Power system relay protection simulation based on MATLAB

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ABSTRACT

MATLAB -based simulation technology can support the analysis and design of relay protection systems. A simulation model is built for the study of power system relay protection. As an example, the power system fault simulation, zero-sequence current protection simulation and transformer differential protection simulation are presented herein. The case studies show that the simulation of power system relay protection is effective and feasible.

Key words: power system; relay protection; simulation; MATLAB
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INTORDUCTION

Power System digital simulation can be divided into two types of simulation study and training simulation. Simulation Study includes a variety of power system stability and transient electromagnetic transient simulation software, integrated electromagnetic transient stability program ,Such as electromagnetic transient software EMTP and widely used in domestic electric power department comprehensive stability program as well as the Mathwork company's newly minted MATLAB, etc. Training simulator includes those belonging to the EMS dispatcher training simulator DTS, substation operator training simulator and power plant unit operation personnel training simulators.

Some of DTS has function of studying simulation, so hardware and software are very large and complex, also the equipment are expensive.

Simulation studies can be divided into non-real-time simulation and testing of real-time simulation. Real-time simulation of power system protection devices currently are used mainly for testing and adjusting the generator excitation system. With physical participation, thus we required simulation system in real time. Real-time simulation software must be finished within a practical step all state variables and state variables to solve the calculation and associated with the physical parameters of the transformation, power amplifier and connection.

From the training requirements of the system, taking MATLAB as a development platform, we used the system's powerful, suitable functions for the development of a number of power system protection simulation modules. Students can construct a simulation model according to the required imitation really power topology structure, power flow calculation, short circuit Calculation, transient simulation calculation and relay protection testing and validation.

POWER FLOW CALCULATION

During systems analysis, it often in need of power flow calculation. So the system integrates the flow calculation module. Power flow calculation used a modular programming method. The calculation module is written in C + + language, so it has fast computing speed. In addition to the core algorithm module used a better convergence of the Newton-Raphson algorithm, to meet the students' purpose of power flow calculation. Taking advantage of the trend of computing systems provide mapping module, through a simple drag and drop mapping method to draw a trend to

be calculated topology, students do power flow calculation by making convenient graphical parameter settings. Compared with the traditional data card fill in power flow calculation method , this method has greater convenience, making the students get rid of the traditional calculation method of dry sex, greatly improving the learning interest. Process of power flow calculation module is shown in Fig.1.
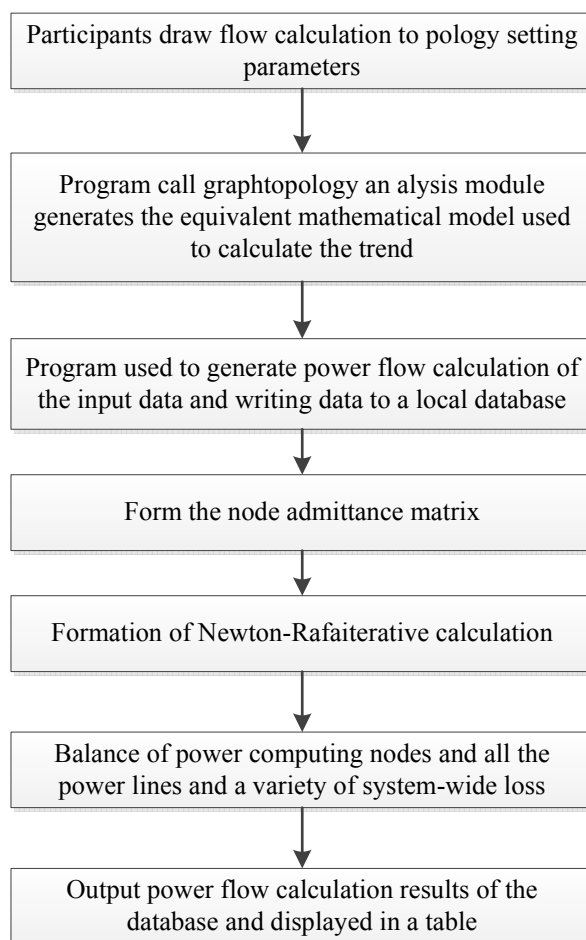
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┌─────────────────────────────────────────┐
│  Participants draw flow calculation to   │
│         pology setting parameters        │
└─────────────────────────────────────────┘
                     │
                     ▼
┌─────────────────────────────────────────┐
│  Program call graphtopology an alysis    │
│  module generates the equivalent         │
│  mathematical model used to calculate    │
│  the trend                               │
└─────────────────────────────────────────┘
                     │
                     ▼
┌─────────────────────────────────────────┐
│  Program used to generate power flow     │
│  calculation of the input data and       │
│  writing data to a local database        │
└─────────────────────────────────────────┘
                     │
                     ▼
┌─────────────────────────────────────────┐
│       Form the node admittance matrix    │
└─────────────────────────────────────────┘
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                     ▼
┌─────────────────────────────────────────┐
│  Formation of Newton-Rafaiterative       │
│  calculation                             │
└─────────────────────────────────────────┘
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                     ▼
┌─────────────────────────────────────────┐
│  Balance of power computing nodes and    │
│  all the power lines and a variety of    │
│  system-wide loss                        │
└─────────────────────────────────────────┘
                     │
                     ▼
┌─────────────────────────────────────────┐
│  Output power flow calculation results   │
│  of the database and displayed in a      │
│  table                                   │
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Fig.1 flow calculation flow chart

