimination of the fault, and the current at the point of fault quickly falls back to 0A.

Through such simulation, the changes in current wave forms of a circuit during normal operation, when a fault occurs, and after fault removal can be visually observed, which is crucial for understanding the behaviour of circuits and designing safer and more reliable power systems.

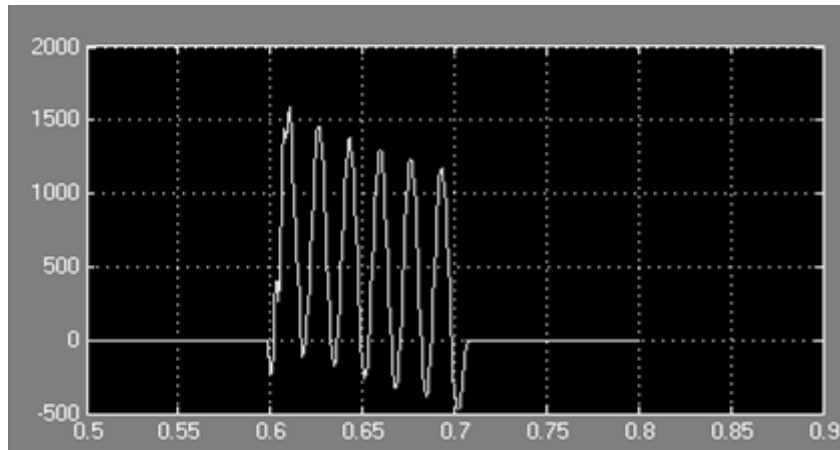


Figure 3: Fault point A phase current.

Another key measurement point in the simulation of a three-phase circuit short-circuit fault is the fault point B phase current. In order to observe this parameter, choosing the fault point B-phase current as the measurement object in the multi-meter component in the simulation. After the simulation is started, the waveform of the fault point B-phase current is shown in Figure 4.

By analyzing this waveform, obtaining the following important conclusions: when the circuit is running stably, the current in phase B at the point of fault is maintained at 0 A because the three-phase circuit short-circuit fault generator is disconnected; however, when the simulation time progresses to 0.6 s, the short-circuit fault generator is closed, and a three-phase short-circuit occurs in the circuit at this time. This resulted in a significant change in the current in phase B at the point of fault, with the current waveform first shifting downwards and then gradually shifting upwards. Then, at 0.7 seconds, the current in phase B at the point of fault quickly returns to 0A as the three-phase circuit short-circuit fault generator is disconnected, which is equivalent to the fault being removed.

Such a simulation result is crucial for understanding and analyzing the performance of the circuit under different operating conditions. It not only reveals how the circuit reacts during a three-phase short circuit, but also demonstrates the circuit's ability to recover quickly after the fault is removed.

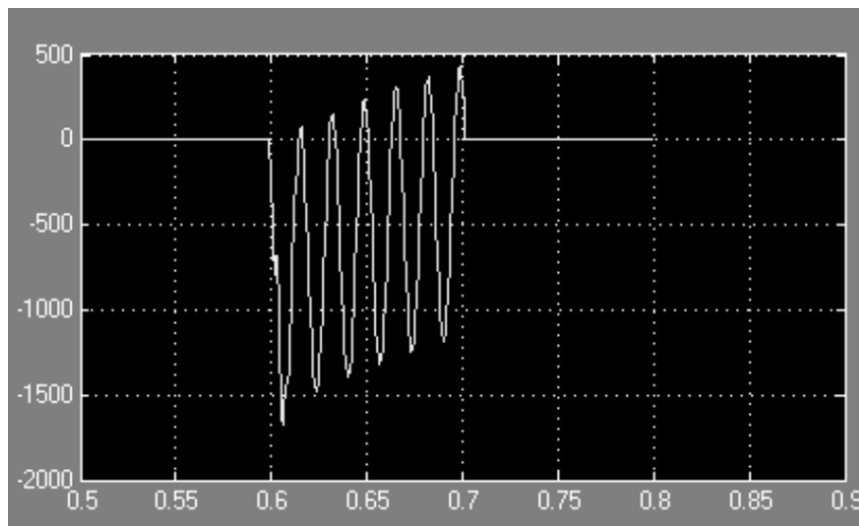


Figure 4: Fault point B phase current.

Select the fault point C phase current as the measured electrical quantity in the multi-meter components. Activate the simulation button, then the current waveform of phase C at the point of fault is shown in Figure 5. Several key conclusions can be drawn from the current waveform of phase C at the point of fault. Firstly, when the circuit is in steady state, the current in phase C at the point of fault remains

at 0 A because the three-phase circuit short-circuit fault generator is disconnected. Next, when the time reaches 0.6 seconds during the simulation process, a three-phase short-circuit occurs in the circuit due to the three-phase circuit short-circuit fault generator closure. This change causes a significant change in the current in phase C at the point of fault and its current waveform shifts upwards reflecting the increase in current.

Finally, when the simulation time reaches 0.7 s, with the three-phase circuit short-circuit fault generator disconnected again, which is equivalent to the simulation of fault elimination, the current of the fault point phase C quickly returns to 0 A. This shows that the circuit can quickly return to normal state after a fault occurs.

