The Simulation of Power Flow Calculation of Power System with Electric Spring Based on Simulink

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Abstract

Due to its obvious convenience and unique advantages, the simulation experiments are increasingly becoming one of the important means to cultivate students' practical ability, especially in the complex power systems. Power system with the high penetration rate of renewable energy is prone various problems due to power imbalance between supply and demand, affecting safe operation of power system. As a new technology, electric spring (ES) can overcome the shortcomings in existing demand-side management mode by transferring fluctuating energy to non-critical loads. However, because the position of the ES connected to the power system will have a direct influence on its effects, it needs to be simulated before application. In this paper, the simulation of power flow operation is taken as an example, the process of building the simulation experimental model based on MATLAB/ Simulink and the main points of parameter setting are detailed. Eventually, the algorithm of Powergui is used to show the application mode and huge potential of the simulation experiment in actual learning.

Keywords

Simulation, Power flow calculation, Power system analysis, Electric spring, MATLAB/ Simulink.

1. Introduction

With the rapid development of computer science, mathematics, control theory and information fusion, computer simulation technology, as an important analysis tool and research method, has been widely used in various theoretical studies and engineering practice. [1-3]The practice is an important part of higher education, especially in engineering, science and other disciplines. It is also an important channel to realize the leap and sublimation of understanding. [4]

In the major of electrical engineering, power flow calculation is a basic method to determine the steady-state operating state of a system given the power system network structure, parameters, and boundary conditions [5] However, the calculated parameters are numerous and the process is complicated. Not only is the accuracy of the results of manual calculations difficult to guarantee, but also complicated calculations are required when parameter changing. The power system simulation module in MATLAB / Simulink is a model library specially used for power system simulation. Combining theoretical learning, it goes through a complete practical process, so as to quickly and effectively draw experimental conclusions. In this paper, we demonstrate the application mode of the software in learning by constructing an example of a simulation model.

2. The principle of electric spring

2.1 The background of the ES

Currently, the operation mode of the power system is that the amount of power generation depends on the needs of users. The grid-connected capacity of wind energy and other renewable energy power generation is increasing year by year. The gap and instability of new energy make its total power generation difficult to accurately predict, which may cause a mismatch between the user's electricity demand and the power provided by the grid. The influence of attributes on the power system is becoming more and more obvious, such as harmonic pollution, voltage fluctuation and frequency flicker [7,8].

Large-scale power grids have certain self-adjusting ability to voltage fluctuations, while small isolated micro-grids have very weak regulating ability. Voltage fluctuations will adversely affect their electrical equipment, and even critical electrical equipment may be damaged in severe cases. Regarding the fluctuation of the grid voltage, reactive power compensation [9,10] is currently the most widely used technology, but this method cannot adjust the active power.

2.2 The basic principle of the ES

The Shu Yuen (Ron) Hui research group of the University of Hong Kong first proposed the concept of electric spring (ES) in September 2012 [11], whose core idea is to couple the concept of mechanical spring to the electric power system, and the car The principle of the shock absorber is similar. In the power grid, the voltage fluctuation on the critical load is controlled within the specified range, and the voltage (energy) fluctuation is transferred to the non-critical load, and the power consumption of the non-critical load is automatically adjusted to achieve automatic balance between power generation and electricity consumption.

Electric spring has reversed the traditional concept that power supply depends on power demand follows power generation in the power system, which can solve the issue due to intermittent and unstable natures of the renewable energy sources such as solar and wind. According to the Vector diagram and phase control algorithm, the critical load voltage is controlled to follow the predefined reference and the ES could operate at capacitive, resistive and inductive modes as line voltage varied.

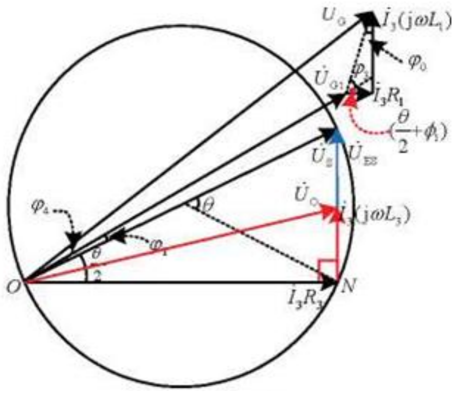

Fig. 1 Resistive modes

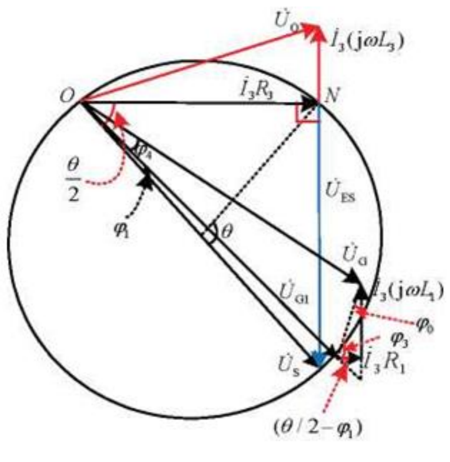

Fig. 2 Inductive modes

3. Model construction

3.1 Model introduction

The parameters of a simple power system are shown in Fig.3.