In the process of power flow calculation, some PV systems in order to maintain a given node voltage, reactive power of them may exceed the permitted range, especially when the power system reactive power is not very abundance more prone to PV node reactive power of crossing the line. Thus, in an iterative process that must be monitored for reactive power PV node, when the reactive power over a given range, the trend of the program should be able to reactive power control to allow these nodes within range.

If PV node i reactive power maximum allowable value Q_iM, the node is calculated in the iterative process of reactive power Q_i, then the reactive power reserves should be: $Q_i = Q_iM - Q_i$.

When Q_i is negative, indicating that the point has been cross-border reactive power, in this case, the intervention must be to reduce the reactive power iteration of this node $| Q_i |$, reactive power to make it back to the upper bound Q_iM. Consequence of this is bound to bring each node voltage systems change, and change the maximum (or reduce the maximum) is the voltage cross-border points. In fact, when the PV node by node i converted to PQ nodes.

Newton's method for flow calculation procedures, the hair in an iterative processPV node reactive power is now out of range when it should translate into PQ node, $(Q_iM - Q_i)$ as the point on the reactive power error. In this case, the structure of the equation should be modified accordingly changes. When power is used when the polar coordinate expression, should be increased corresponding to an equation Q_i in the correction equation, the power when using a rectangular coordinate type, it is necessary to correct the correction equation Qi Vi instead of the equation 2.

In the calculation process, we used a network node number of the power network optimization method. Mainly at least the outlet of the dynamic slip numbered, i.e. the process of elimination in the node, each node after the erasing,

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the number of branches at each node occurs with the node connected to the change (increase, decrease or remain the same) occurs . So, in each elimination of a node, the number of branches has not yet appeared immediately corrected number of nodes, and then choose the least number of branches which qualify a node number, you can expect to get better results.

Through the use of flow calculation module of the system to IEEE30, IEEE4, IEEE6 node system simulation, the result is correct.