This simulation analysis is not only essential for understanding how the circuit behaves under different operating conditions, but also provides an important perspective for assessing the safety and reliability of the circuit. By simulating the current changes under various fault conditions, the circuit can be better designed and optimized to ensure its stability and safety in practical applications.

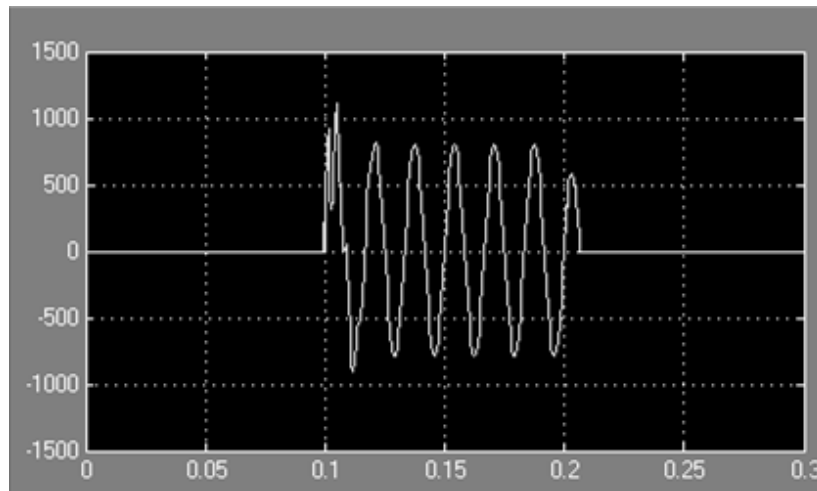


Figure 5: Fault point C phase current.

Select the fault point A-phase, B-phase, C-phase voltage as the measurement of electrical quantities in the multimeter components. Activate the simulation button, then the wave forms of the voltage at the fault point phase A, B and C are shown in Figure 6, and the following conclusions are drawn from the graphs: the voltage at the fault point is the voltage at the transformer end in steady state, and when a short circuit occurs, the voltage at the point of fault quickly becomes 0 V. The normality is restored in 0.7 s, when the transient process occurs.

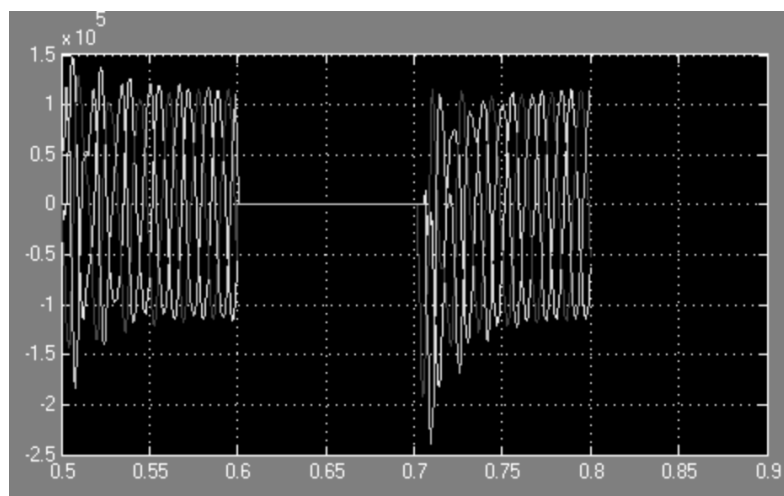


Figure 6: Fault point three-phase voltage.

4. Conclusions

In this paper, a detailed dynamic simulation of the single machine-infinity power system is analyzed by MATLAB software. The system model is successfully constructed, the simulation is implemented, and the simulation results are meticulously analyzed. Through the thorough analysis of the simulation data, the stability and performance of the system can be effectively assessed to provide powerful data support for the design and optimization of the power system.

It is found that the stability of the system can be significantly improved by adjusting the system parameters, such as the damping coefficient and inertia constant of the generator. This analysis is important for understanding the complex dynamic behaviour of power systems and provides direction for further system design and improvement.

This paper demonstrates the process of simulating and analyzing a power system using MATLAB. Not only a practical simulation model is provided, but also a series of optimization suggestions, which provide a new perspective for power system research and practice. Future work will focus on extending the complexity of the simulation model, improving the accuracy of the simulation, as well as exploring more optimization methods in order to keep advancing the power system technology.

References

- [1] Suxiu Li, Lin Liu, Ning Zhang, Hongcai Dai, Jing Lu, *Industrial Development Research on the New Type Power System: Industry Structure, Key Factors and Value Creation [J]. New Type Power Systems, 2024(01): 65-77. (In Chinese)*
- [2] Haibin Su, Jidong Wang, *Simulation and Design of Power Electronics System Based on Simulink/MATLAB [J]. Journal of North China University of Water Resources and Electric Power (Natural Science Edition), 2007(01): 49-51. (In Chinese)*
- [3] Zhixia Han, *Design and realization of experiment system based on Matlab/Simulink [J]. Journal of Shaanxi University of Technology (Natural Science Edition), 2008(02): 28-36. (In Chinese)*