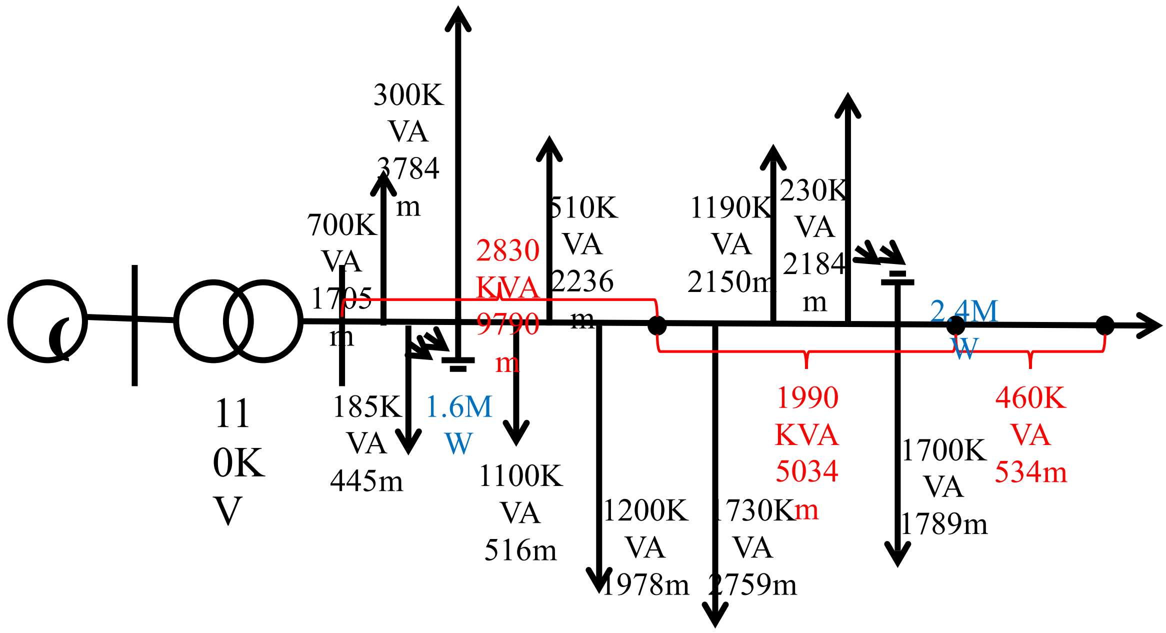

Fig. 3 Power system structure diagram

3.2 Construction of system simulation model

First, according to the given network, find the equivalent parameters of each component required for power flow calculation, and draw the equivalent circuit diagram.

Then, input the data of each branch and the data of each node, use Simulink to build a simulation model, and carry out power flow calculation and simulation.

At last, use MATLAB software to carry out calculation and simulation of the above-mentioned situations.

The system simulation model constructed based on the known conditions is shown in the Fig.4. The system power is directly provided by Three-Phase Sourcel, and the transmission line and system-related main module parameter settings are also shown in the Fig.4, including Three-Phase Sourcel, Three-Phase Transfomer(Two Windings). If you want to connect the ES to the power system, you can use a current source for simulation. At the same time, the position of the electric spring can be flexibly changed.

Because of the power flow calculation, the V-I measurement module must be used as the key node of the power flow calculation, so the V-I measurement module must be installed at the corresponding node.The module adopts Three-Phase V-I Measurment, its setting is shown in Figure 4.3, the fundamental frequency of the effective value calculation module RMS is set to 50Hz.