SHORT-CIRCUIT CALCULATION

Conducting fault protection action, setting the calculation, you need to make short-circuit calculations. In order to meet the purpose of the teaching faculty of short circuit calculation, system design short circuit calculation module. students can choose a variety of symmetrical and asymmetrical short-circuit calculations, such as single-phase shorted to ground, the two-phase short-circuit, two-phase ground short circuit, three-phase short circuit. Students through the use of short-circuit calculation library provides a variety of computing module configured to calculate the required network positive, negative and zero sequence network, you can choose to calculate the short-circuit type, the results will form the curve or waveform display. The main principle of short circuit calculation is to use the simulation method of symmetrical components, Thevenin circuit principle and the principle of superposition. Positive sequence network by setting to zero the power and voltage source plus a constant, the current can be measured by using the Thevenin principle calculated positive sequence reactance. Similarly, the grid can be obtained negative sequence and zero sequence reactance and a combination of potential. The process according to the selected fault types participants calculated short circuit terminal voltage of each program grid. Use the failed port voltage of each sequence grid superimposed on the point of failure, each sequence network voltage, current can be calculated. Flowchart to specific short-circuit calculationAnd used as shown in Equation 2.
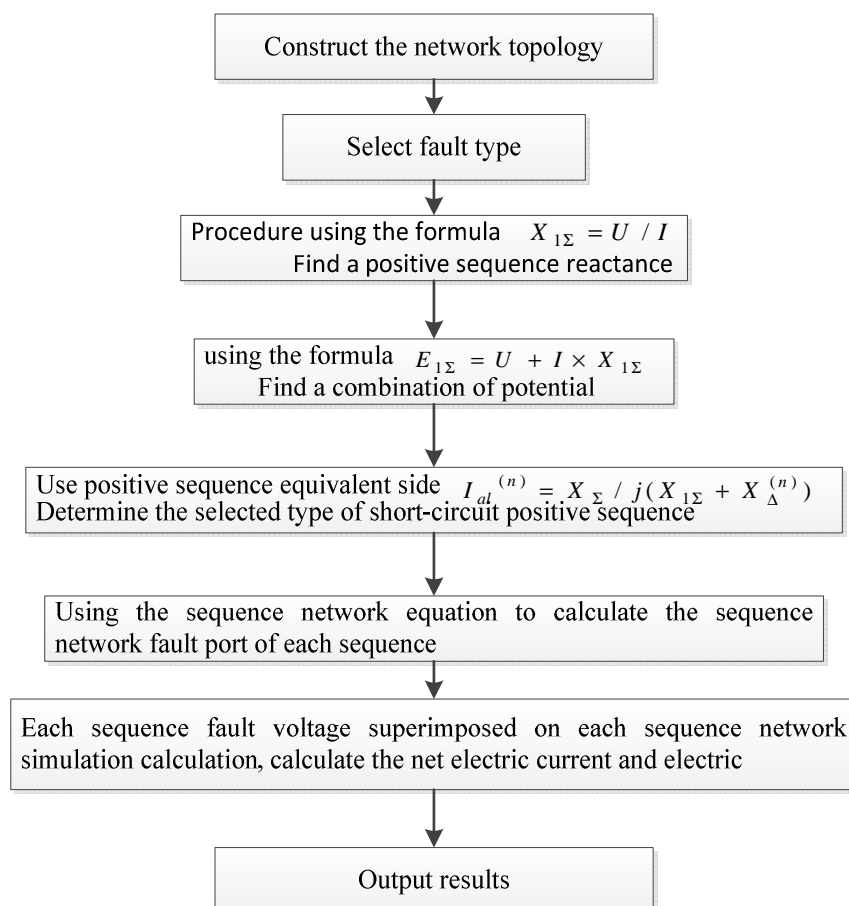
$$\boxed{\text{Construct the network topology}}$$

$$\downarrow$$

$$\boxed{\text{Select fault type}}$$

$$\downarrow$$

$$\boxed{\begin{array}{c}\text{Procedure using the formula} \quad X_{1\Sigma} = U \,/\, I \\ \text{Find a positive sequence reactance}\end{array}}$$

$$\downarrow$$

$$\boxed{\begin{array}{c}\text{using the formula} \quad E_{1\Sigma} = U + I \times X_{1\Sigma} \\ \text{Find a combination of potential}\end{array}}$$

$$\downarrow$$

$$\boxed{\begin{array}{c}\text{Use positive sequence equivalent side} \quad I_{al}^{(n)} = X_{\Sigma} \,/\, j(X_{1\Sigma} + X_{\Delta}^{(n)}) \\ \text{Determine the selected type of short-circuit positive sequence}\end{array}}$$

$$\downarrow$$

$$\boxed{\begin{array}{c}\text{Using the sequence network equation to calculate the sequence} \\ \text{network fault port of each sequence}\end{array}}$$

$$\downarrow$$

$$\boxed{\begin{array}{c}\text{Each sequence fault voltage superimposed on each sequence network} \\ \text{simulation calculation, calculate the net electric current and electric}\end{array}}$$

$$\downarrow$$

$$\boxed{\text{Output results}}$$

Fig.2 short circuit calculation flow chart

CONCLUSION

In MATLAB, the power system model can be set up directly under the Simulation environment, which give full play to the superiority of its simulation platform, and then using MATLAB toolbox abundant resources, can be easily

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controlled in a variety of complex power system simulation method, MALTLAB the calculations based on the basic circuit theory and differential equations solved above, the electromagnetic and electromechanical processes synchronous calculation process, which makes the simulation very careful, may reflect subtle changes. Therefore, protection simulation system based on MATLAB development platform can be built on any system simulation, after all, a new relay transient testing methods.

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