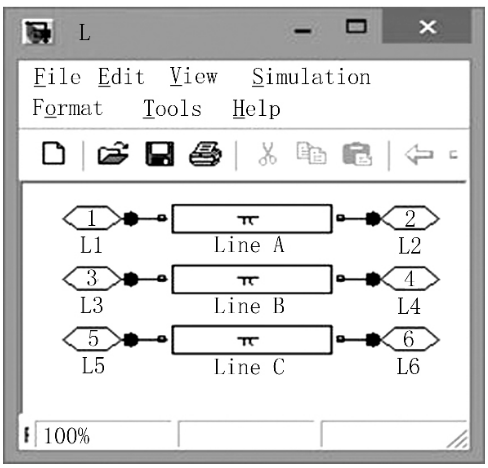

Fig.4.1 The model of Transmission line

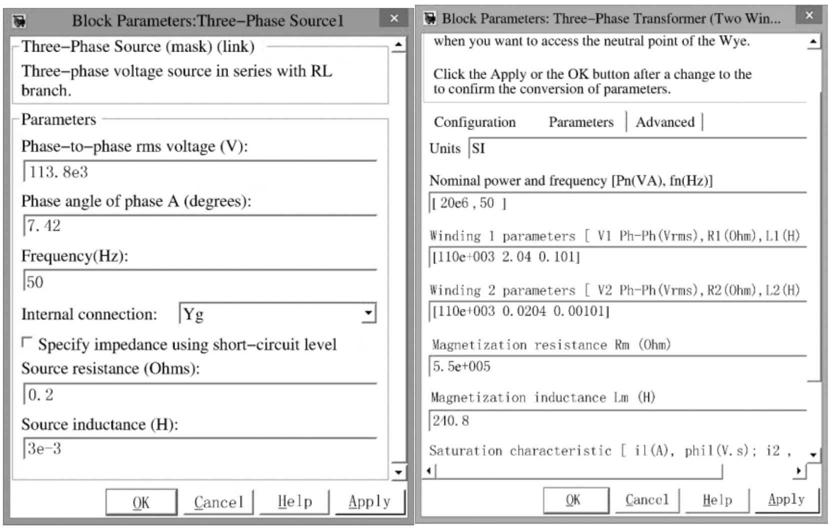

Fig.4.2 The parameter setting of system power and transformer

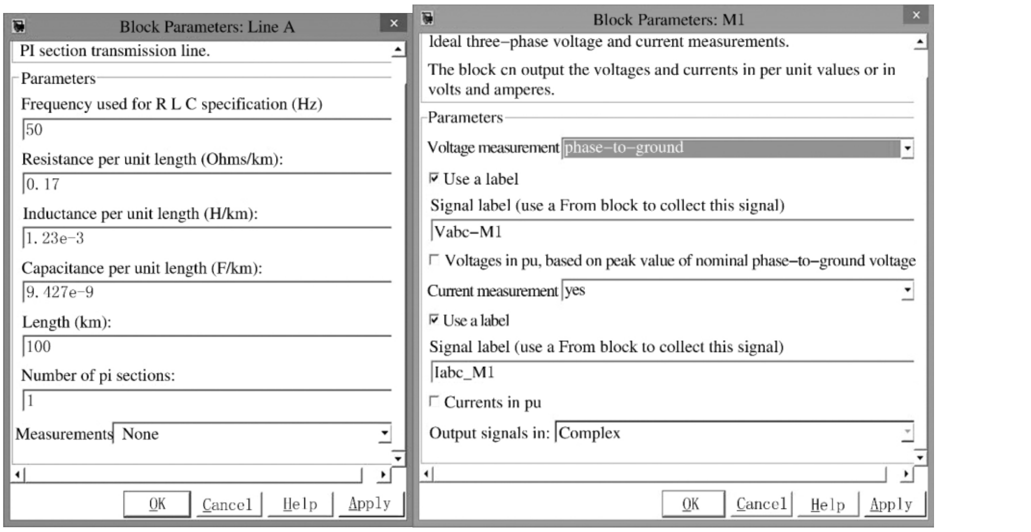

Fig.4.3 The parameter setting of Transmission line and Three-Phase V-1 Measurement

4. Experimental conclusions

The specific results of the simulation power flow calculation are shown in Fig.5. Obviously, it is easy to get this result under the correct modeling and setting.

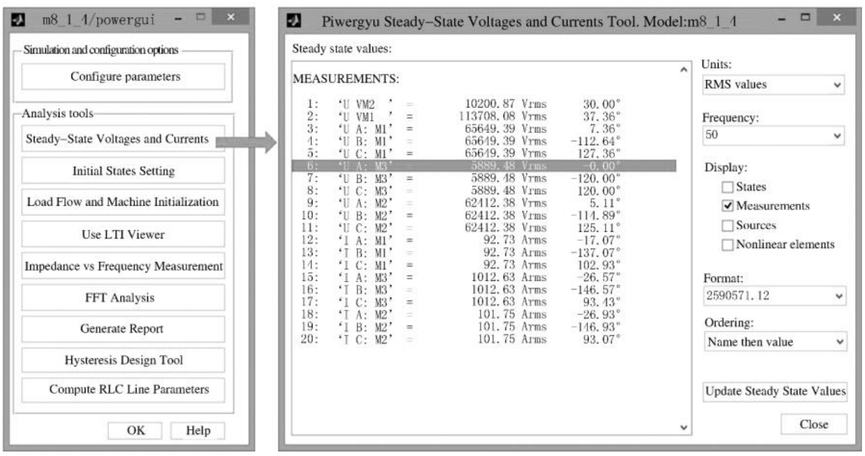

Fig.5 The basic setting of powergui and the result of power flow calculation

This paper takes the power system power flow distribution calculation as the goal. Under the premise that the basic power flow calculation process and method are already familiar, the MATLAB / Simlink model is established according to the relevant parameters.Of course, the establishment of the model involves many core technical details. It takes a lot of hard work for a beginner to establish a correct and usable model.If the parameters are correct, then the conclusion obtained by using this simulation model should also be correct.Therefore, there is great potential for using system simulation methods to improve practical skills, save computational complexity, and increase efficiency.

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